Nyrstar Myra Falls Operation Cycle 6 Environmental Effects Monitoring Program

Interpretive Report

Final Report

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Submitted to: **Nyrstar Myra Falls**
Campbell River, BC

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This report has been prepared by Nautilus Environmental Company Inc. based on data provided by or generated for our client, and the results of this study are for the sole benefit of our client. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

EXECUTIVE SUMMARY

Nyrstar Myra Falls Operations (MFO) is subject to the Metal Diamond Mining Effluent Regulations (MDMER) and, consequently, is required to perform Environmental Effects Monitoring (EEM) studies. The first EEM program was conducted in 2005 by Nautilus Environmental, with four additional Cycles completed since then, in 2008, 2011, 2014 and 2017. The present study represents Cycle 6 of the EEM program, and includes benthic invertebrate and fish population monitoring, analysis of effluent, water quality and sediment monitoring data, and evaluation of acute and sub-lethal toxicity testing results. Findings associated with each of the program elements are summarized below.

Benthic Macroinvertebrate Monitoring

Analysis of the benthic macro-invertebrate community in Myra Creek was conducted using a Control-Impact design, with invertebrate communities from Exposure locations downstream of the mine's discharge compared with communities found at Reference locations upstream of the discharge. The results generally showed differences in community composition between the upstream Reference reach and the Exposure area located downstream of the discharge. However, evaluation of diagnostic metrics associated with sensitive taxa did not show upstream/downstream response patterns that would be suggestive of pollution-related adverse effects, particularly those associated with elevated metals concentrations. This conclusion was also supported by lack of correlations between benthic community metrics and concentrations of sediment metals. Collectively, the analysis suggested that differences in habitat variables (e.g., substrate size) were likely the primary drivers of the variations in community structure upstream and downstream of the discharge. Notably, benthic invertebrate communities at all of the Exposure stations exhibited distributions that fell within the range of "similar to" or "mildly divergent" from the appropriate reference condition established by CABIN for the Fraser River – Georgia Basin Model – 2005, suggesting general agreement with regional metrics.

Fish Population Monitoring

Fish population monitoring at MFO has historically been accomplished using a two-pronged approach: an *in situ* cutthroat trout hatchbox study that monitors the development of eyed-stage cutthroat trout embryos to the swim-up life stage at discrete sites within the Exposure and Reference reaches, and an angling survey that evaluates fish distribution within the creek, as well as various health (i.e., weight, length and condition factor) and population metrics across both reaches. The combination of these elements results in a unique approach that provides a high level of information regarding potential impacts on fish in Myra Creek, and is necessitated by the fact that Myra Creek has a very low density of a single resident fish species, the cutthroat trout

(*Oncorhynchus clarkii*). Moreover, the relatively short length of the downstream Exposure area (~2.5 km), makes it problematic to ensure discrete exposure and reference populations. Notably, due to population constraints of cutthroat trout on Vancouver Island, eyed eggs from rainbow trout (*Oncorhynchus mykiss*) were used for the *in situ* exposures during Cycle 6. Of note, rainbow trout are of the same genus as cutthroat trout and occur in other local watersheds tributary to Buttle Lake where access is not blocked by an impassable waterfall.

The *in situ* hatchbox study demonstrated no significant differences in hatching success, post-hatch survival, normal development or condition factor between the Exposure reach and the Reference area. However, significant increases in length and weight were observed in the downstream area, compared to the Reference area. These latter observations were most likely related to higher stream temperatures associated with the engineered channel and downstream reach, resulting in more rapid growth.

Cutthroat trout abundance observed during the fish survey was higher above MFO's effluent discharge, primarily related to higher numbers of young of the year and juveniles. However, this observation is consistent with previous surveys and was most likely attributable to differences in habitat, rather than direct effects caused by the mine's effluent discharge. Notably, the Reference area of Myra Creek contains numerous off-channel habitats and tributary streams that can be used for refugia, spawning and juvenile rearing purposes. Conversely, the Exposure area of the creek downstream of the discharge is largely limited to the main channel. Notably, a statistically significant ($p < 0.05$) difference in condition factor was observed between fish sampled from Reference and Exposure reaches of the creek, with a lower condition factor in the downstream reach compared to upstream. In terms of critical effect sizes, the difference in condition factor exceeded the ±10 % of the reference mean, potentially warranting further investigation. However, based on comparison with Cycle 5 results, the absence of adverse effects on condition factor observed in the *in situ* exposures, and the fact that downstream fish closest to the discharge exhibited the highest condition factors observed in the Exposure area, it was considered unlikely that the overall difference observed between upstream and downstream areas was related to the discharge.

<u>Effluent Characterization</u>

Effluent chemistry data were summarized and evaluated in the context of discharge limits, as well as results from acute and sub-lethal toxicity testing. In general, all effluent chemistry parameters remained within permitted limits during Cycle 6, the only exception being the concentration of total zinc which marginally exceeded (i.e., by <3%) the discharge limit on one occasion in

December of 2019. With respect to instream levels, copper, cadmium and zinc concentrations exceeded the applicable Canadian Council of Ministers of the Environment (CCME) water quality guidelines (WQGs) at both downstream sites, (i.e., TP-4 and MC-M2), but were lower than observed in the previous Cycle 5 study.

Toxicity tests were also conducted to monitor the acute and chronic toxicity of MFO's effluent. In Cycle 6, acute toxicity tests with *Daphnia magna* and rainbow trout were initially conducted on a quarterly basis, with the frequency increasing to monthly in 2019. With one exception, these tests consistently indicated a lack of toxicity, even at full-strength effluent. Similarly, annual sub-lethal toxicity testing of MFO's effluent with rainbow trout embryo development, *P. subcapitata* growth, *C. dubia* survival and reproduction and duckweed growth tests typically resulted in average IC25 values of at least 83% effluent, further suggesting that only a small level of toxicity was associated with the effluent. Given that the effluent has historically averaged less than 12% of the flows in Myra Creek downstream of the discharge, these results suggest that MFO's effluent has generally not been a concern from an acute or sub-lethal perspective. In addition, the toxicity data continue to suggest improved effluent quality across multiple cycles of the EEM program.

Additional Program Elements

Two additional elements were implemented during the Cycle 6 monitoring program on a one-time basis. The first element was an effluent dilution study conducted in Myra Creek during the summer low-flow period. The study measured various parameters at different distances downstream of the discharge point to determine the point at which mixing fully occurred. Interestingly, the results tended to vary depending on the parameter measured. Parameters such as conductivity ultimately achieved 2 to 4-fold dilutions in Myra Creek and appeared to be fully mixed at TP-4, approximately 1 km downstream of the discharge. Conversely, dissolved copper, cadmium and zinc exhibited relatively consistent concentrations at all sampling points downstream of the discharge. Indeed, based on limited data, concentrations of zinc may have increased at TP-4 and further downstream. Given the inconsistencies observed in parameter dilutions, more detailed sampling may help clarify these observations.

Of note, the effluent dilution study suggested only a 4-fold dilution under current late summer low-flow conditions, which is lower than the approximately 8-fold dilution suggested by historical measurements. The changes in flow patterns may be related to long-term trends in climate change relative to overall precipition and snowpack conditions, and suggest that there is less dilution available during critical low flow periods to ameliorate possible impacts of the discharge, highlighting the importance of managing metals concentrations in the effluent and other mine-related inputs to Myra Creek.

Finally, sediments were collected during the invertebrate sampling program at discrete locations in the Reference and Exposure reaches, and evaluated for metals concentrations. Not surprisingly, metals (e.g., copper, cadmium and zinc) were elevated at sampling sites located downstream of the discharge. However, elevated metals were also observed in sediments collected at one of the Reference sites located near S11 just upstream of the road bridge suggesting a possible source between Arnica Creek and the road bridge. Notably, benthic community metrics at this site were consistent with those found at Reference sites located further upstream, suggesting no associated impacts.

1.0 BACKGROUND

Nyrstar Myra Falls (NMF) is a zinc-copper-lead-gold-silver mine located centrally on Vancouver Island, British Columbia. Its legal mining leases are designated as Strathcona-Westmin (Class B) Provincial Park, which is surrounded by Strathcona (Class A) Provincial Park (Figure 1). The mine produces metal concentrates that are trucked to Campbell River and then loaded onto ships bound for metal refining facilities primarily in Asia. Discharge from the mine and mill operations, along with runoff from various areas of the site, are collected and treated in a series of ponds that drain through a single discharge point into Myra Creek which flows into Buttle Lake approximately 2.5 km downstream of the discharge point. During operations, mean daily discharge from the mine was approximately 32,500 m^3/day on an annual basis between 2016 and 2018; based on this discharge level, NMF is subject to the federal Metal Diamond Mining Effluent Regulations (MDMER).

The MDMER came into effect in June 2018, and require metal mines to monitor effluent quality and its potential effects on the receiving environment (Government of Canada 2018). Of note, the MDMER superseded the previous Metal Mining Effluent Regulations (MMER) (Government of Canada 2002). The objective of these regulations is to determine whether effluent from mining operations is having an effect on local benthic invertebrate community structure, fish populations and fish tissue concentrations of metals. The associated environmental effects monitoring (EEM) studies are designed to provide data that are scientifically defensible and reflect site-specific characteristics, while being consistent with standard guidance that is implemented on a national level. The program is conducted in three-year cycles, with each cycle containing two primary components:

- Effluent characterization and water quality monitoring – effluent chemistry and water quality in the receiving environment are evaluated four times a year (i.e., quarterly), and sublethal (chronic) toxicity is evaluated once or twice a year; and
- Biological monitoring – potential effects of mine effluent on benthic invertebrates (representing fish habitat), fish populations and fish tissue are assessed through field surveys. These surveys are typically conducted once during each cycle, and supporting water quality and habitat data are collected to aid in interpretation of findings.

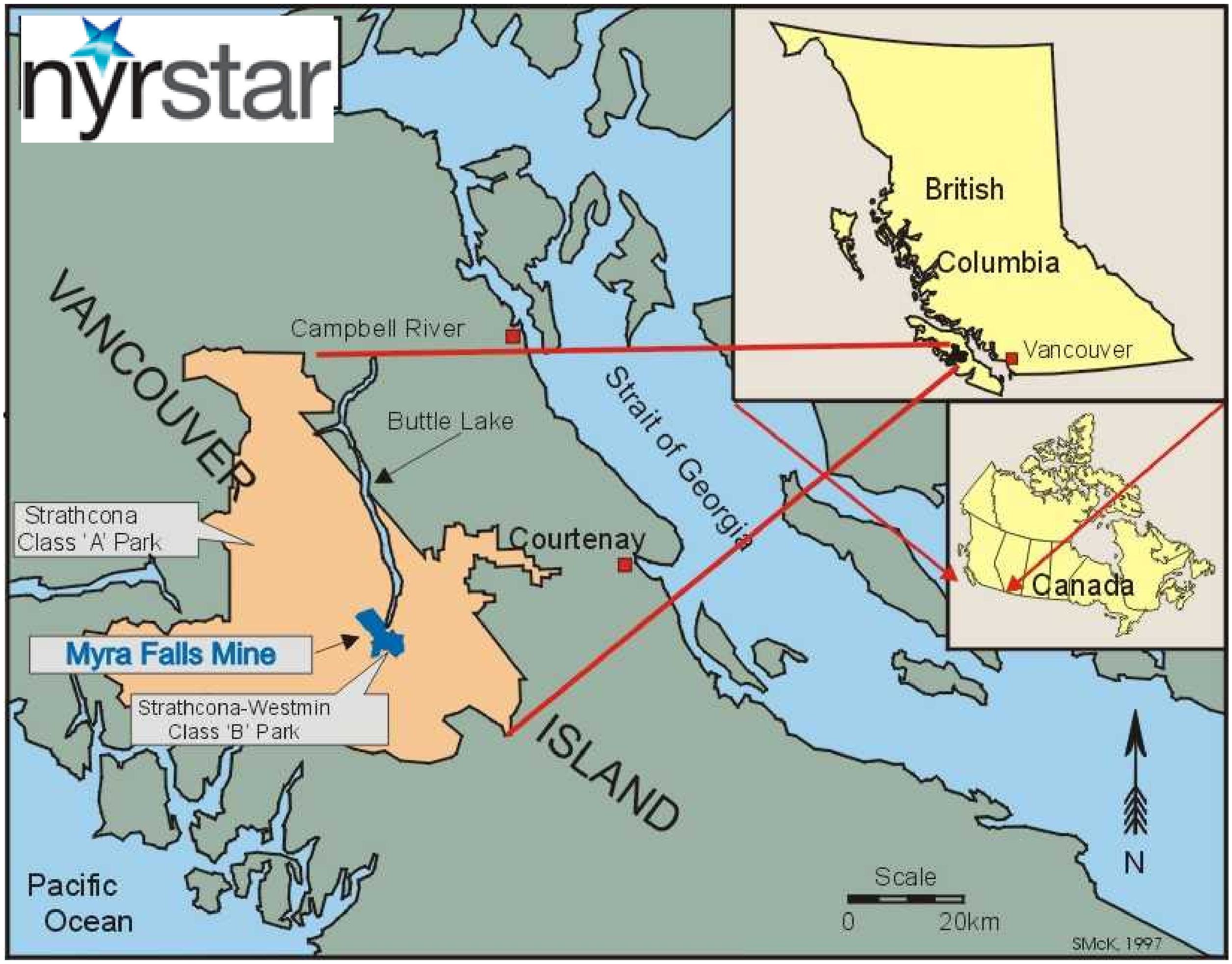


Figure 1. Location of Nyrstar Myra Falls, Vancouver Island, British Columbia.

NMF first became subject to the MDMER (and previously the MMER) on December 6, 2002. However, because historical biological monitoring data were available for the mine, largely from an evaluation of fish and fish habitat conducted in 1999 by Hallam Knight Piesold (1999), the first EEM study was not required until 2005. The results of Cycle 1 suggested that there was moderate enrichment of the benthic invertebrate (BMI) community downstream of the discharge, but no adverse effects on fish. Cycle 2 was conducted in 2008, and again showed an effect on the BMI community downstream of the mine. Although BMI community metrics improved considerably between Cycles 1 and 2, the presence of effects across both Cycles triggered an Investigation of Magnitude and Extent in Cycle 3 (2011). This Cycle entailed a more thorough review of the benthic invertebrate community data, as well as analyses of the results of laboratory toxicity tests and concentrations of various analytes found in the effluent, to determine if there were any relationships with the adverse effects observed. In addition, because the discharge ultimately enters Buttle Lake, which is part of the Class A Strathcona Provincial Park, Cycle 3 included an evaluation of data collected in Buttle Lake to determine if any impacts observed in Myra Creek extended downstream into the lake.

The detailed investigation of Magnitude and Extent revealed three important findings (Nautilus Environmental 2011):

1. Conditions in the benthic community were substantially improved in Cycle 2 relative to Cycle 1;
2. Impacts were limited to a relatively short section of Myra Creek; no adverse effects were apparent downstream in Buttle Lake;
3. The reduced level of effects observed in Cycle 2 relative to Cycle 1 coincided with marked reductions in phosphate concentrations in the discharge; thus, elevated phosphate concentrations were the most likely explanation (i.e., cause) of the enrichment observed in the benthic community downstream of the mine in Cycle 1.

The Investigation of Magnitude and Extent is typically followed by an Investigation of Cause (IOC) to determine what components of the effluent (or other factors) are responsible for the observed effects. However, the most likely cause of the alterations in the benthic community downstream of the discharge (i.e., elevated phosphate concentrations) was already determined during Cycle 3. Consequently, a follow-up field investigation of the BMI communities upstream and downstream of the discharge was conducted in Cycle 4 to provide empirical data with which to evaluate the Cycle 3 findings.

The results of Cycle 4 indicated that the enrichment effects observed in Cycles 1 and 2 were no longer evident, suggesting that the mine's efforts to control phosphate concentrations in the discharge eliminated the effects on benthic community structure. Nevertheless, BMI community structure downstream of the discharge was still significantly different compared to upstream. Further investigation of the data revealed that the differences in community structure were related to habitat, primarily substrate size, with smaller substrate dominating downstream reaches of the creek. This effect on community structure was most apparent in the *Simuliidae*, which varied in abundance between sites by over 3 orders of magnitude. Interestingly, numbers and abundance of *Ephemeroptera*, *Plecoptera* and *Tricoptera* (EPT) taxa did not differ between reaches, indicating no impacts on these important indicator taxa (Nautilus Environmental 2014). Of particular interest, the BMI community attributes for the three Exposure sites located closest to NMF's discharge into Myra Creek were consistent with similar sites located in the same Eco-region of Vancouver Island, providing further confirmation of lack of effects associated with the discharge. The two exposure sites located furthest downstream of the effluent discharge had highly divergent community attributes from those same sites, however, this was likely a localized condition, rather than an effect of the mine's discharge.

Since Cycle 4 of the EEM program concluded that there were no impacts on the BMI community related to the mine's effluent discharge, Cycle 5 was designed as a "re-set" of the EEM program and included the full suite of monitoring components that were evaluated in Cycle 1 and 2 to obtain an update of environmental conditions upstream and downstream of the discharge. The results of the benthic invertebrate survey again indicated that there were statistically significant differences between the Reference and Exposure areas, particularly related to elevated numbers of *Simuliidae sp*. (black flies), which are known to be among the most sensitive species to metal contamination, and predominantly associated with the three lower exposure sites in Myra Creek. In addition, sensitive EPT taxa continued to be well represented in both Reference and Exposure reaches of Myra Creek, collectively suggesting that differences in habitat, rather than effluent composition, were responsible for the observed differences in in BMI communities present in different reaches of the creek.

Evaluation of impacts on the fish community in Myra Creek is based on two lines of evidence, specifically, *in situ* exposure of cutthroat trout early life stages at fixed locations in the Reference and Exposure areas, and a non-destructive survey of adult and juvenile cutthroat trout in both areas. In Cycle 5, the *in situ* exposures demonstrated no significant differences between survival, normal development, wet weight, length or condition factor in the Exposure reaches of the creek (i.e., MC-TP4 and MC-M2) compared to results collected at the Reference site located furthest upstream of the mine's discharge (i.e., MC-M1). Thus, there was no evidence of adverse effects downstream of the mine's discharge.

Cutthroat trout abundance observed during the fish survey in Cycle 5 was higher above MFO's effluent discharge point (observations = 62), compared to Exposure reaches located downstream of the discharge (observations = 38). However, this was attributable to differences in habitat, rather than direct effects caused by the mine's effluent discharge. Notably, the Reference reaches of Myra Creek have numerous off-channel habitats and tributary streams which can be used for refugia, spawning and rearing, resulting in the presence of young of the year (YOY) and juveniles which have generally been absent from downstream areas where the creek is largely limited to the main channel. Interestingly, YOY were observed in Cycle 5 in close proximity to a newly formed side channel that provided suitable spawning habitat, making this the first observation of YOY in downstream reaches since the onset of the EEM program. Despite the difference in fish abundance between reaches, there were no differences observed in length, weights or condition factors of captured fish from the Reference and Exposure reaches Collectively, based on the results of the fish survey and the *in situ* hatchbox study, it was concluded that there were no adverse effects resulting from MFO's effluent discharge on fish populations in Myra Creek.

Given the absence of any impacts related to the discharge observed in Cycle 5, Cycle 6 included the full suite of monitoring components evaluated in Cycles 1, 2 and 5 to provide an update of environmental conditions upstream and downstream of the discharge. Cycle 6 again used a Control/Impact design to compare results obtained from upstream Reference locations with results from downstream Exposure locations. Of note, this approach is appropriate because the mine operation is the only major anthropogenic stressor to Myra Creek.

Specifically, Cycle 6 generated and evaluated data related to chemistry, biology and toxicology to characterize environmental conditions in Myra Creek, with the specific objective of identifying the potential for adverse effects related to the discharge of mine effluent. Notably, exceedances of BC water quality guidelines (i.e., cadmium, aluminum, zinc, and copper) have been detected in Myra Creek in previous cycles of the EEM (e.g., Nautilus Environmental, 2014, 2017), but have not been associated with impacts to biota downstream of the discharge. Unlike previous cycles, Cycle 6 also incorporated sediment sampling and analysis in conjunction with the benthic macroinvertebrate community survey, and conducted a dilution study downstream of the discharge point. Collectively, the overall design of the study was to incorporate sufficient analytical, toxicological, biological and habitat metrics to identify potential effects, as well as natural environmental factors that may influence the biology of the system.

2.0 SITE CHARACTERIZATION

2.1 Myra Creek

Myra Creek is a second-order stream with a watershed of approximately 72 square kilometers located in the mountainous terrain of Strathcona Park on Vancouver Island. The Creek is approximately 13 km in length and is largely unimpacted by anthropogenic influences above the mine operation because of the remote location. However, upstream of the mine, Myra Creek does receive tail race water from the Tennant Lake hydro-electric facilities that help provide NMF's power needs. Flow in the creek fluctuates substantially as a result of seasonal changes in rainfall and snowmelt, but is continuous throughout the year. The creek has low productivity as a result of its short length, relatively steep gradient, low alkalinity and cold water temperatures.

Substantial waterfalls are present in Myra Creek, both above and below the mine site. Upper Myra Falls is approximately 4.5 km above the discharge point, and drops approximately 20 m in elevation. Lower Myra Falls is at the point of entry of Myra Creek into Buttle Lake, approximately 2.5 km below the discharge point, and has a height of approximately 60 m. These waterfalls present barriers to migration of fish and result in a discrete population of fish within Myra Creek.

In 1983, a section of the creek was diverted from its historical channel into a 1.4-km engineered channel that flows through the mine site. The banks of the creek in this section are comprised of rip-rap and are largely free of vegetation. Between 1999 and 2002, the creek bed in this section was narrowed from 20 to 10 m, and habitat improvements were made, including insertion of a deeper thalweg channel, riffle crests and boulder clusters to enhance habitat for aquatic life.

According to "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et al., 1979), Myra Creek would be classified as an upper perennial riverine system with primarily unconsolidated bottom dominated by cobble and gravel. Myra Creek has been classified into four distinct reaches, which were summarized by Hallam Knight Piesold (1999) as follows:

> "*The present day Reach 2, which includes the channelized section, has an average gradient of 1%. It extends from where the Lynx Diversion channel intercepts Myra Creek to the paved road bridge upstream, a stream distance of 1.6 km. Reach 1, situated between Buttle Lake and the Lynx Diversion, has an approximate length of 1.8 km and an average slope of 3.9%. Above Myra Falls, Reach 1 has an average slope of only 0.6%. Reach 3, situated between the paved road bridge over Myra Creek and the confluence with Arnica Creek, has a length of 0.6 km and an average slope of 3%. Reach 4 extends from Arnica Creek to the confluence with Tennant Creek, a stream distance of approximately 1.6 km. The average gradient of Reach 4 is 1.2%*"

Hallam Knight Piesold (1999) surveyed habitat types present within Reaches 1 through 4. Habitat maps were created for each of the four Reaches using a scale of 1:4000 following methods described in Watershed Restoration Technical Circular No. 8, Fish Habitat Assessment Procedures, Level 1 Field Assessment (Johnson and Slaney, 1996). Maps for Reaches 1, 3 and 4 were updated from a prior study conducted in 1982, whereas a new habitat map was created for Reach 2 because this Reach had been diverted since the prior study. These maps showed habitat units distinguished as riffles, pools, glides and cascades according to the dominant habitat within each habitat unit. Large woody debris, dominant bed materials, instream cover and other significant features of the creek were also recorded. Depositional areas within the creek are limited and tend to be associated with pools and deeper sections of glides. Although large flood events (e.g., November 2006) have altered many of the habitat features over time, the general pool/riffle characteristics remain, and are summarized in Table 1.

Table 1. Characteristics of Myra Creek; Reaches 1 through 4 (summarized from Hallam Knight Piesold, 1999). Reaches are shown from upstream to downstream.

	Reach 4	Reach 3	Reach 2	Reach 1
Length	1.6 km	0.6 km	1.6 km	1.8 km
Gradient	1.2%	3.0%	1.0%	3.9%
Substrate	Cobble-gravel	Cobble-gravel	Cobble-gravel	Cobble-gravel
Spawning gravel	Good	Fair	Fair	Excellent
Habitat types				
Pool	16%	0%	5%	26%
Glide	36%	48%	40%	51%
Riffle	43%	48%	55%	23%
Cascade	5%	5%	0%	0%

2.1.1 Aquatic Resources Inventory

The mine and associated facilities are nestled in the narrow Myra Valley between Mt. Phillips and Mt. Myra. These steep, rugged mountains rise from the valley floor, at 300 meter elevations to summits of almost 1800 meters. The slopes are heavily wooded with fir, hemlock and cedar up to 1200 meters, where a transition to alpine meadows occurs. The summits are craggy rock faces, some capped with glacial ice. Myra Creek winds its way through the valley before dropping over 60 meters into Buttle Lake. Precipitation exceeds 150 centimeters per year, which may include up to 5 meters of snow in winter. The temperature ranges from 36°C in summer to -18°C in winter.

Coastal cutthroat trout are the only species of fish that have been observed in Myra Creek; however, they are not fished either commercially or non-commercially. No species that are recognized as rare, threatened or endangered are present in Myra Creek. An impassable waterfall prevents fish from entering Myra Creek from Buttle Lake and, therefore, the population of trout in Myra Creek is discrete from other trout populations. Studies conducted prior to 1999 indicated that cutthroat trout were restricted to Reach 4, upstream of the mine site (Hallam Knight Piesold, 1999). However, more recent surveys have found fish both upstream and downstream of the mine site (Nautilus Environmental, 2005; 2008). Both Hallam Knight Piesold (1999) and Nautilus Environmental (2005 and 2008) concluded that the cutthroat trout population density is low, and is subject to large fluctuations due to periodic flooding events. Overwintering habitat is available upstream and downstream of the mine, but spawning habitat and off-channel high-water refugia are largely restricted to upstream areas (i.e., Reach 4).

2.1.2 Water Collection and Treatment System

The water treatment system collects and treats contaminated groundwater and surface runoff (partially consisting of acid rock drainage), mill effluent, tailings area decant water, mine water and sewage treatment plant effluent. Sewage (i.e., conventional sewage and grey water) is biologically treated and comprises approximately 1% of the total final effluent flow. Most of the surface water, including mine drainage, mill thickener overflows and tailings area decant water, is pumped to the Superpond, where lime slurry is added to facilitate metal hydroxide precipitation. The Superpond effluent discharges into the Myra Pond system, which consists of 6 "polishing" ponds that settle out any remaining suspended particles. The treated water is then discharged into Myra Creek through a Parshall flume. This discharge, called "11A-Runoff", is monitored under MDMER for potential effects on the receiving environment of Myra Creek. Based on annual monthly averages, mean daily discharge was approximately 32,460 m^3/day for the period 2015 - 2018 (C. Schweitzer, NMF, *pers. comm.*, Sept 2018) and mixing occurs within 300 to 400 m downstream of the outfall.

The effluent discharge enters Myra Creek through a culvert on the right bank of the creek looking downstream. Based on data collected from 2015 to 2018, effluent flow averaged approximately 3.79 ± 1.6% of the total flow in Myra Creek, with minimum and maximum values of 2.1 and 9.5%, respectively (C. Schweitzer, NMF, *pers. comm.*, Sept 2018). It should be noted that estimates of effluent concentrations in the creek reported in previous design documents (as much as 75% of total creek flow; Nautilus 2005 and 2008) were based on manual methods that were not very accurate (S. Henderson, NMF, *pers. comm.* Jan 2010); flow meters installed in 2006 corrected this issue.

There are limited inputs of water into Myra Creek downstream of the discharge. Webster Creek is a small tributary that enters Myra Creek 50 m downstream of the effluent discharge; flows are seasonally variable, and are estimated to be less than that of the effluent discharge during high flows. In addition, flows from the Lynx Diversion Ditch enter Myra Creek just downstream of TP-4. Upstream inputs include Arnica Creek and several small seasonal tributaries located between Arnica Creek and the Tennant Lake tail race. These small tributaries are particularly important for spawning and off-channel refugia for the resident cutthroat trout.

2.2 Production Processes

During regular operations, the mine processes approximately 500,000 tonnes of ore annually in a modern milling facility that separates and concentrates the ore into four products: copper, zinc, lead and gold (Knelson) concentrates. Daily average processing rates were 1,437 tonnes of ore in 2015, and following June 2015, the mine was put on care and maintenance and were no longer processing ore. The planned ore processing rate for 2018 is approximately 70 tonnes per hour (C. Schweitzer, NMF, *pers. comm,* Sept 2018). The milling process consists of four stages: crushing, grinding, flotation and filtration.

2.2.1 Crushing

Ore is fed from the 100 tonne surge bin in the head-frame onto a 1.4 km long conveyor using a 48″ x 12′ Hydrastroke feeder. This belt discharges into a 3600 live tonne coarse ore bin. A 48″ x 16′ Hydrastroke feeder and a weightometer on the coarse ore bin discharge controls the feed rate to the crushing plant.

The crushing plant feed is first passed over a 5′ x 12′ double deck screen with 3/4" x 2" slotted openings on the bottom deck. Screen oversize feeds a 5.5′ Symons standard cone crusher. Ore passing the bottom deck reports to the fine ore bins. Product from the secondary crusher reports to the tertiary screen, which is an 8' x 16' single deck with 16mm x 28mm openings. The tertiary crusher, a 5.5′ Symons short head cone crusher, is in closed circuit with the tertiary screen. Tertiary screen undersize reports to two 3500 live tonne fine ore bins. In an effort to blend ore, a reversing conveyor alternates the HW crushing plant product between the two fine ore bins at regular intervals. The HW crushing plant has a nominal capacity of 270 tonnes per hour.

2.2.2 Grinding

The concentrator is designed with two parallel grinding and rougher circuits, each capable of treating 2000 tonnes per day. Both grinding lines are identical and independent. Rod mill feed is drawn from a fine ore bin using two hydraulically driven 60″ slot feeders which discharge onto the rod mill feed belt. Mill feed tonnage is measured and feed rate is controlled with the hydraulic slot/belt feeders while rod mill water is ratioed to feed tonnage. Rod mill discharge density is controlled between 78% and 80% by operator checks and ratio adjustments. Rod mill discharge combines with ball mill discharge in a common pumpbox, and is pumped with a fixed-speed pump to a pair of Krebs D20LB cyclones. Cyclone feed density is measured and controlled by cascading a pumpbox water flow set-point from the cyclone feed density controller. Cyclone underflow is ball mill feed which is 80% to 85% solids. Cyclone overflow is measured and is nominally 42% solids. Product size from the grinding circuit is 75% to 80% -200 mesh and the mean operating work index is 13.4 kWhr/tonne. In 1992, a 30" Knelson gold concentrator was installed on each grinding circuit treating 30 tph of cyclone underflow to recover recirculating free gold.

The copper and zinc rougher scavenger concentrates are reground in essentially identical circuits. Both regrind mills are 7′ x 12′ Dominion rubber-lined mills charged with 1″ balls and driven by 250 Hp motors. The mills are in closed circuit with six 9″ Linatex cyclones. Cyclone underflow ranges between 65% and 75% solids and cyclone overflow is 20 - 35% solids. The copper and zinc regrinds feed their respective first cleaners.

2.2.3 Flotation

Flotation feed grades are variable. Copper ranges from 1.0 to 3.0%, zinc ranges from 3.0% to 10%, lead ranges from 0.1% to 0.5%, and iron ranges from 15% to 30%. A great deal of effort goes into blending ores underground; however, rapid grade fluctuations do occur regularly. A Courier 300 on-stream X-ray analyzer assays 16 streams for Cu, Pb, Zn, Fe, As, and % solids. Assays are reported every 5 minutes with each stream being reassayed every 15 minutes. Sixty-three Outokumpu OK8 (300 cu ft.) flotation machines and two 7' flotation columns are used in the flotation circuit. Air and level control for each bank of cells is managed by the Foxboro Computer. The primary sensor for air control is an Annubar and the final control element is an air-actuated butterfly valve. The primary sensor for level control is an Outokumpu float and angle transmitter, and the final control element is an air-actuated dart valve. The originally supplied Outokumpu field controllers are maintained for backup, startup and shutdown. Nearly all flotation reagent flows are measured by magnetic flow meters and metered into the circuit using small ball valves, which are regulated by the Foxboro computer. In some cases, one flow loop serves two addition points by splitting the flow with small in-house design pinch valves. MIBC and lime are the only reagent flows not measured. MIBC is metered with Pulsa feeder pumps and lime is pulsed into the circuit using air-actuated red jacket valves. Lime is added to a pH set-point. All reagent set-point changes are made by operators.

Copper

There are two independent identical copper rougher circuits, one for each grinding line. Each cyclone overflow is gravity fed to its own 400 cu ft. conditioner at the head of each copper rougher circuit's ten OK8 cells. The last 6 cells of each bank is the rougher scavenger. The pH in the roughers is controlled between 8.5 and 11.2, depending on lead, zinc and iron heads. The primary sensor is a pH probe in the rougher conditioner; a red jacket valve pulses lime into the rod mill feed chute. A 73/27 mixture by weight of Potassium Amyl Xanthate (PAX) and Aerofloat 208 are stage added. The collector blend is added at the ball mill feed chute when Cu heads are high. The blend is also added at the copper conditioner and the copper rougher scavenger transition box. Zinc sulfate is added to the Rod mill and Cu regrind for sphalerite depression. MIBC is also added to each copper rougher and cleaner circuit.

Copper rougher concentrates from both circuits are combined and pumped to the copper regrind pumpbox, where zinc sulfate and collector blend are added to reactivate copper. Lime is added should the pH drop below 10.6 which helps aid lead depression. The Cleaner scavenger bank has three OK8 cells while the first Cleaner bank has four OK8 cells. Copper regrind cyclone overflow reports to the copper first cleaner. Copper first cleaner tail feeds the copper cleaner scavenger whose tail reports to the zinc conditioner tank and whose concentrate reports to the copper regrind feed pumpbox. The copper final concentrate from the column reports to the 32' copper concentrate thickener while the column tail reports to the Cu regrind circuit.

Zinc

Copper rougher scavenger tail and copper cleaner scavenger tail are conditioned in a 1000 cu. ft. tank and split to two 400 cu. ft. conditioners which feed identical zinc rougher circuits. Each zinc rougher has a total of ten OK8 cells. The first four cells make up the rougher bank and the last six make up the rougher scavenger bank. Copper sulfate is added to the zinc conditioner tank and each zinc rougher scavenger drop box. Lime is pulsed into the zinc conditioner tank where the pH is controlled between 11.8 and 12.2, using a red jacket valve. The alkaline pH is required to depress iron. Collector blend is also split between each zinc rougher conditioner and each zinc rougher scavenger drop box. MIBC is also added to each zinc rougher conditioner.

Zinc rougher concentrate from both circuits are combined and pumped to the zinc regrind pumpbox where copper sulfate and collector blend are added to reactivate zinc, and lime is added to raise the pH to 12.3 which helps aid iron depression. Zinc regrind cyclone overflow reports to the zinc first cleaner which is composed of three OK8 cells. Zinc first cleaner tail feeds the zinc cleaner scavenger whose concentrate reports to the zinc regrind feed pumpbox. The zinc cleaner scavenger bank is three OK8 cells. The zinc final column concentrate reports to the 32′ zinc concentrate thickener while the column tail reports to the Zn regrind circuit. The Zn 1st cleaner cell #1 has the option of being diverted to the final concentrate (high Zn heads) or the column feed (low Zn heads).

2.2.4 Filtration

Copper, lead and zinc concentrates are thickened to 70% solids and stored in 3000 cu ft. stock tanks prior to filtration. Both concentrates are filtered using one of five Larox PF32 pressure filters. Three filters are assigned to zinc concentrate. One of the four filters can be used for either concentrate should the need arise. Each filter discharges to its respective concentrate storage bin below.

Concentrate thickener underflow is pumped from the stock tank into the pressure filter using a 3″ x 4″ Worthington pump. When the filter starts its fill cycle, the pump motor switches on. A feed pressure of 80 psi is required for the fill cycle. Each filter is monitored and controlled by a PLC. Operators change fill times, which are nominally 60 seconds, according to cake thickness. After the fill cycle is complete, the cake is pressed further with clean water for 60 seconds. The cake is then air dried with compressed air at 70 to 80 psi. Operators adjust air blow time, which is nominally 180 seconds, according to cake moistures. A 950 cu ft. air receiver is pressurized by two 1250 cfm and one 600 cfm compressors. The filters produce moistures as low as 5%; however, dusting problems require that moistures be kept above 7%.

2.3 Environmental Protection Practices

2.3.1 Environmental Management System - Major Components

The role of the Environmental Department at NMF is to implement and promote the corporate Environmental Policy, monitor the site for environmental regulations and permit compliance, mitigate impacts to the environment and promote environmental awareness to site personnel. Listed are the major components of the Environmental Management System (EMS) at NMF:

- Integrated surface and mine water collection and treatment systems, with a significant volume of water recycled through the system.
- Hazardous waste management (collection, recycling, and off-site disposal of dangerous goods).
- Re-use, reduce and recycle initiatives established property-wide. Power-smart initiatives in place for many years, as well as efforts to reduce diesel fuel use and optimize hydroelectric power sources.
- Emphasis placed on pollution prevention measures, minimizing disturbance to the surrounding environments, and reducing the operational footprint where possible.
- Spill response contingency plans (SERT Team and environmental emergency response plans for fast and appropriate emergency response).
- Coordinate with departments and engineer-of-record to monitor and maintain sub-aerial on-land paste tailings disposal system. Constant electronic and manual monitoring equipment employed, such as piezometers and dataloggers, to monitor geotechnical conditions.
- Seismic upgrade of tailings disposal facility for a 1:1000 year earthquake and flood upgrade of Myra Creek for 1:1000 year flood event.
- Monitoring of effluent and receiving waters at a number of sample points on a daily, weekly and monthly basis. Analysis of samples for chemical and biological parameters. Environmental effects monitored using bio-indicators, including trout, plankton, duckweed and benthic invertebrates.
- Surface flow and groundwater monitoring.
- Quality control & assurance measures for collecting, preparing and analyzing samples. Environmental lab procedure manual produced to maintain consistent practices.
- Ongoing removal of obsolete facilities from the site and reclamation of areas as appropriate, both short-term and long-term.
- Bio-engineering techniques for slope stabilization pre-seeding and planting.
- Minimization of impact on wildlife such as black-tailed deer, Roosevelt elk, bear, wolves, cougars, fish and birds.
- Fish habitat enhancement projects in Myra Creek, Thelwood Creek and Buttle Lake. Efforts in these areas include installations of boulder clusters, riffle crests, thalweg channels, riparian vegetation and large woody debris.

- BC Parks, along with other provincial and federal government agencies, are involved in monitoring and managing NMF's performance. Permits, regulations and routine inspections and sampling by government agencies.
- Two on-site sewage treatment facilities.
- Routine internal and external environmental audits performed in order to maintain high level of environmental protection, while constantly looking for improvements.
- Environmental Management System (EMS) established in-house.
- Inspect water treatment, Discovery Terminal load-out facility, and tailings disposal facilities.

2.3.2 Sustainable Development

NMF has long been active promoting multiple-use resource management concepts and sustainable development. In 2003, NMF was nominated by the International Mining Journal for exemplifying sustainable mining qualities, such as supplier and community involvement in its business. In October 2003, NMF joined other Mining Association of Canada member companies in an initiative known as Towards Sustainable Mining (TSM). The overall purpose of TSM is to develop the life cycle of mining with community involvement, to encourage mutual understanding of the business in order to sustain the overall mining industry. This is based on Guiding Principles of Sustainability where Environmental, Economic and Social Issues are in balance. Important communities of interest for NMF are CAW Union Members, the Campbell River Indian Band, Strathcona Park Public Advisory Committee, Campbell System Water Use Planning Committee, Strathcona Park Lodge, Campbell River Chamber of Commerce, the District of Campbell River Council, the Campbell River Environment Committee and the Friends of Strathcona.

2.3.3 Closure Plans

At some point, the mine will permanently close. The overall objective of NMF's reclamation program is to return the mine site to a condition similar to its natural, pre-mining state – consistent with "Class A" park status. To help ensure this future state, the company has posted security bonding and is engaged in ongoing research. NMF has supported research carried out by others in order to determine the most effective reclamation methods available that will minimize any long-term effects from rock piles and tailings deposits. This research is being conducted in cooperation with industry and government agencies, and has been recognized at several international forums. Nyrstar is following a progressive reclamation plan for the Myra Falls site. Yearly updates track progress and describe the evolution of the Long-term Closure Plan. The reclamation activities will continue for several years after operations cease.

Of note, an updated conceptual decommissioning and mine closure plan was submitted to government agencies on July 31, 2014 by Robertson GeoConsultants on behalf of MFO (Robertson GeoConsultants, 2014); an addendum to this plan was submitted December 31, 2016 (Nyrstar Myra Falls, 2016). The report included updated information and current plans for closure of the operation, proposed closure timelines, and cost estimates for implementation of the closure and post-closure monitoring and treatment systems. The 2016 addendum included an update to the site-wide contaminant load balance model for current and future conditions (Robertson GeoConsultants, 2016). This load balance was used to model several closure scenarios, and the dry cover options put forth in the addendum report were chosen based on the model results. The closure works slated for the five-year progressive closure plan include relocation of potentially acid-generating (PAG) waste rock from the slopes to a new location in the Lynx Tailings Dam Facility (Lynx TDF), and dry covers for the old Tailings Dam Facility and the Lynx TDF outer berm. A ground water recovery system was recommended based on the modelling, and the Lynx Seepage Interception System (Lynx SIS) was completed in 2019.

In 2013, Nautilus Environmental compiled a report identifying parameters of potential concern for the receiving environment associated with NMF (i.e., Thelwood and Myra Creeks, and Buttle Lake), and recommended potential methodologies for developing site-specific objectives for these parameters. Specifically, exceedances of BC water quality guidelines (WQGs) for cadmium and zinc were observed in Buttle Lake, and exceedances were also observed for zinc, cadmium and copper in lower Myra Creek. Notably, aluminum exceeded BC WQGs in both upstream and downstream reaches, suggesting that it is naturally elevated in the system.

NMF was further requested by the BC Ministry of Environment (MOE) to identify the need for site-specific water quality objectives (SSWQOs) using a "5 samples in 30 days" sampling program focused on key times of the year (i.e., low and high flow conditions) consistent with Ministry requirements. In 2017, the data was reviewed by Nautilus Environmental (Nautilus Environmental, 2017), and parameters that exceeded the guideline(s) were further evaluated to determine whether the exceedances were the result of elevated background concentrations that reflected local conditions. Constituents that exceeded WQGs and local background concentrations were flagged for additional investigation and potential development of SSWQOs that would be protective of aquatic life.

Subsequently, the MOE requested that NMF derive Science Based Environmental Benchmarks (SBEBs) for constituents of concern (COCs), rather than the SSQWOs initially proposed. This process was undertaken by Nautilus Environmental, and involved compiling relevant data on concentrations of copper, zinc and cadmium in Myra Creek and deriving site-specific concentrations representative of short and long-term exposure durations that would be protective of biological receptors in Myra Creek (e.g., the benthic macroinvertebrate and fish communities). The derivation process was approved by MOE, and the associated numerical benchmarks are currently being derived and validated.

2.4 Laws Applicable to Myra Falls Operations

The approximate 3300 hectare area of Strathcona-Westmin Provincial Park is held as legal mining claims, crown grants and leases issued under the Mines Act by the Ministry of Energy and Mines (MEM). NMF is required to adhere to the *Health, Safety and Reclamation Code for Mines in British Columbia*, issued by MEM in 2003. The mining operation itself occupies a footprint of less than 200 hectares within the 220,000 hectare Strathcona (Class A) Park (i.e., <0.1% of the park area). As noted in the 1995 Strathcona-Westmin Park Master Plan, the mine operates under use permits issued by BC Parks under authority of the Ministry of Water, Land and Air Protection, and the Park Act. The permitted area includes portions of both Strathcona and Strathcona-Westmin Provincial Parks, and allows the use of Park lands for mining, roads and power generation and transmission.

Under the federal Fisheries Act, the *Metal Mining Effluent Regulations* (MMER) became law in June of 2002. In 2003, NMF received a Transitional Authorization (TA) for the Myra Ponds Effluent (11A-Runoff) site that authorized the discharge of final effluent at a pH of 11 units until December 6th, 2004. The mine currently operates under the MDMER requirements (Government of Canada 2018).

2.4.1 Operating Permits and Licenses

NMF operates under Permit No. M-26 issued by the BC Ministry of Energy and Mines, which outlines mining operations and reclamation requirements.

NMF holds three Park Use Permits issued by BC Parks:

- ST9710029: Thelwood Creek Power Development and Generation (was PUP 1261);
- ST9710035: Main Permit for Mining (was PUP 1363); and
- ST9710036: Tennent Lake Power Development and Generation (was PUP 1364)

NMF holds three Waste Management Branch Permits issued by the BC Ministry of Water, Land and Air Protection, including:

- PE-06858: Tailings Management and Water Treatment Systems;
- PA-2408: Air Emissions Permit;
- PR-2561: Refuse (Non-Hazardous Industrial Materials Landfill) Permit

NMF also holds the conditional water licenses issued by the BC Ministry of Water, Land and Air Protection listed in Table 2.

Table 2. Water Licenses issued by the Ministry of Water, Land and Air Protection.

Conditional Water License No.	Water Course	Purpose
CWL 032063	Tennent Lake	Power Generation
CWL 043113	Webster Creek	Water Take/Diversion
CWL 043379	Arnica Creek	Water Take/Use/Diversion
CWL 058458	Myra Creek	Water Take/Diversion
CWL 064123	Jim Mitchell / Thelwood	Water Take/Use/Diversion
CWL 064124	Patchette Creek	Water Take/Use/Diversion
	Moulder Creek	Water Take/Use/Diversion
	Tennent Creek	Water Take/Use/Diversion
	Ellis Lake	Water Take/Use/Diversion
	McNish Lake	Water Take/Use/Diversion
	Griffiths Lake	Water Take/Use/Diversion
CWL 061484	Myra Creek	Water Take/Discharge
CWL 063974	Thelwood Lake & Creek	Water Take/Discharge

3.0 CYCLE 6 STUDY OBJECTIVES

Since the previous Cycle of the NMF EEM program (Cycle 5) indicated that there was no evidence of adverse effects to biological communities in Myra Creek related to the mine's effluent discharge, Cycle 6 encompassed the full suite of monitoring components, including:

- BMI community analysis;
- Fish monitoring;
- Analysis of lethal and sublethal toxicity testing data; and
- Analysis of chemistry data.

These data were compared to historical data from past EEM Cycles, and also interpreted within the context of a Control/Impact design to identify potential risks to the system associated with discharge to Myra Creek.

Results from previous EEM Cycles indicated that Myra Creek is sensitive to elevated nutrients (i.e., phosphate). In addition, exceedances of BC water quality guidelines (i.e., cadmium, zinc and copper) have been detected (i.e., Nautilus Environmental, 2014, 2017), but have not been associated with adverse effects on resident biota. Conversely, differences in habitat conditions have been shown to have significant effects on community structure in Myra Creek. Consequently, an important component of the Cycle 6 study design is incorporation of sufficient habitat metrics to differentiate between adverse effects associated with mine operations and community responses resulting from variations in habitat conditions. Specifically, the field monitoring components employed a Control/Impact design, where biological endpoints from Reference sites located upstream of the effluent discharge were compared to Exposure sites located downstream of the discharge. The presence of significant differences (i.e., based on pre-determined criteria detailed in the following sections) between Reference and Exposure reaches would suggest that potential effects due to the mine's effluent may be present and would trigger a more thorough evaluation of related data to determine whether the effects were indeed related to the discharge or to an alternative factor (e.g., habitat characteristics, sampling artifacts, etc.).

4.0 BENTHIC MACRO-INVERTEBRATE COMMUNITY STRUCTURE

4.1 Introduction

The Canadian Federal Metal and Diamond Mining Effluent Regulation (MDMER) requires that metal mines monitor the quality and potential effects of their effluents on the natural environment (Government of Canada, 2002). Environmental Effect Monitoring studies (EEM) are designed to identify whether effluents from the mining operation have an impact on local benthic invertebrate communities and fish populations. Benthic macro-invertebrate (BMI) community surveys have previously been conducted in MFO's EEM program during Cycles 1, 2 and 4.

In Cycle 1, enrichment effects were observed in the BMI community within the exposure area compared with the upstream reference area. Specifically, organism densities were much higher downstream of the discharge, and facultative organisms, particularly chironomids and oligochaetes, dominated the community. However, EPT taxa (i.e., mayfly, stonefly and caddisfly taxa) were also present and well-represented in the exposure area, suggesting moderate enrichment, rather than more severe effects resulting in the loss of sensitive taxa.

In Cycle Two, community structure exhibited much closer agreement between the reference and exposure areas, suggesting that the enrichment effects observed in Cycle 1 had been reduced or eliminated. In Cycle 1, all parameter indices (i.e., density, richness, evenness and Bray-Curtis) in the exposure area differed by >2 standard deviations (SD) from the reference (upstream) mean. Conversely, in Cycle 2, all metrics were either 1) not statistically different between the reference and exposure areas; 2) did not respond in the same direction as observed in Cycle 1; or 3) were within 2 SD of the reference mean. Notably, densities differed by over an order of magnitude in Cycle 1, and were nearly identical in Cycle 2. Thus, these data suggested that something occurred between Cycles 1 and 2 that markedly reduced the enrichment effect.

Given the evidence that something had occurred between Cycles 1 and 2 to reduce the enrichment effect observed in Cycle 1, much of the effort associated with Cycle 3 involved an evaluation of mine operations and discharge chemistry to determine if any of the associated parameters had been altered in a manner consistent with the observed response. This analysis suggested that concentrations of nutrients (particularly phosphate) in the effluent were of particular interest. Compared with concentrations of nitrogen-based nutrients (i.e., nitrate, nitrite and ammonia), which tended to remain relatively consistent from year to year throughout both Cycles, concentrations of dissolved and total phosphate declined dramatically over the same period (Table 3). Specifically, concentrations of dissolved phosphate decreased approximately 30 to 40-fold between 2004 and 2008, and concentrations of total phosphate declined by 10 to 15-fold over the same period. Given that this reduction in phosphate concentrations coincided with the same period during which the BMI community in the exposure area lost the attributes associated with enrichment and began to more closely resemble the community present in the upstream reference area, it is likely that the observed enrichment was due to elevated concentrations of phosphate present in the discharge.

Table 3. Annual mean concentrations (mg/L) of nutrients measured in treated effluent from Myra Falls during Cycles 1 and 2. Data show mean, standard deviation and sample size (n) (taken from Nautilus Environmental 2011).

Year	Nitrate	Nitrate + Nitrite	Ammonia	Dissolved Phosphate	Total Phosphate
2004	1.73 ± 0.42 12	1.95 ± 0.47 12	0.99 ± 0.21 12	0.082 ± 0.056 12	0.102 ± 0.055 12
2005	1.65 ± 0.54 12	1.85 ± 0.59 12	0.93 ± 0.40 12	0.042 ± 0.056 12	0.052 ± 0.064 12
2006	1.74 ± 0.50 12	1.89 ± 0.54 12	0.89 ± 0.45 12	0.025 ± 0.050 12	0.059 ± 0.055 12
2007	1.95 ± 0.75 12	2.08 ± 0.75 13	1.19 ± 0.64 12	0.003 ± 0.001 11	0.009 ± 0.002 11
2008	1.78 ± 0.50 6	1.88 ± 0.51 6	0.98 ± 0.13 5	0.002 ± 0.000 5	0.07 0.003 5

Given that Cycle 3 determined the cause (i.e., phosphate) of the observed enrichment in BMI communities downstream of the discharge, Cycle 4 involved additional monitoring of the BMI communities upstream and downstream of the mine to corroborate these findings (Nautilus Environmental 2014).

Of note, the BMI community study completed in Cycle 4 (and Cycle 5) was performed by Sartori Environmental Services (SES) who conducted the benthic invertebrate field studies, as well as collection of supporting water quality and habitat data, and associated data analysis. The results of Cycle 4 indicated that enrichment effects observed in Cycles 1 and 2 were no longer present in downstream locations relative to upstream Reference locations, and that significant differences in community metrics identified between Reference and Exposure locations were related to differences in habitat (i.e., substrate size), rather than direct effects associated the mine's discharge. Notably, Cycle 4 also demonstrated that the BMI community structure directly downstream of the discharge was well-within the range of community metrics associated with other streams located in the same Ecoregion (Nautilus Environmental 2014).

The results of the benthic invertebrate survey conducted in Cycle 5 indicated that there were again statistically significant differences between the Reference and Exposure areas related to diversity (i.e., based on differences observed in the Bray-Curtis and Simpson's Diversity Indices between reaches). Notably, elevated numbers of *Simuliidae sp*. (black flies) were identified at the two lower exposure sites in Myra Creek, which influenced the differences observed in diversity between reaches. Given that *Simuliidae* are known to be among the most sensitive taxa to metal contamination, the fact that this group was well-represented at the downstream locations suggested that MFO's effluent was not eliciting adverse effects related to metal toxicity on BMI communities downstream of the discharge. In addition, sensitive EPT taxa were well-represented in both Reference and Exposure reaches of Myra Creek. The presence of sensitive taxa (*Simuliidae*, *Ephemeroptera*, *Plecoptera* and *Tricoptera*) across both reaches again suggested that differences in habitat, rather than contaminant effects, were more likely responsible for the observed differences in community structure.

In Cycle 6, Sartori Environmental Services (SES) was again commissioned by Nautilus Environmental to conduct the benthic invertebrate field studies, as well as collection of supporting water, sediment and habitat data. Field investigations and data analyses were conducted following the requirements of the Cycle 6 EEM program study design (Nautilus Environmental, 2018). The remainder of this section summarizes the methods and findings of the Cycle 6 benthic invertebrate field sampling program; the corresponding final report completed by SES is provided in Appendix A.

4.2 Methods

4.2.1 Locations of Sampling Sites

Figures 2 and 3 show the locations of the benthic invertebrate sampling sites in both Reference and Exposure areas (as well as the deployment sites for the *in situ* hatchbox study detailed in Section 5.0); the locations of the BMI sampling sites are also summarized in Table 4 below.

Table 4. Benthic invertebrate and water quality sampling stations for the Myra Falls Mine 2019 EEM Program.

Sampling Date	Site #	Approx. Distance from Discharge (m)	Longitude (deg, min, sec)	Latitude (deg, min, sec)
Exposure Area:				
19-Sep-2019	EXP 1	845	W -125° 34′ 51.5″	N 49° 34′ 26.2″
19-Sep-2019	EXP 2	880	W -125° 34′ 50.5″	N 49° 34′ 26.2″
19-Sep-2019	EXP 3	1945	W -125° 34′ 06.6″	N 49° 34′ 31.5″
19-Sep-2019	EXP 4	2105	W -125° 34′ 03.2″	N 49° 34′ 33.3″
19-Sep-2019	EXP 5	2215	W -125° 34′ 03.1″	N 49° 34′ 36.2″
Control Area:				
20-Sep-2019	REF 1	2125	W -125° 37′ 15.5″	N 49° 34′ 06.4″
20-Sep-2019	REF 2	1655	W -125° 36′ 27.4″	N 49° 34′ 16.7″
20-Sep-2019	REF 3	990	W -125° 36′ 27.4″	N 49° 34′ 17.4″
20-Sep-2019	REF 4	690	W -125° 36′ 18.1″	N 49° 34′ 19.1″
20-Sep-2019	REF 5	510	W -125° 36′ 19.6″	N 49° 34′ 19.6″

Figure 2. **Hatchbox, benthic invertebrate, and water sampling stations, Myra Falls EEM Programs: Reference sites.**

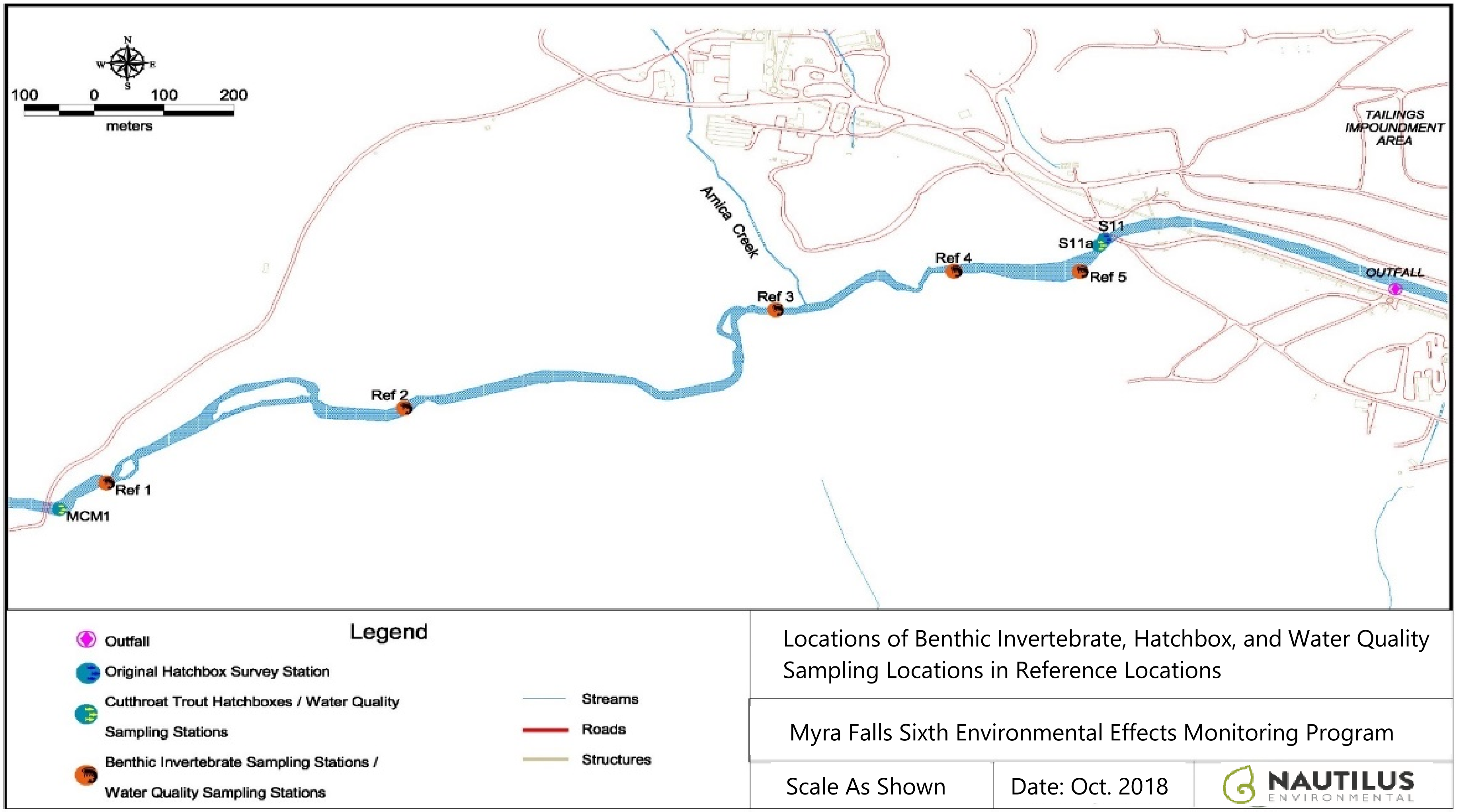
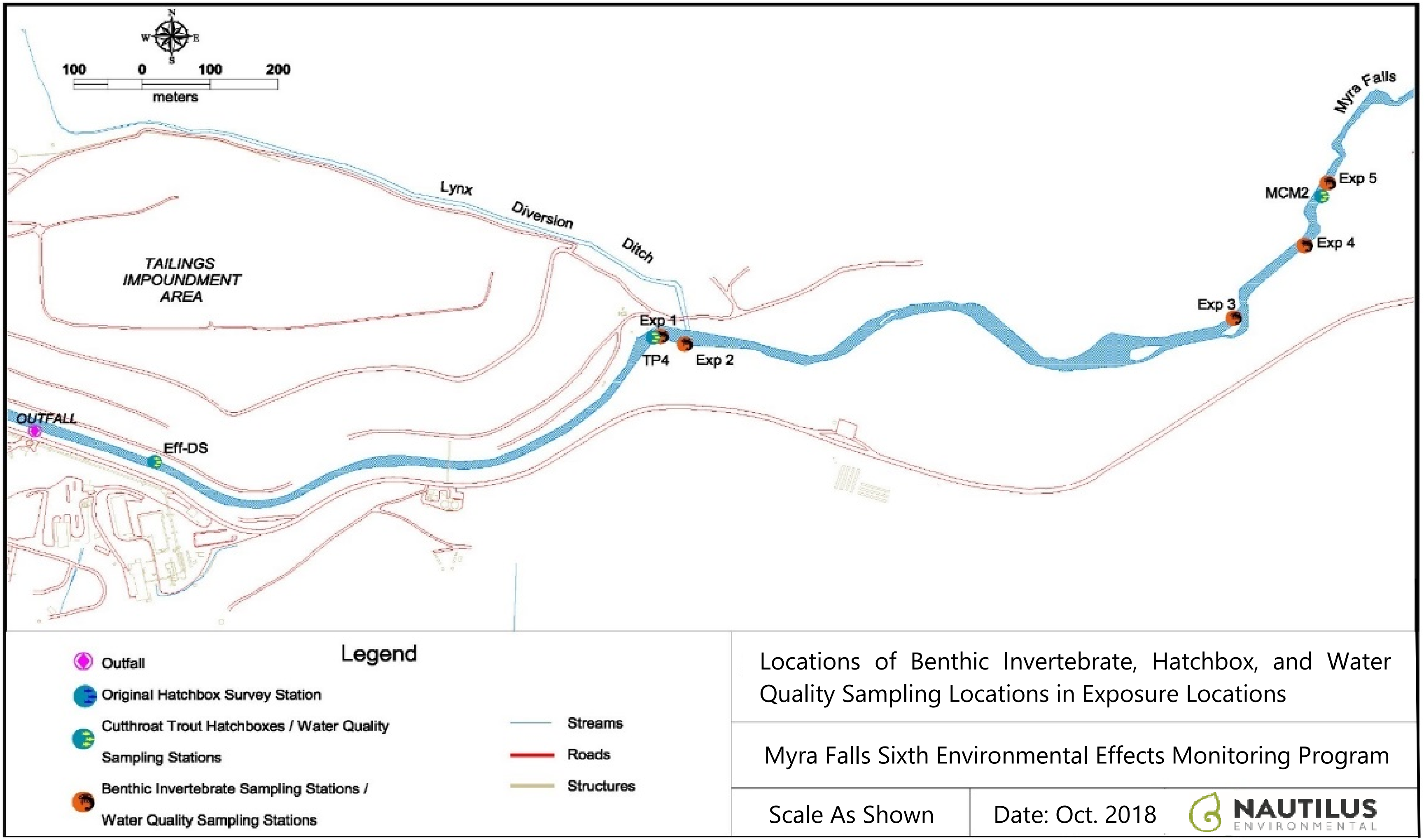


Figure 3. **Hatchbox, benthic invertebrate, and water sampling stations, Myra Falls EEM Programs: Exposure sites.**



4.2.2 Water and Sediment Quality Sampling

In-situ water chemistry {i.e., dissolved oxygen (mg/L and % saturation), pH (units), conductivity (µS/cm) and temperature (ºC)] were measured at each sampling site using a calibrated portable water quality (YSI) meter.

Sediment quality sampling followed the standards described in the British Columbia Field Sampling Manual (Province of British Columbia, 2013). SEI obtained clean sampling jars, preservatives and storage cooler from ALS Laboratories in Burnaby, BC (ALS) prior to the fieldwork. At each site, SEI labelled the sampling jars with the site name, time and date of sampling prior to sample collection. Fine sediments (i.e., silt and sand) were collected manually from each site using rubber gloves. Following sample collection and upon return to the field vehicle, the samples were stored in a cooler with ice packs to avoid parameter deterioration. Delivery of the samples to ALS for analysis took place at the end of the sampling operation and within 48-hours of sample collection due to the 2-day field sampling period.

Quality Assurance (QA) procedures included the following:

- SEI recorded GPS coordinates at each sampling site location to enable sampling personnel to relocate the sampling site for each round of sampling;
- Experienced personnel familiar with sampling standards conducted sampling to ensure consistency and due diligence during field operations;
- *In situ* water quality parameters were measured using properly calibrated instruments as per instrument manufacturer's instructions and schedule;
- Qualified personnel recorded data in a field logbook after stabilization of the meter reading and photographed screen shots of the instrument to check for potential discrepancies.
- Following sample collection, SEI personnel delivered samples in person to ALS within 48 hours of sample collection and filled-out a sample analysis form as part of the chain of custody, including the sampler's name, site ID, time and date of sampling, and all the parameters for analysis.

4.2.3 The Canadian Aquatic Biomonitoring Network

The Canadian Aquatic Biomonitoring Network (CABIN) is an aquatic biological monitoring program for assessing the health of freshwater ecosystems in Canada. CABIN is based on a network of networks approach that promotes inter-agency collaboration and data sharing to achieve consistent and comparable reporting on freshwater quality and aquatic ecosystem conditions in Canada. The program is maintained by Environment Canada to support the collection, assessment, reporting and distribution of biological monitoring information. CABIN allows partners to take their observations and make a formalized scientific assessment using nationally comparable standards.

The CABIN program primarily uses the Reference Condition Approach (RCA) for evaluating whether or not a test site is in reference condition and, if not, then how divergent it is from reference condition.

Reference sites[1] are considered to be minimally affected by human activity. These sites provide the basis on which to compare and judge the health of test sites.

Test sites are in unknown condition and are being examined for possible biological impairment due to some exposure to human activities. Test sites are often assessed because of suspected impacts related to poor water quality or habitat degradation.

This approach relies on the establishment of a large database of biological and habitat data from a wide range of reference sites. The range of reference sites provides the data to develop empirical models that explain the variability among the different benthic communities based on environmental characteristics (e.g., location, hydrology, substrate, bedrock geology and climate). The empirical model predicts the benthic community that should be observed at a test site if the site was in "reference condition". Thus, the further the test site is from the predicted group of reference sites, the more different it is, and the potential for anthropogenic stressors should be considered.

4.2.4 Benthic Invertebrate Sample Collection

The macro-invertebrate sample collection was performed over a two-day period between September 19th and 20th, 2019 in accordance with the CABIN field sampling protocol (Environment Canada, 2012a) by a CABIN certified technician. Sampling was initiated at the downstream end of the study area (Exposure site EXP 5), and proceeded upstream to avoid potential contamination of the lower sites when invertebrates are dislodged during sampling.

[1] *Note that the control sites for this study are not considered to be "reference" sites as per CABIN due to the proximity of the Myra Falls Mine and human activity in the area.*

Samples were collected using a 400-µm kick-net over a period of exactly three minutes to standardize the level of effort. The use of a zigzag sampling pattern across the stream was used to integrate benthic macro-invertebrates from various stream microhabitats within the erosional zone in proportion to their occurrence in a sample reach. Sampling also included stream habitats directly adjacent to the stream bank as this region may have microhabitats such as leaf litter that support a unique fauna. Each sampling kick area and path was pre-defined before entering the creek, targeting riffle habitats with cobble/gravel substrate.

The contents of the kicknet were emptied into a 320µm sieve before being transferred into a 500-mL plastic jar. Each sample was preserved in the field by addition of an 85% ethyl alcohol solution. Care was taken to remove as much creek water as possible to avoid preservative dilution.

4.2.5 Habitat Data Collection

Habitat data was collected *in situ* at each one of the ten sampling site following the CABIN field sheets.

- **Primary site data**: Basin name, estimate of site location coordinates, ecoregion, and stream order are all recorded.
- **Site description**: a broad characterization of the site, including a site drawing and written description, site coordinates, and surrounding land use classification.
- **Reach characteristics**: a description of aquatic habitat types, canopy coverage, macrophyte coverage and streamside vegetation in a defined sampling reach (site).
- **Water chemistry**: measurement of certain physical-chemical water quality parameters which are required by CABIN, such as dissolved oxygen and saturation, pH, water temperature and conductivity.
- **Substrate characteristics**: a 100 pebble count is used to characterize the substrate. The degree of embeddedness of substrate and the size of surrounding material were also determined.
- **Channel measurements**: characterization of the stream channel at current flow and estimate of peak flow conditions. This includes measurements of channel width (bankfull and wetted), depth, velocity and slope.

4.2.6 Sample Analysis

4.2.6.1 Sediment Chemistry

Sediment samples were analyzed at ALS Lab in Burnaby for the following parameters:

- Particle size
- Total Organic Carbon (TOC)
- Total Metals (35 elements)

4.2.6.2 Benthic Invertebrates

4.2.6.2.1 Laboratory Analysis

Benthic invertebrate sample sorting and taxonomic analysis was conducted by Thibault Doix (Living Streams Environmental), a certified taxonomist with the Society for Freshwater Science. The sample sorting process consisted of removing all the benthic invertebrates from the sample matrix prior to taxonomic identification. Each sample was processed as follows:

- The whole sample (i.e., all the jars constituting one sample) was washed with water into 500-µm and 200-µm sieves to remove the preservative. The 500-µm fraction was analyzed, while the 200-500-µm fractions were archived, according to EEM guidance.
- Large materials, such as rocks, twigs and macrophytes were gently and thoroughly washed over the sieve. Washed large materials were placed in a white tray for further examination and to make that sure no organisms were left behind.
- The sieve content was transferred into a white tray for a first sorting under a hands-free magnifier to remove large and conspicuous specimens.
- The tray content was subsequently split into smaller fractions and progressively transferred into a Petri dish for fine sorting under a dissecting microscope. Sorted debris was set aside and preserved in 70% ethanol.
- Removed specimens were separated into coarse family groupings in multi-well plates.
- All organisms removed from the white tray were identified, tallied and recorded on a bench sheet.
- The specimen vials and sorted debris jars were labeled, preserved in 70% ethanol and retained for QC audits of sorting and identification efficiency.

Each organism was identified using a dissecting (10x-90x magnification) or compound microscope (40x-1000x magnification) and appropriate taxonomic identification keys. The taxonomic identification was performed to the lowest level possible (generally genus/species level for insect taxa and family/genus for non-insects). Different life stages (e.g., larvae, nymphs) were identified and enumerated separately. If the condition of a specimen did not allow for a correct identification, it was discarded.

4.2.6.2.2 Quality Assurance/Quality Control

As per the Metal Mining Technical Guidance for Environmental Effects Monitoring (Environment Canada – 2012b), one randomly selected macro-invertebrate sample was sent for QA/QC to Tim Howay (Ruxton Environmental), a certified taxonomist with the Society for Freshwater Science. The sorting precision was calculated as percent sorting efficiency (*%SE*). The QC auditor estimates sorting efficiency by examining randomly selected sample residuals.

- The sorted residue from the original sample is re-sorted.
- The number of organisms found (if any) is recorded.
- The percent sorting efficiency (*%SE*) is calculated using the equation:

$$\%\,SE = \left(1 - \frac{\#\ \text{Organisms Missed}}{\text{Total Organisms Found}}\right) * 100$$

The average percent sorting efficiency (*%SE)* is calculated based on the number of re-sorted samples, and represents the standard sorting efficiency for that project. The average sorting efficiency should be >95%, or all samples in the project have to be re-sorted by the QA/QC Auditor.

The taxonomic identification efficiency was assessed by complete re-identification and enumeration of one sample. If the error rate of the audited sample exceeded 5%, all samples would be resorted and re-identified.

The identification error rate (%IE) is calculated by summing the number of misidentification errors and questionable taxonomic resolution errors.

$$\left(\frac{\#\ \text{Incorrect Identifications}}{\text{Total Organisms Found in Audit}}\right) * 100 = \%\ \text{Identification Error}$$

4.2.7 Benthic Invertebrate Data Analysis

4.2.7.1 CABIN Database

The CABIN database models predict the benthic macro-invertebrate community that is expected to occur at a test site in the absence of environmental disturbance. The probability of the test site belonging to each of the reference site groupings is calculated using the habitat variables for the specific model being used. The reference model used for the Myra Mine 2016 EEM program was the Fraser River – Georgia Basin Model - 2005, which includes the eastern Vancouver Island region. This model comprises five different reference site groups that the samples can be compared to.

Test sites are plotted with the appropriate group of reference sites on two or three axes, each axis representing a group of benthic community attributes. Each test site is assigned to the farthest band to which it resides in the three plots.

The CABIN database assessment is summarized based on where the test site fell within the confidence ellipses:

- A site that falls within the 90% confidence ellipse is designated 'Similar to Reference'.
- A test site that falls within the 90% and 99% confidence ellipses is designated 'Mildly Divergent'.
- A test site that falls within the 99% and 99.9% confidence ellipses is designated 'Divergent'.
- A site that falls outside of the 99.9% confidence ellipses is designated 'Highly Divergent'.

Should the benthic communities at the tested sites differ from the range specified for the reference sites within the selected group, then it is likely that some level of anthropogenic stress has occurred. The data resulting from the taxonomic identification and specimen enumeration, as well as all habitat variables collected *in situ*, were entered into the CABIN database by Thibault Doix, certified CABIN Project Manager.

4.2.7.2 Benthic Invertebrate Community Metrics

The following community metrics were used to assess potential effects on the benthic invertebrate community:

- **Density** (number of organisms/min) – The number of organisms present in the sample was calculated by dividing the raw count data by the total sampling time of 3 minutes;

- **Total richness** (number of taxa) – The number of taxa in each sample was calculated by summing the number of different taxa observed in the sample;
- **Bray-Curtis** (degree of station similarity) - Bray-Curtis correlation coefficients were calculated using density data for all taxa to compare the degree of similarity in community structure between individual stations and the median for the reference area. This index ranges from 0 to 1, with 0 representing two stations with very similar communities, and 1 representing two stations with very dissimilar communities; and,
- **Evenness -** The evenness index represents the abundance of each taxon in proportion to total abundance, and the taxonomic richness at the station. This index ranges from 0 to 1, with 0 representing a community where the relative abundance is attributed to a small number of taxa, and 1 representing a community where the relative abundance is evenly distributed among a large number of taxa.

In addition, Simpson's Diversity Index, which is not one of the effects metrics, was also calculated. This index represents the number of taxa at each station in proportion to the total density of each taxon. This index ranges from 0 to 1, with 0 representing a community with low diversity (small number of taxa present), and 1 representing a community with high diversity.

All metrics were calculated in Microsoft Excel using formulae outlined in the Metal Mining Technical Guidance Document (Environment Canada 2012b).

Community metrics for exposure area stations were compared graphically to the range of variability in the reference area (mean ± two standard deviations), to determine the extent to which exposure metrics exceeded the critical effect size.

4.2.7.3 Additional Metrics

The following metrics are not required as part of the MDMER EEM program, but do provide additional insights as to community structure and differences between sites, specifically:

- **Percent 3 most abundant taxa.**

As diversity declines, fewer taxa dominate the assemblage. Opportunistic species that are less demanding regarding the quality of their habitat typically replace species that require special foods or particular types of physical habitats.

- **EPT taxa richness and % EPT abundance**

Organisms belonging to the insect orders *Ephemereoptera*, *Plecoptera* and *Trichoptera* (EPT) are considered to be the most sensitive to human disturbance of the aquatic habitat. Their abundance and diversity decline quickly under environmental stress.

- **Percent *Ephemeroptera* and *Simuliidae***

Most *Ephemeroptera* (mayflies) and *Simuliidae* (black flies) species are particularity sensitive to heavy metals as compared to other taxonomic groups (Kiffney *et al.*, 1994; Clements *et al.* 2000). These taxa are among the first to disappear as heavy metal input increases.

4.2.7.4 Statistical Analyses

Statistical analyses were conducted in accordance with the Metal Mining Technical Guidance Document (Environment Canada 2012). Summary statistics, including means, medians, standard deviations and errors, minima and maxima, were calculated for the benthic invertebrate community metrics. A non-parametric equivalent of a two-tailed t-test (i.e., the Mann-Whitney U-test) was used to test for differences in community metrics and metal concentration between Reference and Exposure areas at a significance level of α=0.10. The results of the statistical tests are presented in the SES report (Appendix A).

Community metrics for the Exposure area stations were also compared against the range of variability in the Reference area (mean ± two standard deviations) to evaluate the magnitude of differences between the Reference and Exposure area. A difference > 2SD of the Reference area mean was used as the critical effect size to determine if an effect is meaningful in the context of MDMER guidance.

4.2.8 Quality Assurance/Quality Control

A comprehensive QA/QC program was followed to ensure that the data generated was of high quality and scientifically defensible. To meet these objectives, quality control procedures included the following:

- Use of experienced personnel in all aspects of the study;
- Use of a CABIN-certified biologist to lead the field sampling;
- Use of appropriate sampling protocols;
- Use of appropriate number of replicates to allow proper statistical analyses;
- Calibration and proper maintenance of instruments to ensure accurate measurements;
- Proper documentation and record keeping to allow traceability of performance;
- Adequate supervision and training of staff to ensure that methods were followed;

- Proper handling and storage of samples to ensure their integrity;
- Taxonomic identification and sample sorting QA/QC performed on one randomly chosen sample;
- Peer-review of documents, checking electronic data files for transcription errors and providing copies of raw data output files with the final report; and
- Rigorous review of the data, analyses and report by a Registered Professional Biologist to ensure they are of acceptable quality and are scientifically defensible

4.3 Results and Discussion

4.3.1 Sampling Conditions

The occurrence of several rain events during the first half of September 2019 affected the hydrology of Myra Creek prior to the field investigations. With the occurrence of a short window of drier weather and a long-range forecast calling for several days of rain, SEI made the decision in consultation with Nautilus Environmental and Nyrstar Environmental Managers to trigger the sampling operation. Despite higher flows than in previous sampling programs, turbidity levels (See Table 7) and access to the creek bed were suitable for sample collection. Although the "significant amount of time (...) to allow the hydrologic conditions to stabilize before sampling" indicated by the CABIN protocol was not achieved, it was felt that changes in hydrological conditions would similarly affect the upstream and downstream reaches and any differences in community structure relative to the effluent discharge would still be apparent.

4.3.2 Habitat Characteristics

Tables 5 and 6 below summarize the primary habitat metrics collected at each invertebrate sampling site in both Reference and Exposure areas. Of note, a number of substrate features differed significantly between reaches (Mann-Whitney U-test, $p<0.05$); % cobble was greater in the Reference area, % pebble was higher in the Exposure area, and the median diameter (D50) of the substrate was smaller in the Exposure area.

Table 5. Habitat features associated with benthic invertebrate sampling sites on Myra Creek, September 2019.

Site #	Slope (m/m)	Average Depth (cm)	Max. Depth (cm)	Average Velocity (m/s)	Canopy Coverage (%)	Dominant Stream Side Vegetation	Bankfull Width (m)	Wetted Width (m)
REF 1	0.02	78.5	120	0.39	1-25	Coniferous Trees	26	15
REF 2	0.05	42	68	0.28	1-25	Coniferous Trees	50	15.5
REF 3	0.025	61.3	85	0.41	51-75	Coniferous Trees	21	12
REF 4	0.02	68.5	97	0.4	51-75	Coniferous Trees	24.5	20.5
REF 5	0.01	44.7	51	0.56	1-25	Coniferous Trees	22.1	19.3
EXP 1	0.005	84.4	160	0.32	0	Deciduous Trees	25	15
EXP 2	0.03	45.7	75	0.54	1-25	Deciduous Trees	26.5	23.1
EXP 3	0.025	27.7	43	0.87	51-75	Coniferous Trees	35	15.4
EXP 4	0.02	28.3	53	0.64	1-25	Deciduous Trees	32	22.6
EXP 5	0.02	34.8	61	0.66	1-25	Deciduous Trees	32	19.6

Table 6. Substrate features associated with benthic invertebrate sampling sites on Myra Creek, September 2019.

Site #	%Boulder (>25.6mm)	%Cobble (6.4-25.6mm)	%Gravel (1.6-6.4mm)	%Pebble (0.2-1.6mm)	%Sand, Silt, Clay (<0.2mm)	D50 (cm)	% Embeddedness
REF 1	8	82	0	10	0	12.3	26-50%
REF 2	3	79	0	18	0	9.0	0-25%
REF 3	4	75	0	21	0	9.5	0-25%
REF 4	11	74	0	15	0	13.0	0-25%
REF 5	26	62	1	11	0	18.25	26-50%
EXP 1	11	64	0	25	0	9.3	0-25%
EXP 2	11	65	0	24	0	9.3	0-25%
EXP 3	0	61	0	38	0	7.2	0-25%
EXP 4	1	33	3	63	0	5.3	0-25%
EXP 5	2	35	8	51	4	5.1	0-25%

4.3.3 Water Quality

Table 7 below summarizes the *in situ* water quality data results associated with the benthic invertebrate sampling sites in both reference and exposure areas.

Table 7. Water quality data associated with benthic invertebrate sampling on Myra Creek, September 19-20, 2019.

Site #	Temp (°C)	pH	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)
REF 1	10.3	N/R*	10.3	28	0.00
REF 2	10.4	N/R*	10.5	28	0.66
REF 3	10	N/R*	10.5	29	0.00
REF 4	10.8	N/R*	10.6	29	0.76
REF 5	11.3	N/R*	10.7	50	0.00
EXP 1	11.6	N/R*	10.4	110	0.04
EXP 2	11.6	N/R*	10.4	110	0.04
EXP 3	11.7	N/R*	10.4	106	0.01
EXP 4	11.6	N/R*	12.6	105	0.10
EXP 5	11.3	N/R*	11.2	115	3.27

*N/R: not reported due to meter displaying unreliable results in the field

4.3.4 Sediment Quality

Table 8 below summarizes the results of the sediment quality analyses associated with the benthic invertebrate sampling sites in both Reference and Exposure areas. The majority of parameters analyzed exhibited discrete concentration distributions between the Reference and Exposure areas (the results of the Mann-Whitney U-Tests are presented in the SES report (Appendix A). Also of potential interest, was the presence of locally elevated concentrations of selected metals at REF005 (e.g., cadmium, copper, lead and zinc). Although they were generally lower than observed at the Exposure sites, they were approximately 3-fold greater than measured at other Reference sites. Note that sediment sampling was difficult with a very limited abundance of suitable substrate at most sites, requiring in some instances collection of sediments from outside of the immediate invertebrate sampling site. Given the lack of available substrate, replicates were not collected.

Table 8. **Sediment metals concentrations in Upstream and Downstream reaches of Myra Creek collected in September 2019.**

	Stations									
	Upstream					Downstream				
Parameters	**REF001**	**REF002**	**REF003**	**REF004**	**REF005**	**EXP001**	**EXP002**	**EXP003**	**EXP004**	**EXP005**
pH (1:2 soil:water)	6.61	6.9	6.92	6.89	6.86	7.06	6.98	6.71	6.33	6.82
TOC	0.05	0.077	0.126	0.118	0.156	0.144	0.057	0.433	1.08	0.05
Aluminum	12600	12100	12700	13800	16500	17300	17800	19600	20900	18000
Antimony	0.47	0.28	0.33	1.13	0.6	0.43	0.39	0.67	1.00	0.24
Arsenic	4.62	3.04	3.93	58.4	13.6	18.2	10.3	15.2	18.2	4.91
Barium	55	29.2	38.2	55.1	29.8	37.3	45.2	65.1	237	23.3
Beryllium	0.18	0.17	0.17	0.2	0.21	0.2	0.2	0.28	0.34	0.19
Cadmium	0.065	0.049	0.061	0.077	0.342	0.664	0.636	1.47	1.2	0.764
Calcium	3980	3570	3670	4200	5470	4300	5380	6280	6440	4970
Chromium	13.4	12.3	13.8	14.9	16.6	14.9	17.2	19.9	23	19.6
Cobalt	8.73	8.72	9.25	9.73	13.9	13.7	13.9	15.8	13.2	15.7
Copper	21.4	20.1	18.4	22.1	57.2	53.8	58.7	119	184	54.7
Iron	24100	22700	21500	25200	41200	32300	32800	34400	38400	32900
Lead	2.18	1.75	1.94	2.35	9.83	13.4	14.3	21.9	61.2	9.81
Lithium	6.1	6.3	6	6.4	6.4	6.6	7.1	7.5	6.9	6.4
Magnesium	8530	8830	8640	9150	11100	12200	12100	12200	12700	13000
Manganese	534	515	604	565	634	778	803	1090	584	863
Molybdenum	0.58	0.41	0.64	1.74	0.75	0.56	0.53	6.46	3.23	0.72
Nickel	10.4	13.5	9.1	10.3	14.6	14.6	16.2	15.9	16.4	15.8
Phosphorus	299	290	308	371	327	335	328	354	444	848
Potassium	320	330	320	380	240	230	250	390	380	200
Selenium	0.2	0.2	0.2	0.2	0.2	<0.20	<0.20	0.52	0.69	<0.20
Silver	<0.10	<0.10	<0.10	<0.10	<0.10	0.1	0.1	0.21	0.59	0.1
Sodium	70	54	75	83	94	82	87	117	112	56
Strontium	12.3	8.04	9.51	11.4	13	10.6	11.9	17	18.5	11.5
Titanium	743	682	780	809	1300	874	974	1250	1260	783
Uranium	0.383	0.455	0.343	0.374	0.42	0.749	0.263	0.572	0.603	0.279
Vanadium	50.7	57.3	48.7	56.1	166	72.6	75.1	84.9	99.3	73.9
Zinc	46.9	46.7	50.2	55.3	129	218	225	378	386	201
Zirconium	1.3	1	1.4	1.4	2.5	2.2	2.8	2.5	2.3	2.1

All concentrations are reported in mg/kg (wet weight), unless otherwise indicated.

4.3.5 Benthic Invertebrate Community Composition

Summary statistics for community metrics from Reference and Exposure areas are summarized in Table 9 below. Detailed benthic community composition found at each site are presented in the SES report (Appendix A).

One sample of identified organisms and sorted debris (Exposure Site REF005) was submitted to Mr. Tim Howay of Ruxten Environmental in Vancouver, BC for confirmation of identification and sorting efficiency. Taxonomic identification efficiency was determined to be 100% with a discrepancy in abundance for one taxon of (n=1 specimen). Sorting efficiency was determined to be 99.3% with n=2 specimens missed in the initial sorting. The results of the identification and sample sorting QA/QC are also presented in the SES report (Appendix A).

Table 9. Summary statistics for benthic invertebrate community metrics in control and exposure areas for the Myra Falls 2019 EEM Program

		Median	Mean	Maxima	Minima	Standard Deviation	Standard Error
Reference Sites	Total Abundance	285	302	411	175	96	43
	Density (Org./min)*	95	101	137	58	32	14
	Richness*	27	26	27	22	2	1
	Bray-Curtis*	0.32	0.32	0.42	0.23	0.08	0.04
	Evenness*	0.32	0.32	0.41	0.25	0.06	0.03
	Simpson's Diversity	0.86	0.87	0.91	0.85	0.02	0.01
	% 3 most abundant taxa	0.54	0.53	0.62	0.41	0.09	0.04
	EPT Richness	18.00	18.40	21.00	17.00	1.67	0.75
	% EPT	0.92	0.90	0.96	0.79	0.07	0.03
	%*Ephemerotpera+Simuliidae*	0.38	0.42	0.52	0.33	0.08	0.04
Exposure Sites	Total Abundance	195	187	248	137	47	21
	Density (Org./min)*	65	62	83	46	16	7
	Richness*	20	20	25	17	3	1
	Bray-Curtis*	0.62	0.58	0.67	0.48	0.08	0.04
	Evenness*	0.12	0.13	0.16	0.10	0.03	0.01
	Simpson's Diversity	0.62	0.60	0.70	0.43	0.11	0.05
	% 3 most abundant taxa	0.77	0.78	0.83	0.72	0.05	0.02
	EPT Richness	13.00	14.40	17.00	12.00	2.41	1.08
	% EPT	0.87	0.89	0.96	0.80	0.06	0.03
	%*Ephemerotpera+Simuliidae*	0.71	0.71	0.79	0.63	0.07	0.03

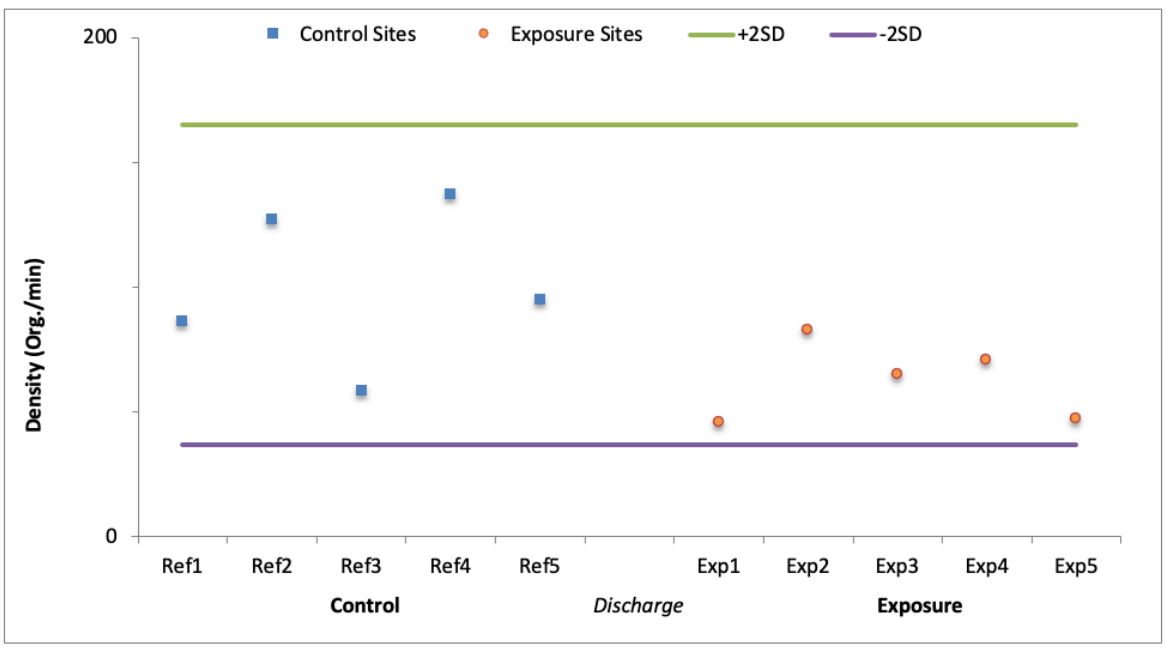
* Effects endpoints for EEM

4.3.6 Benthic Invertebrate Community Metrics

4.3.6.1 Density

Figure 4 below summarizes the density of organisms (organisms per minute) at the different sampling locations in both reference and exposure areas. The data shows that higher benthic invertebrate densities were observed at most of the reference sites, with the exception of site REF3. Nevertheless, invertebrate densities at all 5 of the exposure sites are within two standard deviations of the reference mean. The Mann-Whitney test results indicate that there is a significant difference in density between reaches (p=0.06).

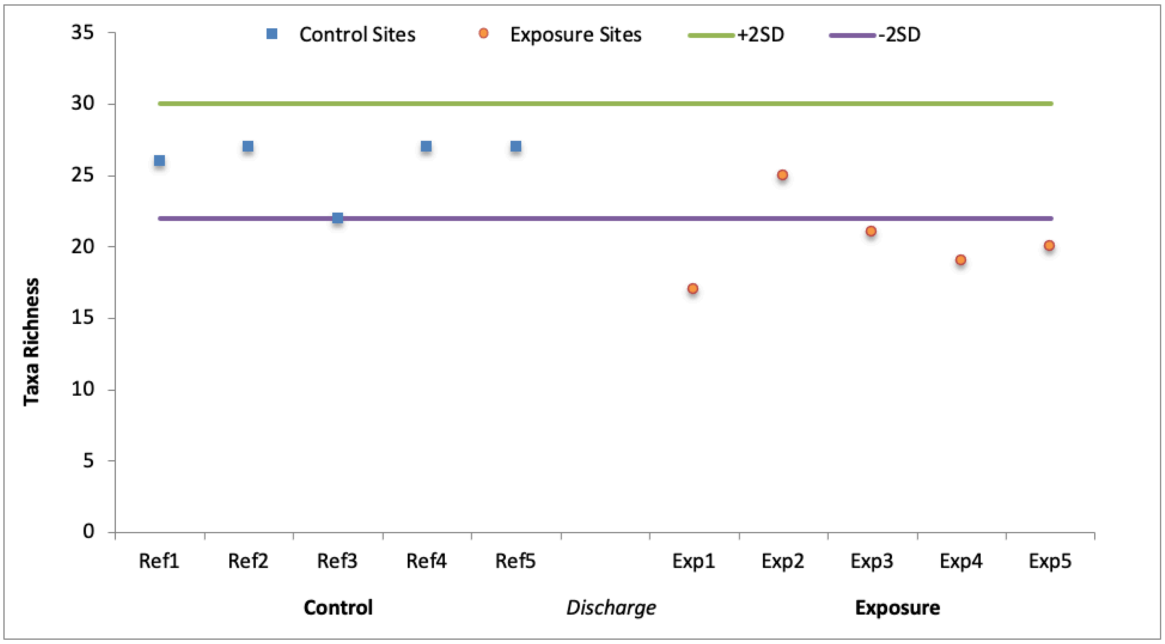
Figure 4. Benthic Invertebrate density (Org./min) at control and exposure sites for the Myra Falls 2019 EEM Program



4.3.6.2 Taxonomic Richness

Figure 5 below summarizes the taxonomic richness (total number of taxa) at the different sampling locations in both reference and exposure areas. The data shows that the total number of taxa is generally lower at the Exposure sites as compared with the Refences sites. It is also outside of two standard deviations of the reference mean, with the exception of Exposure site EXP 2. The Mann-Whitney test results indicates that there is a significant difference in taxonomic richness between reaches (p=0.02).

Figure 5. Benthic taxonomic richness (# taxa) at control and exposure sites for the Myra Falls 2019 EEM Program

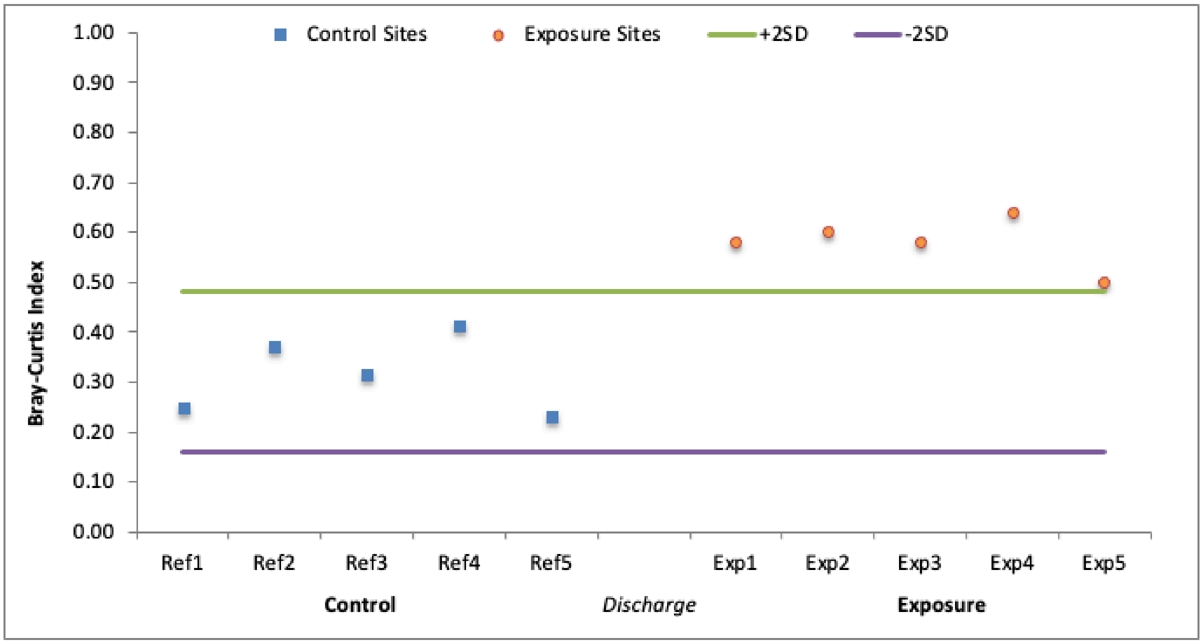


4.3.6.3 Bray Curtis Index of Dissimilarity

Figure 6 below summarizes the Bray-Curtis Index of Dissimilarity values between each site and the reference median in both reference and exposure areas. The data shows that the benthic communities in the Exposure area are different from those in the Reference area, with the Bray-Curtis index value of all 5 exposure outside of two standard deviations of the reference mean.

The Bray-Curtis Index of dissimilarity is already a statistical test that examines the differences between community structure at two different sites. Interpreting the meaning of a Mann-Whitney test on the output of another statistical test, or its effect size effect was therefore not considered to be relevant for the purpose of our study. Thus, it was not included in our analysis.

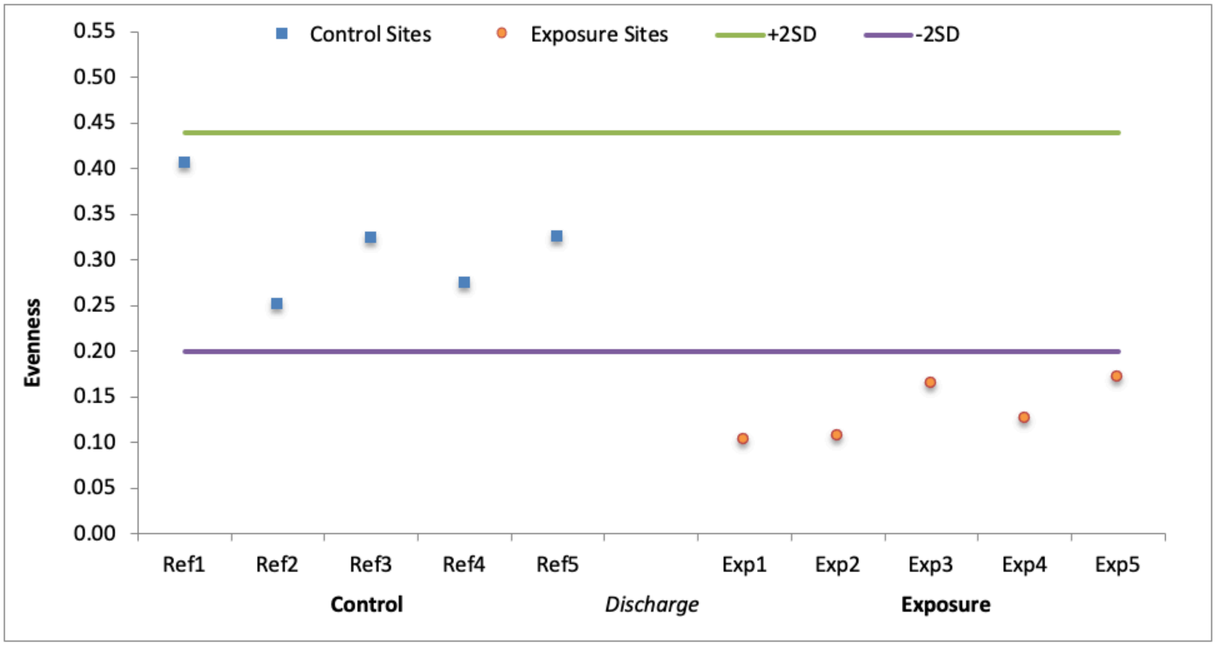
Figure 6. Bray-Curtis Index of Dissimilarity at control and exposure sites for the Myra Falls 2019 EEM Program



4.3.6.4 Evenness

Figure 7 below summarizes the evenness values between each site and the reference median in both reference and exposure areas. The data shows that the abundance of benthic invertebrate populations is more evenly distributed across taxa at the Reference sites compared with the Exposure sites. Evenness values fell outside of two standard deviations of the reference mean at all 5 exposure sites.

Figure 7. Evenness values at control and exposure sites for the Myra Falls 2019 EEM Program



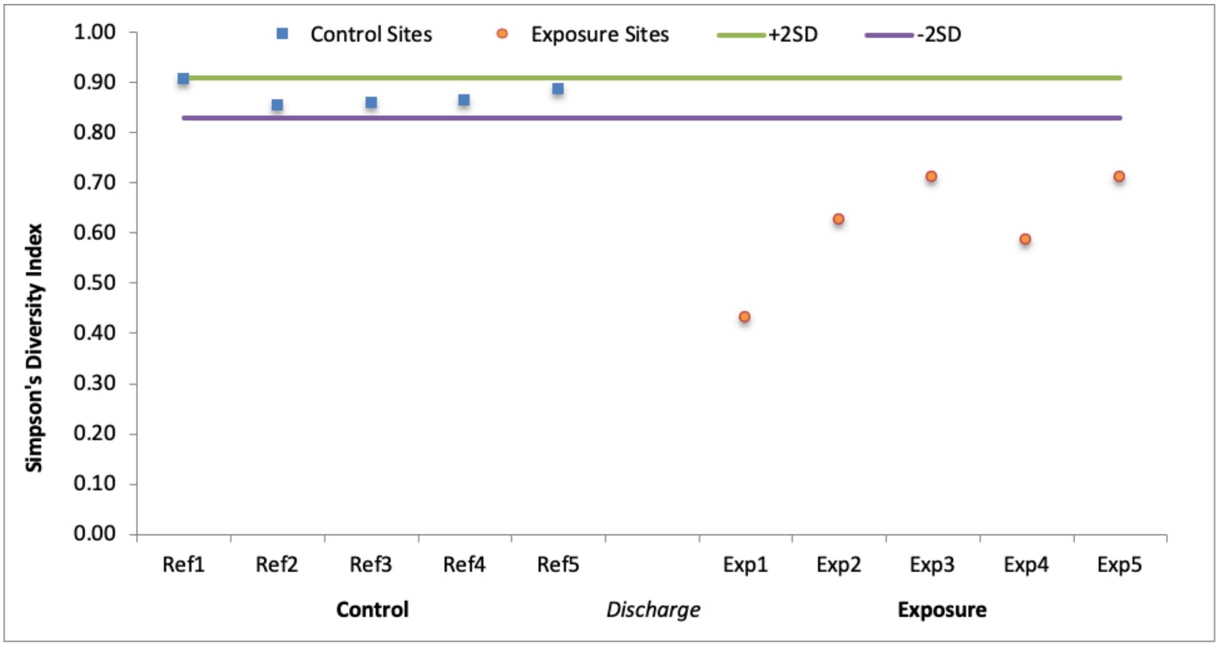
The Mann-Whitney test results indicates that there is a significant difference in evenness between reaches (p=0.01). The effect size for this metric (r=0.80) shows a high difference in magnitude between reference and exposure sites.

4.3.6.5 Simpson's Index of Diversity

Figure 8 below summarizes the Simpson's Index of Diversity (SDI) values between each site and the reference median in both reference and exposure areas. Benthic communities in the reference area show a rather high level of diversity with SDI values ranging from 0.85 to 0.91. In the exposure area, SDI values ranged between 0.43 and 0.80, with all sites being outside of two standard deviations of the reference mean.

The SDI is a non-linear index; therefore, the Mann-Whitney test is not appropriate to test for significant differences between sites.

Figure 8. Simpson's diversity values at control and exposure sites for the Myra Falls 2019 EEM Program

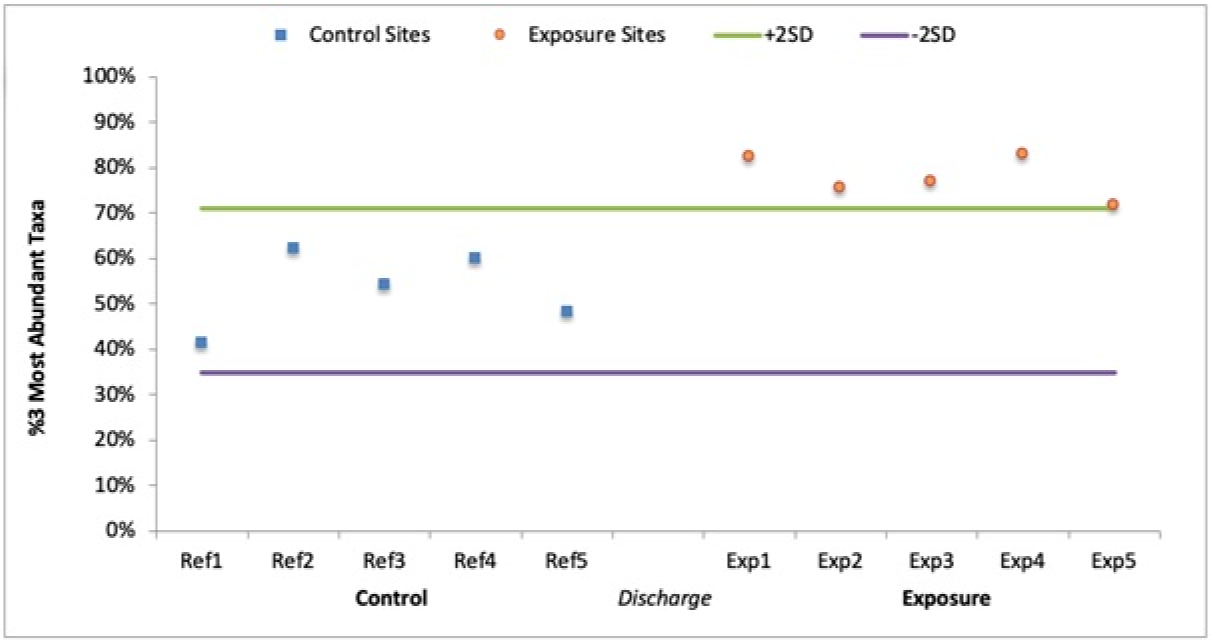


4.3.6.6 Percent 3-Most Abundant Taxa

Figure 9 below summarizes the relative abundance of the 3 most abundant taxa values between each site and the reference median in both reference and exposure areas. The data shows that the relative abundance of the three dominant taxa falls above two standard deviation of the reference median at all 5 exposure sites.

The use of a statistical test is not relevant for this metric since it was generally calculated using three different taxa from one site to another.

Figure 9. Percent 3 most abundant taxa values at control and exposure sites for the Myra Falls 2019 EEM Program



4.3.6.7 EPT Richness and % EPT

Figure 10 and Figure 11 below summarize the *Ephemeroptera*, *Trichoptera* and *Plecoptera* (EPT) richness and percent EPT, respectively, observed between each site and the reference median in both reference and exposure areas. The data shows that the EPT richness is generally lower in the exposure reach with three of the five metric values falling outside two standard deviations of the reference median (EXP2 and EXP4 were within the ± 2SD range). Conversely, the percent EPT ratios were within the reference envelope at all 5 exposure sites. The Mann-Whitney test results indicate that there is a significant difference in EPT richness between reaches (*p*=0.03), whereas the percent EPT does not show a significant difference between reaches (p=0.83).

Figure 10. EPT richness values at control and exposure sites for the Myra Falls 2019 EEM Program

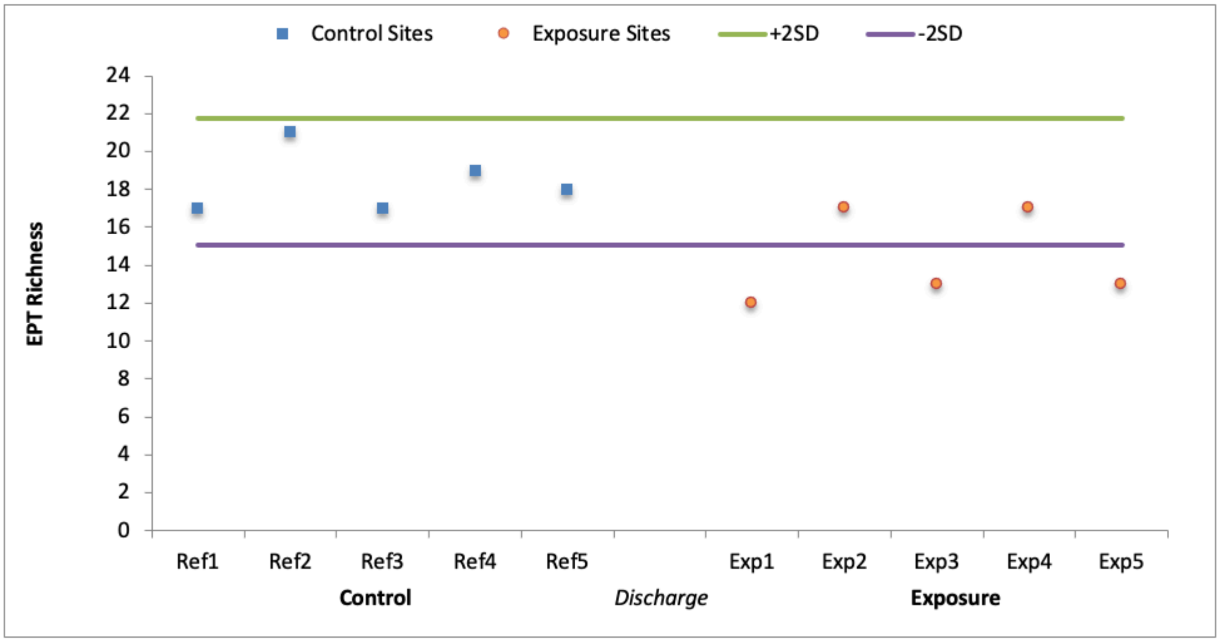
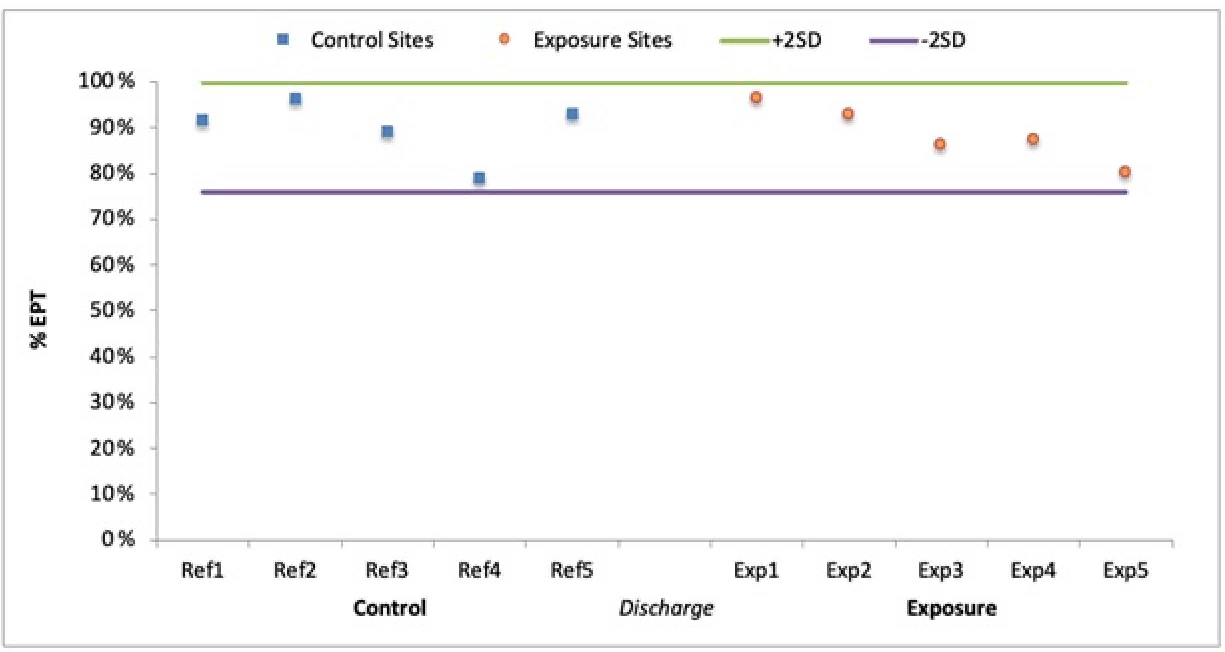


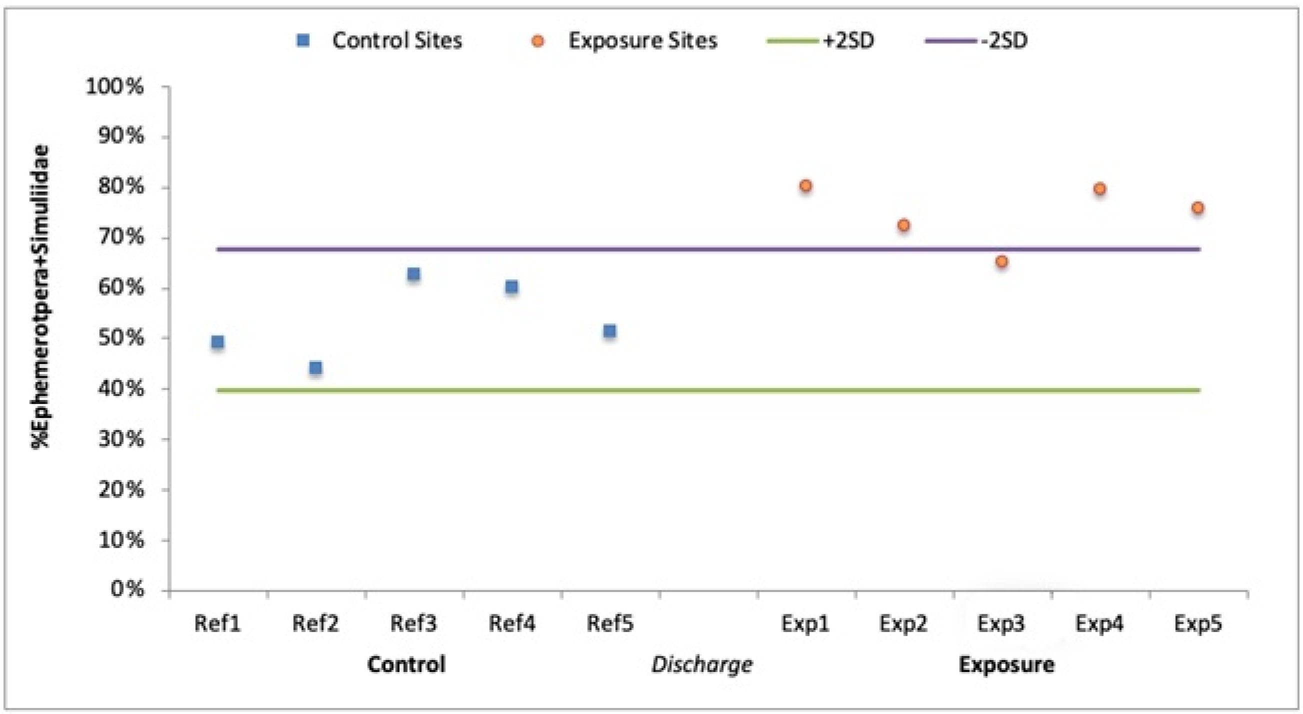
Figure 11. Percent EPT values at control and exposure sites for the Myra Falls 2019 EEM Program



4.3.6.8 Percent Ephemeroptera + Simuliidae

Figure 12 below summarizes the percent *Ephemeroptera* + *Simuliidae* between each site and the reference median in both the Reference and Exposure areas. The results show that the percent *Ephemeroptera* + *Simuliidae* ratio is greater in the Exposure reach compared with the Reference sites and falls outside two standard deviation of the reference median at all 5 exposure sites, except at site EXP3. The Mann-Whitney test results indicated that there was a significant difference in percent *Ephemeroptera* + *Simuliidae* between reaches (p=0.01).

Figure 12. Percent Ephemeroptera + Simuliidae values at control and exposure sites for the Myra Falls 2019 EEM Program



4.3.7 Comparison to CABIN Reference Sites

4.3.7.1 Reference Site Group Attribution

The CABIN database uses the geographical and habitat variables collected *in situ* to evaluate the similarity of the study sites to each of the biological reference groups from the Fraser River – Georgia Basin 2005 model. This model contains five different groups of reference sites, and the probability of a given study site belonging to each of the reference groups is determined based on their respective habitat characteristics. Those habitat characteristics include:

- Ecoregion
- Latitude
- Slope
- Stream order
- Coniferous tree presence
- Wetted width
- Maximum velocity
- Average Depth
- Dominant Substrate
- Embeddedness
- pH

The results of these calculations are summarized in Table 10, and show that all Myra Creek sites sampled in 2019 fell into Reference Site Group 1.

Table 10. Probability of the test sites for the Myra Falls Mine 2019 EEM Program to belong to one of the five Reference Groups included in the Fraser River – Georgia Basin 2005 model

Site	Group 1	Group 2	Group 3	Group 4	Group 5
Reference Sites					
REF 1	98.30%	0.00%	1.40%	0.20%	0.10%
REF 2	72.20%	0.10%	17.50%	7.40%	2.70%
REF 3	90.90%	0.00%	6.40%	1.90%	0.70%
REF 4	96.30%	0.00%	3.00%	0.40%	0.20%
REF 5	98.40%	0.00%	1.40%	0.00%	0.20%
Exposure Sites					
EXP 1	92.40%	0.00%	3.10%	4.30%	0.20%
EXP 2	90.30%	0.20%	7.00%	1.30%	1.10%
EXP 3	87.10%	0.60%	9.30%	0.20%	2.70%
EXP 4	81.10%	2.10%	10.40%	1.60%	4.70%
EXP 5	85.40%	1.30%	8.60%	1.60%	3.10%

4.3.7.2 Benthic Community Comparison with CABIN Reference Sites

The results of the CABIN database analysis in Table 11 below indicate that the benthic communities at all 5 of the control sites are in reference condition. In the exposure reach, the majority of the sites are mildly divergent to reference condition (EXP 1, EXP 2, EXP 3, and EXP 5) whereas site EXP 2—one of the two sites closest to the mine discharge—is considered to be in reference condition.

Table 11. Summary table of the distance from reference condition for the control and exposure sites

Site #	Distance from Reference Condition
REF 1	Similar to reference condition
REF 2	Similar to reference condition
REF 3	Similar to reference condition
REF 4	Similar to reference condition
REF 5	Similar to reference condition
Site #	**Distance from Reference Condition**
EXP 1	Mildly divergent from reference condition
EXP 2	Similar to reference condition
EXP 3	Mildly divergent from reference condition
EXP 4	Mildly divergent from reference condition
EXP 5	Mildly divergent from reference condition

4.3.8 Discussion

Interpreting the results of the 2019 benthic invertebrate assessment on Myra Creek is problematic because many of the community metrics exhibited clear differences between Reference and Exposure reaches. Similar differences between reaches have been observed in previous cycles and require thoughtful analysis to separate community responses related to differences in habitat from responses to elevated concentrations of metals since habitat differences and elevated metals tend to be associated with the downstream reach relative to upstream. Of note, the ability to separately evaluate these potential causal factors speaks well of the study design and personnel carrying out the sampling and analysis. Generally speaking, most of the community metrics exhibited statistically significant differences between the Reference and Exposure reaches, and also demonstrated little or no overlap between values obtained from the Exposure sites and the ± 2SD envelope around the Reference area median, suggesting that the observed differences were highly unlikely to be the result of sampling error. Notable exceptions to this generalization include:

- Density: there was a statistically significant difference in median values, but all of the Exposure sites fell within ± 2SD of the Reference mean.
- Taxanomic richness: there was a statistically significant difference in median values, and one of five Exposure sites fell within ± 2SD of the Reference median. Of note, overall taxa richness was virtually identical upstream and downstream of the discharge, totalling 45 and 44 taxa, respectively.
- EPT richness: there was a statistically significant difference in median values, but two of the five Exposure sites fell within ± 2SD of the Reference mean.
- % EPT individuals: there was no statistically significant difference in median values, and all of the five Exposure sites fell within ± 2SD of the Reference mean.
- % Ephemeroptera + Simuliidae individuals: there was a statistically significant difference in median values; notably, values for four of the five Exposure sites were greater than the upper bound of ± 2SD of the Reference mean.

Of primary interest to this study is the extent to which the effluent discharge is responsible for differences observed in benthic invertebrate community metrics in the upstream and downstream reaches. This question was evaluated directly by comparing distributions of different metrics known to be sensitive to elevated concentrations of metals; specifically, EPT richness, % EPT individuals and % Ephemeroptera + Simuliidae individuals. These are discussed in greater detail below:

- EPT richness: EPT taxa are generally considered to be among the most sensitive BMI taxa to environmental disturbances, including elevated metals concentrations. Thus, reduced numbers of EPT taxa is a potential cause for concern. However, this metric is based on the number of EPT taxa per sample, so while it may reflect a lower frequency of individuals, it does not necessarily reflect an overall reduction in diversity across a given reach. Specifically, a total of 26 EPT taxa were identified in the Exposure reach, compared with 28 in the Reference reach. Of interest, there were 7 EPT taxa identified in the Reference reach that were not found in the Exposure reach. Of these, 6 taxa were represented by single individuals found at only 1 or two sites in the Reference area, implying a rare occurrence and a reasonably high probability of not being found at all. Conversely, there were 5 taxa found in the Exposure reach that were not present in the Reference reach; four of these taxa would be considered "rare" in terms of frequency. Interestingly, there was one taxon in each of the two reaches that was represented in relatively high abundance, but not present at all in the complimentary reach. Overall, these data suggest a similar level of diversity of EPT taxa across reaches.

- % EPT individuals: this metric measures the proportion of EPT individuals relative to total individuals in a sample. The underlying assumption is that numbers of individuals representing these sensitive taxa will be preferentially reduced relative to overall numbers in the presence of an external perturbation that doesn't affect less sensitive taxa. Interestingly, the % EPT individuals exceeded 80% in all samples regardless of location, with no difference between the Reference and Exposure locations. Thus, this metric does not indicate the presence of any adverse effect that would be expected to selectively impact sensitive taxa.
- % Ephemeroptera + Simuliidae individuals: this metric is similar to the one above, but looks specifically at mayflies and black flies which provide a more focussed assessment of community response to toxic concentrations of metals. In this case, there was a statistically significant difference between Reference and Exposure reaches, with only one sample from the Exposure reach falling within the ± 2SD reference envelope; however, the values associated with Exposure reach were generally *higher* than observed in the Reference reach, indicating that metals were not responsible for observed differences in community structure between the two reaches.

Overall, analysis of the benthic invertebrate community metrics suggests that the design and implementation of the program enabled detections of relatively small differences between reaches. Importantly, diagnostic evaluation of the data suggested that elevated metals concentrations were not responsible for any of the observed differences, and ultimately suggests that community differences were likely driven by habitat differences related to substrate composition in the two reaches (i.e., % cobble, % pebble and D50). This finding is consistent with previous EEM studies at the site, and also with comparisons to the CABIN reference condition, which showed that the Exposure sites were either equal to or mildly divergent from the expected reference condition. Thus, the observed differences in community structure might be apparent at the reach level on a given stream, but were less apparent when compared at a regional level that integrates a broader array of habitat combinations.

Further support for the lack of effects relative to metals comes from inspection of the data for sediment metals in Table 8. Specifically, none of the community metrics responsed in a manner consistent with differences in metals concentrations. For examples, metals concentrations at REF005 were approximately 3-fold higher than at other Reference sites, but there was no apparent response of the exposure metrics relative to the other Reference sites. Similarly, sediment metals concentrations varied by approximately 2 to 3-fold across sites in the Exposure reach, with no associated changes in the pattern of community metrics.

Notably, the elevated number of *Simuliidae* (black flies) observed at the three lower Exposure sites during the two previous sampling cycles (2013 and 2016) was not observed this year. Specimens from this family typically cling to the surface of boulders and cobbles, and the elevated flows that occurred prior to the invertebrate sampling may have reduced their presence by increasing natural drift. Of note, MFO recently commissioned an updated analysis of wet and dry seasons, which identified that the onset of the rainy season was associated with the latter half of September (Wood Environment and Infrastructure 2019). Based on these data, future invertebrate sampling operations should be completed within the first two weeks of September.

5.0 FISH POPULATION STUDIES

A fish monitoring study is required as part of the EEM program at NMF because discharge from the mine operation comprises more than 1% of the volume in Myra Creek 250 m downstream of the discharge point. The study is designed to evaluate fish populations and determine if there are differences in growth, reproduction, survival or condition of fish between Reference and Exposure reaches. Notably, fish tissue mercury analysis is not necessary at this site because mercury concentrations measured in the effluent characterization have not exceeded 0.10 µg/L (i.e., mercury in the effluent was less than detection [<0.01 µg/L] in all monthly samples collected for the period 2015 – 2018) (C. Schweitzer, NMF, *pers. comm.*, Sept 2018). Following the transition from the MMER to the MDMER, a study evaluating selenium in fish tissue is also now required if effluent characterization reveals a concentration of total selenium in the effluent that is equal to or greater than 10 µg/L. Based on a total of 149 observations from 2016 to 2018, the maximum measured concentration of selenium was 1.06 µg/L, with an average of 0.51 ± 0.16 µg/L, indicating no exceedances of the thresholds outlined in Schedule 5, s. 9(1)(d) and s. 13 (2)(d).

The assessment of fish health in Myra Creek is focused on cutthroat trout because it is the only fish species found in the creek. However, conducting a fish monitoring program in this system is complicated by the low density of fish present (Hallam Knight Piesold, 1999; Nautilus Environmental 2005; 2008), which limits the number available for sampling. Thus, destructive sampling of fish in the creek is not appropriate because the number of fish collected would impose a significant impact on the overall population of cutthroat trout in Myra Creek. An option would be to use non-destructive sampling to obtain information on fish condition; however, Environment Canada guidance recommends a minimum sample size of 100 fish be collected in each sampling area, which would not be possible due to the limited population size. In addition, because of the short length of the fish-bearing reach, resident fish utilize both the Reference and Exposure reaches, which precludes the definitive separation of exposure history necessary to assign fish to Control or Impact groups.

Environment Canada has suggested alternative approaches for use in EEM programs conducted under the MDMER in cases where a fish population survey is not appropriate. These methods include use of mesocosms and caged bivalves. Maintaining caged bivalves in a fast flowing system such as Myra Creek would be problematic, and interpreting the results in the context of effects on fish populations would be somewhat speculative, at best. Mesocosms have been used for fish monitoring in river systems; however, these studies have typically used small-bodied fish, and mesocosm studies using salmonids have been restricted to juvenile fish (Environment Canada, 2002) because of difficulties in holding sufficient numbers of adult fish under realistic conditions in mesocosm tanks. Thus, since cutthroat trout are the only fish which have been observed in Myra Creek, a mesocosm study would likely be restricted to an evaluation of juvenile fish.

Given the limitations associated with the suggested alternatives, the guidance document also indicates that "*Mines may choose other scientifically defensible methods provided that the results can determine if the effluent is having effects on the fish population (growth, reproduction, condition and survival)*". Consequently, an alternative method was proposed and implemented in the previous EEM Cycles and, based on positive results, was again put into use in Cycle 6. This approach consists of evaluating eyed-stage cutthroat trout embryos that are reared through hatch to the swim-up stage in hatchboxes placed in the creek in Exposure and Reference reaches. The methodology is based on BC MOE guidance for field studies (BCMWLAP 2003), with refinements that improve its usefulness for routine use in a regulatory context (Chalmers et al., 2014). Notably, it provides laboratory-level sensitivity for detecting adverse effects on lethal and sub-lethal (e.g., growth and deformities) endpoints.

Consistent with previous years, the *in situ* early life stage approach was also supplemented with a fish survey conducted during the late summer-early fall low-flow period in which fish in both reaches were sampled using angling techniques, enumerated, weighed and measured to assess abundance, condition factor and age distributions. Spawning and rearing areas were also surveyed for evidence of young of the year (YOY) and juveniles.

5.1 *In Situ* Exposures

5.1.1 Introduction

An *in situ* hatchbox study has inherent advantages over a mesocosm study because it provides a more realistic exposure to the organisms that reflects site-specific variability in flow, temperature, and water chemistry that are incorporated into the exposure. Of note, the statistical sensitivity associated with detecting an adverse effect using either the hatchbox or mesocosm approaches would not be expected to differ substantially if similar numbers of fish and replicates were used in both approaches. However, hatchboxes provide increased flexibility to improve statistical sensitivity because additional stations or replicates can be added for relatively little additional cost, since the only material cost is for the boxes themselves, compared with the substantial construction efforts or rental costs required for mesocosms. Hatchboxes can also be co-located with sites used for invertebrate community assessments, thus providing more relevance to the overall dataset. Finally, the hatchbox approach also provides more flexibility for future monitoring programs if Focused Monitoring or Investigation of Cause is required. While this assessment does not incorporate a reproductive end-point, alternative options such as non-destructive sampling and mesocosm studies would also be limited in this regard.

Hatchbox studies have been used successfully in British Columbia for environmental monitoring of mining and pulp and paper mill sites (Graham Van Aggelen, Environment Canada, *pers. comm.*), evaluations of storm water runoff from urban and industrial sites, risk assessments of abandoned mine sites (Howard Bailey, Nautilus Environmental, *pers. comm.*), and in past cycles of NMF's EEM program (Nautilus Environmental 2005; 2008; 2017). These applications have proven to be a useful and effective tool for environmental monitoring, providing a combination of site-specific exposure and a high degree of statistical sensitivity. General guidance for conducting these evaluations have been summarized in the BC Ministry of Water Land and Air Protection guide for field sampling (http://wlapwww.gov.bc.ca/air/wamr/labsys/field_man_pdfs/part_c.pdf; BCWLAP, 2003), with further refinements described by Chalmers et al. (2014). Of note, similar *in situ* studies of embryo development using various designs of hatchboxes have also been implemented elsewhere in Canada (e.g., Lachance et al., 2000).

As with Cycles 1, 2 and 5, the study plan involved placing modified Whitlock-Vibert hatchboxes containing eyed-stage trout embryos in Myra Creek at Exposure and Reference stations that have been used previously and are shown in Figure 2. Due to their presence in Myra Creek, previous EEM cycles (i.e., 1 thru 5) focused on using cutthroat trout. Unfortunately, the use of cutthroat trout for research activities in 2019 was not possible due to population constraints, and rainbow trout embryos were substituted instead. As noted previously, rainbow trout are a close relative of cutthroat trout and are present in locally in other tributaries of Buttle Lake. In summary, the *in situ* testing approach monitors developing embryos and hatched fish in the receiving environment to evaluate embryonic development, hatching success, survival, incidence of deformities, and growth under real-world conditions. Thus, the approach encompasses a number of sensitive life stages and developmental transition periods across an extended exposure period, while integrating real-time environmental and exposure variables.

5.1.2 Methods

Embryos were exposed in Whitlock-Vibert hatchboxes (Federation of Fly Fishers, MO), which are comprised of two rectangular chambers located one above the other, one for embryo development and the other for rearing of hatched fish. The external faces of the embryo chamber are plastic grids with small squares that allow passage of water through the box, but prevent loss of embryos. Internally, the face dividing the embryo chamber from the rearing chamber is comprised of slats that are narrow enough to prevent passage of unhatched embryos, but wide enough to permit migration of hatched fish into the rearing chamber. Thus, upon hatch, alevins are able to migrate from the embryo chamber through the slats into the larger rearing chamber.

The hatchboxes were originally designed to allow migration of fish out of the hatchboxes and into the natural environment. However, since this study required that fish be retained at the end of the exposure, the boxes were modified by applying a plastic screen to the external faces of the rearing chamber to prevent escape of the hatched fish. The screen was held in place using small plastic zip-ties.

On May 1st, 2019, eyed-stage rainbow trout embryos were obtained from Omega Fish Hatcheries (Port Alberni, BC) and transported by road to the MFO mine site in coolers containing ice packs. Thirty embryos were assigned to each replicate hatchbox and four hatchboxes were deployed at each sampling location. The embryos were gently transferred into the top chamber of the hatchbox using a plastic spoon. The hatchboxes were then sealed and placed in stainless steel cages that were filled with washed rocks (1-2 inches in diameter) and subsequently placed in the streambed. Prior to placement, the sites were prepared by digging a depression approximately six inches deep into the creek substrate. The cages were positioned in the streambed so that the hatchboxes were approximately at the same depth as the streambed, and additional rocks were then placed around the outside of the cage to anchor it and shield it from the direct impacts of the current and sunlight. Figure 13 shows different steps in deploying the hatchboxes.

Figure 13. *In situ* hatchbox setup

As has been performed in previous EEM Cycles (i.e., 1, 2 and 5), two reference sites (MC-M1 and S11-A) were located upstream of the discharge in Reaches 3 and 4 (Figure 2), and two exposure locations (i.e., TP-4 and MC-M2) were located downstream of the discharge in Reach 1 (Figure 3). An additional effluent plume station, EFF-DS, located just downstream of the effluent discharge in Reach 2, was also included to provide an indication of "worst-case" effects within the immediate vicinity of the mine's 11-A discharge (Figure 3). An extra measure of protection from increased flow was put in place for the EFF-DS site by placing the stainless steel cages in plastic milk crates filled with washed rocks to aid in dampening potential flow-related trauma, as occasionally observed in this reach in previous cycles.

A laboratory control was conducted concurrently in dechlorinated municipal water using the same batch of eyed-stage trout used to initiate the field study. These embryos were transported on ice in a cooler back from MFO to the Nautilus Environmental laboratory in Burnaby, BC. For consistency, four replicates of thirty embryos were deployed to 3.5-L plastic tubs containing 3-L of test water on May 2nd, 2019. The exposures were maintained in a refrigerator under 24-h darkness at similar temperatures as the exposures being carried out in Myra Creek, and were used both as a negative control to evaluate organism health and to monitor developmental milestones. Creek temperatures in the reference and exposure reaches were monitored by mine staff and relayed to the laboratory on a weekly basis. Thus, timing of developmental milestones could be determined in the laboratory and prevented the need for unnecessary disturbance of the *in situ* exposures. The laboratory control was maintained at 6 ± 1°C during the first 22 days of the exposure. This was increased to 7 ± 1°C on Day 23 of the exposure, where it was maintained until the completion of the test. Temperature of the laboratory control was monitored daily and water quality (i.e., pH, conductivity and dissolved oxygen concentrations), survival and developmental milestones were monitored daily. Water changes were also performed three times per week and consisted of ~60% renewal of the test solutions.

The hatchboxes deployed to Myra Creek were inspected roughly every 7-10 days (i.e., Day 9, 21, 28 and 36 of the exposure) during the exposure to ensure that the boxes were not clogged with particulates or detritus, that creek water levels were still at an appropriate level for the chosen deployment locations, and to monitor the status of the test organisms. Any mortalities were recorded and removed to prevent fungal growth. Additionally, measurements of temperature, pH, conductivity and dissolved oxygen concentrations were collected during each inspection. Water samples were also collected from each station for analysis of anions, nutrients, dissolved organic carbon (DOC), and total and dissolved metals at test initiation, Day 21, and test termination. These measurements were completed by ALS Environmental (Burnaby, BC).

Exposures at all locations were terminated on June 6, 2019 (Day 36 of the exposure). The negative control was terminated the following day on June 7, 2019 (Day 36 of the lab exposure). Upon termination, the surviving fish were sacrificed, lengths measured to the nearest 0.5 mm (i.e., standard length, based on distance from the tip of the snout to the end of the caudal peduncle) and deformities assessed. The fish were then pooled for each replicate (i.e., hatchbox) and weighed to the nearest hundredth of a gram (wet weight). The replicates from each station were then pooled, frozen and sent to ALS Environmental for analysis of moisture content and tissue metal concentrations.

Endpoints collected from the reference and exposure areas were compared statistically to determine whether there were any significant differences ($p \leq 0.05$) in hatching success, post-hatch survival, incidence of deformities, length, wet weight, or condition factor. Condition factor was calculated using the formula:

$$\mathrm{CF} = \frac{10^5 W}{L^3}$$

Where:

- CF is the condition factor
- W is the weight of the fish in grams (g).
- L is the length of the fish in millimeters (mm); the value is cubed because growth measured as weight of salmonids is proportional to growth in volume.
- 10^5 represents a constant determined for condition factor of salmonids by Fulton (1902)

5.1.3 Results and Discussion

5.1.3.1 Water Chemistry

Dissolved oxygen, pH and temperature measurements collected during the study were all within an acceptable range for rainbow trout; dissolved oxygen ranged between 9.0 and 10.8 mg/L, pH was between 7.1 and 7.7, and temperature was between 6.9 and 11.4°C. Of these variables, only temperature varied appreciably between sites. The MC-M1 and S11-A Reference locations experienced a range in temperatures from 6.9 to 9.8°C, whereas the Exposure locations, MC-TP4 and MC-M2, were typically a degree warmer with temperatures ranging between 7.7 and 11.4°C. The highest temperatures were measured at the EFF-DS location, and ranged between 9.0 and 11.4°C.

Unsurprisingly, conductivity measurements at sampling locations located downstream of the effluent were substantially higher than upstream Reference locations. The average conductivities at the MC-M1 and S11-A were 20 and 24 µS/cm, respectively, compared with average conductivity measurements for the EFF-DS, MC-TP4 and MC-M2 exposure locations of 203, 67 and 68 µS/cm, respectively. General water quality data collected during the study are provided in Appendix B.

Analytical results for key parameters of interest collected during the *in situ* study are summarized in Table 12. Based on three measurements, the average total cadmium concentration observed at the downstream discharge location (EFF-DS; 0.14 µg/L) was marginally higher than the recommended Canadian Council of Ministers of the Environment (CCME) long term water quality guidelines of 0.13 µg/L for cadmium at a hardness of 82 mg/L. Conversely, average total cadmium concentrations measured at TP-4 and MC-M2 were below the guideline at their respective hardness levels. Average total copper concentrations exceeded the recommended guideline of 0.002 mg/L at the EFF-DS and TP-4 locations by less than two-fold, and were under the guideline at MC-M2. Finally, average total zinc concentrations exceeded the CCME long-term water quality guidelines of 0.007 mg/L at all three downstream locations (EFF-DS, TP-4 and MC-M2) by factors of two- to five-fold, with the greatest exceedances associated with EFF-DS. All other parameters of interest were below recommended guidelines, and no exceedances were observed in any of the upstream sites. Analytical datasheets can also be found in Appendix B.

Table 12. Average analytical chemistry results from samples collected during the rainbow trout *in situ* hatchbox study (n=3).

Parameter	Stations				
	Upstream		Downstream		
	MC-M1	S11-A	EFF-DS	TP-4	MC-M2
Hardness	8.0 ± 1.4	9.8 ± 0.2	82 ± 22	26 ± 6.3	27 ± 7.6
Total nitrogen	0.091 ± 0.07	0.037 ± 0.01	0.28 ± 0.34	0.16 ± 0.08	0.13 ± 0.07
Total phosphorus	<0.002	<0.002	<0.002	<0.002	<0.002
Sulphate	0.87 ± 0.13	0.96 ± 0.14	72 ± 25	16 ± 6.4	16 ± 7.5
DOC	2.2 ± 0.48	2.1 ± 0.64	2.3 ± 0.92	2.2 ± 0.89	2.0 ± 0.46
Total aluminum	0.06 ± 0.03	0.04 ± 0.02	0.10 ± 0.03	0.05 ± 0.02	0.05 ± 0.02
Total cadmium (µg/L)	<0.005	0.009 ± 0.00	**0.14 ± 0.07**	0.050 ± 0.01	0.046 ± 0.01
Total copper	<0.0005	<0.0005	**0.0033 ± 0.00**	**0.0032 ± 0.00**	0.0013 ± 0.00
Total iron	0.028 ± 0.02	0.010 ± 0.00	0.035 ± 0.02	0.014 ± 0.01	0.013 ± 0.00
Total lead (µg/L)	0.062 ± 0.01	0.050 ± 0.00	1.60 ± 1.60	0.305 ± 0.24	0.263 ± 0.20
Total selenium	<0.00005	<0.00005	0.00027 ± 0.00	0.00009 ± 0.00	0.00008 ± 0.00
Total silver	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Total zinc	<0.003	<0.003	**0.039 ± 0.01**	**0.016 ± 0.00**	**0.016 ± 0.00**

SD = standard deviation; all concentrations are reported in mg/L, unless otherwise indicated; Bolded values represent an exceedance of CCME long term WQGs.

5.1.3.2 Biological Endpoints

The negative control treatment tested in the laboratory met acceptability criteria provided by Environment Canada (1998) of ≥60% viability; survival was 91%, and deformities were observed in <1% of the surviving fish. All fish hatched in the negative control by Day 20 of the exposure, and the test was completed on Day 36, when the organisms reached the swim-up life stage (i.e., absorbed their yolk sac). Average wet weight and length in the laboratory control was 97 mg/organism and 22.7 mm/organism, respectively, and condition factor averaged 0.83.

Interpretation of the *in situ* test results was complicated by variable numbers of missing fry spread out across replicates in both the Reference and Exposure areas (Table 13). Notably, there appeared to be no bias in the number of missing fry with respect to treatment group (Mann-Whitney U-test; $p>0.05$), but the relatively large variability among replicates complicated the data analysis. Because this isn't something that we have experienced in the past, we evaluated the possibility that it may have been related to the fish used for the exposure. As noted under Methods, because of shortages of cutthroat trout eyed embryos, eyed embryos from rainbow trout from a different source were used in Cycle 6. Moreover, inspection of lengths and weights and condition factor at swim-up indicated that these fry tended to be longer, weighed less and exhibited lower CF than those in Cycle 5. Thus, the most likely explanation of the missing fish is that they were able to find enough variability amongst the perforations in the hatchboxes that they could wiggle through. Occasional observations of yolk sacs wedged into perforations provided supporting evidence for this hypothesis.

Table 13. Total Missing Fish Following 36 days of Exposure in Myra Creek

	Stations				
	Upstream		Downstream		
Replicates	**MC-M1**	**S11-A**	**EFF-DS**	**TP-4**	**MC-M2**
A	4	10	7	3	13
B	1	24	3	15	11
C	1	7	13	1	3
D	0	27	13	1	10
Average ± SD	1.5 ± 1.7	17 ± 10	9.0 ± 4.9	5.0 ± 6.7	9.3 ± 4.3

Given this confounding factor, the following assumptions and caveats were incorporated into the data analysis to minimize the potential impact of the missing fry:

- Hatching success: the hatchboxes were inspected the day after hatching was completed in the laboratory controls. All embryos had hatched, but there were already some missing fry. However, the overall numbers were low and, consequently, they were treated as mortalities or non-viable embryos. Thus, hatching success was calculated based on the number of alevins identified at the time of inspection divided by the initial number of embryos present in the hatchbox (i.e., 30).

- Survival: given the cold temperatures and relatively frequent inspection of the hatchboxes, dead alevins should have been conserved in the hatchboxes, leading to accurate recording of mortalities among fry present. However, given that there were missing fish, we have no way of accounting or estimating mortalities among that population. Therefore, escaped/missing fish were censored from observations associated with a particular hatchbox and the total "n" for a given hatchbox was calculated as the sum of observed mortalities plus the number of fry remaining at the end of the exposure. To minimize impacts of small sample size on the analysis, this approach was applied to all replicates for which at least 50% of the initial 30 embryos distributed to each hatchbox could be accounted for at the end of the exposure. Ultimately, only two of the 20 replicates used to initiate the study exhibited >50% missing fry, so there was virtually no impact on the overall power to detect differences between reaches following their deletion from the dataset.
- Length, weight and condition factor: since these sublethal metrics are based on fish remaining at the end of the exposure, only replicates that exhibited a fry recovery at least 50% of the initial eyed embryos were used for the associated analyses. Thus, an "n" of approximately 15 organisms should be sufficient to characterize the mean associated with any given replicate hatchbox. Of note, this criterion was met in 18 of 20 hatchboxes, again ensuring a high level of statistical power across reaches.

Test endpoints for the control and exposed fish are summarized in Table 14; raw data are in Appendix B.

Table 14. Results of the *in situ* rainbow trout hatchbox development study (mean ± SD).

	Stations					
	Laboratory	Upstream		Downstream		
Endpoint	**Control**	**MC-M1**	**S11-A**	**EFF-DS**	**TP-4**	**MC-M2**
Hatching Success (%)	1.0 ± 0.0	96 ± 1.7	80 ± 16.6	83 ± 2.7	89 ± 7.4	83 ± 2.7
Post-Hatch Survival (%)	1.0 ± 0.0	92 ± 2.4	81 ± 8.5	88 ± 5.2	86 ± 0.6	77 ± 13.7
Deformities (%)	0.8 ± 1.7	0.0 ± 0.0	0.0 ± 0.0	0.8 ± 1.7	2.5 ± 3.2	0.0 ± 0.0
Length (mm)	22.7 ± 0.6	23.0 ± 0.7	23.2 ± 0.7	24.6 ± 0.6	24.1 ± 1.0	24.8 ± 0.6

Wet weight (mg)	97 ± 2	97 ± 2	99 ± 1	115 ± 10	108 ± 5	117 ± 2
Condition factor	0.83 ± 0.02	0.80 ± 0.01	0.79 ± 0.02	0.77 ± 0.07	0.77 ± 0.05	0.76 ± 0.03

SD = standard deviation

Overall, hatching success and post-hatch survival were similar between upstream and downstream reaches. The incidence of deformities observed in fry at test termination was also low, regardless of reach. For perspective, average hatching success ranged between 80 and 96% in the upstream Reference reach and between 83 and 89% in the downstream Exposure reach. Similarly, post-hatch survival ranged between 81 and 92% in the Reference reach and between 77 and 86% in the Exposure reach. The incidence of deformities averaged between 0.0 and 2.5% across both reaches.

Interestingly, swim-up fry from the Exposure reach tended to be slightly larger than those from the Reference reach, exhibiting average lengths and weights that were approximately 6 and 15%, respectively, greater than observed in the Reference reach. Although the differences were relatively small, they were statistically significant. However, mean condition factors differed by <4% between reaches with no associated finding of statistical significance. Notably, the EFF-DS site, which is located within the mixing zone just downstream of the effluent discharge, did not exhibit any evidence of adverse effects when compared with Exposure sites located further downstream outside of the mixing zone.

Concentrations of metals and percent moisture in whole bodies of fish collected from the hatchboxes are shown in Table 15. In general, differences in concentrations across sites were unremarkable.

Table 15. Fish tissue metal concentrations collected from the rainbow trout *in situ* hatchbox study.

	Stations					
	Upstream		Downstream			Lab
Parameters	MC-M1	S11-A	EFF-DS	TP-4	MC-M2	Control
Physical						
Moisture (%)	85.0	87.2	89.4	90.9	86.8	81.6
Total metals						
Aluminum	<1.0	<1.0	2.5	<1.0	<1.0	<1.0
Antimony	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Arsenic	0.0258	0.0312	0.0232	0.0206	0.0265	0.0405
Barium	0.15	0.248	0.15	0.055	0.108	0.176
Beryllium	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Bismuth	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium	<0.0020	<0.0020	0.0049	<0.0020	0.0028	<0.0020
Calcium	335	513	545	249	454	437
Cesium	0.0019	0.0019	0.0015	0.0013	0.002	0.0028
Chromium	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Cobalt	0.0042	0.0045	0.0055	<0.0040	0.0054	0.0053
Copper	0.701	0.778	0.694	0.516	0.781	0.966
Iron	5.2	6.1	7.3	3.7	6.8	7.3
Lead	<0.010	<0.010	0.021	<0.010	0.013	<0.010
Lithium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium	187	221	154	113	199	281
Manganese	0.185	0.337	0.406	0.135	0.281	0.339
Molybdenum	<0.0080	0.0087	0.0289	<0.0080	0.0102	0.0134
Nickel	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Phosphorus	1820	2070	1590	1240	1980	2620
Potassium	1340	1560	2000	1450	2260	1820
Rubidium	1.15	1.29	0.937	0.862	1.33	1.87
Selenium	0.236	0.263	0.185	0.157	0.246	0.314
Sodium	700	808	757	553	849	866
Strontium	0.285	0.434	0.484	0.207	0.359	0.448
Tellurium	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Thallium	0.00096	0.00096	0.00294	0.0016	0.00291	0.00046
Tin	0.04	0.029	0.023	0.022	0.05	0.033
Uranium	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Vanadium	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	8.95	11.4	9.51	6.04	9.8	13.5
Zirconium	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040

All concentrations are reported in mg/kg (wet weight), unless otherwise indicated.

5.2 Fish Survey

5.2.1 Introduction

Fish surveys have been performed previously in Cycles 1, 2 and 5 of the EEM. Of note, Cycle 1 involved both an angling survey and the deployment of minnow traps. Minnow traps were not deployed in subsequent cycles due to low overall success rate (only 3 of 24 traps deployed resulted in any captures) that precluded effectively quantifying any aspect of the fish population

In general, the angling surveys have been conducted during late summer low-flow period, and have demonstrated the presence of cutthroat trout both above and below the mine's discharge point. However, there has typically been a greater abundance of fish observed in the Reference Area largely driven by the presence of young of the year and juveniles, which reflects the presence of off-channel habitat and tributary streams that are suitable for rearing, refugia and spawning. Of note, YOY were observed downstream of the discharge during the Cycle 5 survey in close proximity to a naturally-formed side channel, further supporting the hypothesis that previous lack of observations of smaller fish downstream of the discharge has been a function of suitable habitat and not water quality. Of note, a dramatic decrease in the cutthroat trout population in Myra Creek occurred between Cycles 1 and 2, and was associated with a severe flood event in mid-November 2006, which essentially flushed most of the fish out of Myra Creek into Buttle Lake (Nautilus Environmental 2008); however, the numbers showed significant recovery by Cycle 5.

5.2.2 Methods

Adult fish were sampled upstream and downstream of the discharge point using angling techniques (i.e., dry fly). The fly was presented to specific locations, and any fish observed were recorded and the size noted. Presentations were performed in a sequential fashion to different locations to avoid double-counting fish. All fish caught were carefully weighed and measured prior to returning the fish to the stream. Weights were measured using a hanging scale to the nearest gram. Fish lengths were measured from the tip of the snout to the end of the caudal peduncle (to the nearest 0.5 mm) using a ruler. Condition factor was calculated using the same formula described for the *in situ* hatchbox study in Section 5.1.

During the survey, juvenile fish were also noted and recorded by year class (based on size) by carefully observing key habitat areas, including:

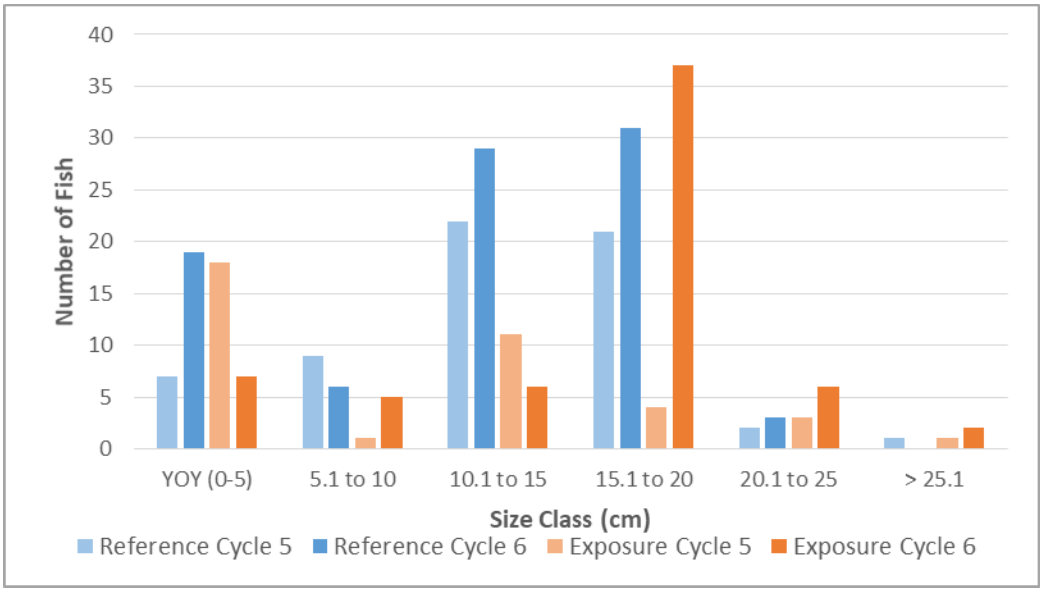
- Shallow margins of large pools;
- Waters adjacent to habitat features such as boulders, root wads and large woody debris;
- Off-channel pools and tributaries; and,
- Areas with slow moving water and overhanging vegetation.

The survey was conducted on August 29 and 30th, 2019 and involved two biologists from Nautilus Environmental (Dr. Howard Bailey and Connor Pettem). The survey was initiated just upstream of the engineered channel, near site S11-A at 11:00 AM on August 29th, and approximately 6 hours of fishing effort were spent covering approximately 1.5 km of the upstream Reference reach of the creek. Following completion of the Reference reach, approximately 6 hours of fishing effort were spent in the downstream Exposure reach, beginning around 10:00 AM the following day, August 30th, and extending from the downstream end of the engineered channel at the TP-4 station to the MC-M2 station located just upstream of lower Myra Falls (approximately 1.8 km).

5.2.3 Results and Discussion

Results obtained from the fish survey are shown in Figure 14, which compares size distributions and numbers of cutthroat trout between Cycle 5 and 6. In Cycle 5 a total of 100 cutthroat trout were observed or recorded during the angling survey, with 62 found in the Reference reach and 38 observed in the Exposure reach. In Cycle 6, 145 cutthroat trout were observed or recorded; of these, 85 were in the Reference reach and 60 were observed in the Exposure reach. Consistent with Cycle 5, YOY were again observed in the Exposure reach, in close proximity to the side-channel noted previously. From a historical perspective, in Cycle 1 (2005), a total of 182 cutthroat trout were caught or observed in the angling survey in the Reference reach, compared with 36 fish in the Exposure area. In Cycle 2 (2008), 28 cutthroat trout were observed in the Reference reach, and 9 were observed in the Exposure area. YOY were not observed in the Exposure reach in either of these cycles.

Figure 14. **Length distributions for fish observed during the 2019 Angling Fish Survey in the Reference and Exposure reaches of Myra Creek.**



Similar to past EEM Cycles, a greater number of fish were observed above the effluent discharge point in the Reference reaches of the creek compared to the downstream Exposure area. However, the proportion of fish observed in the Exposure reaches has steadily increased across Cycles. For example, 42% (60 of 145 total observations) of observed fish were present in the Exposure reaches of the creek in this Cycle compared to 17% (37 of 216 total observations) in Cycle 1, 24% (9 of 37 total observations) in Cycle 2, and 38% (38 of 100 total observations) in Cycle 5. Of additional note, is that comparison of overall numbers in Cycles 5 and 6 to Cycle 2 shows continued recovery of the population following the flood event in 2006.

Of the 145 fish observed during the angling survey, 71 fish were captured; 43 in the Reference reaches and 28 in the Exposure area. Measurements of lengths and weights for these fish are presented in Figure 15. Notably, fish in both reaches of the creek generally occupied a similar size range, with lengths ranging between 10 and 33 cm and weights between 12 and 132 g. However, there were over twice as many fish between 13 and 18 cm captured in the Reference area compared with the Exposure area, and fish in this size range tended to weigh more than their counterparts collected from the Exposure area. Figure 16 shows a scatterplot of lengths and weights of fish collected from the Reference and Exposure reaches of the creek in Cycles 2, 5 and 6. These data, representing a span of 12 years, suggest a similar distribution of metrics across cycles, implying an overall level of consistency between monitoring events. Raw data are presented in Appendix C.

Figure 15. Length and weight of fish captured during the 2019 angling fish survey in the Reference and Exposure reaches of Myra Creek.

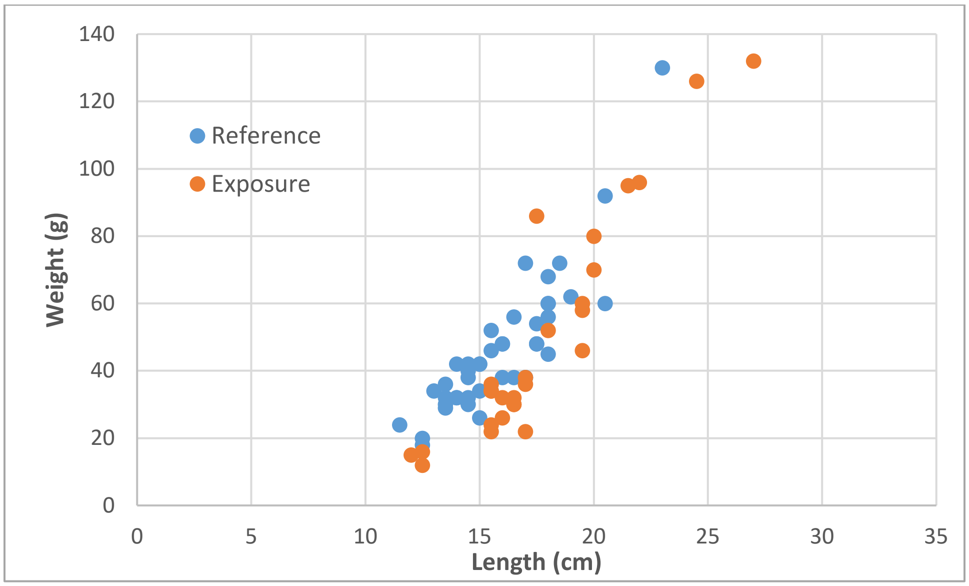
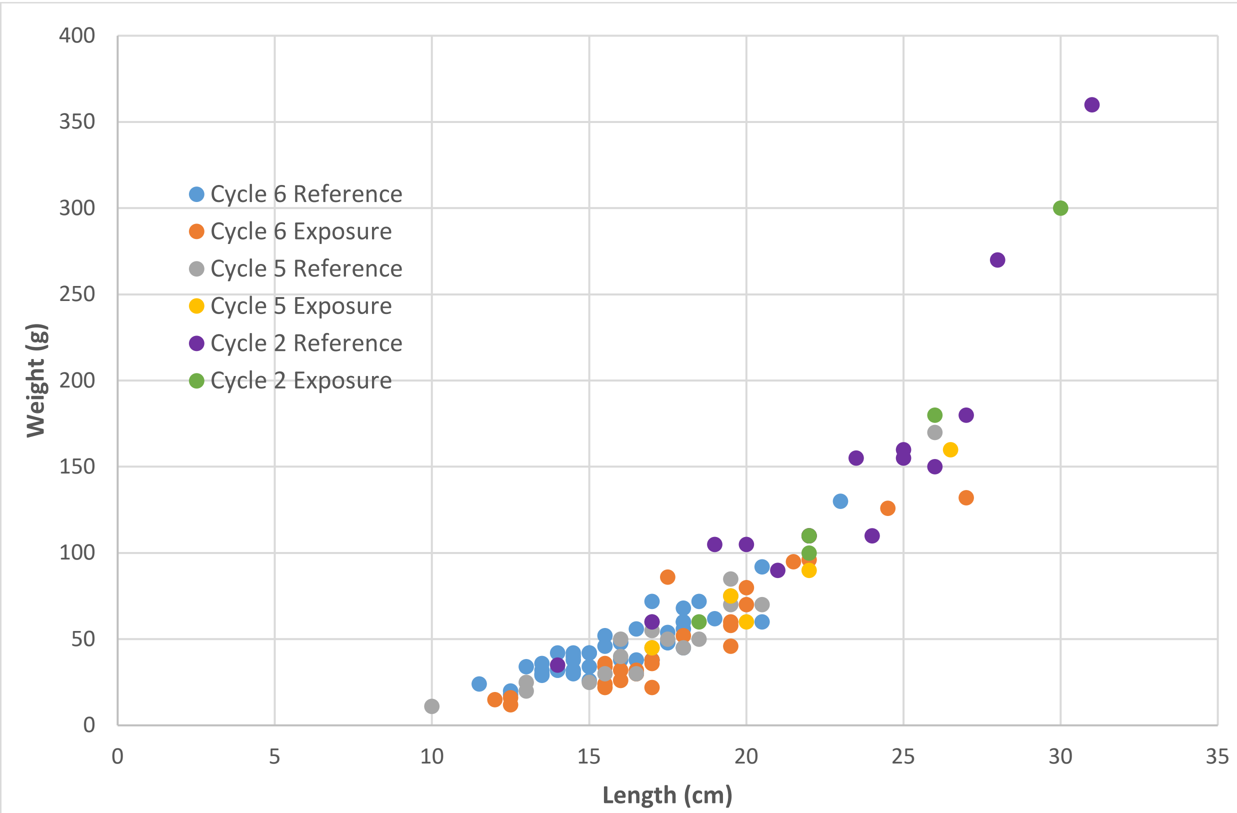


Figure 16. Comparison of length and weight measurements collected from fish captured during the Cycle 2, Cycle 5 and Cycle 6 angling surveys in the Reference and Exposure reaches of Myra Creek.



Growth metrics for Cycle 6 are summarized in Table 16. The average length of fish captured in the Reference reaches of Myra Creek was 15.2 cm compared to 17.4 cm in the Exposure reaches, and weight averaged 46 g/fish in the Reference area, compared to 50 g/fish in the Exposure area. The average CF in the Reference reaches of Myra Creek was 1.12, compared to 0.80 in the exposure reaches; of note, these values were significantly different ($p<0.05$). For comparison, in Cycle 5 the average CF in the Reference area was 0.96, compared to 0.90 in the Exposure area, suggesting an increase in CF in the Reference area, and a decrease in CF in the Exposure area across cycles (Figure 17).

Table 16. Growth metrics for fish during Cycle 6 angling survey

	Reference Reach	Exposure Reach
Length (cm)	15.2 ± 2.4	17.4 ± 3.5*
Weight (g)	46.1 ± 20.1	50.0 ± 32.9
Condition Factor	1.1 ± 0.23	0.81 ± 0.20*

* represents statistically significant from Reference reach ($p < 0.05$).

Given the presence of a statistically significant difference in CF between fish sampled upstream and downstream of the discharge, the implication is that this observation may be a result of exposure to the effluent. Conversely, the absence of differences in CF in the *in situ* exposures conducted at fixed sites upstream and downstream of the discharge argues against that connection. Consequently, a more detailed evaluation of the fish survey data from Cycles 5 and 6 was conducted in an effort to tease apart some of the contributing variables. These data are summarized in Table 17. Of interest, the average CF in the exposure reach for different size classes tended to be lower in Cycle 6 than observed in Cycle 5, but not significantly so. Of perhaps greater interest was the CF for the 10.1 – 15 cm size class from the Reference area in Cycle 6, which averaged more than 20% higher than other size classes in the Reference area, and was also similarly greater than any of the relevant size classes from the Reference area in Cycle 5. Comparison of these data suggests that the elevated CF in the Reference area in Cycle 6 was an unusual case. In addition, the sample size available for comparisons was approximately 3-fold greater in Cycle 6 compared with Cycle 5, which increased the ability to attach statistical significance to relatively small differences between means.

Another point of interest is the pattern of condition factors observed downstream of the discharge. Of note, half of the fish weighed and measured in the Exposure area were collected in the vicinity of TP-4, which is closest to the discharge point. Assuming the effluent was responsible for the observed difference in CF between the Reference and Exposure areas, one would expect the CF to be lowest in closest proximity to the discharge point. However, this was not the case, as the CF of these fish was 0.9 ± 0.2, while the fish collected further downstream exhibited an average CF of 0.7 ± 0.1. While these observations do not rule out the possible contribution of the effluent to differences in CF between reaches in Cycle 6, they help provide context for additional data evaluation in Cycle 7.

Figure 17. A boxplot comparing fish condition factor from cutthroat trout captured during Cycle 5 and Cycle 6 angling fish surveys in the Reference and Exposure reaches of Myra Creek.

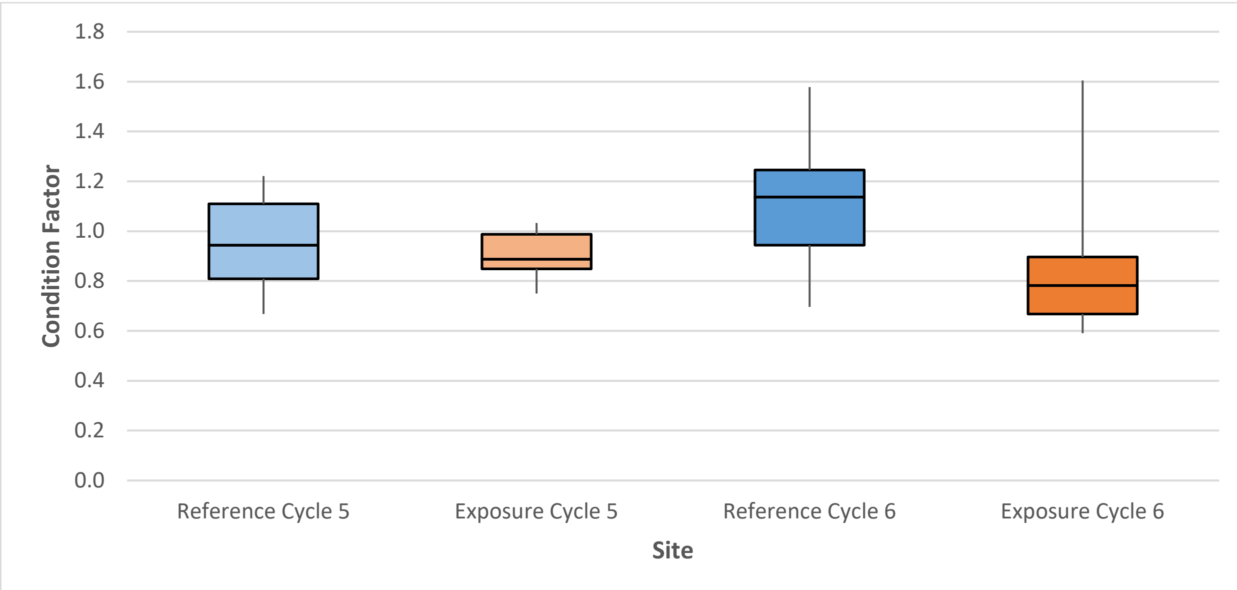


Table 17. Condition factor based on size classes between Cycles 5 and 6.

Length (cm)	Cycle 5				Cycle 6			
	Reference	n	Exposure	n	Reference	n	Exposure	n
YOY (0-5)	N/A	0	N/A	0	N/A	0	N/A	0
5.1 to 10	1.1 ± 0.0	1	N/A	0	N/A	0	N/A	0
10.1 to 15	0.9 ± 0.2	3	0.9 ± 0.1	3	1.2 ± 0.2	20	0.8 ± 0.1	3
15.1 to 20	1.0 ± 0.2	13	0.9 ± 0.1	2	1.0 ± 0.2	20	0.8 ± 0.2	20
20.1 to 25	0.9 ± 0.1	2	0.9 ± 0.0	1	0.9 ± 0.2	3	0.8 ± 0.1	4
> 25.1	N/A	0	N/A	0	N/A	0	0.7 ± 0.0	1

6.0 EFFLUENT CHARACTERIZATION: ANALYSIS OF ANALYTICAL CHEMISTRY DATA

6.1 Introduction

As mentioned in Section 2.2, the mine collects and treats wastewater from a number of surface and underground sources. All water is directed to the head of the primary treatment pond (i.e., the Superpond), where lime is added to precipitate metal hydroxides. The Superpond discharges into the Myra Polishing Pond system to settle out any remaining suspended particles, and the treated water is then discharged into Myra Creek. This discharge, called "11A-Runoff", is monitored under the MDMER, which includes measurements of toxicity (see section 8.0), as well as water chemistry, through daily, weekly, monthly and quarterly sampling. MFO also measures surface water chemistry at various locations in Myra Creek throughout the year in order to understand conditions both upstream and downstream of the operation.

At the point of discharge of the 11-A Runoff, Myra Creek is fast flowing and turbulent, and mixing occurs rapidly within 300 to 400 m downstream of the outfall. Based on annual monthly averages, mean daily discharge was approximately 32,460 m^3/day for the period 2015 - 2018 (C. Schweitzer, NMF, *pers. comm*., Sept 2018) and mixing occurs within 300 to 400 m downstream of the outfall. Downstream of the outfall, inputs to Myra Creek are limited.

Webster Creek is a small tributary that enters Myra Creek 50 m downstream of the effluent discharge. Webster Creek's flows are seasonally variable, and are estimated to be less than the discharge. The Lynx Diversion diverts clean surface water (i.e., stormwater and snowmelt) around the old decommissioned tailings disposal facility (TDF); the diversion enters Myra Creek downstream of the engineered channel in proximity to the MC-TP4 sampling location, and flows are estimated to be approximately equal to the effluent during run-off conditions.

The most recent update on analytical chemistry of MFO's effluent quality as part of the EEM biological monitoring studies was in the Cycle 5 report. This study investigated concentrations of the various parameters and compared them to applicable CCME water quality guidelines (WQGs). Parameters measured in samples collected from the 11-A Run-off location were compared to discharge limits detailed in MFO's discharge permit CWL 061484.

The present study reviewed MFO's effluent and water quality data collected between January 1, 2019 and December 31, 2019 to aid in interpretation of results collected during the field program.

Particular focus was given to concentrations of aluminum, cadmium, copper and zinc due to observed exceedances of BC water quality guidelines noted in previous studies.

6.2 Methods

As part of MFOs environmental monitoring requirements, mine staff collect daily, weekly, monthly and quarterly grab samples to measure a variety of analytical parameters in surface waters. Weekly samples were collected from the 11-A Run-off effluent (i.e., treated effluent) and monthly from the MC-TP4 and MC-M2 locations.

Sampling included measurements of total and dissolved aluminum, cadmium, calcium, copper, iron, lead, manganese, phosphorus and zinc. Additional measurements included total suspended solids (TSS), sulphate, water hardness, alkalinity and temperature. These same parameters were measured quarterly at the upstream MC-M1 location. All parameters were measured by CARO Analytical (Richmond, BC).

The current study evaluated concentrations of the various parameters and compared them to applicable CCME water quality guidelines (WQGs). Parameters measured in samples collected from the 11-A Run-off location were also compared to discharge limits detailed in MFO's discharge permit CWL 061484. Exceedances of either effluent limits or WQGs were flagged for additional evaluation of their potential to elicit adverse effects on biota during the 2019 field season.

6.3 Results and Discussion

Concentrations of selected paramenters measured in weekly grab samples collected from the 11-A Run-off location are shown in Table 18 and tabulated in Appendix D. Total copper was below the permit discharge limit of 0.6 mg/L copper in all 49 samples collected between January 1 and December 31, 2019, averaging 0.02 mg/L and a maximum of 0.21 mg/L. Total cadmium concentrations averaged 0.63 µg/L and a maximum of 5.9 µg/L, below permit discharge limits of 50 µg/L in all 49 samples. Maximum and average total weekly lead concentrations measured in the 11-A run-off discharge were 0.085 and 0.004 mg/L, respectively (n = 49). Both of these values fell below the total lead discharge limit of 0.20 mg/L. Finally, total zinc concentrations averaged 0.18 mg/L and reached a maximum of 1.6 mg/L, exceeding the discharge limit of 1 mg/L on only one occasion (December 18, 2019). Of potential interest, the weekly distribution of total zinc and copper concentrations are shown Figure 18, and generally demonstrate effective control of metals concentrations in the effluent.

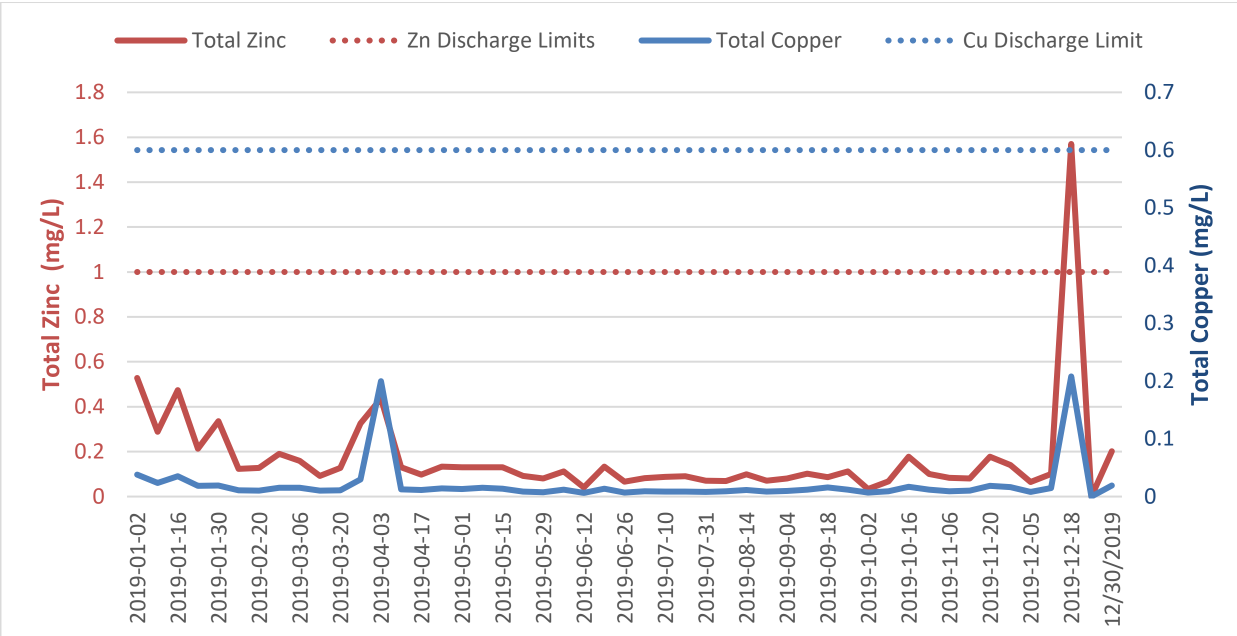
In terms of dissolved concentrations of metals in the effluent, weekly dissolved copper concentrations collected from the 11-A run-off discharge were all below the 0.2 mg/L discharge limit, as the maximum concentration was 0.017 mg/L, over the 49 sampling events. Similarly, concentrations of dissolved zinc were all less than the discharge limit of 0.5 mg/L, reaching a maximum value of 0.12 mg/L (Table 18). Of note, concentrations of dissolved copper, cadmium and zinc were substantially less than their respective total concentrations (Table 18), which is important given that the dissolved form is generally considered to represent the bioavailable fraction.

Table 18. 2019 weekly (January through December) water quality parameter measurements for the 11-A effluent relative to the mine's discharge limits

	Effluent (mg/L)					
Parameters	**Average**	**Standard deviation**	**Maximum**	**Minimum**	**95th percentile**	**Discharge limit**
pH (pH unit)	7.8	0.44	8.8	6.6	8.6	11.0
Total aluminum	0.31	0.24	1.7	0.11	0.75	n/a
Dissolved aluminum	0.22	0.13	0.72	0.02	0.57	n/a
Total cadmium (µg/L)	0.63	0.89	5.9	0.14	2.2	50
Dissolved cadmium (µg/L)	0.13	0.14	0.64	0.01	0.55	n/a
Total calcium	94.3	17.7	136	66.4	133	n/a
Total copper	0.022	0.039	0.21	0.006	0.13	0.6
Dissolved copper	0.0021	0.0024	0.017	0.0006	0.0047	0.2
Total iron	0.14	0.44	3.1	0.016	0.27	n/a
Total lead	0.0044	0.012	0.085	0.0005	0.0092	0.2
Total manganese	0.049	0.038	0.22	0.014	0.15	n/a
Total zinc	0.18	0.23	**1.6**	0.034	0.50	1.0
Dissolved zinc	0.020	0.020	0.12	0.002	0.062	0.5
TSS	5.9	7.5	**54**	2.0	10	25.0
Total phosphorus	0.029	0.020	0.050	0.010	0.050	n/a
Hardness	248	44.1	347	163	334	n/a
Total alkalinity	25	13	103	1.0	42	n/a

SD = standard deviation; all concentrations are reported in mg/L, unless otherwise indicated; Bolded values represent an exceedance of discharge limits. Samples taken weekly for a total of 49 measurements.

Figure 18. **Results of weekly water chemistry measurements from grab samples collected from the 11-A Run-off effluent relative to zinc and copper limits in MFOs discharge permit.**



Averages of MFO's monthly water quality monitoring data for Myra Creek stations are compared to applicable CCME WQGs in Table 19. Notably, no exceedances of CCME water quality guidelines were observed for total cadmium, copper and zinc at MC-M1 located upstream of the discharge. Conversely, exceedances of CCME water quality guidelines for total cadmium, copper and zinc occurred at both sampling locations located downstream of MFOs effluent discharge (i.e., MC-TP4 and MC-M2) (Table 19). In addition, exceedances in dissolved concentrations relative to their respective total WQGs were also observed for all three metals at both downstream sites, with the exception of copper where the average dissolved concentration only exceeded the total guideline at TP-4. Of note, exceedances of WQGs by the average dissolved fractions tended to be relatively small, particularly for copper and cadmium which were within two-fold of their respective guidelines. Conversely, average concentrations of dissolved zinc were approximately 5-fold higher than the long-term guideline.

Table 19. 2019 monthly (January through December) water quality parameter measurements at locations within Myra Creek relative to applicable CCME water quality guidelines

	Stations			CCME
	Upstream	Downstream		
Parameters	MC-M1*	TP-4	MC-M2	WQG
pH (pH unit)	6.6 ± 0.7	7.2 ± 0.1	7.2 ± 0.1	>6.5 and <9
Total aluminum	0.04 ± 0.009	0.07 ± 0.02	0.06 ± 0.02	0.1
Dissolved aluminum	0.036 ± 0.02	0.048 ± 0.02	0.043 ± 0.02	--
Total cadmium (µg/L)	<0.010	**0.14 ± 0.12**	**0.12 ± 0.10**	0.09
Dissolved cadmium (µg/L)	<0.010	**0.11 ± 0.095**	**0.11 ± 0.096**	--
Total calcium	4.0 ± 1.8	19 ± 8.4	17 ± 6.5	--
Total copper	<0.0004	**0.004 ± 0.004**	**0.004 ± 0.003**	0.002
Dissolved copper	<0.0004	**0.003 ± 0.002**	0.002 ± 0.002	--
Total iron	0.014 ± 0.006	0.020 ± 0.012	0.014 ± 0.005	0.3
Total lead	0.0003 ± 0.0002	0.0005 ± 0.0005	0.0005 ± 0.0003	0.001
Total manganese	0.001 ± 0.002	0.008 ± 0.003	0.006 ± 0.003	--
Total zinc	<0.0040	**0.046 ± 0.034**	**0.044 ± 0.031**	0.007
Dissolved zinc	<0.0040	**0.035 ± 0.028**	**0.036 ± 0.027**	--
Total phosphorus	<0.050	0.039 ± 0.019	0.043 ± 0.016	--
Dissolved phosphorus	<0.050	0.039 ± 0.019	0.043 ± 0.016	--
Hardness	9.9 ± 4.1	49 ± 22	44 ± 17	--
Ammonia (as N)	0.03 ± 0.008	n/a	0.08 ± 0.05	--
Nitrate (as N)	0.02 ± 0.009	n/a	0.12 ± 0.12	13.0
Nitrite (as N)	0.009 ± 0.003	n/a	0.01 ± 0.002	0.2
Total alkalinity	8.83 ± 4.5	14.6 ± 4.0	15.4 ± 4.3	--

SD = standard deviation; all concentrations are reported in mg/L, unless otherwise indicated; Bolded values represent an exceedance of CCME WQGs; *MC-M1 averages based on a sample size of 6.

7.0 EFFLUENT CHARACTERIZATION: ANALYSIS OF TOXICITY TEST RESULTS

7.1 Introduction

MFO has been required to perform acute toxicity testing on its effluent on a quarterly basis, which involves 96-h rainbow trout fry and 48-h water flea (*Daphnia magna*) survival tests. However, beginning in 2019, the frequency of acute toxicity testing was increased to a monthly basis. In addition, MFO is required to perform sublethal toxicity tests on its effluent on an annual basis using a freshwater fish, invertebrate, plant and algal species. This testing program includes a 7-d rainbow trout (*Oncorhynchus mykiss*) embryo viability test, a 7-d water flea (*Ceriodaphnia dubia*) survival and reproduction test, a 7-d duckweed (*Lemna minor*) growth inhibition test, and a 72-h green alga (*Pseudokirchneriella subcapitata*) growth inhibition test.

Cycle 5 provided the last update on the historical acute toxicity testing program, which summarized a total of thirty-one acute rainbow trout survival tests and thirty-one 48-h *D. magna* survival tests conducted between 2011 and 2017. Results of these toxicity tests produced LC50 values >100% effluent in all cases but three, wherein LC50 values of 100%, 74.3% and 70.7% effluent were determined for the 48-h *D. magna* tests performed in August 2013, August 2017 and December 2017.

Cycle 5 also provided an update on MFO's sublethal toxicity testing, and included a summary of all sub-lethal toxicity tests completed through 2017. These results suggested that the most sensitive species has been *C. dubia*, with an average IC25 for reproduction of 40% effluent. The next most sensitive species was duckweed, with an average IC25 for frond growth of 53% effluent. The remaining species were relatively insensitive to the effluent, with average IC25s for *R. subcapitata* growth and rainbow trout embryo viability of 89% and 100% effluent, respectively.

The following sections provide details on acute and sublethal toxicity test results that have been completed since Cycle 5 of the EEM program, and also evaluates the findings in the context of effluent characterization results from previous Cycles of MFO's EEM program.

7.2 Methods

For each sampling event, a grab sample of the 11A-Runoff effluent was collected by mine staff and shipped to the Nautilus Environmental toxicity testing laboratory in Burnaby, BC. The following acute survival tests were performed quarterly through 2018, and monthly from 2019 onwards:

- Fish – 96-h rainbow trout (*Oncorhynchus mykiss*) fry survival test (Environment Canada 2000, EPS 1/RM/13, with 2007 & 2016 amendments);
- Invertebrate – 48-h water flea (*Daphnia magna*) survival test (Environment Canada 2000; EPS 1/RM/14, with 2016 amendments).

Additionally, the following sublethal tests were performed annually on MFOs effluent:

- Fish – 7-d rainbow trout (*Oncorhynchus mykiss*) embryo viability (Environment Canada 1998; EPS 1/RM/28; Canaria et al. 1999);

- Invertebrate – 7-d water flea (*Ceriodaphnia dubia*) survival and growth (Environment Canada 2007a, EPS 1/RM/21);
- Plant – 7-d duckweed (*Lemna minor*) growth represented by frond length and dry weight (Environment Canada 2007b, EPS 1/RM/37); and,
- Algae – 72-h green alga (*Raphidocelis* subcapitata [formerly known as *Pseudokirchneriella subcapitata*; *Selenastrum capricornutum*]) growth (Environment Canada 2007c, EPS 1/RM/25).

For all tests, organisms were exposed to a series of effluent concentrations that were produced through dilution of the 100% full strength sample using clean laboratory water. To ensure data quality, all tests included a control group and reference toxicant testing. The control group represents a treatment exposed to unaltered laboratory water. A reference toxicant test is an exposure that involves organisms being tested in a spiked sample, with organism response being compared to historical sensitivity of that species at the toxicology laboratory. Test methodologies were consistent with guidance provided in their respective Environment Canada protocols. For EEM programs, the key endpoints of interest include survival based on the LC50 value (i.e., the concentration required to produce a 50% effect on survival) for both acute and sublethal tests, and IC25 and EC25 values (i.e., the inhibitory or effect concentration required to elicit a 25% effect) associated with sublethal endpoints.

7.3 Results and Discussion

7.3.1 Acute Toxicity Tests

MFO has been required to conduct acute toxicity testing on their effluent using *Daphnia magna* and rainbow trout on a quarterly basis, increasing to monthly in 2019. Since Cycle 5 of the EEM program, MFO has conducted twenty 96-h rainbow trout survival tests and twenty 48-h *D. magna* survival tests between 2018 and the first quarter of 2020.

With only one exception, these toxicity tests resulted in LC50 values of >100% effluent; notably, the 48-h *D. magna* test performed in September 2019 resulted in a LC50 value of 70.7% effluent. These results indicate that MFO's effluent has generally not exhibited acute toxicity even at full strength during testing conducted over the past three years. These data further suggest that the mine's effluent quality has continued to improve over the years, as acute toxicity to *D. magna* was observed on eighteen occasions between 2004 and 2006, on six occasions between 2007 and 2011, on four occasions between 2012 and 2017, and on one occasion between 2018 and today.

Toxicity to rainbow trout on the other hand has never been a major issue, with only one toxic sample identified in over 14 years of monitoring.

7.3.2 Sub-lethal Toxicity Tests

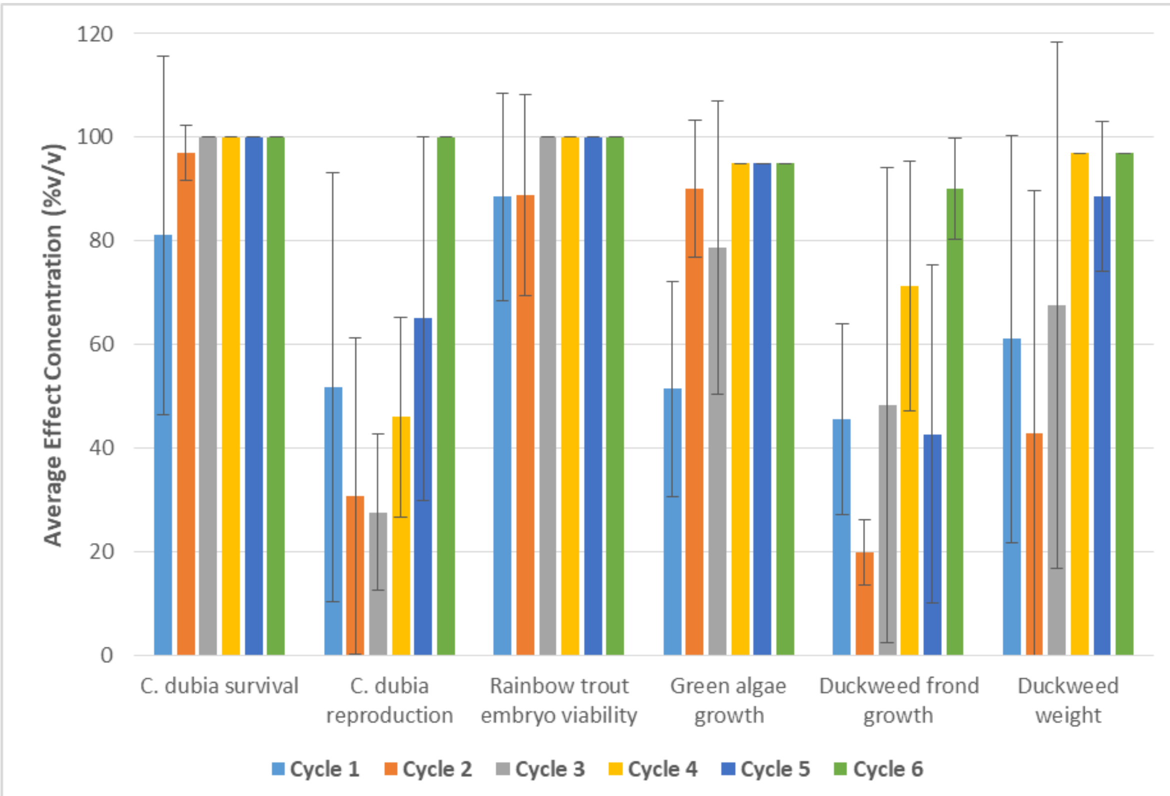
Between 2018 and 2020, sub-lethal toxicity testing has been conducted annually for a total of 3 events, and the results, along with those since 2003 (i.e., Cycle 1) are presented in Table 20. Figure 19 compares the mean responses for each endpoint between each cycle. The results for Cycle 6 generally represent a continued improvement across previous cycles. Of note, between the four testing protocols there are a total of six endpoints, making a grand total of 18 test endpoints over the three testing events. Of these 18, only one IC25 was less than a nominal full-strength effluent. As shown in Table 20 and Figure 19, the frequency and magnitude of adverse effects has diminished across monitoring cycles.

Table 20. Summary of endpoints (LC50s and IC25s) from sublethal toxicity tests conducted during Cycles 1 through 6.

		LC50 and IC25 values (% effluent)					
		Ceriodaphnia dubia		Rainbow trout embryo	*Raphidocelis subcapitata*	*Lemna minor*	
Cycle Number	**Test Date**	**Survival**	**Reproduction**	**Viability**	**Growth**	**Frond growth**	**Weight**
Cycle 1	May 2003	72	26	51	64	35	>97
	Oct. 2003	>100	57	>100	80	63.4	>97
	May 2004	>100	26	>100	33	39	25
	Nov. 2004	14.4	1.5	80	65	73.6	>97
	Apr. 2005	>100	>100	>100	36.1	33.5	23.4
	Nov. 2005	>100	>100	>100	30.8	28.6	27.1
Cycle 2	May 2006	91	65	>100	75.2	13.5	17
	May/Jun. 2007	>100	<6.25	66.5	>100	26	15
	May 2008	>100	21	>100	>95	20	>97
Cycle 3	May 2009	>100	14	>100	46	6	>97
	May 2010	>100	44	>100	>95	>97	9
	Nov. 2011	>100	25	>100	>95	42	>97
Cycle 4	May 2012	>100	60	>100	>95	>97	>97
	May 2013	>100	24	>100	>95	49	>97
	May 2014	>100	54	>100	>95	68	>97
Cycle 5	Apr. 2015	>100	30	>100	>95	5	>97
	Jun. 2016	>100	65	>100	>95	62	>97
	Jun. 2017	>100	>100	>100	>95	61	72
Cycle 6	Apr. 2018	>100	>100	>100	>95	>97	>97
	May 2019	>100	>100	>100	>95	83.2	>97

All values are listed as % volume/volume effluent; SD = standard deviation; Average and SD calculations were performed by assigning >values as the highest concentration tested (i.e., >100% = 100%, >97% = 97%, etc.).

Figure 19. A comparison of mean endpoints collected from sub-lethal toxicity tests on MFO's effluent during Cycles 1 through 6.



8.0 EFFLUENT MIXING DATA

The MDMER requires an estimate of the effluent concentration in the Exposure area at l00 m and 250 m downstream from the discharge point (Schedule 5, s. 13 (2)(a)). Of note, both of these distances fall within the engineered channel which has never been a primary focus of the monitoring program due to obvious difference in habitat relative to other sections of Myra Creek. As a general characterization of effluent mixing, conductivity measurements were taken at mid-depth across the engineered channel at the discharge point (0 m), and 100 m and 250 m downstream, as well as at TP4 and MC-M2. Three measurements were taken across Myra Creek at each sampling distance (i.e., near-side (closest to the discharge pipe), middle, and far side) to characterize not only dilution, but also plume dispersion. The sampling was conducted on August

29th, 2019. Visually, the creek flow was very low, but could not be quantified because the flow gauge was not operating. However, the conductivity measurements provide a relative estimate of flow based on dilution. Of note, the effluent flow for the day was roughly 34,624 m^3/day (C. Schweitzer, NMF, *pers. comm*., May 2020), similar to their mean daily discharge of approximately 32,460 m^3/day.

Conductivity measurements at different distances downstream of the discharge are summarized in Table 21. Conductivity was measured at 573 µS/cm at the point of discharge, with values of approximately 30 µS/cm mid-stream and far bank. By 100 m downstream, the plume was still well delineated and extended to mid-stream with relatively little mixing (i.e., < 25% dilution). By 250 m, the plume was largely dispersed, but lateral variation was still apparent, with conductivity measurements suggesting a range of 30 to 50% dilution across the creek. Conductivity measurements observed at TP4, approximately 1 km downstream of the discharge, were nearly uniform, suggesting well-mixed conditions at approximately 44% effluent. Interestingly, conductivities decreased by an additional 10% by MC-M2, possibly suggesting additional inputs of less mineralized water between the two sampling points (e.g., inputs from the Clean water diversion ditch, localized sources of run-off or surfacing hyporheic flows).

Table 21. Conductivity measurements in Myra Creek at different locations downstream of the effluent discharge (August 29, 2019)

Conductivity (µS/cm)	Stations				
	0 m	**100 m**	**250 m**	**TP-4**	**MC-M2**
Near-side	573	531	317	267	238
Middle	33	449	243	268	239
Far-side	31	57	202	264	237

In addition to the conductivity measurements, grab samples were collected at different distances downstream of the discharge (near side only) and submitted to ALS Environmental (Burnaby, BC) for analysis of a range of inorganic analytes, including dissolved metals and Total Kjeldahl Nitrogen (TKN). Selected parameters of interest are summarized in Table 22 to further demonstrate the dilution effect of the creek downstream of the discharge. Of interest, most of these parameters have been identified in previous cycles as being contaminants of potential concern. It is interesting to note that sulfate, aluminum and TKN exhibited the expected downward trend in concentrations with increasing distance from the discharge point, exhibiting an approximately 50% dilution 250 m downstream of the discharge and a 3 to 4-fold decrease in concentration at MC-M2. Conversely, concentrations of dissolved cadmium and copper remained relatively unchanged between the discharge point and MC-M2, whereas dissolved zinc concentrations appeared to increase downstream of the discharge (Table 22). Without more detailed sampling, it is not possible to resolve the differences in spatial concentration trends, but the presence of additional inputs in this reach cannot be ruled out.

Regardless of the differences in parameter concentration trends, parameters that exhibited monotonic decreases in concentrations with increasing distance from the discharge only achieved maximum 2 to 4-fold decreases in concentration, which are substantially less than dilution predictions based on historical measurements of creek and effluent flows. The current data, collected during summer low flow period, may be related to relatively recent changes in climate conditions, resulting in earlier loss of the snow pack at higher elevations and a commensurate decrease in late-summer base flows, ultimately reducing creek flows available to dilute the effluent.

Table 22. Comparison of dissolved concentrations of selected analytes at different distances downstream of the discharge point (August 29, 2019)

	Sampling Stations				
Parameter	**0 m**	**100 m**	**250 m**	**TP-4**	**MC-M2**
Sulfate	246	225	124	100	85
TKN	0.8	0.7	0.4	0.3	0.2
Aluminum	0.31	0.29	0.16	0.09	0.07
Cadmium (µg/L)	0.14	0.15	0.15	0.16	0.15
Copper	0.003	0.003	0.002	0.002	0.002
Zinc	0.029	0.032	0.043	0.048	0.046

All parameters are reported in mg/L, unless otherwise indicated.

9.0 GENERAL CONCLUSIONS AND DISCUSSION

Benthic Invertebrates

The results of the benthic invertebrate community study generally showed differences in community composition between the upstream Reference reach and the Exposure area located downstream of the discharge. However, comparison of diagnostic metrics related to pollution-sensitive taxa did not show upstream/downstream response patterns that would be suggestive of related adverse effects, particularly those associated with elevated metals concentrations, a conclusion supported by lack of correlations between benthic community response metrics and concentrations of sediment metals. Collectively, the analysis suggested that differences in habitat variables (e.g., substrate size) are likely the primary drivers of the variations in community structure upstream and downstream of the discharge. Notably, all of the Exposure stations exhibited benthic invertebrate communities that fell within the range of "similar to" or "mildly divergent" from the appropriate reference condition established by CABIN for the Fraser River – Georgia Basin Model – 2005, suggesting overall concordance with regional metrics.

Fish Health

The *in situ* hatchbox study demonstrated no significant differences in hatching success, post-hatch survival, normal development or condition factor between the Exposure reach and the upstream Reference area. Notably, a significant increase in length and weight was observed at all three downstream sites compared to the upstream Reference area. These latter observations were most likely related to higher stream temperatures associated with the engineered channel and downstream reaches, resulting in more rapid growth. Overall, this comparison suggests that MFO's effluent is not eliciting adverse effects on early life-stage development of trout in lower Myra Creek.

Cutthroat trout abundance observed during the fish survey was higher above MFO's effluent discharge (observations = 85), compared to the Exposure reach located downstream of the discharge (observations = 60). However, as has been noted in previous EEM cycles, this is most likely a function of habitat differences between the two reaches; specifically, the preponderance of overwintering, spawning and rearing habitat is primarily located upstream of the discharge point in the middle and upper portions of the Reference reach. Consequently, the difference in abundance estimates is largely driven by larger numbers of YOY and juvenile fish present in the upstream reaches. However, as observed in Cycle 5, YOY fish were again found in the Exposure reach, in conjunction with the new side channel.

The survey also found significant differences between Reference and Exposure reaches with respect to lengths and condition factor of captured fish. The significant difference in average length was due to higher abundance of smaller juvenile fish in the upstream Reference area, which skewed the length distribution towards smaller fish compared with the Exposure area. The difference in condition factors between Reference and Exposure areas tended to be largely driven by juvenile size classes and specifically by an atypically high average value for juvenile fish in the Reference area (i.e., >30% higher than observed for the same size class in Cycle 5). While we don't have an explanation for the elevated condition factor observed in juvenile fish from the Reference area during this particular survey, there is no data to suggest that the effluent discharge was responsible for lower CFs in the Exposure area; specifically, there was a gradient in CFs downstream of the discharge, with the *highest* values associated with the closest sampling point to the outfall. In addition, differences in condition factor were not observed in the *in situ* study conducted at fixed exposure sites in the Reference and Downstream reaches.

Effluent and Water Chemistry

Virtually no exceedances in total concentrations of metals of interest (copper, cadmium and zinc) were observed relative to permitted effluent levels. In addition, dissolved concentrations were all below their respective permit limits. Average concentrations of dissolved metals at downstream receiving water sites (i.e., TP-4 and MC-M2) were generally within two fold of their respective CCME WQGs, with the exception of zinc which averaged approximately 5-fold higher.

Toxicity Testing

Monitoring of acute toxicity to rainbow trout and *Daphnia magna* in MFO's effluent showed that the effluent has been largely non-toxic during quarterly and monthly tests conducted over the past three years, with only one sample exhibiting toxicity to *D. magna*. Similarly, annual sub-lethal toxicity tests conducted on MFO's effluent since 2017 have generally not exhibited toxicity, except for one of the endpoints for the duckweed test that exhibited a small level of effect during one of the testing events. Overall, the toxicity data continue to suggest improved effluent quality across multiple cycles of the EEM program.

Effluent Dilution

Given that the effluent has typically averaged less than 12% of the flows in Myra Creek downstream of the discharge, an evaluation of effect levels from the toxicity tests suggests that MFO's effluent has generally not been a major concern from an acute or sub-lethal perspective, which is generally consistent with the lack of adverse biological effects observed at Myra Creek sampling locations across multiple EEM cycles. However, data from the recent effluent dilution study conducted during the summer low-flow period suggests that the potential for dilution under these conditions may be appreciably less than historically observed, perhaps as low as two- to four-fold, and should continue to be evaluated in future monitoring cycles. Nonetheless, effects thresholds from acute and sublethal toxicity tests conducted during this cycle suggest that the effluent should not be associated with toxicity even at these reduced dilution levels.

With respect to effluent dilution, it is notable that concentrations of some parameters of interest, particularly dissolved metals of potential concern, did not follow expected patterns of reduced concentrations upon entering Myra Creek. For example, dissolved copper and zinc concentrations averaged approximately 0.002 and 0.020 mg/L, respectively, in the effluent (Table 18), and approximately 0.003 and 0.035 mg/L downstream at TP-4/MC-M2 (Table 19)), essentially showing no evidence of dilution and even possibly suggesting an increase in concentrations. Given these observations, it would be not be unreasonable to consider the potential for additional inputs of elevated metals concentrations entering the creek in the reach associated with the engineered channel. Conversely, a potentially interesting and easily testable alternative hypothesis follows from the observation that total metals concentrations in the effluent are approximately 10-fold higher than the dissolved fraction, leading to the possibility that receiving environment conditions of lower pH and mineralization would favor dissolution of at least some portion of the fine metal-bearing particulates entering the creek, and thereby offset the presumed effect of dilution on the dissolved fraction. This alternative could be worth investigating since it may have a significant bearing on understanding the dynamics of metals concentrations in Myra Creek and associated implications for management. Briefly, such an investigation might initially involve measuring total and dissolved fractions across a range of dilutions of the effluent at different time periods following mixing and evaluating the results in the context of data available from the field.

10.0 IMPLICATIONS FOR CYCLE 7

A study design for the seventh Cycle of MFO's EEM program will be required to be submitted to Environment Canada by December, 2021, in anticipation of conducting the EEM field program in 2022. Since data from the present study generally demonstrated that there were no measureable effects to biota within Myra Creek that could be directly attributed to MFO's effluent, the Cycle 7 EEM program should be designed similarly to the present study to ensure consistency and continuity between programs. That being said, the difference in CF values between the Reference and Exposure reaches of the creek was greater than the MDMER critical effect size (CES) of ±10%

of the reference mean, suggesting further investigations in future studies may be warranted. Based on the revised Metal and Diamond Mining Effluent Regulations (SOR/2018-99), if the cause of any effect on the fish population is not known, an investigation of cause will be included in future examinations if "the results of the previous **two** biological monitoring studies indicate a similar type of effect, **and** for an effect indicator with an assigned critical effect size, the absolute value of the magnitude of the effect is equal to or greater than the absolute value of its critical effect size in either of those studies." In this case, while the difference is greater than the absolute value of its CES, similar effects have not been observed in previous Cycles so a subsequent investigation of cause is not required in the next monitoring cycle. Regardless, observations of condition factor associated with fish downstream of the discharge will receive additional scrutiny with respect to presence and relationships with possible causal factors.

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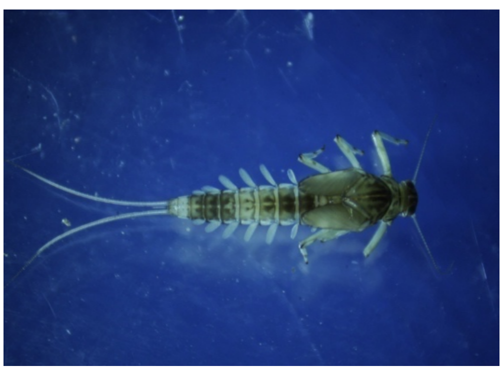
APPENDIX A – Benthic Invertebrate report by Sartori Environmental Services

Myra Falls Environmental Effect Monitoring - Cycle 6 (2019)

Benthic Invertebrate Community Structure Assessment Using the CABIN Protocol



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Authentication & Acknowledgement

This report has been reviewed and authenticated by Mr. J. Alex Sartori, R.P.Bio. of Sartori Environmental Inc., with significant authoring by Mr. Thibault Doix.

SARTORI ENVIRONMENTAL INC.

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1 Introduction

The Canadian Federal Metal Mining Effluent Regulation (MMER) require that metal mines monitor the quality and potential effects of their effluents on the natural environment (Government of Canada, 2002). Environmental Effect Monitoring studies (EEM) are designed to identify whether effluents from the mining operation have an impact on local benthic invertebrate communities and fish populations.

Myra Falls Operation (MFO) is a zinc-copper-gold-silver mine located within the Strathcona-Westmin Provincial Park on Vancouver Island, BC (Nautilus Environmental, 2015). Effluent from Nyrstar's Myra Falls Operations is discharged into Myra Creek, a 13-km second-order stream with a watershed of approximately 72 square kilometers, which discharges into Buttle Lake. Nyrstar Myra Falls regularly conducts EEM studies under the MMER to identify whether site operations are having an adverse impact on the receiving environment. These studies are typically repeated over 3-year cycles to monitor the presence and extent of impacts, as well as trends that may occur over time.

Sartori Environmental Inc. (SEI) was commissioned by Nautilus Environmental to conduct field studies and report on the benthic invertebrate component of the EEM, along with the collection of supporting sediment and habitat quality data.

The following report summarizes the findings of the 2019 benthic invertebrate field sampling program (Cycle 6).

2 Methods

2.1 Sampling Site Location

Figure 1 and Figure 2 below show the location of the benthic invertebrate sampling sites in both reference and exposure areas and the location of the sampling sites are summarized in Table 1 below.

Table 1: Benthic invertebrate and water quality sampling stations for the Myra Falls Mine 2019 EEM Program

Sampling Date	Site #	Approx. Distance from Discharge (m)	Longitude (deg, min, sec)	Latitude (deg, min, sec)
Control Area:				
20-Sep-2019	REF 1	2125	W -125° 37’ 15.5”	N 49° 34’ 06.4”
20-Sep-2019	REF 2	1655	W -125° 36’ 27.4”	N 49° 34’ 16.7”
20-Sep-2019	REF 3	990	W -125° 36’ 27.4”	N 49° 34’ 17.4”
20-Sep-2019	REF 4	690	W -125° 36’ 18.1”	N 49° 34’ 19.1”
19-Sep-2019	REF 5	510	W -125° 36’ 19.6”	N 49° 34’ 19.6”
Exposure Area:				
19-Sep-2019	EXP 1	845	W -125° 34’ 51.5”	N 49° 34’ 26.2”
19-Sep-2019	EXP 2	880	W -125° 34’ 50.5”	N 49° 34’ 26.2”
19-Sep-2019	EXP 3	1945	W -125° 34’ 06.6”	N 49° 34’ 31.5”
19-Sep-2019	EXP 4	2105	W -125° 34’ 03.2”	N 49° 34’ 33.3”
19-Sep-2019	EXP 5	2215	W -125° 34’ 03.1”	N 49° 34’ 36.2”

Figure 1: Map showing the location of benthic invertebrate sampling stations in reference area

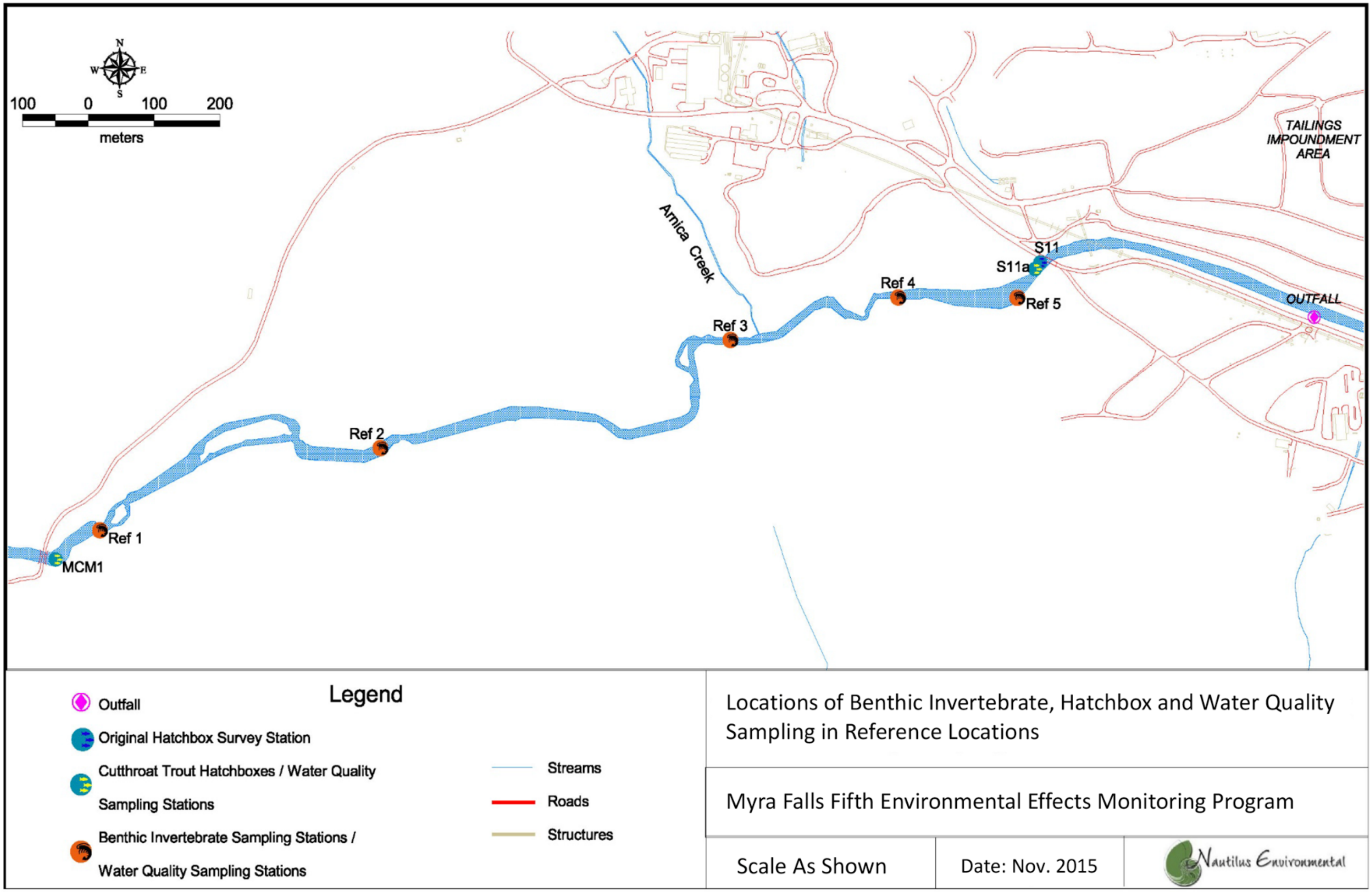
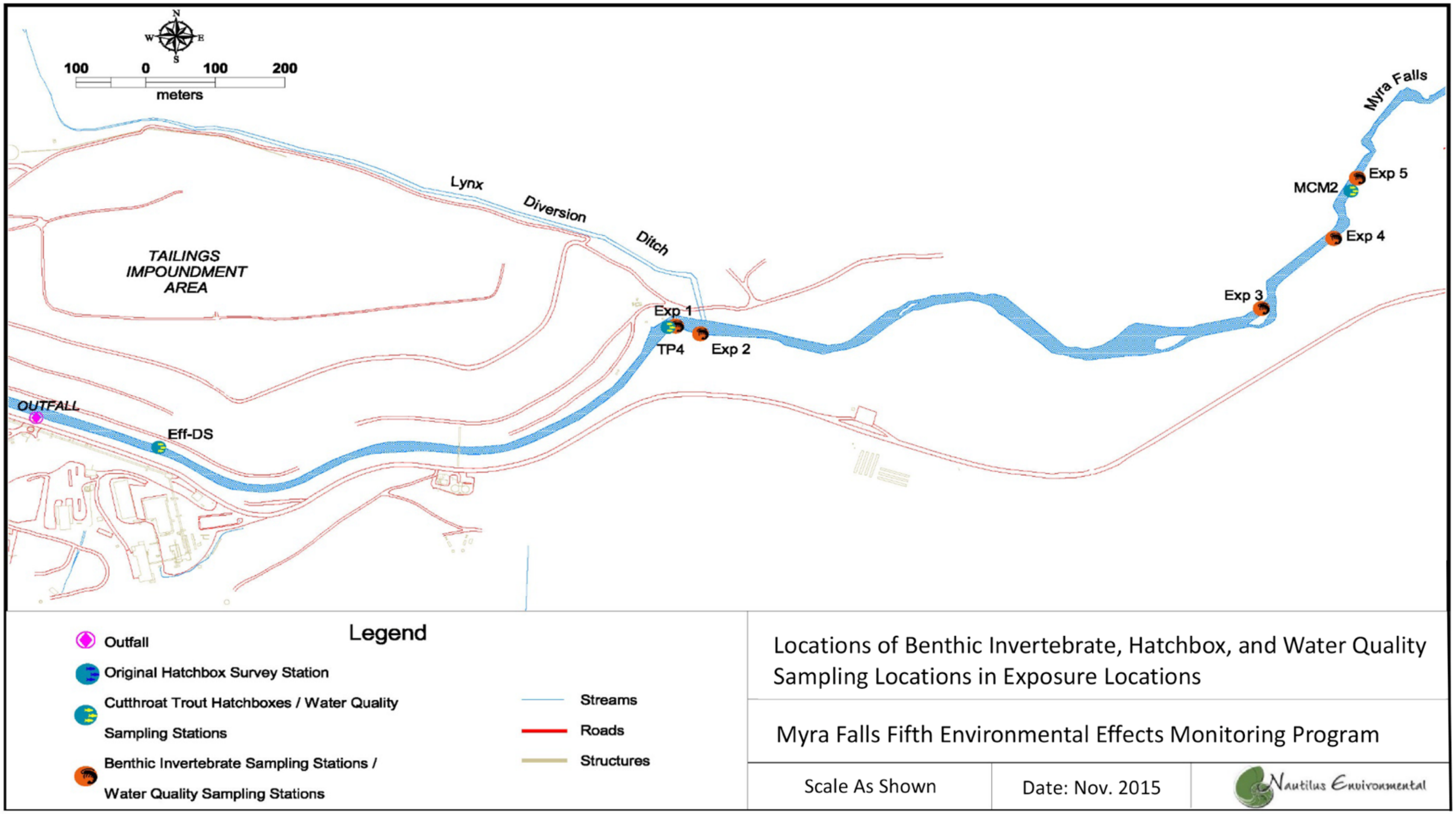


Figure 2: Map showing the location of benthic invertebrate sampling stations in exposure area



2.2 Water and Sediment Quality

Sediment quality sampling followed the standards described in the British Columbia Field Sampling Manual (Province of British Columbia, 2013). SEI obtained clean sampling jars, preservatives and storage cooler from ALS Laboratories in Burnaby, BC (ALS) prior to the fieldwork. At each site, SEI labelled the sampling jars with the site name, time and date of sampling prior to sample collection. SEI filled each sampling jar by collecting sediments by grabbing fine sediments (i.e sand and silt) directly by hand using rubber gloves. The presence of suitable substrate was sporadic and generally in small quantity requiring several replicates to fill the jar.

Following sample collection and upon return to the field vehicle, SEI stored samples in a cooler with ice packs to avoid parameter deterioration. Delivery of the sediment samples to ALS for analysis took place at the end of the sampling operation and within 48-hours of sample collection due to the 2-day field sampling period.

Sediment quality monitoring Quality Assurance (QA) procedures included the following: SEI recorded GPS coordinates at each sampling site location to enable sampling personnel to relocate the sampling site for each round of sampling. Experienced personnel familiar with sampling standards conducted sediment quality sampling to ensure consistency and due diligence during field operations.

In situ water quality parameters were measured using properly calibrated instruments as per instrument manufacturer's instructions and schedule. Qualified personnel recorded data in a field logbook after stabilization of the meter reading and photographed screen shots of the instrument to check for potential discrepancies.

Following sample collection, personnel delivered samples in person to ALS within forty-eight hours of sample collection and filled-out a sample analysis form as part of the chain of custody (COC), which included, the sampler's name, site ID, time and date of sampling, and all the parameters for analysis.

In-situ water chemistry {*i.e.*, dissolved oxygen (mg/L), pH (units), conductivity (µS/cm), and water and air temperature (^{o}C)] were measured at each sampling site using a calibrated portable water quality (YSI) meter.

2.3 The Canadian Aquatic Biomonitoring Network (CABIN)

The Canadian Aquatic Biomonitoring Network (CABIN) is an aquatic biological monitoring program for assessing the health of freshwater ecosystems in Canada. CABIN is based on the network of networks approach that promotes inter-agency collaboration and data sharing to achieve consistent and comparable reporting on freshwater quality and aquatic ecosystem conditions in Canada. The program is maintained by Environment Canada to support the collection, assessment, reporting and distribution of biological monitoring information. CABIN allows partners to take their observations and make a formalized scientific assessment using nationally comparable standards.

The CABIN program primarily uses the Reference Condition Approach (RCA) for evaluating whether or not a test site is in reference condition, and if not, then how divergent it is from reference condition. **Reference sites**[1] are considered to be minimally affected by human activity. These sites provide the basis on which to compare and thus judge the health of test sites.

Test sites are in unknown condition and are being examined for possible biological impairment due to some exposure to human activities. Test sites are often assessed because of suspected impacts from poor water quality or habitat degradation.

This approach relies on the establishment of a large database of biological and habitat data from a wide range of reference sites. The wide range of reference sites provides the data to develop empirical models that explain the variability among the different benthic communities based on environmental characteristics (e.g. location, hydrology, substrate, bedrock geology, and climate). The empirical model predicts the benthic community that should be observed at a test site if the site was in "reference condition". The further the test site is from the predicted group of reference sites, the more different it is. The assumption of RCA is that if a site is different from what is expected, there must be some anthropogenic stress exerted on the benthic community.

2.4 Benthic Invertebrate Sample Collection

The macro-invertebrate sample collection was performed over a two-day period between September 19th and 20th, 2019 in accordance with the CABIN field sampling protocol (Environment Canada, 2012a) by a CABIN certified technician. Sampling was initiated at the downstream end of the study area (Exposure site EXP 5) and moving upstream to avoid potential contamination of the lower sites when invertebrates as dislodged during sampling.

Samples were collected using a 400µm kick-net over a period of exactly three minutes to standardize the level of effort. A zigzag sampling pattern across the stream is used to integrate benthic macro-invertebrates from various stream microhabitats within the erosional zone in proportion to their occurrence in a sample reach. Sampling must also include stream habitats directly adjacent to the stream bank as this region may have microhabitats such as leaf litter that support a unique fauna. Each sampling kick area and path was pre-defined before entering the creek, targeting riffle habitats with cobble/gravel substrate.

The content of the kicknet was emptied into a 320µm sieve before being transferred into a 500mL plastic jar. Each sample was preserved in the field by addition of an 85% ethyl alcohol solution. Care was taken to remove as much creek water as possible to avoid preservative dilution.

[1] *Note that the control sites for this study are not considered to be "reference" sites as per CABIN due to the proximity of the Myra Falls Mine and human activity in the area.*

2.5 Habitat Data Collection

Habitat data was collected *in situ* at each one of the ten sampling site following the CABIN field sheets.

- **Primary Site Data**: Basin name, estimate of site location coordinates, ecoregion, and stream order are all recorded.
- **Site Description**: a broad characterization of the site. It includes a site drawing and written description, site coordinates, and surrounding land use classification.
- **Reach characteristics**: a description of aquatic habitat types, canopy coverage, macrophyte coverage, streamside vegetation and canopy coverage in a defined sampling reach (site).
- **Water chemistry**: measurement of certain physical-chemical water quality parameters which are required by CABIN such as dissolved oxygen and saturation, pH, water temperature and conductivity. Most can be collected with in-situ field meters.
- **Substrate characteristics**: a 100-pebble count is used to characterize the substrate. The degree of embeddedness of substrate and the size of surrounding material are also determined.
- **Channel measurements**: characterization of the stream channel at current flow and estimate of peak flow conditions. This includes measurements of channel width (bankfull and wetted), depth, velocity and slope.

2.6 Sample Analysis

2.6.1 Sediment Chemistry

Sediment samples were analyzed at ALS Lab in Burnaby for the following parameters:

- Particle size
- Total Organic Carbon (TOC)
- Total Metals (35 elements)

2.6.2 Benthic Invertebrates

2.6.2.1 Laboratory Analysis

Benthic invertebrate sample sorting and taxonomic analysis was conducted by Thibault Doix (Living Streams Environmental), certified taxonomist with the Society for Freshwater Science. The sample sorting process consists in removing all the benthic invertebrates from the sample matrix prior to taxonomic identification. Each sample was processed as follow:

- The whole sample (i.e. all the jars constituting one sample) was washed with water into 320µm sieves to remove preservative.
- Large material, rocks, twigs, macrophytes were gently and thoroughly washed over. Washed large material was placed in a white tray for further examination and to make that sure no organisms were left behind.

- The sieve content was transferred into a white tray for a first sorting under a hands-free magnifier to remove large and conspicuous specimens.
- The tray content was subsequently split into smaller fractions and progressively transferred into a Petri dish for fine sorting under a dissecting microscope. Sorted debris was set aside and preserved in 85% ethanol.
- Removed specimens were separated into coarse family groupings in multi-well plates.
- All organisms removed from the white tray were identified, tallied and recorded on a bench sheet.
- The specimen vial and sorted debris jars were labeled, preserved in 85% ethanol and retained for Quality Assurance/Quality Control (QA/QC) audits of sorting and identification efficiency.

Each organism was identified using dissecting (10x-90x magnification) or compound microscopes (40x-1000x magnification) and appropriate taxonomic identification keys. The taxonomic identification was performed to the lowest level possible (generally genus/species level for insect taxa and family/genus for non-insects). Different life stages (e.g., larvae, nymphs) were identified and enumerated separately.

If the condition of a specimen did not allow for a correct identification, it was discarded.

2.6.2.2 Quality Assurance/Quality Control

As per the Metal Mining Technical Guidance for Environmental Effects Monitoring (Environment Canada – 2012b), one randomly selected macro-invertebrate sample was sent for QA/QC to Tim Howay (Ruxten Environmental), certified taxonomist with the Society for Freshwater Science. The sorting precision was calculated as **percent sorting efficiency (*%SE*)**. The QC auditor estimated sorting efficiency by examining randomly selected sample residuals.

- The sorted residue from the original sample is re-sorted.
- The number of organisms found is recorded (if any).
- The percent sorting efficiency (%SE) is using the equation:

$$\%\,SE = \left(1 - \frac{\#\ Organisms\ Missed}{Total\ Organisms\ Found}\right) * 100$$

The average percent sorting efficiency (*%SE)* is calculated based on the number of re-sorted samples and represents the standard sorting efficiency for that project. The average sorting efficiency should be >95%, or all samples in the project have to re-sorted by the QA/QC Auditor.

The taxonomic identification efficiency was assessed by complete re-identification and enumeration of one sample. If the error rate of the audited sample exceeded 5%, all samples are resorted and re-identified.

The **identification error rate (%IE)** is calculated by summing the number of misidentification errors and questionable taxonomic resolution errors.

$$\%\ Identification\ Error = \left(\frac{\#\ Incorrect\ Identifications}{Total\ Organisms\ Found\ in\ Audit}\right)*100$$

2.7 Benthic Invertebrates Data Analysis

2.7.1 CABIN Database

The CABIN database models predict the benthic macro-invertebrate community that is expected to occur at a test site in the absence of environmental disturbance. The probability of the test site belonging to each of the reference site groupings is calculated using the habitat variables for the specific model being used. The reference model used for the Myra Mine 2019 EEM program was the Fraser River – Georgia Basin Model - 2005, which includes the eastern Vancouver Island region. This model comprises five different reference site groups that the samples can be compared to.

Test sites are plotted with the appropriate group of reference sites on two or three axes, each axis representing a group of benthic community attributes. Each test site is assigned to the farthest band to which it resides in the three plots.

The CABIN database assessment is summarized based on where the test site fell within the confidence ellipses:

- A site that falls within the 90% confidence ellipse is designated *'Similar to Reference*'.
- A test site that falls within the 90% and 99% confidence ellipses is designated *'Mildly Divergent'*.
- A test site that falls within the 99% and 99.9% confidence ellipses is designated '*Divergent*'.
- A site that falls outside of the 99.9% confidence ellipses is designated *'Highly Divergent'*.

Should the benthic communities at the tested sites differ from those of the range of reference sites within the selected group then some anthropogenic stress can be suspected. The data resulting from the taxonomic identification and specimen enumeration as well as all habitat variable collected *in situ* was entered into the CABIN database by Thibault Doix, certified CABIN Project Manager.

2.7.2 Benthic Invertebrate Community Metrics

The following community metrics were used to assess potential effects on the benthic invertebrate community:

- **Density** (number of organisms/min) – The number of organisms present in the sample was calculated by dividing the raw count data by the total sampling time of 3 minutes;

- **Total taxa richness** (number of taxa) – The number of taxa in each sample was calculated by summing the number of different taxa observed in the sample;
- **Total number of taxa –** The total number of different invertebrate groups (i.e. family, genus, or species) observed in the sample.
- **Bray-Curtis** (degree of station dissimilarity) - Bray-Curtis correlation coefficients were calculated using density data for all taxa to compare the degree of similarity in community structure between individual stations and the median for the reference area. This index ranges from 0 to 1, with 0 representing two stations with similar communities, and 1 representing two stations with dissimilar communities; and,
- **Simpson's Evenness -** The evenness index represents the abundance of each taxon in proportion to total abundance, and the taxonomic richness at the station. This index ranges from 0 to 1, with 0 representing a community where the relative abundance is attributed to a small number of taxa and 1 representing a community where the relative abundance is evenly distributed among a large number of taxa.

In addition, Simpson's Diversity Index, which is not one of the effects metrics, was also calculated. This index represents the number of taxa at each station in proportion to the total density of each taxon. This index ranges from 0 to 1, with 0 representing a community with low diversity (small number of taxa present), and 1 representing a community with high diversity.

All metrics were calculated in Microsoft Excel using formulae outlined in the Metal Mining Technical Guidance Document (Environment Canada, 2012b).

Community metrics for exposure area stations were compared graphically to the range of variability in the reference area (mean ± two standard deviations). This is the critical effect size used to determine if an effect is meaningful for pulp and paper EEM. A similar effect size has not been established for metal mining EEM, but the pulp and paper critical effect size is used in this study as a benchmark for comparison.

2.7.3 Additional metrics

The following metrics are not required as part of the MMER EEM program, but do provide additional insights as to community structure and differences between sites, specifically:

- **Percent 3 most abundant taxa.**

As diversity declines, a few taxa dominate the assemblage. Opportunistic species that are less demanding regarding the quality of their habitat typically replace species that require special foods or particular types of physical habitats.

- **EPT taxa richness.**

Organisms belonging to the insect orders *Ephemereoptera*, *Plecoptera* and *Trichoptera* (EPT) are considered to be the most sensitive to human disturbance of the aquatic habitat. Their abundance and diversity decline quickly under environmental stress.

- **Percent *Ephemeroptera* and *Simuliidae***

Most *Ephemeroptera* (mayflies) and *Simuliidae* (black flies) species are particularity sensitive to heavy metals as compared to other taxonomic groups (Kiffney *et al.,* 1994; Clements *et al.* 2000). These taxa are the first to disappear as heavy metal input increases.

2.7.4 Statistical analysis

Statistical analyses were conducted in accordance with the Metal Mining Technical Guidance Document (Environment Canada 2012). Summary statistics, including means, medians, standard deviations and errors, minima and maxima, were calculated for the benthic invertebrate community metrics. A non-parametric equivalent of a two-tailed t-test (i.e., the Mann-Whitney U-test) was used to test for differences in community metrics and metal concentration between Reference and Exposure areas at a significance level of α=0.10. The effect size (*r*) is a measure of the strength of an observed trend (i.e. the differences in taxonomic richness or density observed between the reference site and the exposure sites). Generally, effect sizes between 0-0.29 are considered small, 0.3-0.49 are medium, and anything above 0.5 is considered large. The Results of the statistical tests are presented in **Appendix A and B**.

Community metrics for the Exposure area stations were also compared against the range of variability in the Reference area (mean ± two standard deviations) to evaluate the magnitude of differences between the Reference and Exposure area. A difference > 2SD of the Reference area mean is the critical effect size used to determine if an effect is meaningful for Pulp and Paper EEM and is useful as a benchmark for comparison.

2.8 Quality Assurance/Quality control

A comprehensive QA/QC program was followed to ensure that the data generated is of high quality and scientifically defensible. To meet these objectives, quality control procedures will include the following:

- Use of experienced personnel in all aspects of the study;
- Use of a CABIN-certified biologist to lead the field sampling;
- Use of appropriate sampling protocols;
- Use of appropriate number of replicates to allow proper statistical analyses;
- Calibration and proper maintenance of instruments to ensure accurate measurements;
- Proper documentation and record keeping allowing traceability of performance;
- Adequate supervision and training of staff to ensure that methods are followed;

- Proper handling and storage of samples to ensure their integrity;
- Procedures in place to address issues that may arise during sampling, and to ensure the implementation of appropriate corrective actions;
- Taxonomic identification and sample sorting QA/QC performed on one randomly chosen sample;
- Peer-review of documents, checking electronic data files for transcription errors and providing copies of raw data output files with the final report; and
- Rigorous review of the data, analyses and report by a Registered Professional Biologist to ensure they are of acceptable quality and are scientifically defensible.

3 Results

3.1 Sampling Conditions

The occurrence of several rain events during the first half of September 2019 affected the hydrology of Myra Creek prior to the field investigations. With the occurrence of a short window of drier weather and a long-range forecast calling for several days of rain, SEI made the decision in consultation with Nautilus Environmental and Nyrstar Environmental Managers to trigger the sampling operation despite higher flows than in previous sampling programs. Turbidity levels (See Table 4) and access to the creek bed were suitable for sample collection, however, the "significant amount of time (...) to allow the hydrologic conditions to stabilize before sampling" required by the CABIN protocol could not be achieved.

3.2 Habitat Characteristics

Tables 2 and 3 below summarize some of the main habitat metrics collected at each invertebrate sampling site in both reference and exposure areas.

Table 2. Habitat features associated with benthic invertebrate sampling sites on Myra Creek, September 2019.

Site #	Slope (m/m)	Average Depth (cm)	Max. Depth (cm)	Average Velocity (m/s)	Canopy Coverage (%)	Dominant Stream Side Vegetation	Bankfull Width (m)	Wetted Width (m)
REF 1	0.02	78.5	120	0.39	1-25	Coniferous Trees	26	15
REF 2	0.05	42	68	0.28	1-25	Coniferous Trees	50	15.5
REF 3	0.025	61.3	85	0.41	51-75	Coniferous Trees	21	12
REF 4	0.02	68.5	97	0.4	51-75	Coniferous Trees	24.5	20.5
REF 5	0.01	44.7	51	0.56	1-25	Coniferous Trees	22.1	19.3
EXP 1	0.005	84.4	160	0.32	0	Deciduous Trees	25	15
EXP 2	0.03	45.7	75	0.54	1-25	Deciduous Trees	26.5	23.1
EXP 3	0.025	27.7	43	0.87	51-75	Coniferous Trees	35	15.4
EXP 4	0.02	28.3	53	0.64	1-25	Deciduous Trees	32	22.6
EXP 5	0.02	34.8	61	0.66	1-25	Deciduous Trees	32	19.6

Table 3. Habitat features associated with benthic invertebrate sampling sites on Myra Creek, September 2019 (continued).

Site #	%Boulder (>25.6mm)	%Cobble (6.4-25.6mm)	%Gravel (1.6-6.4mm)	%Pebble (0.2-1.6mm)	%Sand, Silt, Clay (<0.2mm)	D50 (cm)	% Embeddedness
REF 1	8	82	0	10	0	12.3	26-50%
REF 2	3	79	0	18	0	9.0	0-25%
REF 3	4	75	0	21	0	9.5	0-25%
REF 4	11	74	0	15	0	13.0	0-25%
REF 5	26	62	1	11	0	18.25	26-50%
EXP 1	11	64	0	25	0	9.3	0-25%
EXP 2	11	65	0	24	0	9.3	0-25%
EXP 3	0	61	0	38	0	7.2	0-25%
EXP 4	1	33	3	63	0	5.3	0-25%
EXP 5	2	35	8	51	4	5.1	0-25%

3.3 Water Quality

Table 4 below summarizes the *in situ* water quality data results associated with the benthic invertebrate sampling sites in both reference and exposure areas.

Table 4. Water quality data associated with benthic invertebrate sampling on Myra Creek, September 19-20, 2019.

Site #	Temp (^{o}C)	pH	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)
REF 1	10.3	N/R*	10.3	28	0.00
REF 2	10.4	N/R*	10.5	28	0.66
REF 3	10	N/R*	10.5	29	0.00
REF 4	10.8	N/R*	10.6	29	0.76
REF 5	11.3	N/R*	10.7	50	0.00
EXP 1	11.6	N/R*	10.4	110	0.04
EXP 2	11.6	N/R*	10.4	110	0.04
EXP 3	11.7	N/R*	10.4	106	0.01
EXP 4	11.6	N/R*	12.6	105	0.10
EXP 5	11.3	N/R*	11.2	115	3.27

*N/R: not reported due to meter displaying unreliable results in the field

3.4 Sediment Quality

Table 5 below summarizes the sediment quality data results associated with the benthic invertebrate sampling sites in both reference and exposure areas. The majority of parameters analyzed exceeded the upper limit of the reference sites mean +2SD, except for Antimony, Arsenic, Potassium, Titanium, and Vanadium. Furthermore, the following parameters (n= 14) show significant differences between exposure and reference sites (the results of the Mann-Whitney U-Test are presented in Appendix A):

Table 5: Summary statistics for sediment quality data associated with benthic invertebrate sampling on Myra Creek, September 19-20, 2019. Note that only parameters exceeding the detection limit are displayed.

			Reference Sites						Exposure Sites					
Analyte	**Units**	**Detection Limit**	**Median**	**Mean**	**Maxima**	**Minima**	**Standard Deviation**	**Standard Error**	**Median**	**Mean**	**Maxima**	**Minima**	**Standard Deviation**	**Standard Error**
pH (1:2 soil:water)	pH	0.1	6.89	6.84	6.92	6.61	0.13	0.06	6.82	6.78	7.06	6.33	0.29	0.13
Gravel (4.75mm - 3in.)	%	1	16.45	13.75	17.70	4.40	6.31	3.15	1.00	4.80	20.00	1.00	8.50	3.80
Medium Sand (0.425mm - 2.0mm)	%	1	52.60	51.04	62.30	41.00	8.80	3.93	57.40	47.52	84.40	1.80	38.68	17.30
Fines (<0.075mm)	%	1	1.40	1.57	1.90	1.40	0.29	0.17	3.35	8.40	25.90	1.00	11.86	5.93
Coarse Sand (2.0mm - 4.75mm)	%	1	18.55	19.60	26.10	15.20	5.03	2.51	12.80	12.00	15.20	8.00	3.67	2.12
Fine Sand (0.075mm - 0.425mm)	%	1	17.40	21.00	54.70	3.10	21.02	9.40	8.30	33.90	81.70	1.00	39.41	17.62
Total Organic Carbon	%	0.05	0.12	0.11	0.16	0.05	0.04	0.02	0.14	0.35	1.08	0.05	0.44	0.19
Aluminum (Al)	mg/kg	50	12700.00	13540.00	16500.00	12100.00	1767.20	790.32	18000.00	18720.00	20900.00	17300.00	1492.31	667.38
Antimony (Sb)	mg/kg	0.1	0.47	0.56	1.13	0.28	0.34	0.15	0.43	0.55	1.00	0.24	0.30	0.13
Arsenic (As)	mg/kg	0.1	4.62	16.72	58.40	3.04	23.69	10.59	15.20	13.36	18.20	4.91	5.72	2.56
Barium (Ba)	mg/kg	0.5	38.20	41.46	55.10	29.20	12.91	5.77	45.20	81.58	237.00	23.30	88.19	39.44
Beryllium (Be)	mg/kg	0.1	0.18	0.19	0.21	0.17	0.02	0.01	0.20	0.24	0.34	0.19	0.07	0.03
Cadmium (Cd)	mg/kg	0.02	0.07	0.12	0.34	0.05	0.13	0.06	0.76	0.95	1.47	0.64	0.37	0.17
Calcium (Ca)	mg/kg	50	3980.00	4178.00	5470.00	3570.00	764.31	341.81	5380.00	5474.00	6440.00	4300.00	897.76	401.49
Chromium (Cr)	mg/kg	0.5	13.80	14.20	16.60	12.30	1.63	0.73	19.60	18.92	23.00	14.90	3.05	1.36
Cobalt (Co)	mg/kg	0.1	9.25	10.07	13.90	8.72	2.18	0.98	13.90	14.46	15.80	13.20	1.21	0.54
Copper (Cu)	mg/kg	0.5	21.40	27.84	57.20	18.40	16.47	7.37	58.70	94.04	184.00	53.80	57.30	25.62
Iron (Fe)	mg/kg	50	24100.00	26940.00	41200.00	21500.00	8093.39	3619.48	32900.00	34160.00	38400.00	32300.00	2496.60	1116.51
Lead (Pb)	mg/kg	0.5	2.18	3.61	9.83	1.75	3.48	1.56	14.30	24.12	61.20	9.81	21.19	9.48
Lithium (Li)	mg/kg	2	6.30	6.24	6.40	6.00	0.18	0.08	6.90	6.90	7.50	6.40	0.43	0.19
Magnesium (Mg)	mg/kg	20	8830.00	9250.00	11100.00	8530.00	1060.59	474.31	12200.00	12440.00	13000.00	12100.00	391.15	174.93
Manganese (Mn)	mg/kg	1	565.00	570.40	634.00	515.00	48.98	21.91	803.00	823.60	1090.00	584.00	181.96	81.37
Molybdenum (Mo)	mg/kg	0.1	0.64	0.82	1.74	0.41	0.53	0.24	0.72	2.30	6.46	0.53	2.59	1.16
Nickel (Ni)	mg/kg	0.5	10.40	11.58	14.60	9.10	2.34	1.05	15.90	15.78	16.40	14.60	0.70	0.31
Phosphorus (P)	mg/kg	50	308.00	319.00	371.00	290.00	32.13	14.37	354.00	461.80	848.00	328.00	220.83	98.76

			Reference Sites						Exposure Sites					
Analyte	**Units**	**Detection Limit**	**Median**	**Mean**	**Maxima**	**Minima**	**Standard Deviation**	**Standard Error**	**Median**	**Mean**	**Maxima**	**Minima**	**Standard Deviation**	**Standard Error**
Potassium (K)	mg/kg	100	320.00	318.00	380.00	240.00	50.20	22.45	250.00	290.00	390.00	200.00	88.60	39.62
Selenium (Se)	mg/kg	0.2	Below Detection Limit						0.61	0.61	0.69	0.52	0.12	0.08
Silver (Ag)	mg/kg	0.1	Below Detection Limit						0.10	0.22	0.59	0.10	0.21	0.09
Sodium (Na)	mg/kg	50	75.00	75.20	94.00	54.00	14.92	6.67	87.00	90.80	117.00	56.00	24.69	11.04
Strontium (Sr)	mg/kg	0.5	11.40	10.85	13.00	8.04	2.04	0.91	11.90	13.90	18.50	10.60	3.59	1.60
Titanium (Ti)	mg/kg	1	780.00	862.80	1300.00	682.00	248.97	111.34	974.00	1028.20	1260.00	783.00	217.81	97.41
Uranium (U)	mg/kg	0.05	0.38	0.40	0.46	0.34	0.04	0.02	0.57	0.49	0.75	0.26	0.21	0.10
Vanadium (V)	mg/kg	0.2	56.10	75.76	166.00	48.70	50.57	22.62	75.10	81.16	99.30	72.60	11.24	5.03
Zinc (Zn)	mg/kg	2	50.20	65.62	129.00	46.70	35.60	15.92	225.00	281.60	386.00	201.00	92.11	41.19
Zirconium (Zr)	mg/kg	1	1.40	1.52	2.50	1.00	0.57	0.26	2.30	2.38	2.80	2.10	0.28	0.12

- Aluminium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Lead
- Lithium
- Magnesium
- Manganese
- Nickel
- Phosphorus
- Zinc
- Zirconium

Note that sediment sampling was proven to be difficult with a very limited abundance of suitable substrate at most sites, requiring in some instances to collect sediments outside of the invertebrate sampling site. In light of the lack of available substrate, replicates could not be collected as required.

3.5 Benthic Invertebrate Community Composition

Summary statistics and results from statistical analyses conducted to test for differences in community metrics between reference and exposure areas are summarized in Table 6 below. Detailed benthic community composition found at each site are presented in **Appendix B**, and the results of the identification and sample sorting QA/QC on one sample are presented in **Appendix C.**

One sample of identified organisms and sorted debris (Exposure Site REF005) was submitted to Mr. Tim Howay of Ruxten Environmental in Vancouver, BC for confirmation of identification and sorting efficiency. Taxonomic identification efficiency was determined to be 100% with a discrepancy in abundance for one taxon of (n=1 specimen). Sorting efficiency was determined to be 99.3% with n=2 specimens missed in the initial sorting.

Table 6: Summary statistics for benthic invertebrate abundance in control and exposure areas for the Myra Falls 2019 EEM Program

		Median	Mean	Maxima	Minima	Standard Deviation	Standard Error
Reference Sites	Total Abundance	285	302	411	175	96	43
	Density (Org./min)*	95	101	137	58	32	14
	Richness*	27	26	27	22	2	1
	Bray-Curtis*	0.32	0.32	0.42	0.23	0.08	0.04
	Evenness*	0.32	0.32	0.41	0.25	0.06	0.03
	Simpson's Diversity	0.86	0.87	0.91	0.85	0.02	0.01
	% 3 most abundant taxa	0.54	0.53	0.62	0.41	0.09	0.04
	EPT Richness	18.00	18.40	21.00	17.00	1.67	0.75
	% EPT	0.92	0.90	0.96	0.79	0.07	0.03
	%Ephemerotpera+Simuliidae	0.38	0.42	0.52	0.33	0.08	0.04

		Median	Mean	Maxima	Minima	Standard Deviation	Standard Error
Exposure Sites	Total Abundance	195	187	248	137	47	21
	Density (Org./min)*	65	62	83	46	16	7
	Richness*	20	20	25	17	3	1
	Bray-Curtis*	0.62	0.58	0.67	0.48	0.08	0.04
	Evenness*	0.12	0.13	0.16	0.10	0.03	0.01
	Simpson's Diversity	0.62	0.60	0.70	0.43	0.11	0.05
	% 3 most abundant taxa	0.77	0.78	0.83	0.72	0.05	0.02
	EPT Richness	13.00	14.40	17.00	12.00	2.41	1.08
	% EPT	0.87	0.89	0.96	0.80	0.06	0.03
	%Ephemerotpera+Simuliidae	0.71	0.71	0.79	0.63	0.07	0.03

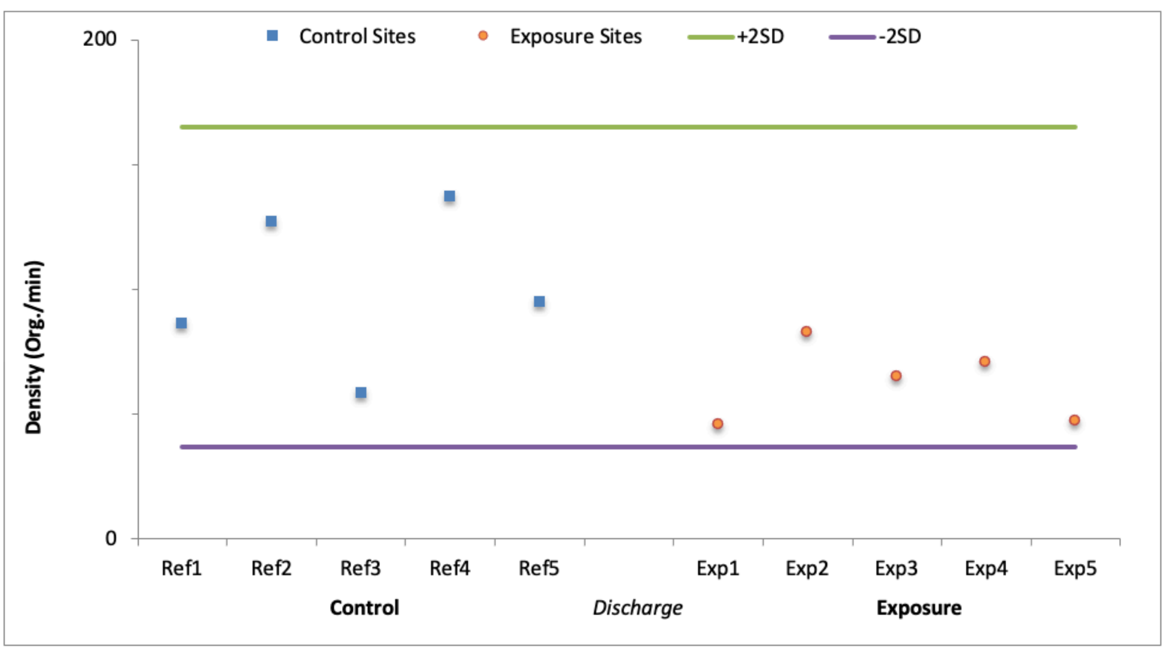
* Effects endpoints for EEM

3.6 Benthic Invertebrate Community Metrics

3.6.1 Density

Figure 3 below summarizes the density of organisms (organisms per minute) at the different sampling locations in both reference and exposure areas. The data shows that higher benthic invertebrate densities are observed at most of the reference sites, with the exception of site REF3. Nevertheless, invertebrate densities at all 5 of the exposure sites are within two standard deviations of the reference mean. The Mann-Whitney test results indicates that there is a significant difference in density between reaches (p=0.06). The effect size for this metric (r=0.59) shows a high difference in magnitude between reference and exposure sites.

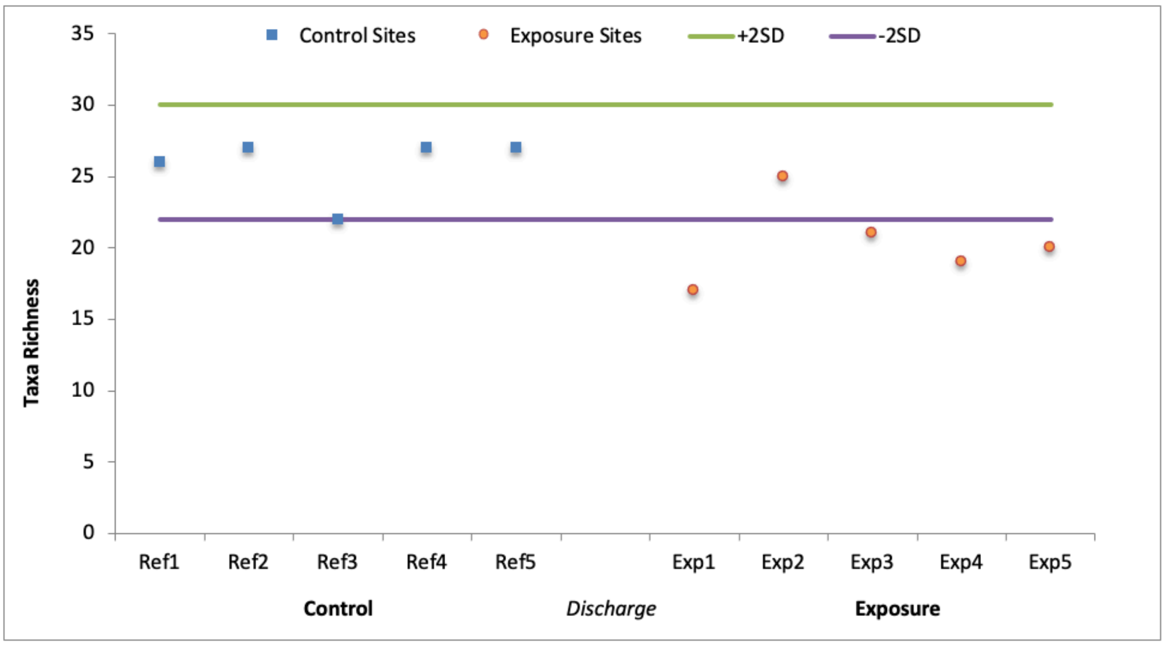
Figure 3: Benthic Invertebrate density (Org./min) at control and exposure sites for the Myra Falls 2019 EEM Program



3.6.2 Taxonomic Richness

Figure 4 below summarizes the taxonomic richness (total number of taxa) at the different sampling locations in both reference and exposure areas. The data shows that the total number of taxa is generally lower at the exposure sites as compared with the refences sites. It is also outside of two standard deviations of the reference mean, with the exception of Exposure site EXP 2. The Mann-Whitney test results indicates that there is a significant difference in taxonomic richness between reaches (p=0.02). The effect size for this metric (r=0.74) shows a high difference in magnitude between reference and exposure sites.

Figure 4: Benthic taxonomic richness (# taxa) at control and exposure sites for the Myra Falls 2019 EEM Program

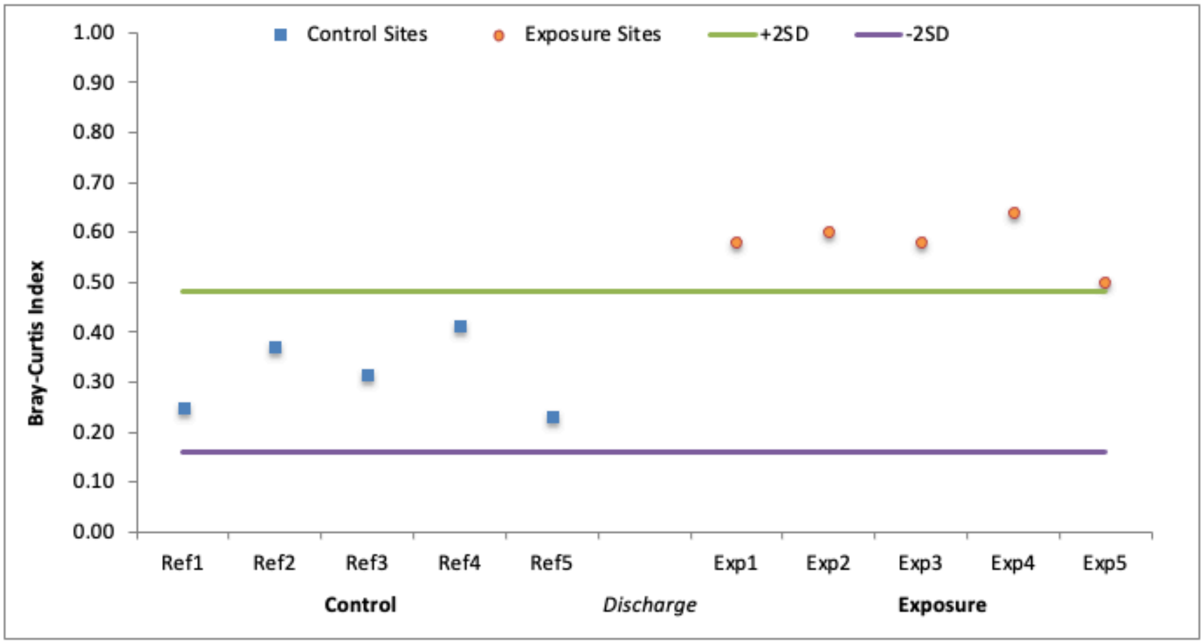


3.6.3 Bray-Curtis Index of Dissimilarity

Figure 5 below summarizes the Bray-Curtis Index of Dissimilarity values between each site and the reference median in both reference and exposure areas. The data shows that the benthic communities in the Exposure area are different from those in the Reference area, with the Bray-Curtis index value of all 5 exposure outside of two standard deviations of the reference mean.

The Bray-Curtis Index of dissimilarity is already a statistical test that examines the differences between community structure at two different sites. Interpreting the meaning of a Mann-Whitney test on the output of another statistical test, or its effect size effect was therefore not considered to be relevant for the purpose of our study. Thus, it was not included in our analysis.

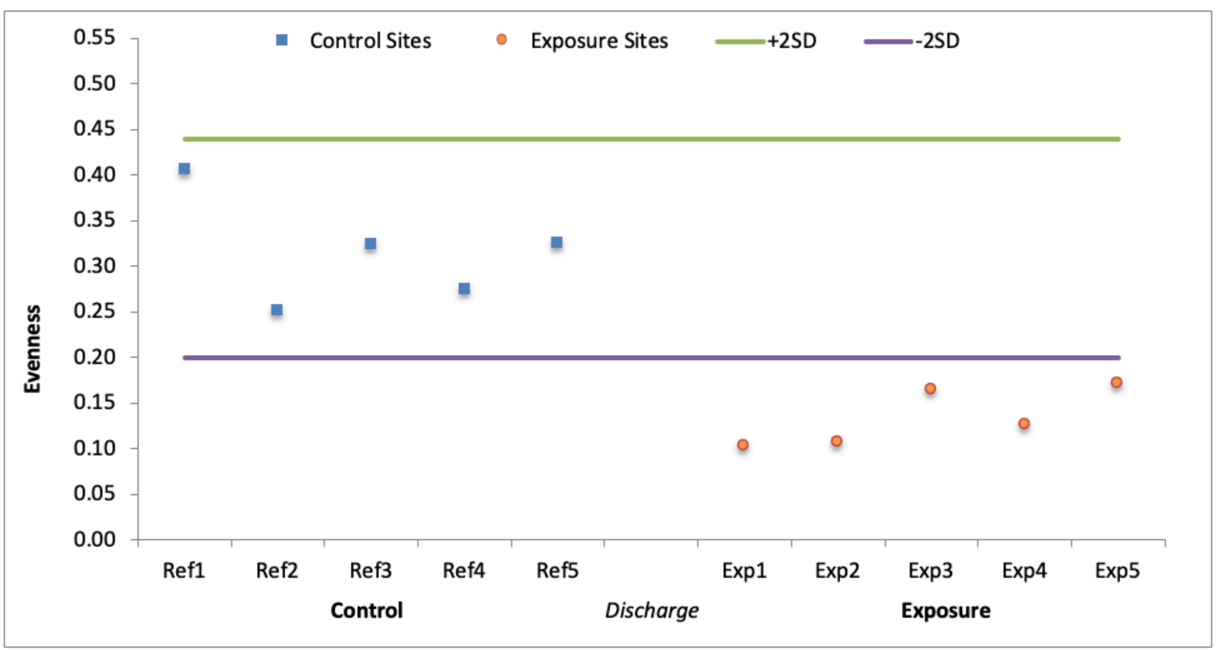
Figure 5: Bray-Curtis Index of Dissimilarity at control and exposure sites for the Myra Falls 2019 EEM Program



3.6.4 Evenness

Figure 6 below summarizes the evenness values between each site and the reference median in both reference and exposure areas. The data shows that the abundance of benthic invertebrate populations is more evenly distributed across taxa at the Reference sites compared with the Exposure sites. Evenness values fall outside of two standard deviations of the reference mean at all 5 exposure sites.

Figure 6: Evenness values at control and exposure sites for the Myra Falls 2019 EEM Program



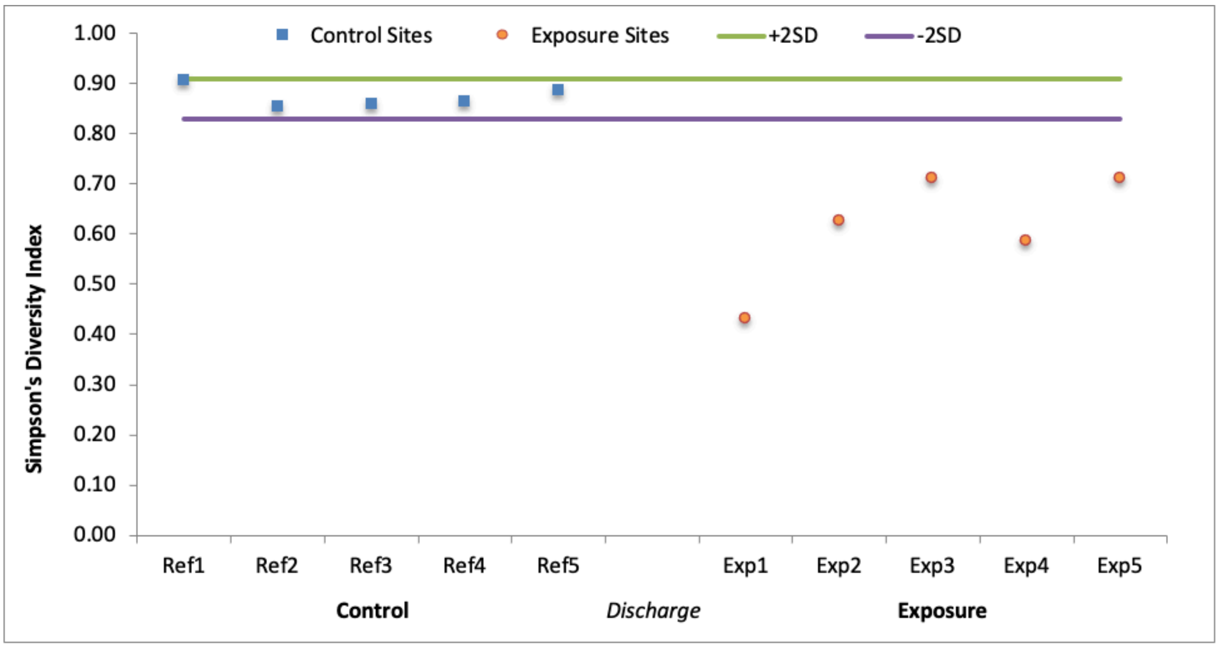
The Mann-Whitney test results indicates that there is a significant difference in evenness between reaches (p=0.01). The effect size for this metric (r=0.80) shows a high difference in magnitude between reference and exposure sites.

3.6.5 Simpson's Index of Diversity

Figure 7 below summarizes the Simpson's Index of Diversity (SDI) values between each site and the reference median in both reference and exposure areas. Benthic communities in the reference area show a rather high level of diversity with SDI values ranging from 0.85 to 0.91. In the exposure area, SDI values ranged between 0.43 and 0.80, with all sites being outside of two standard deviations of the reference mean.

The SDI is a non-linear index; therefore, the Mann-Whitney test is not appropriate to test for significant differences between sites.

Figure 7: Simpson's diversity values at control and exposure sites for the Myra Falls 2019 EEM Program

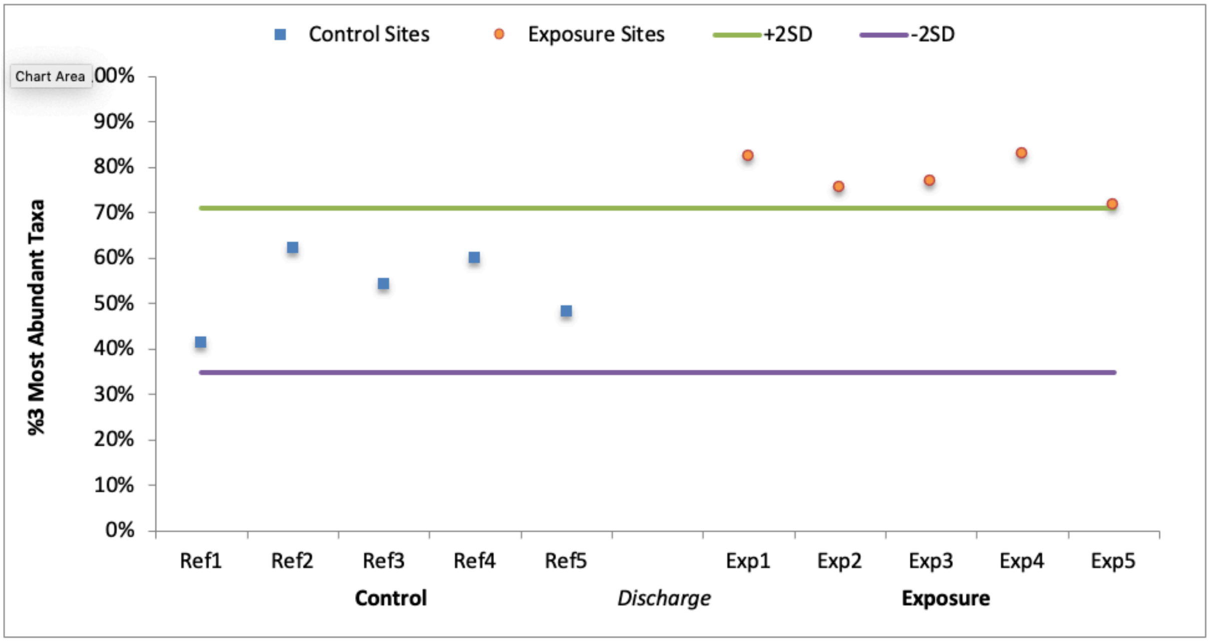


3.6.6 Percent 3 Most Abundant Taxa

Figure 8 below summarizes the relative abundance of the 3 most abundant taxa values between each site and the reference median in both reference and exposure areas. The data shows that the relative abundance of the three dominant taxa falls above two standard deviation of the reference median at all 5 exposure sites.

The use of a statistical test is not relevant for this metric since it was generally calculated using three different taxa from one site to another.

Figure 8: Percent 3 most abundant taxa values at control and exposure sites for the Myra Falls 2019 EEM Program



3.6.7 EPT Richness and Percent EPT

Figure 9 and Figure 10 below summarize the *Ephemeroptera*, *Trichoptera* and *Plecoptera* (EPT) richness and percent EPT, respectively, observed between each site and the reference median in both reference and exposure areas. The data shows that the EPT richness is generally lower in the exposure reach with metric values falling outside two standard deviation of the reference median except at exposure site EXP2 and EXP4. Nevertheless, the percent EPT ratio is within the reference median at all 5 exposure sites.

The Mann-Whitney test results indicates that there is a significant difference in EPT richness between reaches (p=0.03) with a high difference in magnitude between reference and exposure sites (r=0.59). On the other hand, the percent EPT does not show a significant difference between reaches (p=0.83) with a low difference in magnitude (r=0.07).

Figure 9: EPT richness values at control and exposure sites for the Myra Falls 2019 EEM Program

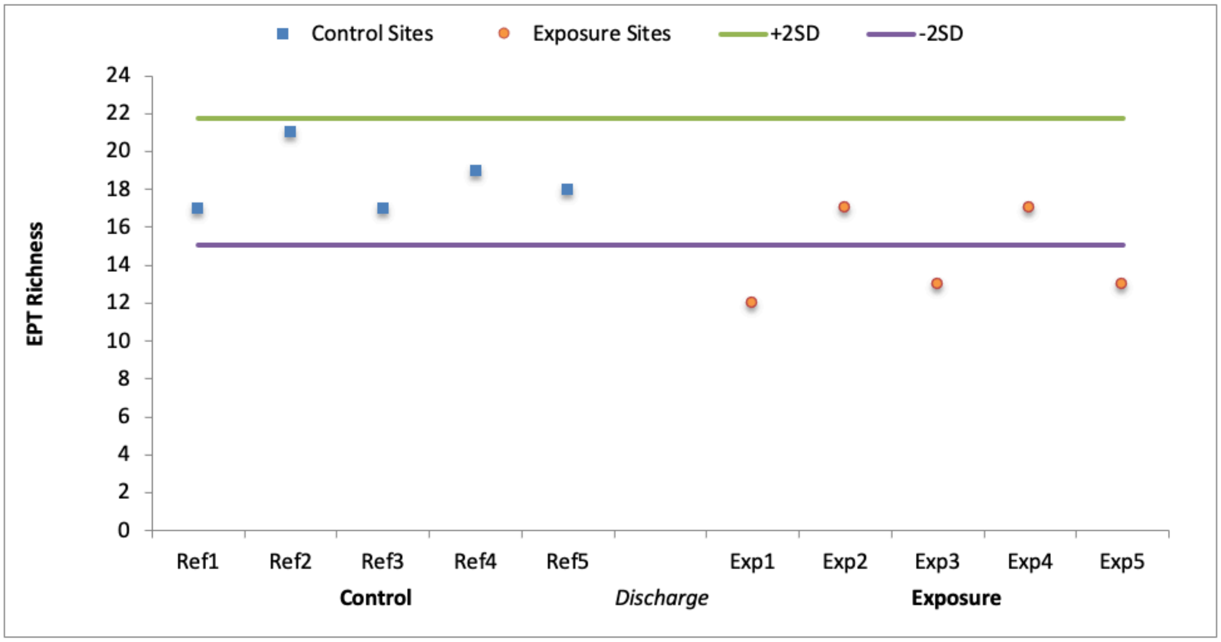
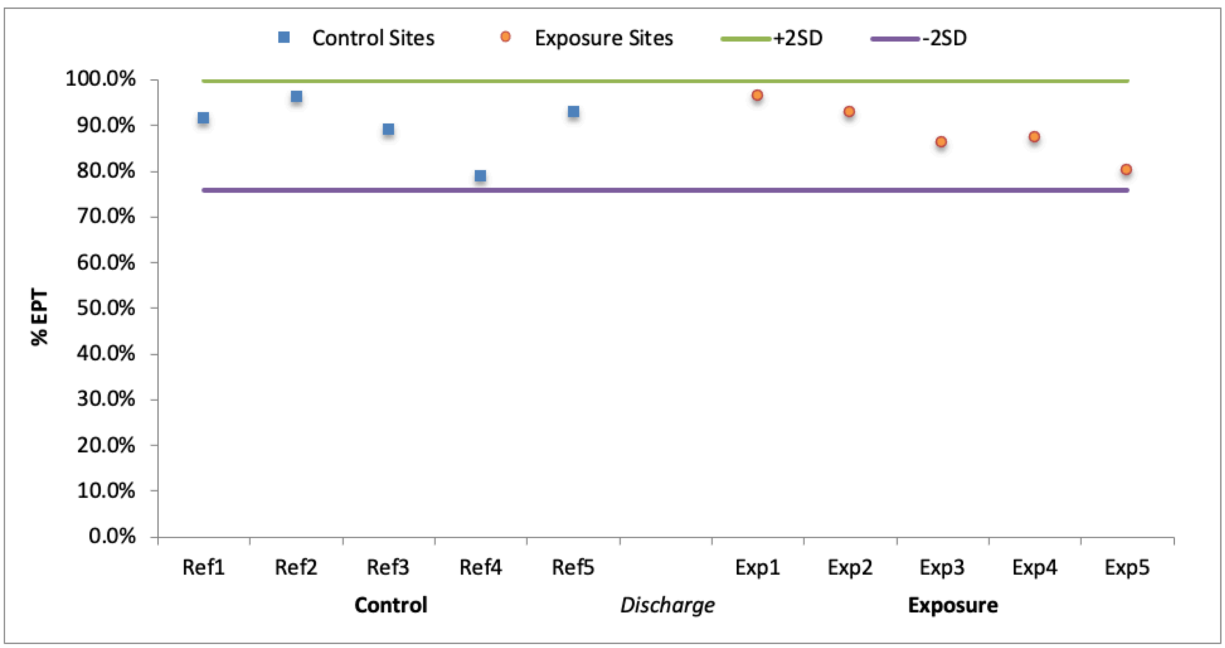


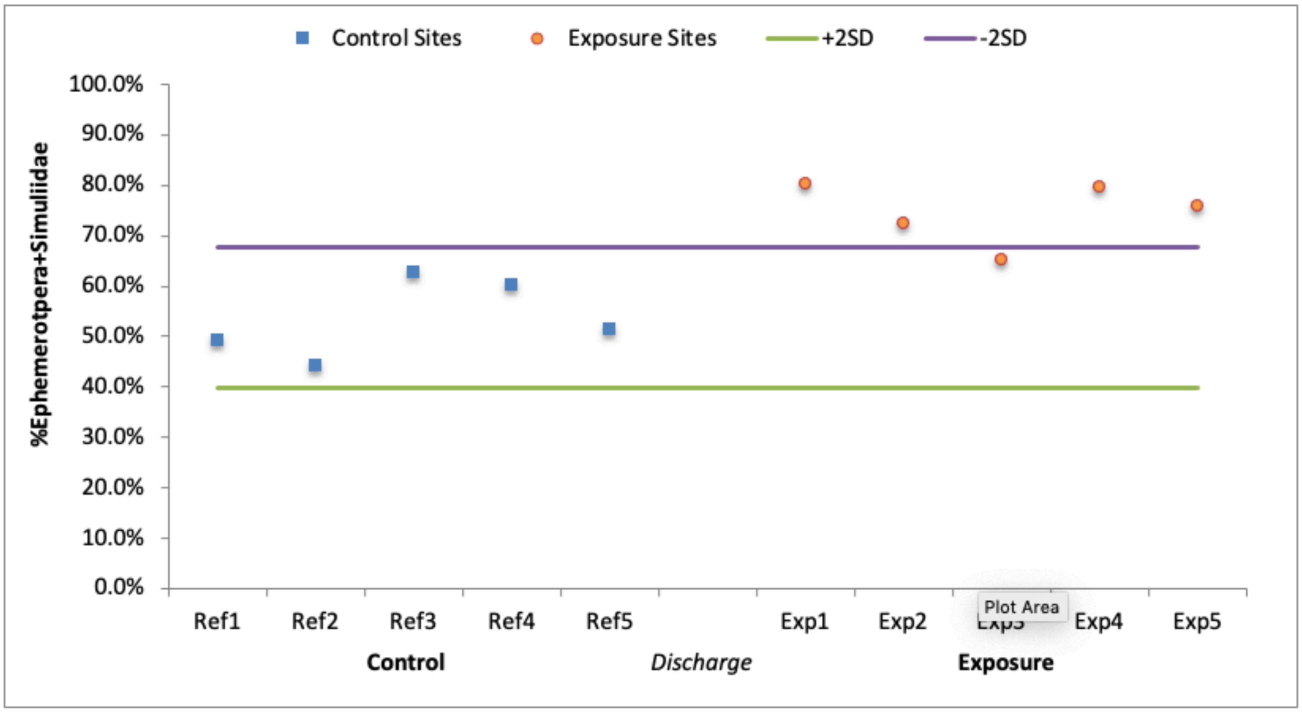
Figure 10: Percent EPT values at control and exposure sites for the Myra Falls 2019 EEM Program



3.6.8 Percent Ephemeroptera+Simuliidae

Figure 11 below summarizes the percent *Ephemeroptera* + *Simuliidae* between each site and the reference median in both reference and exposure areas. The results show that the percent *Ephemeroptera* + *Simuliidae* ratio is greater is the exposure reach as compared with the reference sites and falls outside two standard deviation of the reference median at all 5 exposure sites, except at site EXP3. The Mann-Whitney test results indicates that there is a significant difference in percent *Ephemeroptera* + *Simuliidae* between reaches (p=0.01). The effect size for this metric (r=0.79) shows a high difference in magnitude between reference and exposure sites.

Figure 11: Percent Ephemeroptera + Simuliidae values at control and exposure sites for the Myra Falls 2019 EEM Program



3.6.9 Comparison to CABIN Reference Sites

3.6.9.1 Reference Site Group Attribution

The CABIN database uses the geographical and habitat variables collected *in situ* to evaluate the similarity of the study sites to each of the biological reference groups from the Fraser River – Georgia Basin 2005 model. This model contains five different groups of reference sites, and the probability of a given study site belonging to each of the reference groups is determined based on their respective habitat characteristics. Those habitat characteristics include:

- Ecoregion
- Latitude
- Slope
- Stream order
- Coniferous tree presence
- Wetted width
- Maximum velocity
- Average Depth
- Dominant Substrate
- Embeddedness
- pH

The results of these calculations are summarized in Table 7, and show that all Myra Creek sites sampled in 2019 fell into Reference Site Group 1.

Table 7: Probability of the test sites for the Myra Falls Mine 2019 EEM Program to belong to one of the five Reference Groups included in the Fraser River – Georgia Basin 2005 model

Site	Group 1	Group 2	Group 3	Group 4	Group 5
Reference Sites					
REF 1	98.30%	0.00%	1.40%	0.20%	0.10%
REF 2	72.20%	0.10%	17.50%	7.40%	2.70%
REF 3	90.90%	0.00%	6.40%	1.90%	0.70%
REF 4	96.30%	0.00%	3.00%	0.40%	0.20%
REF 5	98.40%	0.00%	1.40%	0.00%	0.20%
Exposure Sites					
EXP 1	92.40%	0.00%	3.10%	4.30%	0.20%
EXP 2	90.30%	0.20%	7.00%	1.30%	1.10%
EXP 3	87.10%	0.60%	9.30%	0.20%	2.70%
EXP 4	81.10%	2.10%	10.40%	1.60%	4.70%
EXP 5	85.40%	1.30%	8.60%	1.60%	3.10%

3.6.9.2 Benthic Community Comparison with CABIN Reference Sites

The results of the CABIN database analysis in Table 8 below indicate that the benthic communities at all 5 of the control sites are in reference condition. In the exposure reach, the majority of the sites are mildly divergent to reference condition (EXP 1, EXP 2, EXP 3, and EXP 5) whereas site EXP 2—one of the two sites closest to the mine discharge—is considered to be in reference condition.

Table 8: Summary table of the distance from reference condition for the control and exposure sites

Site #	Distance from Reference Condition
REF 1	Similar to reference condition
REF 2	Similar to reference condition
REF 3	Similar to reference condition
REF 4	Similar to reference condition
REF 5	Similar to reference condition

Site #	Distance from Reference Condition
EXP 1	Mildly divergent from reference condition
EXP 2	Similar to reference condition
EXP 3	Mildly divergent from reference condition
EXP 4	Mildly divergent from reference condition
EXP 5	Mildly divergent from reference condition

4 Discussion

The results of the 2019 invertebrate assessment on Myra Creek showed some notable differences in benthic invertebrate communities between reference (control) and exposure sites. These differences can be explained, in part, by a lower taxonomic richness and overall diversity of invertebrates of each individual site within the exposure reach (see Table 6). Nevertheless, the CABIN analysis shows that the exposure sites are similar to mildly divergent from reference condition, whereas all reference (control) sites are all in 'reference condition'. The overall taxonomic richness is also almost identical in both reaches with a total of 45 and 44 taxa in the reference and exposure reaches, respectively.

The relationship between metal concentration in sediments and benthic community metrics was tested using a Spearman's rank correlation test to determine whether any changes in these metrics would be related to changes metal concentration. This test was performed on the 11 metals showing a significantly higher concentration within the exposure reach as compared with the reference reach (see Appendix A). Strong positive correlations were observed between Nickel concentration and Organism density (p=0.04) and EPT richness (p=0.01), between Manganese concentration and Simpson's Diversity Index (p=0.04), and between cobalt concentration and Simpson's Diversity Index (p=0.04). Since the correlation is positive, the metal concentration does not show a negative impact on benthic communities.

Based on the habitat metrics selected in the CABIN reference model, organisms belonging to the *Ephemerellidae* (e.g. *Drunella*) family have a high probability of presence within both reference and exposure areas (p=0.90-0.91). *Ephemerellidae* specimens are, however, almost entirely absent from the Exposure area (n=1), contributing to the divergence from reference condition. This taxon is present in very low abundance (n=≤2) at only two sites within the reference area, showing a low probability of capture. The taxonomic analysis showed that all specimens were in their late stages of development, indicating that other specimens may have hatched into adults prior to the sample collection.

Ephemeroptera (mayflies) and *Simuliidae* taxa, known to be sensitive to heavy-metal contamination (Kiffney *et al.,* 1994; Clements *et al.* 2000), are more abundant within the exposure area as compared with the reference area, ranging from 65.1% to 80.3% of the total abundance. Furthermore, exposure site EXP2—one of the two sites located closest to the mine discharge—displays the highest taxonomic richness (n=25) as well as the highest invertebrate density (n=83 ind./min) of all the exposure sites. Conversely, exposure site EXP1, located immediately upstream of site EXP2 showed the lowest taxonomic richness of all 10 studied sites.

The elevated number of *Simuliidae* (black flies) observed at the three lower exposure sites during the two previous sampling cycles (2013 and 2016) was not observed this year. Specimens from this family typically cling to the surface of boulders and cobbles and the higher flows prior to the invertebrate sampling may have reduced their presence by increasing natural drift. Overall organism abundance and taxonomic richness may also have been affected in both reference and exposure reaches. It is worth mentioning that based on the past ten years of weather data, the Myra Falls mine operator has decided to shift its rainy season preparedness from September 30th to September 15th (Craig Schweitzer, pers. comm.). Thus, it is recommended that future invertebrate sampling operations be conducted within the first two weeks of September.

Overall, the detailed results of the benthic community analysis for the year 2019 does not show any evidence of adverse effects related to the mine discharge (or any seeps that may also be present in the upstream portion of the Exposure reach).

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Appendix A – Mann-Whitney U-test Results for Metal Concentration in Sediments

Mann-Whitney U Test Results for Metal Concentration in Sediments					
Analyte	**U-statistic**	**Z-score**	**P-value**	**Effect size (r)**	**Comments**
pH (1:2 soil:water)	12	0.20	1.00	0.00	Not significantly different (p>0.10)
Total Organic Carbon	9.5	-0.53	0.60	0.17	Not significantly different (p>0.10)
Aluminum (Al)	0	-2.65	0.01	0.79	Significantly different (p<0.10)
Antimony (Sb)	12	0.2	0.58	0.00	Not significantly different (p>0.10)
Arsenic (As)	7	-1.05	0.29	0.33	Not significantly different (p>0.10)
Barium (Ba)	10	-0.40	0.35	0.13	Not significantly different (p>0.10)
Beryllium (Be)	5	-1.48	0.14	0.47	Not significantly different (p>0.10)
Cadmium (Cd)	0	-2.66	0.01	0.79	Significantly different (p<0.10)
Calcium (Ca)	3	-1.91	0.03	0.59	Significantly different (p<0.10)
Chromium (Cr)	1.5	-2.20	0.03	0.70	Significantly different (p<0.10)
Cobalt (Co)	2.5	-1.99	0.05	0.63	Significantly different (p<0.10)
Copper (Cu)	2	-2.15	0.03	0.66	Significantly different (p<0.10)
Iron (Fe)	5	-1.44	0.15	0.46	Not significantly different (p>0.10)
Lead (Pb)	1	-2.41	0.02	0.73	Significantly different (p<0.10)
Lithium (Li)	1	-2.33	0.02	0.74	Significantly different (p<0.10)
Magnesium (Mg)	0	-2.51	0.01	0.80	Significantly different (p<0.10)
Manganese (Mn)	2	-2.15	0.03	0.66	Significantly different (p<0.10)
Mercury (Hg)	12	1.00	1.00	0.00	Not significantly different (p>0.10)
Molybdenum (Mo)	10	-0.40	0.70	0.13	Not significantly different (p>0.10)
Nickel (Ni)	0.5	-2.41	0.02	0.76	Significantly different (p<0.10)
Phosphorus (P)	3	-1.91	0.06	0.59	Significantly different (p<0.10)
Potassium (K)	10.5	0.32	0.75	0.10	Not significantly different (p>0.10)
Selenium (Se)	7.5	-1.34	0.18	0.42	Not significantly different (p>0.10)
Silver (Ag)	7.5	-1.34	0.18	0.42	Not significantly different (p>0.10)
Sodium (Na)	7	-1.02	0.31	0.33	Not significantly different (p>0.10)
Strontium (Sr)	7	-1.02	0.31	0.33	Not significantly different (p>0.10)
Titanium (Ti)	6	-1.22	0.22	0.40	Not significantly different (p>0.10)
Tungsten (W)	10	-0.80	0.42	0.25	Not significantly different (p>0.10)
Uranium (U)	10	-0.40	0.69	0.13	Not significantly different (p>0.10)
Vanadium (V)	5	-1.44	0.15	0.46	Not significantly different (p>0.10)
Zinc (Zn)	0	-2.65	0.01	0.79	Significantly different (p<0.10)
Zirconium (Zr)	3.5	-1.79	0.07	0.56	Significantly different (p<0.10)

Appendix B – Mann-Whitney U-test Results for Benthic Community Metrics

Mann-Whitney U Test Results for Benthic Community Metrics					
Metric	**U-statistic**	**Z-score**	**P-value**	**Effect size (r)**	**Comments**
Total Abundance	3	1.88	0.06	0.59	Significantly different (p<0.10)
Density	3	1.88	0.06	0.59	Significantly different (p<0.10)
Richness	1	2.33	0.02	0.74	Significantly different (p<0.10)
Bray-Curtis	n.c.	n.c.	n.c.	n.c.	
Simpson	n.c.	n.c.	n.c.	n.c.	
Evenness	0	2.51	0.01	0.80	Significantly different (p<0.10)
% 3 most abundant taxa	n.c.	n.c.	n.c.	n.c.	
EPT Richness	2	2.16	0.03	0.68	Significantly different (p<0.10)
% EPT	11	0.21	0.83	0.07	Not significantly different (p>0.10)
%Ephemerotpera+Simuliidae	0	-2.51	0.01	0.79	Significantly different (p<0.10)

n.c.: not calculated

Appendix C - Detailed Benthic Invertebrate Community Lists

Taxonomic Identification:	Thibault Doix, Certified Taxonomist Living Streams Environmental Services E-mail: livingstreams@live.ca Cell: (778)-385-1447			Project: Myra Falls Mine EEM, September 2019									
			Sampling Date:	20-Sep-2019	20-Sep-2019	20-Sep-2019	20-Sep-2019	19-Sep-2019	19-Sep-2019	19-Sep-2019	19-Sep-2019	19-Sep-2019	19-Sep-2019
Class	**Order**	**Family**	**Genus/ Species**	**REF001**	**REF002**	**REF003**	**REF004**	**REF005**	**Exp001**	**Exp002**	**Exp003**	**Exp004**	**Exp005**
Cl. CLITELLATA	**O. Haplotaxida**	**F. Enchytraeidae**								1			
	O. Lumbriculida	**F. Lumbriculidae**	(Unidentified)	2									
			Kincaidiana hexatheca										4
Cl. ARACHNIDA	**O. Prostigmata**	**F. Hydryphantidae**	*Protzia sp.*							1			
Cl. INSECTA	**O. Ephemeroptera**	**F. Ameletidae**	*Ameletus sp.*	3	5	1		3	2				2
		F. Baetidae	*Baetis sp.*	49	98	54	120	61	102	148	98	135	75
		F. Ephemerellidae	(early instar)	2	1		1	1					
			Serratella sp.										1
			Drunella coloradensis	1									
			Drunella spinifera		1								
		F. Heptageniidae	*Cinygma sp.*		1								
			Cinygmula sp.	22	23	10	8	28	2	4			
			Epeorus sp.	6	13	10	15	15				2	
			Epeorus longimanus				2			5		1	1
			Ironodes sp.	6	1		14		2	11	7	3	
			Rhithrogena sp.	25	14	18	29	26		4	1	1	9
		F. Leptophlebiidae	*Paraleptophlebia sp.*	17	18	7	6	12	4	1	3	1	4
	O. Plecoptera	**F. Capniidae**	(Early instar/Damaged)						5	3	8	12	2
			Mesocapnia sp.						2			4	
		F. Chloroperlidae	*Kathroperla sp.*					1					
			Sweltsa sp.	32	61	14	30	45	1	1	2	1	4
		F. Leuctridae	*Despaxia augusta*								1	2	
			Paraleuctra sp.					1			1		
		F. Nemouridae	*Visoka cataractae*	13	10	4	4	21		9	8	3	
			Zapada cinctipes	20	79	23	74	32	6	28	34	15	7
			Zapada columbiana			2	2						
			Zapada oregonensis gr.									1	
		F. Perlodidae	*Megarcys sp.*	1	1	3		1	2	4		1	5
			Skwala sp.								2	1	1
	O. Trichoptera	**F. Apataniidae**	*Apatania sp.*		3	1	2		2				2
		F. Brachycentridae	*Micrasema sp.*				1						
		F. Glossosomatidae	*Glossosoma sp.*		3			10		1			
		F. Hydropsychidae	(Early instar/Damaged)							2	2	1	
			Hydropsyche sp.		1						1		
			Parapsyche sp.			1	3			1			
		F. Hydroptilidae	*Agraylea sp.*	2	2	1	3	3		1			1
		F. Lepidostomatidae	*Lepidostoma sp.*	26	16	4	6	2					
		F. Limnephilidae	*Ecclisomyia sp.*	9	5			2		1			
		F. Polycentropodidae	*Polycentropus sp.*			1	1		2				
		F. Rhyacophilidae	*Rhyacophila sp.*	3	12	2	3	1		6		1	
	O. Diptera	**F. Ceratopogonidae**	*Probezzia sp.*								1		1
		F. Chironomidae	(Early instar)								1		2
			Orthocladiinae (early instar)					4					
			Tanypodinae (early instar)	1	1		1	1			1		
			Brillia sp.	3	2	1	9	1	1	1	3		
			Corynoneura sp.	2									
			Eukiefferiella sp.		1	1	1			1			
			Cricotopus/Orthocladius sp.				1	1	1		1		
			Pagastia sp.		2		1			2			1
			Parametriocnemus sp.					1					
			Tanytarsus sp.	1	1	1	1	1					
			Tvetenia sp.	8	7	5	20	6	1	3	1		
			Thienemannimyia sp.						1				
		F. Empididae	*Oreogeton sp.*	1						2	1	1	
		F. Simuliidae	*Simulium sp.*			11	53	4		7	18	26	18
		F. Tipulidae	*Dicranota sp.*	3				1	1				1
			Hexatoma sp.	1									1
			Total Number of Organisms	259	382	175	411	285	137	248	195	212	142
			Total Number of Taxa	26	27	22	27	27	17	25	21	19	20

Appendix D - Taxonomic Identification and Sample Sorting QA/QC Results

QA/QC Taxonomist: Tim Howay, certified taxonomist with the Society for Freshwater Science
Ruxten
Environmental

3662 Tuaq Dr. Vancouver B.C.

E-mail: tim.howay@ruxten.com

QA/QC date: March 16, 2020

Sampling Date: 19-Sep-2019

Class	Order	Family	Genus/ Species	REF005	QA/QC Counts	ID Errors	Sorting QA/QC
Cl. INSECTA	**O. Ephemeroptera**	**F. Ameletidae**	*Ameletus sp.*	3	3		
		F. Baetidae	*Baetis sp.*	61	60		*1*
		F. Ephemerellidae	(early instar)	1	1		
		F. Heptageniidae	*Cinygmula sp.*	28	28		
			Epeorus sp.	15	15		
			Rhithrogena sp.	26	26		
		F. Leptophlebiidae	*Paraleptophlebia sp.*	12	12		
	O. Plecoptera	**F. Chloroperlidae**	*Kathroperla sp.*	1	1		
			Sweltsa sp.	45	45		
		F. Leuctridae	*Paraleuctra sp.*	1	1		
		F. Nemouridae	*Visoka cataractae*	21	21		
			Zapada cinctipes	32	32		
		F. Perlodidae	*Megarcys sp.*	1	1		
	O. Trichoptera	**F. Glossosomatidae**	*Glossosoma sp.*	10	10		
		F. Hydroptilidae	*Agraylea sp.*	3	3		
		F. Lepidostomatidae	*Lepidostoma sp.*	2	2		
		F. Limnephilidae	*Ecclisomyia sp.*	2	2		
		F. Rhyacophilidae	*Rhyacophila sp.*	1	1		
	O. Diptera	**F. Chironomidae**	Orthocladiinae (early instar)	4	4		*1*
			Tanypodinae (early instar)	1	1		
			Brillia sp.	1	1		
			Total Number of Organisms	**285**	**284**	**IE=0%**	**SE=99.3%**
			Total Number of Taxa	**27**	**27**		

Appendix E – Results of the Spearman Rank Correlation Test for Benthic Metrics in the exposure sites vs. metal concentration in sediments

Results of the Spearman Rank Test								
Analyte	**Density (Org./min)***	**Taxa Richness**	**Evenness**	**Simpson's Diversity**	**% 3 most abundant taxa**	**EPT Richness**	**% EPT**	**%Ephemerotpera +Simuliidae**
Aluminum (Al)	r=0.4 p=0.5	r=0.1 p=0.87	r=0.67 p=0.22	r=0.4 p=0.50	r=0.3 p=0.62	r=0.53 p=0.36	r=-0.6 p=0.28	r=-0.3 p=0.62
Cadmium (Cd)	r=-0.1 p=0.87	r=-0.1 p=0.87	r=0.72 p=0.17	r=0.5 p=0.39	r=0.3 p=0.62	r=-0.05 p=0.93	r=-0.6 p=0.28	r=-0.3 p=0.62
Calcium (Ca)	r=0.7 p=0.19	r=0.3 p=0.62	r=0.41 p=0.49	r=0.3 p=0.62	r=0.4 p=0.50	r=0.74 p=0.15	r=-0.3 p=0.62	r=-0.4 p=0.50
Chromium (Cr)	r=0.4 p=0.50	r=0.1 p=0.87	r=0.67 p=0.22	p=0.4 r=0.50	r=0.3 p=0.62	r=0.53 p=0.36	r=-0.6 p=0.28	r=-0.3 p=0.62
Cobalt (Co)	r=-0.1 p=0.87	r=0.6 p=0.28	r=0.67 p=0.22	r=0.9 p=0.04	r=-0.7 p=0.19	r=-0.26 p=0.67	r=-0.6 p=0.28	r=-0.8 p=0.11
Copper (Cu)	r=0.7 p=0.19	r=0.3 p=0.62	r=0.41 p=0.49	r=0.3 p=0.62	r=0.4 p=0.50	r=0.74 p=0.15	r=-0.3 p=0.62	r=-0.4 p=0.50
Lead (Pb)	r=0.6 p=0.28	r=0.1 p=0.87	r=0.05 p=0.93	r=0.3 p=1	r=0.7 p=0.19	r=0.58 p=0.30	r=0.1 p=0.87	r=-0.2 p=0.75
Lithium (Li)	r=0.6 p=0.28	r=0.6 p=0.28	r=0.10 p=0.87	r=0.4 p=0.50	r=0.2 p=0.75	r=0.37 p=0.54	r=0.1 p=0.87	r=-0.7 p=0.19
Magnesium (Mg)	r=-0.41 p=0.49	r=-0.46 p=0.43	r=0.56 p=0.33	r=0.10 p=0.87	r=-0.05 p=0.93	r=-0.14 p=0.83	r=--0.67 p=0.22	r=0.31 p=0.61
Manganese (Mn)	r=-0.1 p=0.87	r=0.6 p=0.28	r=0.67 p=0.22	r=0.9 p=0.04	r=-0.7 p=0.19	r=-0.26 p=0.67	r=-0.6 p=0.28	r=-0.8 p=0.10
Nickel (Ni)	r=0.9 p=0.04	r=0.4 p=0.50	r=0.15 p=0.80	r=0.10 p=0.87	r=0.3 p=0.62	r=0.95 p=0.01	r=-0.1 p=0.87	r=-0.3 p=0.62
Phosphorus (P)	r=-0.3 p=0.62	r=-0.3 p=0.62	r=0.72 p=0.17	r=0.3 p=0.62	r=-0.1 p=0.87	r=-0.05 p=0.93	r=-0.8 p=0.10	r=0.1 p=0.87
Zinc (Zn)	r=0.6 p=0.28	r=0.1 p=0.87	r=0.05 p=0.93	r=0.3 p=1	r=0.7 p=0.19	r=0.58 p=0.30	r=-0.1 p=0.87	r=-0.2 p=0.74
Zirconium (Zr)	r=0.8 p=0.10	r=0.7 p=0.19	r=-0.15 p=0.80	r=0.2 p=0.75	r=0.1 p=0.87	r=0.58 p=0.31	r=0.3 p=0.62	r=-0.6 p=0.28

APPENDIX B – *In situ* cutthroat trout hatchbox study data

MCMI

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls Nyrstar
Sample ID: EEM Cycle 6 - MCMI
Work Order #: NA

Start Date & Time: May 1/19 @ 1500
Stop Date & Time: June 6/19 @ 1430
Test Species: *Redside shiner*

~~Concentration~~ Replicates	Rep	Day of Test - No. of Mortalities												Total Dead Eggs/Embryos/ Alevins
		1	9	21	28	36								
Red Rep 1	1	0	1	1	1	0								3 Dead
	2													
Hatched	3		0	28	25	23								
Missing	4			0	2	2								4 Missing
Red + Green Rep 2	1	0	0	2	0	0								2 Dead
	2													
Hatched	3		3	27	27	27								
Missing	4			1	0	0								1 Missing
Green Rep 3	1	0	1	1	0	0								2 Dead
	2													
Hatched	3		1	27	27	27								
Missing	4			1	0	0								1 Missing
Black Rep 4	1	0	1	1	0	0								2 Dead
	2													
Hatched	3		0	28	28	28								
Missing	4			0	0	0								0 Missing
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CMP	CMP	CMP	CMP	KJL								CMP

Comments:

Reviewed by: **Date reviewed:**

S11-A

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls Nyrstar
Sample ID: EEM-Cycle 6 S11A
Work Order #: NA

Start Date & Time: May 1/19 @ 1400
Stop Date & Time: June 6/19 @ 1400
Test Species: *Oncorhynchus mykiss*

ied
ied +
Green
Green
Black

~~Concentration~~ CP Replicates	Rep	Day of Test - No. of Mortalities 1	9	21	28	36								Total Dead Eggs/Embryos/ Alevins
Rep 1	1	0	3	1	0	1								5 Dead
	2													
Hatched	3	0	1	24	23	15								
Missing	4	0	0	2	1	7								10 Missing
Rep 2	1	0	1	0	0	0								1 Dead
	2													
Hatched	3	0	1 ①	18	17	5								
Missing	4	0	0	11	1	12								24 Missing
Rep 3	1	0	0	1	0	2								3 Dead
	2													
Hatched	3	0	2	29	27	20								
Missing	4	0	0	0	2	5								7 Missing
Rep 4	1	0	1	1	0	0								2 Dead
	2													
Hatched	3	0	1	22	6	1								
Missing	4	0	0	6	16	5								27 Missing
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CMP	CMP	CMP	CMP	CMP								CMP

Comments: ① Trapped in Hatch box Slit, Dead

Reviewed by:

Date reviewed:

EFF-DS

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls Nyrstar
Sample ID: EEM Cycle 6 - EFF-DS
Work Order #: NA

Start Date & Time: May 1/19 @ 1300
Stop Date & Time: June 6/19 @ 1300
Test Species: *Oncorhynchus mykiss*

ied

ied + Green

+ Green

Black

~~Concentration~~ Replicates	Rep	1	9	21	28	36								Total Dead Eggs/Embryos/Alevins
	1	0	2	1	0	0								3 Dead
Rep 1	2													
Hatched	3	0	6	24	20	20								
Missing	4	0	0	3	4	0								7 Missing
	1	0	4	1	0	0								5 Dead
Rep 2	2													
Hatched	3	0	12	24	22	22								
Missing	4	0	0	1	2	0								3 Missing
	1	0	1	0	0	0								1 Dead
Rep 3	2													
Hatched	3	0	6	26	17	16								
Missing	4	0	0	3	9	1								13 Missing
	1	0	0	1	0	1①								2 Dead
Rep 4	2													
Hatched	3	0	8	23	16	15								
Missing	4	0	0	6	7	0								13 Missing
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CMP	CMP	CMP	CMP	CMP								CMJ

Comments: ① 1 Fish w/ Yolk Sac Edema

Reviewed by: ______ **Date reviewed:** ______

TP4

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls Nyrstar
Sample ID: EEM Cycle 6 - TP4
Work Order #: NA

Start Date & Time: May 1/19 @ 1200
Stop Date & Time: June 6/19 @ 1230
Test Species: *Redside shiner*

~~Concentration~~ Replicates	Rep	Day of Test - No. of Mortalities												Total Dead Eggs/Embryos/ Alevins
		1	9	21	28	36								
Red — Rep 1	1	0	1	3	0	0								4 Dead
	2													
Hatched	3		5	23	23	23								
Missing	4		0	3	0	0								3 Missing
Red + Green — Rep 2	1	0	0	1	1	0								2 Dead
	2													
Hatched	3		1	29	13	13								
Missing	4		0	0	15	0								15 Missing
Green — Rep 3	1	0	4	0	0	0								4 Dead
	2													
Hatched	3		1	25	25	25								
Missing	4		0	1	0	0								1 Missing
Black — Rep 4	1	0	3	0	1	0								4 Dead
	2													
Hatched	3		0	26	25	25								
Missing	4		0	1	0	0								1 Missing
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CMP	CMP	CMP	CMP	KSL								CMP

Comments:

Reviewed by: ____________ **Date reviewed:** ____________

MCM2

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls Nyrstar
Sample ID: EEM Cycle 6 -MCM2
Work Order #: NA

Start Date & Time: May 1/19 @ 1100
Stop Date & Time: June 6/19 @ 1100
Test Species: *Oncorhynchus mykiss*

	Cl ~~Concentration~~ Rellicates	Rep	Day of Test - No. of Mortalities 1	9	21	28	36								Total Dead Eggs/Embryos/ Alevins
Red		1	0	2	3 ①	2	0								7 Dead
	Rep 1	2													
	Hatched	3	0	5	22	13	10								
	Missing	4	0	0	3	10	0								13 Missing
Red + Green		1	0	3	0	0	0								3 Dead
	Rep 2	2													
	Hatched	3	0	6	25	18	16								
	Missing	4	0	0	2	7	2								11 Missing
Green		1	0	5	1 ①	1	0								7 Dead
	Rep 3	2													
	Hatched	3	0	3	23	20	20								
	Missing	4	0	0	1	2	0								3 Missing
Black		1	0	2	0	0	0								2 Dead
	Rep 4	2													
	Hatched	3	0	3	26	19	18								
	Missing	4	0	0	2	7	1								10 Missing
		1													
		2													
		3													
		4													
		1													
		2													
		3													
		4													
		1													
		2													
		3													
		4													
		1													
		2													
		3													
		4													
	Tech Initials		CMP	CMP	CMP	CMP	CMP								CMP

Comments: ① Mat of Sediment in Bottom of Hatch box.

Reviewed by: ____________ **Date reviewed:** ____________

MC-M1

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Nyrstar Myra Falls
Sample ID: EEM Cycle 6 - MCM1
Work Order #: NA

Start Date & Time: May1/19 @ 1500
Stop Date & Time: June 6/19 @ 1430
Test Species: *Oncorhynchus mykiss*

Concentration	Days												
	0	9		21		28		36					
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	7.3		6.9		8.2		9.6		7.9				
DO (mg/L)	10.6		10.8		10.5		9.7		10.4				
pH	7.2		7.1		7.2		7.2		7.3				
Cond. (µS/cm)	28	18		18		16		18					
Initials	CMP /JRE	CMP/KJL		CMP/KJL		CMP/SSM		CMP/KJL					

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 DO meter/probe: 5 / D-5 pH meter/probe: 5 / P-5 Conductivity meter/probe: CP / 5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP, KJL SSM
Reviewed by:
Date reviewed:

Sample Description:

Comments:

311-A

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Nyrstar Myra Falls
Sample ID: EEM Cycle 6 - S11-A
Work Order #: NA

Start Date & Time: May 1/19 @ 1500
Stop Date & Time: June 6/19 @ 1430
Test Species: *Oncorhynchus mykiss*

Concentration	Days												
	0	9		21		28		36					
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	7.1		8.0		8.8		9.8		7.9				
DO (mg/L)	10.5		10.6		10.3		9.3		10.5				
pH	7.3		7.3		7.3		7.3		7.4				
Cond. (µS/cm)	33	22		23		20		23					
Initials	CMP/JRE	CMP/KJL		CMP/KJL		CMP/SSM		CMP/KJL					

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 DO meter/probe: 5 / D-5 pH meter/probe: 5 / P-5 Conductivity meter/probe: CP-5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP, KJL, SSM
Reviewed by:
Date reviewed:

Sample Description:

Comments:

EFF-DS

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Nyrstar Myra Falls
Sample ID: EEM Cycle 6 - EFF-DS
Work Order #: NA

Start Date & Time: May 1/19 @ 1500
Stop Date & Time: June 6/19 @ 1430
Test Species: *Oncorhynchus mykiss*

Concentration	Days												
	0	9		21		28		36					
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	9.0		9.4		10.2		11.4		9.4				
DO (mg/L)	10.1		10.2		10.0		9.0		10.2				
pH	7.6		7.4		7.5		7.7		7.6				
Cond. (µS/cm)	265	117		155		212		265					
Initials	CMP /SRE	CMP/KJL		CMP/KJL		CMP/SSM		CMP/KJL					

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 **DO meter/probe:** S / D-S **pH meter/probe:** S P-S **Conductivity meter/probe:** CP-/5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP, KJL, SSM
Reviewed by:
Date reviewed:

Sample Description:

Comments:

TP4

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client:	Nyrstar Myra Falls	**Start Date & Time:**	May 1/19 @ 1500
Sample ID:	EEM Cycle 6 - TP4	**Stop Date & Time:**	June 6/19 @ 1430
Work Order #:	NA	**Test Species:**	*Oncorhynchus mykiss*

Concentration	Days 0	9		21		28		36					
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	7.7		9.4		9.8		11.0		8.4				
DO (mg/L)	10.6		10.4		10.2		9.5		10.2				
pH	7.2		7.2		7.3		7.3		7.3				
Cond. (µS/cm)	92	42		53		63		84					
Initials	JRE /CMP	CMP/KJL		CMP/KJL		CMP/SSM		CMP/KJL					

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 **DO meter/probe:** 5 / D5 **pH meter/probe:** 5 P5 **Conductivity meter/probe:** CP / 5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP KJL SSM

Reviewed by:

Date reviewed:

Sample Description:

Comments:

MC-M2

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Nyrstar Myra Falls
Sample ID: EEM Cycle 6 - MCM2
Work Order #: NA

Start Date & Time: May 1/19 @ 1300
Stop Date & Time: June 6/19 @ 1430
Test Species: *Oncorhynchus mykiss*

Concentration	Days 0	9		21		28		36					
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	6.9		9.9		8.1		9.7		8.4				
DO (mg/L)	10.6		10.0		10.3		9.6		10.0				
pH	7.2		7.3		7.4		7.3		7.4				
Cond. (µS/cm)	9.4	43		54		61		89					
Initials	JRE /CMP	CMP/KJL		CMP/KJL		CMP/SSM		CMP/KJL					

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 **DO meter/probe:** 5 / D5 **pH meter/probe:** 5 R5 **Conductivity meter/probe:** CP / 5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP, KJL, SSM
Reviewed by:
Date reviewed:

Sample Description:

Comments:

Lab Control

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls-EEM Cycle 6 **Start Date & Time:** May 2/19 @1400
Sample ID: Lab Reference Controls **Stop Date & Time:** June 7/19 @1330
Work Order #: NA **Test Species:** *Oncorhynchus mykiss*

Concentration	Rep	Day of Test - No. of Mortalities												Total Dead Eggs/Embryos/ Alevins
		1	2	3	4	5	6	7	8	9	10	11	12	
Rep A	1	0	0	0	0	1	0	0	1	0	2①	0	0	4
	2													
Hatched	3	1	0	2	0	3	6	7	13	19	22	25	27	
	4													
Rep B	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2													
Hatched	3	0	0	1	0	0	2	3	7	13	16	18	23	
	4													
Rep C	1	0	0	1	0	1	0	0	0	1	0	0	0	3
	2													
Hatched	3	0	0	0	1	3	7	10	11	11	16	20	20	
	4													
Rep D	1	0	0	0	2	0	0	0	1	0	0	1	0	4
	2													
Hatched	3	0	0	1	2	7	8	10	16	17	17	17	24	
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML

Comments: ① Hatched then all Died

Reviewed by: **Date reviewed:**

Version 1.1 Issued October 6, 2015 Nautilus Environmental Company Inc.

Lab Control

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls - EEM Cycle 6 **Start Date & Time:** May 2/19 @ 1400
Sample ID: Lab Reference Controls **Stop Date & Time:** June 7/19 @ 1330
Work Order #: NA **Test Species:** *Oncorhynchus mykiss*

Concentration	Rep	Day of Test - No. of Mortalities												Total Dead Eggs/Embryos/ Alevins
		13	14	15	16	17	18	19	20	21	22	23	24	
Rep A	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2													
Hatched	3	29	30											
	4													
Rep B	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2													
Hatched	3	27	29	29	30									
	4													
Rep C	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2													
Hatched	3	23	25	29	30.									
	4													
Rep D	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2													
Hatched	3	24	24	26	26	27	27	29	30					
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML	CML

Comments:

Reviewed by: **Date reviewed:**

Lab Control

Embryo-Alevin Toxicity Test
Daily Mortality

Client: Myra Falls EEM Cycle 6
Sample ID: Lab Reference Control
Work Order #: NA

Start Date & Time: May 2/19 @1400
Stop Date & Time: June 7/19 @ 1330
Test Species: *Oncorhynchus mykiss*

Concentration	Rep	Day of Test - No. of Mortalities												Total Dead Eggs/Embryos/ Alevins
		25	26	27	28	29	30	31	32	33	34	35	36	
Ref A	1	0	0	0	0	0	0	0	0	0	0	0	0	
	2													
	3													
	4													
Ref B	1	0	0	0	0	0	0	0	0	0	0	0	0	
	2													
	3													
	4													
Ref C	1	0	0	0	0	0	0	0	0	0	0	0	0	
	2													
	3													
	4													
Ref D	1	0	0	0	0	0	0	0	0	0	0	0	0	
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
	1													
	2													
	3													
	4													
Tech Initials		CML	CML	CML	SSM	SSM	SSM	CML	CML	CML	CML	CML	CML	CML

Comments:

Reviewed by: **Date reviewed:**

Lab Control

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client:	Myra Falls-EEM Cycle 6	**Start Date & Time:**	May 2/19 @ 1400
Sample ID:	Lab Reference Controls	**Stop Date & Time:**	June 7/19 @ 1330
Work Order #:	NA	**Test Species:**	*Redside shiner*

Lab Concentration Ref	Days 0	1		2		3		4		5		6	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	5.6	6.0	5.3	/	5.5	5.9	5.5	/	5.5	6.0	5.6	/	5.7
DO (mg/L)	10.8	13.1	12.8	/	12.7	13.0	12.8	/	12.7	12.9	12.7	/	12.7
pH	7.2	7.2	7.1	/	7.1	7.1	7.1	/	7.0	7.0	7.0	/	7.1
Cond. (µS/cm)	33	35		—		33		—		34		—	
Initials	CMP	CMP		CMP		CMP		CMP		CMP		CMP	

Lab Concentration Ref	Days	7		8		9		10		11		12	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	/	6.1	5.8	/	5.9	6.2	6.0	/	6.1	6.4	6.2	/	6.3
DO (mg/L)	/	12.8	12.9	/	12.8	12.7	12.6	/	12.7	12.8	12.6	/	12.7
pH	/	7.1	7.0	/	7.1	6.9	7.0	/	7.0	7.0	7.1	/	7.0
Cond. (µS/cm)	/	33				34				35			
Initials	/	CMP		CMP		CMP		CMP		CMP		CMP	

Lab Concentration Ref	Days	13		14		15		16		17		18	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	/	6.6	6.4	/	6.4	6.7	6.5	/	6.6	6.4	6.6	/	6.5
DO (mg/L)	/	12.7	12.4	/	12.8	12.6	12.7	/	12.5	12.7	12.5	/	12.7
pH	/	6.8	7.0	/	7.0	6.8	7.0	/	7.0	6.9	7.1	/	7.0
Cond. (µS/cm)	/	34		—		35		—		34		—	
Initials	/	CMP		CMP		CMP		CMP		CMP		CMP	

Lab Concentration Ref	Days	19		20		21		22		23		24	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)	/		6.6	6.3	6.5	6.7	6.9	/	6.9	6.9	7.1	/	7.2
DO (mg/L)	/		12.4	12.6	12.5	12.4	12.6	/	12.7	12.8	12.6	/	12.7
pH	/		7.1	6.8	6.9	6.8	7.0	/	7.1	7.0	7.1	/	7.0
Cond. (µS/cm)	/	—		33		35		36		33		34	
Initials	/	CMP		CMP		CMP		CMP		CMP		CMP	

Thermometer: CP-5 **DO meter:** 5-DS **pH meter:** 5-PS **Conductivity meter:** CP5

	Control			
Hardness*	/			
Alkalinity*	/			

* mg/L as CaCO3

Analysts: CMP, KJ2 SSM

Reviewed by:

Date reviewed:

Sample Description:

Comments:

Lab Control

Embryo-Alevin Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Myra Falls - EEM Cycle 6
Sample ID: Lab Reference Control
Work Order #: NA
Start Date & Time: May 2/19 @ 1400
Stop Date & Time: June 7/19 @ 1330
Test Species: *Oncorhynchus mykiss*

Concentration: Lab Ref	Days	25		26		27		28		29		30	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)		7.3	7.4	/	7.7	7.7	7.8	/	8.0	8.0	8.2	/	8.2
DO (mg/L)		12.6	12.4	/	12.1	12.1	12.0	/	12.0	12.0	11.9	/	11.9
pH		7.0	7.1	/	7.0	7.0	7.1	/	7.1	7.0	7.0	/	7.1
Cond. (µS/cm)		34		—		35		—		34		—	
Initials		CMP		CMP		CMP		SSM		SSM		SSM	

Concentration: Lab Ref	Days	31		32		33		34		35		36	
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)		8.0	8.1	/	8.1	8.1	8.3	/	8.2	8.2	8.1	/	8.2
DO (mg/L)		11.9	11.9	/	12.0	11.9	11.8	/	11.7	11.9	11.6	/	11.7
pH		7.0	7.1	/	7.0	7.0	7.0	/	7.1	7.1	7.0	/	7.1
Cond. (µS/cm)		33		—		36		—		34		—	
Initials		CMP		CMP		CMP		CMP		CMP		CMP	

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Concentration	Days												
	init.	new	old	new	old	new	old	new	old	new	old	new	old
Temperature (°C)													
DO (mg/L)													
pH													
Cond. (µS/cm)													
Initials													

Thermometer: CP-5 **DO meter:** 5-DS **pH meter:** 5-PS **Conductivity meter:** CP5

	Control			
Hardness*				
Alkalinity*				

* mg/L as CaCO3

Analysts: CMP, KJR, SSM
Reviewed by:
Date reviewed:

Sample Description:

Comments:

Lab Control
Rep1

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM Lab Control
Work Order No.: NA
Start Date: May 2/19 @ 1400
Termination Date: June 7/19 @ 1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
Cont. Rep1	1	22.7	0	0	0	0	
	2	23.8					
	3	23.6					
	4	23.4					
	5	22.4					
	6	22.1					
	7	22.3					
	8	23.4					
	9	23.1					
	10	24.2					
	11	22.7					
	12	22.1					
	13	22.6					
	14	23.1					
	15	22.9					
	16	22.6					
	17	22.6					
	18	22.7					
	19	22.4					
	20	21.9					
	21	22.0					
	22	21.9					
	23	22.1					
	24	22.5					
	25	23.0					
	26	22.7					
	27						
	28						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.508g / 26 Fish = 0.0965g
Number of survivors: 26
Number of deformed/have difficulty swimming: ∅

Initials: CMP

Lab Control
Rep2

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM Lab Control
Work Order No.: NA

Start Date: May 2/19 @ 1400
Termination Date: June 7/19 @ 1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
Cont Rep2	QA1	22.6	0	0	0	0	
	2	23.1					
	3	23.4					
	4	22.9					
	5	23.0					
	6	22.7					
	7	23.1					
	8	23.4		3			Mossy Eye + Jaw Protusion
	9	22.7		0			
	10	22.6					
	11	22.1					
	12	23.0					
	13	22.6					
	14	22.8					
	15	21.9					
	16	22.6					
	17	23.2					
	18	23.0					
	19	21.9					
	20	22.7					
	21	22.4					
	22	23.6					
	23	23.0					
	24	22.7					
	25	22.6					
	26	22.9					
	27	21.7					
	28	22.3					
	29	23.0					
	30	22.8					
	~~31~~						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.984g / 30 Fish = 0.0995g
Number of survivors: 30
Number of deformed/have difficulty swimming: 1

Initials: CMP

Lab Control
Rep3

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM Lab Control
Work Order No.: NA
Start Date: Mar2/19@1400
Termination Date: June7/19@1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
Cont. Rep 3	1	23.1	0	0	0	0	
	2	23.7					
	3	22.9					
	4	21.7					
	5	22.0					
	6	24.1					
	7	23.8					
	8	23.1					
	9	22.9					
	10	23.8					
	11	24.2					
	12	22.8					
	13	22.7					
	14	23.1					
	15	23.0					
	16	23.6					
	17	23.5					
	18	21.9					
	19	22.7					
	20	22.5					
	21	22.9					
	22	23.0					
	23	22.6					
	24	21.9					
	25	22.7					
	26	22.9					
	27	24.0					
	~~28~~						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.624g/27 Fish = 0.0972g
Number of survivors: 27
Number of deformed/have difficulty swimming: Ø

Initials: CMP

Lab Control
Rep 4

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM Lab Control
Work Order No.: NA

Start Date: May 2/19 @ 1400
Termination Date: June 7/19 @ 1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
Cont. Rep 4	1	21.3	0	0	0	0	
	2	21.2					
	3	22.3					
	4	22.1					
	5	21.7					
	6	21.9					
	7	23.7					
	8	23.2					
	9	21.9					
	10	22.6					
	11	22.9					
	12	23.1					
	13	21.7					
	14	24.0					
	15	23.1					
	16	22.1					
	17	21.9					
	18	22.4					
	19	23.3					
	20	21.9					
	21	22.2					
	22	22.7					
	23	21.9					
	24	22.3					
	25	23.4					
	26	22.6					
	~~27~~						
	28						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.488g / 26 Fish = 0.0957g
Number of survivors: 26
Number of deformed/have difficulty swimming: 0

Initials: CMP

MCM1
Rep 1

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM MCM1
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM1-Rep1	QA21	22.7	0	0	0	0	
	2	21.6					
	3	22.6					
	4	23.1					
	5	22.9					
	6	22.7					
	7	23.0					
	8	21.9					
	9	23.4					
	10	23.4					
	11	23.0					
	12	22.6					
	13	22.8					
	14	22.7					
	15	21.6					
	16	23.2					
	17	23.1					
	18	22.9					
	19	23.4					
	20	23.1					
	21	22.8					
	22	24.2					
	23	23.1					
	24						
	25						
	26						
	27						
	28						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.202g / 23 Fish = 0.0957g
Number of survivors: 23
Number of deformed/have difficulty swimming: ∅

Initials: CMP

MCMI
Rep 2

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM MCMI
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCMI-Rep 2	1	23.4	0	0	0	0	
	2	24.5					
	3	22.5					
	4	21.7					
	5	22.6					
	6	22.7					
	7	23.3					
	8	24.1					
	9	22.9					
	10	23.7					
	11	24.3					
	12	22.6					
	13	22.4					
	14	21.9					
	15	23.7					
	16	23.0					
	17	23.6					
	18	23.7					
	19	23.4					
	20	23.7					
	21	24.1					
	22	22.7					
	23	22.8					
	24	23.1					
	25	22.6					
	26	21.9					
	27	22.0					
	28						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.679g / 27 Fish = 0.0992g
Number of survivors: 27
Number of deformed/have difficulty swimming: ∅

Initials: CMP

MCMI Rep3

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM MCMI
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCMI-Rep3	1	23.7	0	0	0	0	
	2	23.4					
	3	21.9					
	4	22.7					
	5	23.1					
	6	23.0					
	7	24.1					
	8	22.7					
	9	21.8					
	10	22.0					
	11	22.3					
	12	22.7					
	13	22.5					
	14	23.4					
	15	23.1					
	16	23.7					
	17	23.2					
	18	22.7					
	19	24.1					
	20	23.8					
	21	24.0					
	22	22.7					
	23	22.6					
	24	23.0					
	25	22.7					
	26	23.4					
	27	23.6					
	28						
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.668g / 27 Fish = 0.0988g
Number of survivors: 27
Number of deformed/have difficulty swimming: Ø

Initials: CMP

MCM1
Rep4

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar- Cycle 6 EEM MCM1
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ ~~1730~~ 1430 CP

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM1 Rep4	1	23.1	0	0	0	0	
	2	23.7					
	3	24.0					
	4	21.6					
	5	22.7					
	6	22.4					
	7	22.0					
	8	23.0					
	9	23.7					
	10	24.0					
	11	22.8					
	12	22.6					
	13	23.1					
	14	23.7					
	15	24.2					
	16	21.9					
	17	22.3					
	18	22.6					
	19	23.5					
	20	22.9					
	21	22.7					
	22	22.4					
	23	22.3					
	24	23.1					
	25	23.4					
	26	23.6					
	27	23.1					
	28	22.9					
	29						
	30						
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.658g / 28 Fish = 0.0949g
Number of survivors: 28
Number of deformed/have difficulty swimming: ∅

Initials: CMP

S11A
Rep 1

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM S11-A
Start Date: May 11/19 @ 1500
Work Order No.: NA
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
S11-A Rep 1	QA31	23.4	0	0	0	0	
	2	23.1					
	3	23.2					
	4	22.8					
	5	22.7					
	6	23.3					
	7	24.0					
	8	23.1					
	9	22.9					
	10	22.8					
	11	23.1					
	12	23.3					
	13	23.2					
	14	23.7					
	15	~~3~~22.9					
	16						
	17						
	18						
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	40						

Total Weight (pooled): 1.443g / 15 Fish = 0.0962g
Number of survivors: 15
Number of deformed/have difficulty swimming: 0

Initials: CMP

S11A
Rep 2

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM S11-A
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
S11A Rep 2	1	22.7	0	0	0	0	
	2	22.9					
	3	23.1					
	4	23.4					
	5	22.8					
	6						
	7						
	8						
	9						
	10						
	11						
	12						
	13						
	14						
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	38						
	39						
	40						

Total Weight (pooled): 0.513g / 5 Fish = 0.1026g
Number of survivors: 5
Number of deformed/have difficulty swimming: ϕ

Initials: CMP

S11A
Rep3

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle6 EEM S11-A

Work Order No.: NA

Start Date: May 1/19 @ 1500

Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
S11A-Rep3	QA 1	23.3	0	0	0	0	
	2	23.1					
	3	23.4					
	4	22.9					
	5	23.7					
	6	23.5					
	7	22.7					
	8	23.0					
	9	22.8					
	10	23.7					
	11	23.4					
	12	23.2					
	13	23.0					
	14	24.0					
	15	23.7					
	16	22.9					
	17	22.4					
	18	23.3					
	19	24.0					
	20	23.2					
	21						
	22						
	23						
	24						
	25						
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	29						
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	31						
	32						
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	36						
	37						
	38						
	39						
	40						

Total Weight (pooled): 2.032g / 20 Fish = 0.1016g

Number of survivors: 20

Number of deformed/have difficulty swimming: ϕ

Initials: CMP

S11 A
Rep 4

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM S11-A
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
S11A-Rep4	1	23.9	0	0	0	0	
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
	12						
	13						
	14						
	15						
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	37						
	38						
	39						
	40						

Total Weight (pooled): 0.119g / 1 Fish = 0.119g
Number of survivors: 1
Number of deformed/have difficulty swimming: Ø

Initials: CMP

EFF-DS
Rep 1

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Nyrstar Myra Falls - Cycle 6 EEM EFF-DS
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
EFF-DS Rep 1	1	24.1	0	0	0	0	
	2	24.6					
	3	24.3					
	4	24.1					
	5	23.9					
	6	25.0					
	7	24.3					
	8	24.2					
	9	24.7					
	10	24.0					
	11	23.8					
	12	24.8					
	13	24.7					
	14	24.4					
	15	24.0					
	16	23.6					
	17	24.1					
	18	24.6					
	19	23.9					
	20	24.2					
	21						
	22						
	23						
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Total Weight (pooled): 2.242g/20 Fish = 0.1121g
Number of survivors: 20
Number of deformed/have difficulty swimming: ∅

Initials: CMP

EFF-DS
Rep 2

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM EFF-DS

Work Order No.: NA

Start Date: May 1/19 @ 1500

Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
EFF-DS Rep2	QA4 1	25.1	0	0	0	0	
	2	25.7					
	3	26.0					
	4	25.3					
	5	26.3					
	6	24.8					
	7	25.9	0	3 ①	0	0	① Missing 1 Eye
	8	24.4	0	0	0	0	
	9	24.7					
	10	25.3					
	11	25.7					
	12	24.9					
	13	25.1					
	14	25.3					
	15	26.0					
	16	24.7					
	17	25.3					
	18	25.2					
	19	24.9					
	20	25.7					
	21	25.0					
	22	24.7					
	23						
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Total Weight (pooled): 2.680g / 22 Fish = 0.122g

Number of survivors: 22

Number of deformed/have difficulty swimming: 1

Initials: CMP

EFF-DS
Rep3

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle6 EEM EFF-DS
Work Order No.: NA

Start Date: May1/19 @ 1500
Termination Date: June6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
EFF-DS Rep3	1	24.7	0	0	0	0	
	2	24.4					
	3	25.1					
	4	24.3					
	5	25.4					
	6	24.0					
	7	24.6					
	8	24.3					
	9	25.1					
	10	24.4					
	11	24.2					
	12	24.7					
	13	25.0					
	14	24.1					
	15	24.3					
	16	24.2					
	17						
	18						
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Total Weight (pooled): 1.625g / 16 Fish = 0.1016g
Number of survivors: 16
Number of deformed/have difficulty swimming: ∅

Initials: CMP

EFF-DS
Rep 4

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM EFF-DS
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
EFF-DS Rep 4	1	25.1	0	0	0	0	
	2	24.7					
	3	24.1					
	4	24.6					
	5	24.3					
	6	24.1					
	7	23.9					
	8	25.1					
	9	24.1					
	10	24.0					
	11	24.3					
	12	24.1					
	13	24.2					
	14	24.7					
	15	23.8					
	16						
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	40						

Total Weight (pooled): 1.842g / 15 Fish = ~~0.123~~ CP 0.1228g
Number of survivors: 15
Number of deformed/have difficulty swimming: Ø

Initials: CMP

TP4
Rep1

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM TP4
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
TP4 Rep1	1	24.6	0	0	0	0	
	2	25.1					
	3	24.8					
	4	25.5					
	5	24.4					
	6	23.9					
	7	25.1					
	8	24.7					
	9	20.1	~~3~~ 2	3	0	1	Missing Bottom Jaw, Yolk Sac, Scoliosis
	10	24.4	0	0	0	0	
	11	25.1					
	12	24.7					
	13	25.1					
	14	24.8					
	15	25.1					
	16	24.9					
	17	25.3					
	18	25.4					
	19	25.8					
	20	24.9					
	21	25.1					
	22	24.4					
	23	24.7					
	24						
	25						
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	40						

Total Weight (pooled): 2.523g / 23 Fish = 0.1097g
Number of survivors: 23
Number of deformed/have difficulty swimming: 1

Initials: CMP

TP4
Rep 2

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM TP4
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
TP4 Rep 2	1	20.1	0	0	0	0	
	2	23.9					
	3	24.7					
	4	23.6					
	5	24.1					
	6	24.3					
	7	23.9					
	8	23.7					
	9	19.8	3	0	0	0	Scoliosis
	10	24.1	0	0	0	0	
	11	23.8	0	0	0	0	
	12	24.4	0	3	0	0	Bottom Jaw Extension + Missing Eye
	13	24.0	0	0	0	0	
	14						
	15						
	16						
	17						
	18						
	19						
	20						
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	40						

Total Weight (pooled): 1.323g / 13 Fish = 0.1018g
Number of survivors: 13
Number of deformed/have difficulty swimming: 2

Initials: CMP

TP4
Rep 3

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM TP4
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
TP4-Rep3	QA51	23.3	0	0	0	0	
	2	24.2					
	3	24.1					
	4	23.7					
	5	23.6					
	6	24.0					
	7	23.9					
	8	23.8					
	9	24.1					
	10	23.9					
	11	25.0					
	12	24.7					
	13	23.8					
	14	23.0					
	15	23.7					
	16	24.0					
	17	23.8					
	18	24.4					
	19	25.1					
	20	24.6					
	21	24.4					
	22	23.9					
	23	23.7					
	24	24.0					
	25	23.8					
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Total Weight (pooled): 2.847g / 25 Fish = 0.1139g
Number of survivors: 25
Number of deformed/have difficulty swimming: 0

Initials: CMP

TP4
Rep4

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM TP4
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
TP4- Rep4	1	24.9	0	0	0	0	
	2	24.4					
	3	24.1					
	4	24.2					
	5	23.8					
	6	23.9					
	7	24.1					
	8	23.6					
	9	24.3					
	10	24.8					
	11	25.1					
	12	23.7					
	13	23.2					
	14	22.9					
	15	24.0					
	16	24.8					
	17	23.7					
	18	23.6					
	19	23.9					
	20	24.7					
	21	23.4					
	22	24.4					
	23	23.9					
	24	24.7					
	25	25.1					
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Total Weight (pooled): 2.591g / 25 Fish = 0.1036g
Number of survivors: 25
Number of deformed/have difficulty swimming: Ø

Initials: CMP

MCM2
Rep1

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM - MCM2
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM2-Rep1	QA6 1	24.6	0	0	0	0	
	2	24.8					
	3	24.3					
	4	25.0					
	5	25.1					
	6	24.7					
	7	24.4					
	8	25.3					
	9	24.7					
	10	25.1					
	11						
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Total Weight (pooled): 1.151g / 10 fish = 0.1151g
Number of survivors: ~~10~~ ~~9~~ 10
Number of deformed/have difficulty swimming: ∅

Initials: CMP

MCM2
Rep2

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM MCM2
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM2-Rep2	1	26.1	0	0	0	0	
	2	25.4					
	3	24.9					
	4	25.1					
	5	24.7					
	6	25.3					
	7	25.2					
	8	26.0					
	9	24.7					
	10	24.8					
	11	25.6					
	12	25.1					
	13	26.1					
	14	25.4					
	15	25.5					
	16	25.7					
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Total Weight (pooled): 1.881g / 16 Fish = 0.1176g
Number of survivors: 16
Number of deformed/have difficulty swimming: Ø

Initials: CMP

MCM2
Rep3

Embryo-Alevin-Fry Toxicity Test Data Sheet
Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar – Cycle 6 EEM MCM2
Work Order No.: NA

Start Date: May 1/19 @ 1500
Termination Date: June 6/19 @ 1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM2-Rep3	1	25.1	0	0	0	0	
	2	24.0					
	3	25.7					
	4	23.8					
	5	24.4					
	6	25.0					
	7	24.7					
	8	24.9					
	9	25.3					
	10	23.8					
	11	24.3					
	12	24.7					
	13	24.9					
	14	25.0					
	15	23.7					
	16	23.6					
	17	24.0					
	18	24.3					
	19	24.8					
	20	24.1					
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Total Weight (pooled): 2.301 g / 20 FISH = 0.1151 g
Number of survivors: 20
Number of deformed/have difficulty swimming: 0

Initials: CMP

MCM2
Rep4

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar-Cycle 6 EEM MCM2
Work Order No.: NA

Start Date: May 1/19 @1500
Termination Date: June 6/19 @1430

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
MCM2-Rep4	1	24.9	0	0	0	0	
	2	25.1					
	3	25.3					
	4	23.6					
	5	24.4					
	6	24.0					
	7	25.1					
	8	24.3					
	9	25.6					
	10	26.0					
	11	24.2					
	12	24.6					
	13	24.0					
	14	24.2					
	15	24.3					
	16	25.1					
	17	25.3					
	18	23.9					
	19						
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Total Weight (pooled): 2.142g/18Fish = 0.119g
Number of survivors: 18
Number of deformed/have difficulty swimming: 0

Initials: CMP

QA – 10% Deformity Re-Check by Bonnie Lo

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar – Cycle 6 EEM

Work Order No.: NA

Start Date: May 2/19 @ 1400

Termination Date: June 7/19 @ 1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
QA1-Cont-2	1	–	0	0	0	0	
	2	–					
	3	–					
	4	–					
	5	–					
	6	–		3			
	7	–		0			
	8	–					
	9	–					
	10	–					
QA2-MCM1-1	11		0	0	0	0	
	12						
	13						
	14						
	15						
	16						
	17						
	18						
	19						
	20						
QA3-S11A-1	21		0	0	0	0	
	22						
	23						
	24						
	25						
	26						
	27						
	28						
	29						
	30						
QA4-EFF05-2	31		0	0			
	32						
	33						
	34						
	35						
	36						
	37						
	38						
	39			3			Missing eye
	40			0			

Total Weight (pooled):

Number of survivors:

Number of deformed/have difficulty swimming:

Initials: BPL

QA - 10% Deformity Re-Check by Bonnie Lo

Embryo-Alevin-Fry Toxicity Test Data Sheet

Swim-up wet weight, length and deformities

Client: Myra Falls Nyrstar - Cycle 6 EEM

Work Order No.: N/A

Start Date: May 2/19 @ 1400

Termination Date: June 7/19 @ 1330

Sample ID	Fish	Length (mm)	Skeletal	Craniofacial	Finfold	Edema	Comments
QA5-TP4-3	1	—	0	0	0	0	
	2	—					
	3	—					
	4	—					
	5	—					
	6	—					
	7	—					
	8	—					
	9	—					
	10	—					
QA6-MCM2-1	11	—	0	0	0	0	
	12	—					
	13	—					
	14	—					
	15	—					
	16	—					
	17	—					
	18	—					
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	40						

Total Weight (pooled):

Number of survivors:

Number of deformed/have difficulty swimming:

Initials: BPL

NAUTILUS ENVIRONMENTAL
ATTN: Connor Pettem
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 02-May-19
Report Date: 17-MAY-19 13:52 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2261114
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Joanne Lee
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L2261114-1	L2261114-2	L2261114-3	L2261114-4	L2261114-5
	Sample ID	L2261114-1	L2261114-2	L2261114-3	L2261114-4	L2261114-5
	Description	water	water	water	water	water
	Sampled Date	01-MAY-19	01-MAY-19	01-MAY-19	01-MAY-19	01-MAY-19
	Sampled Time	08:35	01:30	12:00	10:00	02:30
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	9.53	25.0	22.3	9.90	71.0
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0190
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	0.98	1.11	1.10	0.96	1.68
	Fluoride (F) (mg/L)	<0.020	<0.020	<0.020	<0.020	0.054
	Nitrate (as N) (mg/L)	0.0116	0.0198	0.0194	0.0106	0.0519
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.058	<0.050	0.055	<0.050	<0.050
	Total Nitrogen (mg/L)	0.070	<0.050	0.074	<0.050	0.052
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Phosphorus (P)-Total (mg/L)	0.0028	<0.0020	0.0027	<0.0020	0.0027
	Sulfate (SO4) (mg/L)	0.99	13.8	13.9	1.08	65.0
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.83	1.55	1.45	1.59	1.29
Total Metals	Aluminum (Al)-Total (mg/L)	0.0933	0.0656	0.0700	0.0580	0.120
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00013	0.00014	0.00014	0.00012	0.00020
	Barium (Ba)-Total (mg/L)	0.00479	0.00514	0.00529	0.00417	0.00840
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.0000050	0.0000473	0.0000519	0.0000083	0.000123
	Calcium (Ca)-Total (mg/L)	3.58	8.80	8.40	3.93	26.1
	Cesium (Cs)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00010
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	<0.00050	0.00156	0.00151	<0.00050	0.00398
	Iron (Fe)-Total (mg/L)	0.048	0.018	0.021	0.011	0.060
	Lead (Pb)-Total (mg/L)	0.000062	0.000252	0.000317	<0.000050	0.00120
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.144	0.586	0.569	0.154	2.26
	Manganese (Mn)-Total (mg/L)	0.00845	0.00272	0.00273	0.00071	0.00891
	Molybdenum (Mo)-Total (mg/L)	0.000245	0.000247	0.000234	0.000228	0.000263
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Total (mg/L)	<0.050	0.078	0.082	<0.050	0.236
	Rubidium (Rb)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2261114-1	L2261114-2	L2261114-3	L2261114-4	L2261114-5
	Sample ID	L2261114-1	L2261114-2	L2261114-3	L2261114-4	L2261114-5
	Description	water	water	water	water	water
	Sampled Date	01-MAY-19	01MAY-19	01-MAY-19	01-MAY-19	01-MAY-19
	Sampled Time	08:35	01:30	12:00	10:00	02:30
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
WATER						
Total Metals	Selenium (Se)-Total (mg/L)	<0.000050	0.000052	0.000059	<0.000050	0.000125
	Silicon (Si)-Total (mg/L)	0.92	1.04	1.04	0.92	1.32
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000016
	Sodium (Na)-Total (mg/L)	0.619	0.873	0.885	0.605	1.77
	Strontium (Sr)-Total (mg/L)	0.00713	0.0237	0.0233	0.00793	0.0905
	Sulfur (S)-Total (mg/L)	<0.50	4.25	4.18	<0.50	20.3
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00114	<0.00030	DLM <0.00060	<0.00030	DLM <0.0012
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000032	0.000024	0.000027	0.000024	0.000020
	Vanadium (V)-Total (mg/L)	0.00050	<0.00050	<0.00050	<0.00050	0.00062
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0175	0.0165	<0.0030	0.0350
	Zirconium (Zr)-Total (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0592	0.0586	0.0587	0.0574	0.0902
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.00421	0.00482	0.00464	0.00409	0.00623
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000462	0.0000395	0.0000086	0.0000457
	Calcium (Ca)-Dissolved (mg/L)	3.57	8.95	7.92	3.69	24.6
	Cesium (Cs)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	0.00102	0.00087	<0.00020	0.00069
	Iron (Fe)-Dissolved (mg/L)	<0.010	0.014	<0.010	<0.010	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000059	<0.000050	<0.000050	0.000057
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	0.151	0.634	0.603	0.170	2.33
	Manganese (Mn)-Dissolved (mg/L)	0.00040	0.00157	0.00109	0.00038	0.00213
	Molybdenum (Mo)-Dissolved (mg/L)	0.000217	0.000232	0.000216	0.000203	0.000265
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2261114-1	L2261114-2	L2261114-3	L2261114-4	L2261114-5
	Description	water	water	water	water	water
	Sampled Date	01-MAY-19	01-MAY-19	01-MAY-19	01-MAY-19	01-MAY-19
	Sampled Time	08:35	01:30	12:00	10:00	02:30
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	0.069	0.113	0.105	0.068	0.282
	Rubidium (Rb)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	0.00021
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000118
	Silicon (Si)-Dissolved (mg/L)	0.924	1.05	1.04	0.971	1.36
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	0.647	0.907	0.883	0.667	1.97
	Strontium (Sr)-Dissolved (mg/L)	0.00760	0.0248	0.0232	0.00761	0.0885
	Sulfur (S)-Dissolved (mg/L)	<0.50	4.03	4.33	<0.50	21.2
	Tellurium (Te)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tungsten (W)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Dissolved (mg/L)	0.000030	0.000024	0.000025	0.000026	0.000021
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	0.0149	0.0132	0.0023	0.0110
	Zirconium (Zr)-Dissolved (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Boron (B)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Nickel (Ni)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L2261114-1, -2, -3, -4, -5
Matrix Spike	Sulfate (SO4)	MS-B	L2261114-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

NAUTILUS ENVIRONMENTAL
ATTN: Connor Pettem
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 23-MAY-19
Report Date: 06-JUN-19 18:02 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2278340
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Joanne Lee
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2278340-1	L2278340-2	L2278340-3	L2278340-4	L2278340-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	6.97	21.3	21.7	9.77	67.9
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0206
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	0.61	0.76	0.75	0.59	1.31
	Fluoride (F) (mg/L)	<0.020	<0.020	<0.020	<0.020	0.041
	Nitrate (as N) (mg/L)	<0.0050	0.0151	0.0160	<0.0050	0.0589
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0016
	Total Kjeldahl Nitrogen (mg/L)	<0.050	0.055	<0.050	<0.050	0.062
	Total Nitrogen (mg/L)	0.173	0.175	0.225	<0.030	0.110
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	0.73	10.6	11.3	0.81	52.3
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	2.71	2.47	3.20	2.81	2.45
Total Metals	Aluminum (Al)-Total (mg/L)	0.0388	0.0380	0.0404	0.0358	0.0705
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	<0.00010	0.00015	0.00013	0.00014	0.00015
	Barium (Ba)-Total (mg/L)	0.00305	0.00398	0.00407	0.00318	0.00661
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.0000050	0.0000339	0.0000392	0.0000091	0.0000755
	Calcium (Ca)-Total (mg/L)	2.69	7.94	7.75	3.71	23.0
	Cesium (Cs)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	<0.00050	0.00094	0.00676	<0.00050	0.00242
	Iron (Fe)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	0.011
	Lead (Pb)-Total (mg/L)	<0.000050	0.000065	0.000057	<0.000050	0.000244
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.117	0.484	0.489	0.151	1.73
	Manganese (Mn)-Total (mg/L)	0.00058	0.00183	0.00205	0.00046	0.00758
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.000215	0.000207	0.000246	0.000199	0.000347
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Total (mg/L)	<0.050	0.054	0.064	<0.050	0.253
	Rubidium (Rb)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2278340-1	L2278340-2	L2278340-3	L2278340-4	L2278340-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Total Metals	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	0.000059	<0.000050	0.000117
	Silicon (Si)-Total (mg/L)	0.72	0.91	0.88	0.77	1.26
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	0.503	0.703	0.734	0.504	1.70
	Strontium (Sr)-Total (mg/L)	0.00553	0.0197	0.0205	0.00632	0.0809
	Sulfur (S)-Total (mg/L)	<0.50	3.40	3.64	<0.50	17.4
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	<0.00030	<0.00030	<0.00030	0.00037	<0.00030
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Total (mg/L)	0.000021	0.000016	0.000017	0.000018	0.000013
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00054
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0134	0.0139	0.0033	0.0268
	Zirconium (Zr)-Total (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0402	0.0354	0.0403	0.0323	0.0649
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	<0.00010	<0.00010	0.00015	0.00013	0.00011
	Barium (Ba)-Dissolved (mg/L)	0.00364	0.00414	0.00434	0.00329	0.00713
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	DTMF 0.0000371	0.0000276	DTMF 0.000296	0.0000052	0.0000413
	Calcium (Ca)-Dissolved (mg/L)	2.58	7.70	7.84	3.64	24.1
	Cesium (Cs)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	0.00076	0.00085	<0.00020	0.00059
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000115
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	0.127	0.509	0.511	0.163	1.87
	Manganese (Mn)-Dissolved (mg/L)	0.00029	0.00106	0.00102	0.00017	0.00181
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2278340-1	L2278340-2	L2278340-3	L2278340-4	L2278340-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19	22-MAY-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM1	MYRA FALLS MCM2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Dissolved Metals	Molybdenum (Mo)-Dissolved (mg/L)	0.000240	0.000227	0.000227	0.000203	0.000349
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	<0.050	0.071	0.065	<0.050	0.284
	Rubidium (Rb)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	0.00020
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000139
	Silicon (Si)-Dissolved (mg/L)	0.714	0.912	0.927	0.819	1.30
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	0.521	0.684	0.717	0.482	1.75
	Strontium (Sr)-Dissolved (mg/L)	0.00546	0.0191	0.0194	0.00647	0.0792
	Sulfur (S)-Dissolved (mg/L)	<0.50	3.62	4.02	<0.50	19.1
	Tellurium (Te)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tungsten (W)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Uranium (U)-Dissolved (mg/L)	0.000019	0.000012	0.000013	0.000015	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0011	0.0134	0.0128	0.0032	0.0129
	Zirconium (Zr)-Dissolved (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Copper (Cu)-Total	MS-B	L2278340-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Total	MS-B	L2278340-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DTMF	Dissolved concentration exceeds total for field-filtered metals sample. Metallic contaminants may have been introduced to dissolved sample during field filtration.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

ALS Test Code	Matrix	Test Description	Method Reference**
HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

ALS Test Code	Matrix	Test Description	Method Reference**
HG-T-CVAA-VA	Water	Total Mercury in Water by CVAAS or CVAFS	EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Reference Information

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA4500-P(J)/NEMI9171/USGS03-4174

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

NAUTILUS ENVIRONMENTAL
ATTN: Connor Pettem
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 09-JUN-19
Report Date: 19-JUN-19 15:19 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2288065
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Joanne Lee
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2288065-1	L2288065-2	L2288065-3	L2288065-4	L2288065-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM 1	MYRA FALLS MCM 2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	7.43	35.9	32.9	9.60	107
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	0.0319	0.0356	<0.0050	0.173
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	0.58	0.95	0.93	0.60	2.19
	Fluoride (F) (mg/L)	<0.020	0.027	0.025	<0.020	0.098
	Nitrate (as N) (mg/L)	<0.0050	0.100	0.0933	<0.0050	0.429
	Nitrite (as N) (mg/L)	<0.0010	0.0016	0.0015	<0.0010	0.0072
	Total Kjeldahl Nitrogen (mg/L)	<0.050	0.081	0.079	<0.050	0.279
	Total Nitrogen (mg/L)	<0.030	0.165	0.168	0.030	0.671
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	0.88	24.8	23.5	0.99	100
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.92	2.00	2.08	1.88	3.11
Total Metals	Aluminum (Al)-Total (mg/L)	0.0613	0.0414	0.0435	0.0269	0.111
	Antimony (Sb)-Total (mg/L)	<0.00010	0.00014	0.00014	<0.00010	0.00057
	Arsenic (As)-Total (mg/L)	<0.00010	0.00015	0.00019	0.00013	0.00038
	Barium (Ba)-Total (mg/L)	0.00405	0.00807	0.00820	0.00324	0.0285
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	0.013
	Cadmium (Cd)-Total (mg/L)	<0.0000050	0.0000581	0.0000579	0.0000092	0.000205
	Calcium (Ca)-Total (mg/L)	2.86	12.6	12.5	3.70	39.8
	Cesium (Cs)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000017
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00016
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	<0.00050	0.00127	0.00131	<0.00050	0.00360
	Iron (Fe)-Total (mg/L)	0.027	<0.010	<0.010	<0.010	0.035
	Lead (Pb)-Total (mg/L)	0.000073	0.000471	0.000541	<0.000050	0.00336
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.135	0.739	0.681	0.159	2.45
	Manganese (Mn)-Total (mg/L)	0.00328	0.00191	0.00175	0.00047	0.00551
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.000257	0.000660	0.000680	0.000259	0.00230
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Total (mg/L)	<0.050	0.387	0.387	<0.050	1.71
	Rubidium (Rb)-Total (mg/L)	<0.00020	<0.00020	0.00021	<0.00020	0.00081

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2288065-1	L2288065-2	L2288065-3	L2288065-4	L2288065-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM 1	MYRA FALLS MCM 2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Total Metals	Selenium (Se)-Total (mg/L)	<0.000050	0.000144	0.000155	<0.000050	0.000577
	Silicon (Si)-Total (mg/L)	0.76	1.03	0.99	0.79	1.54
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	0.552	1.16	1.12	0.512	3.39
	Strontium (Sr)-Total (mg/L)	0.00616	0.0380	0.0370	0.00684	0.138
	Sulfur (S)-Total (mg/L)	<0.50	8.31	7.90	<0.50	34.9
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00108	<0.00030	<0.00030	<0.00030	0.00033
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00023
	Uranium (U)-Total (mg/L)	0.000024	0.000017	0.000017	0.000019	0.000015
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00054
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0174	0.0180	<0.0030	0.0539
	Zirconium (Zr)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0270	0.0356	0.0377	0.0263	0.0978
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	0.00014	0.00014	<0.00010	0.00056
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00017	0.00015	0.00012	0.00030
	Barium (Ba)-Dissolved (mg/L)	0.00319	0.00626	0.00628	0.00316	0.0146
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	0.013
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000497	0.0000420	0.0000088	0.0000380
	Calcium (Ca)-Dissolved (mg/L)	2.77	13.2	12.1	3.58	38.7
	Cesium (Cs)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000015
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00026	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	0.00089	0.00080	<0.00020	0.00094
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000093	0.000075	<0.000050	0.000122
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	0.124	0.738	0.680	0.161	2.51
	Manganese (Mn)-Dissolved (mg/L)	0.00033	0.00131	0.00093	0.00033	0.00147
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2288065-1	L2288065-2	L2288065-3	L2288065-4	L2288065-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19
	Sampled Time	12:00	12:30	12:45	13:00	13:15
	Client ID	MYRA FALLS MCM 1	MYRA FALLS MCM 2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
WATER						
Dissolved Metals	Molybdenum (Mo)-Dissolved (mg/L)	0.000250	0.000688	0.000664	0.000261	0.00222
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	<0.050	0.390	0.388	<0.050	1.80
	Rubidium (Rb)-Dissolved (mg/L)	<0.00020	0.00021	0.00020	<0.00020	0.00083
	Selenium (Se)-Dissolved (mg/L)	<0.000050	0.000133	0.000163	<0.000050	0.000605
	Silicon (Si)-Dissolved (mg/L)	0.733	0.970	0.945	0.756	1.45
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	0.502	1.10	1.05	0.512	3.31
	Strontium (Sr)-Dissolved (mg/L)	0.00580	0.0376	0.0359	0.00670	0.134
	Sulfur (S)-Dissolved (mg/L)	<0.50	8.19	7.97	<0.50	35.5
	Tellurium (Te)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tungsten (W)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00024
	Uranium (U)-Dissolved (mg/L)	0.000019	0.000016	0.000014	0.000016	0.000014
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	0.0151	0.0134	0.0057	0.0106
	Zirconium (Zr)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Laboratory Control Sample	Boron (B)-Dissolved	MES	L2288065-1, -2, -3, -4, -5
Matrix Spike	Dissolved Organic Carbon	MS-B	L2288065-1, -2, -3, -4
Matrix Spike	Total Nitrogen	MS-B	L2288065-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

ALS Test Code	Matrix	Test Description	Method Reference**
CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

ALS Test Code	Matrix	Test Description	Method Reference**
HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

ALS Test Code	Matrix	Test Description	Method Reference**
HG-T-CVAA-VA	Water	Total Mercury in Water by CVAAS or CVAFS	EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA4500-P(J)/NEMI9171/USGS03-4174

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

Reference Information

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

NAUTILUS ENVIRONMENTAL
ATTN: Connor Pettem
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 09-JUN-19
Report Date: 23-JUL-19 18:03 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2288066
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Joanne Lee
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2288066-1	L2288066-2	L2288066-3	L2288066-4	L2288066-5
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19	06-JUN-19
	Sampled Time	22:00	22:30	23:00	23:30	
	Client ID	MYRA FALLS MCM 1	MYRA FALLS MCM 2	MYRA FALLS TP4	MYRA FALLS S11A	MYRA FALLS EFF-DS
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	85.0	86.8	90.9	87.2	89.4
Metals	Aluminum (Al)-Total (mg/kg wwt)	<1.0	<1.0	<1.0	<1.0	2.5
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg wwt)	0.0258	0.0265	0.0206	0.0312	0.0232
	Barium (Ba)-Total (mg/kg wwt)	0.150	0.108	0.055	0.248	0.150
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg wwt)	<0.20	<0.20	<0.20	<0.20	<0.20
	Cadmium (Cd)-Total (mg/kg wwt)	<0.0020	0.0028	<0.0020	<0.0020	0.0049
	Calcium (Ca)-Total (mg/kg wwt)	335	454	249	513	545
	Cesium (Cs)-Total (mg/kg wwt)	0.0019	0.0020	0.0013	0.0019	0.0015
	Chromium (Cr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040
	Cobalt (Co)-Total (mg/kg wwt)	0.0042	0.0054	<0.0040	0.0045	0.0055
	Copper (Cu)-Total (mg/kg wwt)	0.701	0.781	0.516	0.778	0.694
	Iron (Fe)-Total (mg/kg wwt)	5.2	6.8	3.7	6.1	7.3
	Lead (Pb)-Total (mg/kg wwt)	<0.010	0.013	<0.010	<0.010	0.021
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg wwt)	187	199	113	221	154
	Manganese (Mn)-Total (mg/kg wwt)	0.185	0.281	0.135	0.337	0.406
	Molybdenum (Mo)-Total (mg/kg wwt)	<0.0080	0.0102	<0.0080	0.0087	0.0289
	Nickel (Ni)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040
	Phosphorus (P)-Total (mg/kg wwt)	1820	1980	1240	2070	1590
	Potassium (K)-Total (mg/kg wwt)	1340	2260	1450	1560	2000
	Rubidium (Rb)-Total (mg/kg wwt)	1.15	1.33	0.862	1.29	0.937
	Selenium (Se)-Total (mg/kg wwt)	0.236	0.246	0.157	0.263	0.185
	Sodium (Na)-Total (mg/kg wwt)	700	849	553	808	757
	Strontium (Sr)-Total (mg/kg wwt)	0.285	0.359	0.207	0.434	0.484
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg wwt)	0.00096	0.00291	0.00160	0.00096	0.00294
	Tin (Sn)-Total (mg/kg wwt)	0.040	0.050	0.022	0.029	0.023
	Uranium (U)-Total (mg/kg wwt)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
	Vanadium (V)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Zinc (Zn)-Total (mg/kg wwt)	8.95	9.80	6.04	11.4	9.51
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2288066-6				
	Description	Tissue				
	Sampled Date	07-JUN-19				
	Sampled Time	12:00				
	Client ID	LAB CONTROL				
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	81.6				
Metals	Aluminum (Al)-Total (mg/kg wwt)	<1.0				
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020				
	Arsenic (As)-Total (mg/kg wwt)	0.0405				
	Barium (Ba)-Total (mg/kg wwt)	0.176				
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020				
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020				
	Boron (B)-Total (mg/kg wwt)	<0.20				
	Cadmium (Cd)-Total (mg/kg wwt)	<0.0020				
	Calcium (Ca)-Total (mg/kg wwt)	437				
	Cesium (Cs)-Total (mg/kg wwt)	0.0028				
	Chromium (Cr)-Total (mg/kg wwt)	<0.040				
	Cobalt (Co)-Total (mg/kg wwt)	0.0053				
	Copper (Cu)-Total (mg/kg wwt)	0.966				
	Iron (Fe)-Total (mg/kg wwt)	7.3				
	Lead (Pb)-Total (mg/kg wwt)	<0.010				
	Lithium (Li)-Total (mg/kg wwt)	<0.10				
	Magnesium (Mg)-Total (mg/kg wwt)	281				
	Manganese (Mn)-Total (mg/kg wwt)	0.339				
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0134				
	Nickel (Ni)-Total (mg/kg wwt)	<0.040				
	Phosphorus (P)-Total (mg/kg wwt)	2620				
	Potassium (K)-Total (mg/kg wwt)	1820				
	Rubidium (Rb)-Total (mg/kg wwt)	1.87				
	Selenium (Se)-Total (mg/kg wwt)	0.314				
	Sodium (Na)-Total (mg/kg wwt)	866				
	Strontium (Sr)-Total (mg/kg wwt)	0.448				
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040				
	Thallium (Tl)-Total (mg/kg wwt)	0.00046				
	Tin (Sn)-Total (mg/kg wwt)	0.033				
	Uranium (U)-Total (mg/kg wwt)	<0.00040				
	Vanadium (V)-Total (mg/kg wwt)	<0.020				
	Zinc (Zn)-Total (mg/kg wwt)	13.5				
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-WET-MICR-CCMS-VA	Tissue	Metals in Tissue by CRC ICPMS (WET)	EPA 200.3/6020B

This method is conducted following British Columbia Lab Manual method "Metals in Animal Tissue and Vegetation (Biota) - Prescriptive". Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with addition of hydrogen peroxide. Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020B).

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-MICR-VA	Tissue	Moisture in Tissue	Puget Sound WQ Authority, Apr 1997

This analysis is carried out gravimetrically by drying the sample at <60 deg. C.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

APPENDIX C – Angling survey data

Myra Falls Fish Survey August 29,30 2019

Reference Sites

Sample ID	Location	Length (cm)	Weight (g)	Condition Factor
1	Car Bridge Pool	13.5	30	1.22
2		20.5	92	1.07
3		16.5	38	0.85
4		18	60	1.03
5		17.5	48	0.90
6		17.5	CO	CO
7		23	130	1.07
8		17	CO	CO
9		15	CO	CO
10		14	42	1.53
11		16.5	56	1.25
12		15	42	1.24
13		16	48	1.17
14		13.5	29	1.18
15		15	CO	CO
16		16	CO	CO
17	Car Bridge To Arnica	13	34	1.55
18		13	CO	CO
19		15	CO	CO
20		14.5	32	1.05
21		14.5	CO	CO
22		17	72	1.47
23		12	CO	CO
24		13	CO	CO
25		14	CO	CO
26		15	42	1.24
27		18	60	1.03
28		17.5	54	1.01
29		10	CO	CO
30		13.5	36	1.46
31		18.5	72	1.14
32		18	68	1.17

33		14.5	40	1.31
34		13.5	32	1.30
35		13.5	CO	CO
36	Just Below Arnica	12.5	20	1.02
37		11.5	24	1.58
38		10	CO	CO
39		15	CO	CO
40		15.5	52	1.40
41		15.5	46	1.24
42		15	CO	CO
43		17	38	0.77
44		15	CO	CO
45		12	CO	CO
46		15	CO	CO
47		12.5	CO	CO
48		14	32	1.17
49		13	CO	CO
50		14.5	42	1.38
51		18	CO	CO
52		18	CO	CO
53		16	48	1.17
54		17	38	0.77
55	Arnica Creek	15	CO	CO
56		14.5	30	0.98
57		15	34	1.01
58		19	62	0.90
59		15	CO	CO
60		15	CO	CO
61		15	CO	CO
62		16	CO	CO
63		20.5	60	0.70
64		16	CO	CO
65		16	CO	CO
66		15	CO	CO
67		16	CO	CO

68		11	CO	CO
69		17	CO	CO
70	Above Arnica, near Island	18	45	0.77
71		17.5	48	0.90
72		15	26	0.77
73		10	CO	CO
74		13	CO	CO
75		13	CO	CO
76		12	CO	CO
77		14	32	1.17
78		18	56	0.96
79		12.5	18	0.92
80		14.5	38	1.25
81		16	38	0.93
82		15	CO	CO
83		15	CO	CO
84		15	CO	CO
85		18	CO	CO
	Total Caught	43		
	Total Call Outs	42		

Myra Falls Fish Survey August 29,30 2019

Exposure Sites

Sample ID	Location	Length (cm)	Weight (g)	Condition Factor
1	Under Bridge TP4	15	CO	CO
2		20	80	1
3		15	CO	CO
4		16	CO	CO
5		32.5	CO	CO
6		16.5	32	0.71
7		17	CO	CO
8		17	CO	CO
9		18	CO	CO
10		24.5	126	0.86
11		13	CO	CO
12		16	26	0.63
13		16.5	30	0.67
14		19.5	60	0.81
15		20	CO	CO
16		21	CO	CO
17		12	15	0.87
18		17.5	86	1.60
19		15	CO	CO
20		21.5	95	0.96
21		22.5	CO	CO
22		13	CO	CO
23		16.5	30	0.67
24		16	32	0.78
25		15.5	36	0.97
26		15.5	34	0.91
27		22	96	0.90
28		16	CO	CO
29		15	CO	CO
30		15	CO	CO
31	TP4 100M D/S	20	70	0.88

32		16	CO	CO
33		17	32	0.65
34		13	CO	CO
35		18	CO	CO
36		15.5	22	0.59
37		16	CO	CO
38	TP4 200M D/S	17	CO	CO
39		16	CO	CO
40		19.5	46	0.62
41		16	CO	CO
42		17	CO	CO
43	Top of Deep Pool	27	132	0.67
44		12.5	16	0.82
45		18	52	0.89
46		17	CO	CO
47		15.5	34	0.91
48		17	38	0.77
49		17	CO	CO
50		15.5	CO	CO
51	100M U/S M2	16	CO	CO
52		17	CO	CO
53		20	CO	CO
54		16.5	CO	CO
55		15.5	24	0.64
56		17	CO	CO
57		19.5	58	0.78
58		22	CO	CO
59		12.5	12	0.61
60		17	36	0.73
	Total Caught	28		
	Total Call Outs	32		

APPENDIX D – Effluent and receiving water analytical chemistry data

NAUTILUS ENVIRONMENTAL
ATTN: Connor Pettem
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-SEP-19
Report Date: 11-SEP-19 17:22 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2340392

Project P.O. #: Effluent Mixing Study

Job Reference:

C of C Numbers:

Legal Site Desc:

Hilary Woods
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L2340392-1 Water 03-SEP-19 15:00 EFF-DS 0M	L2340392-2 Water 03-SEP-19 15:00 100M	L2340392-3 Water 03-SEP-19 15:00 250M	L2340392-4 Water 03-SEP-19 15:00 TP4	L2340392-5 Water 03-SEP-19 15:00 MCM2
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.491	0.450	0.217	0.171	0.142
	Nitrate (as N) (mg/L)	1.07	0.977	0.546	0.517	0.459
	Nitrite (as N) (mg/L)	0.0158	0.0140	0.0076	0.0058	0.0038
	Total Kjeldahl Nitrogen (mg/L)	0.798	0.689	0.367	0.270	0.198
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	246	225	124	99.7	84.9
Total Metals	Aluminum (Al)-Total (mg/L)	0.351	0.327	0.181	0.130	0.0907
	Antimony (Sb)-Total (mg/L)	0.00262	0.00241	0.00132	0.00104	0.00092
	Arsenic (As)-Total (mg/L)	0.00096	0.00085	0.00053	0.00046	0.00031
	Barium (Ba)-Total (mg/L)	0.0237	0.0231	0.0149	0.0139	0.0135
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.045	0.041	0.024	0.019	0.017
	Cadmium (Cd)-Total (mg/L)	0.000192	0.000211	0.000155	0.000168	0.000163
	Calcium (Ca)-Total (mg/L)	83.5	77.8	46.3	36.6	33.3
	Cesium (Cs)-Total (mg/L)	0.000050	0.000049	0.000026	0.000021	0.000017
	Chromium (Cr)-Total (mg/L)	0.00018	0.00022	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00011	0.00011	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	0.00533	0.00580	0.00302	0.00340	0.00241
	Iron (Fe)-Total (mg/L)	<0.010	0.013	0.010	<0.010	<0.010
	Lead (Pb)-Total (mg/L)	0.000642	0.000843	0.000401	0.000390	0.000157
	Lithium (Li)-Total (mg/L)	0.0021	0.0019	0.0011	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	8.27	7.56	4.21	3.44	3.10
	Manganese (Mn)-Total (mg/L)	0.0194	0.0201	0.0117	0.00939	0.00682
	Molybdenum (Mo)-Total (mg/L)	0.00390	0.00356	0.00205	0.00171	0.00210
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Total (mg/L)	3.60	3.27	1.75	1.41	1.31
	Rubidium (Rb)-Total (mg/L)	0.00137	0.00132	0.00071	0.00056	0.00064
	Selenium (Se)-Total (mg/L)	0.000618	0.000624	0.000267	0.000239	0.000284
	Silicon (Si)-Total (mg/L)	3.19	3.03	2.14	1.97	1.89
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	11.7	11.1	6.02	4.93	4.07
	Strontium (Sr)-Total (mg/L)	0.306	0.279	0.153	0.126	0.108
	Sulfur (S)-Total (mg/L)	92.1	84.4	44.8	36.5	31.0
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Total (mg/L)	0.000012	0.000010	<0.000010	<0.000010	<0.000010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2340392-1	L2340392-2	L2340392-3	L2340392-4	L2340392-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-SEP-19	03-SEP-19	03-SEP-19	03-SEP-19	03-SEP-19
	Sampled Time	15:00	15:00	15:00	15:00	15:00
	Client ID	EFF-DS 0M	100M	250M	TP4	MCM2
Grouping	**Analyte**					
WATER						
Total Metals	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tungsten (W)-Total (mg/L)	0.00232	0.00212	0.00111	0.00084	0.00055
	Uranium (U)-Total (mg/L)	0.000028	0.000026	0.000023	0.000021	0.000017
	Vanadium (V)-Total (mg/L)	0.00085	0.00079	0.00053	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	0.0436	0.0511	0.0423	0.0471	0.0450
	Zirconium (Zr)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.306	0.287	0.158	0.0882	0.0658
	Antimony (Sb)-Dissolved (mg/L)	0.00282	0.00261	0.00145	0.00107	0.00096
	Arsenic (As)-Dissolved (mg/L)	0.00087	0.00083	0.00054	0.00043	0.00033
	Barium (Ba)-Dissolved (mg/L)	0.0212	0.0209	0.0156	0.0142	0.0142
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.045	0.041	0.023	0.019	0.017
	Cadmium (Cd)-Dissolved (mg/L)	0.000141	0.000152	0.000154	0.000163	0.000151
	Calcium (Ca)-Dissolved (mg/L)	89.7	82.1	47.8	37.9	33.6
	Cesium (Cs)-Dissolved (mg/L)	0.000056	0.000049	0.000028	0.000020	0.000020
	Chromium (Cr)-Dissolved (mg/L)	0.00013	0.00013	0.00011	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00012	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00259	0.00257	0.00209	0.00212	0.00240
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Lead (Pb)-Dissolved (mg/L)	0.000081	<0.000050	0.000070	0.000103	0.000166
	Lithium (Li)-Dissolved (mg/L)	0.0023	0.0020	0.0011	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	8.29	7.86	4.31	3.30	2.84
	Manganese (Mn)-Dissolved (mg/L)	0.0130	0.0148	0.0102	0.00918	0.00590
	Molybdenum (Mo)-Dissolved (mg/L)	0.00389	0.00370	0.00218	0.00173	0.00209
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.61	3.37	1.89	1.42	1.32
	Rubidium (Rb)-Dissolved (mg/L)	0.00128	0.00123	0.00069	0.00050	0.00062
	Selenium (Se)-Dissolved (mg/L)	0.000698	0.000586	0.000311	0.000244	0.000231
	Silicon (Si)-Dissolved (mg/L)	3.18	3.00	2.14	1.94	1.83
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	11.3	10.4	6.19	4.88	3.97
	Strontium (Sr)-Dissolved (mg/L)	0.287	0.267	0.156	0.118	0.0997

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L2340392-1	L2340392-2	L2340392-3	L2340392-4	L2340392-5
Description		Water	Water	Water	Water	Water
Sampled Date		03-SEP-19	03-SEP-19	03-SEP-19	03-SEP-19	03-SEP-19
Sampled Time		15:00	15:00	15:00	15:00	15:00
Client ID		EFF-DS 0M	100M	250M	TP4	MCM2
Grouping	**Analyte**					
WATER						
Dissolved Metals	Sulfur (S)-Dissolved (mg/L)	90.9	84.1	44.1	34.6	29.0
	Tellurium (Te)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	0.000011	<0.000010	<0.000010	<0.000010	<0.000010
	Thorium (Th)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Tungsten (W)-Dissolved (mg/L)	0.00218	0.00201	0.00108	0.00080	0.00050
	Uranium (U)-Dissolved (mg/L)	0.000026	0.000025	0.000020	0.000018	0.000016
	Vanadium (V)-Dissolved (mg/L)	0.00071	0.00068	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0287	0.0319	0.0428	0.0484	0.0458
	Zirconium (Zr)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9031832
Report Date: 2019-04-03 17:07:22

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project Effluent Characterization
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9031832-01	9051312-01	9080697-05	9081523-01	N001934-01	9110068-05
CLIENT ID				MC-M1	MC-M1	MC-M1	MC-M1	MC-M1	MC-M1
DATE SAMPLED				2019-03-20	2019-05-14	2019-08-07	2019-08-14	2019-11-13	2019-11-14
DATE RECEIVED				2019-03-22	2019-05-15	2019-08-09	2019-08-16	2019-11-15	2019-11-18
MATRIX				Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**						
Anions	Chloride	mg/L	0.1	0.85	0.7		0.49	0.63	
Anions	Fluoride	mg/L	0.1	0.1	0.1		0.1	0.1	
Anions	Nitrate+Nitrite (as N)	mg/L	0.005	0.0233	0.01	0.0185	0.032	0.02	0.005
Anions	Nitrite (as N)	mg/L	0.005	0.005	0.01		0.01	0.01	
Anions	Sulfate	mg/L	1	1.5	1	1.4	1.7	1.8	1
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	12.4	7.14	11.5	13.1	12.6	2.81
Calculated Parameters	Nitrate (as N)	mg/L	0.01	0.0233	0.02		0.032	0.01	
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.0831	0.0395	0.0214	0.0177	0.0268	0.0284
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.005	0.005	0.0057	0.0059	0.0055	0.005
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.005	0.005	0.0103	0.0071	0.0227	0.0205
Dissolved Metals	Cadmium, dissolved	mg/L	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Calcium, dissolved	mg/L	0.2	4.63	2.66	4.3	4.9	4.73	0.98
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.0005	0.00095	0.00077	0.00083	0.00086	0.00121
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	0.199	0.119	0.188	0.199	0.19	0.086
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00031	0.0002	0.0002	0.0002	0.0002	0.00355
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00031	0.00021	0.00043	0.00047	0.00039	0.00024
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Silicon, dissolved	mg/L	1	1.2	1	1	1.1	1	1
Dissolved Metals	Silver, dissolved	mg/L	0.00005	0.00005	0.00005	0.000053	0.00005	0.00005	0.000108
Dissolved Metals	Sodium, dissolved	mg/L	0.1	0.41	0.49	0.62	0.67	0.64	0.44
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.0106	0.0057	0.0108	0.0121	0.0114	0.003
Dissolved Metals	Sulfur, dissolved	mg/L	3	3	3	3	3	3	3
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Metals	Uranium, dissolved	mg/L	0.00002	0.000034	0.000026	0.000023	0.000023	0.000037	0.00002
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	11.4	6.8	8.3	12.8	12.7	1
General Parameters	Alkalinity, Phenolphthalein (as CaCO3)	mg/L	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3)	mg/L	1	11.4	6.8	8.3	12.8	12.7	1
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1
General Parameters	Ammonia, Total (as N)	mg/L	0.02	0.034	0.038		0.024	0.02	
General Parameters	Carbon, Total Organic	mg/L	0.5	1.37	1.31		0.5	1.36	
General Parameters	Carbon, Dissolved Organic	mg/L	0.5	1.37	1.2		0.5	1.24	
General Parameters	Phosphorus, Total (as P)	mg/L	0.002	0.002	0.0053	0.0043	0.0021	0.002	0.004
General Parameters	Solids, Total Suspended	mg/L	2	2	2	2	2	2	2
General Parameters	pH	pH units	0.1	6.43	6.57	7.04	7.41	7.03	5.39
General Parameters	Conductivity (EC)	uS/cm	2	33	19	27	30.7	27.3	7.5
Radioactivity Parameters	Radium-226	Bq/L	0.005	0.005			0.006	0.005	
Total Metals	Aluminum, total	mg/L	0.005	0.0448	0.0456	0.0264	0.0259	0.0356	0.039
Total Metals	Antimony, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Total Metals	Arsenic, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Barium, total	mg/L	0.005	0.0052	0.005	0.006	0.0062	0.0053	0.005
Total Metals	Beryllium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.005	0.0075	0.007	0.0066	0.024	0.0287
Total Metals	Cadmium, total	mg/L	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Total Metals	Calcium, total	mg/L	0.2	5.03	2.82	4.74	5.37	5.2	0.95
Total Metals	Chromium, total	mg/L	0.0005	0.0005	0.00091	0.00129	0.00157	0.00077	0.00137
Total Metals	Cobalt, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Total Metals	Copper, total	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Total Metals	Iron, total	mg/L	0.01	0.01	0.01	0.01	0.015	0.01	0.026
Total Metals	Lead, total	mg/L	0.0002	0.0002	0.00059	0.0002	0.0002	0.0002	0.0002
Total Metals	Lithium, total	mg/L	0.0001	0.0001	0.0001	0.00013	0.00015	0.0001	0.0001
Total Metals	Magnesium, total	mg/L	0.01	0.221	0.125	0.208	0.231	0.214	0.083
Total Metals	Manganese, total	mg/L	0.0002	0.0005	0.0002	0.00036	0.00039	0.00033	0.00425
Total Metals	Mercury, total	mg/L	0.00001	0.00001	0.00001		0.00001	0.00001	
Total Metals	Molybdenum, total	mg/L	0.0001	0.00034	0.00031	0.00039	0.00052	0.00035	0.00029
Total Metals	Nickel, total	mg/L	0.0004	0.0004	0.0004	0.0004	0.00041	0.0004	0.0004
Total Metals	Phosphorus, total	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Metals	Potassium, total	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Metals	Selenium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Silicon, total	mg/L	1	1.2	1	1.2	1.2	1.3	1.6
Total Metals	Silver, total	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Metals	Sodium, total	mg/L	0.1	0.8	0.53	0.69	0.78	0.67	0.43
Total Metals	Strontium, total	mg/L	0.001	0.0114	0.0057	0.0115	0.0129	0.0117	0.0032
Total Metals	Sulfur, total	mg/L	3	3	3	3	3	3	3
Total Metals	Tellurium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Thallium, total	mg/L	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Total Metals	Thorium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Metals	Uranium, total	mg/L	0.00002	0.000037	0.000024	0.000026	0.000084	0.000038	0.00002
Total Metals	Vanadium, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.003
Total Metals	Zinc, total	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Total Metals	Zirconium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9010115-01	9010700-01	9011446-02	9011871-01	9020019-01	9020980-01	9021485-01
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-01-02	2019-01-09	2019-01-16	2019-01-23	2019-01-30	2019-02-13	2019-02-20
DATE RECEIVED				2019-01-03	2019-01-10	2019-01-18	2019-01-25	2019-02-01	2019-02-15	2019-02-22
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	338	321	314	328	347	295	296
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.0363	0.151	0.108	0.236	0.0204	0.165	0.155
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.00076	0.00037	0.00032	0.00023	0.00021	0.00031	0.00025
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0183	0.0185	0.0194	0.016	0.0164	0.0127	0.0124
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0205	0.0175	0.019	0.0166	0.016	0.0191	0.0202
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000635	0.000175	0.000441	0.000131	0.000448	0.000095	0.000066
Dissolved Metals	Calcium, dissolved	mg/L	0.2	118	108	108	115	128	97.1	101
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00083
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.00021	0.0001	0.0001	0.0001	0.00011	0.0001	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00199	0.00129	0.00139	0.00097	0.00118	0.0007	0.00124
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.01	0.067	0.01	0.01	0.01	0.01	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00292	0.00279	0.00222	0.00256	0.00257	0.00243	0.00204
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	10.2	12.1	10.7	9.92	6.39	12.6	10.3
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.0806	0.0308	0.0174	0.0104	0.00992	0.0106	0.00322
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00074	0.00053	0.0005	0.00046	0.00049	0.00044	0.00046
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.0006	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.99	1	0.84	0.87	0.93	0.96	1.03
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.0006	0.0005	0.0005	0.0005	0.0005	0.00077	0.0005
Dissolved Metals	Silicon, dissolved	mg/L	1	2.2	2.2	2	1.9	2.5	2.6	2.9
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Sodium, dissolved	mg/L	0.1	5.77	4.76	4.46	4.93	5.67	6.43	6.61
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.409	0.359	0.352	0.396	0.424	0.313	0.335
Dissolved Metals	Sulfur, dissolved	mg/L	3	118	127	111	121	111	109	101
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.00002	0.00002	0.000022	0.00002	0.00002	0.00002	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.005	0.0087	0.005	0.005	0.005	0.005	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.00002	0.000023	0.00002	0.00002	0.00002	0.00002	0.00002
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.12	0.0274	0.0459	0.0197	0.0672	0.0178	0.0132
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	28	23.3	24.7	22	49	21.8	24.5
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	28	23.3	24.7	22	49	21.8	24.5
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	10	7.8	8.2	5.8	8.8	7.2	4.4
General Parameters	pH	pH units	0.1	7.41	7.48	7.58	8.08	7.85	7.68	7.88
General Parameters	Conductivity (EC)	uS/cm	2	583	718	641	733	771	673	661
Total Metals	Aluminum, total	mg/L	0.005	0.161	0.206	0.232	0.359	0.108	0.199	0.165
Total Metals	Antimony, total	mg/L	0.0002	0.00082	0.00038	0.0003	0.00024	0.00023	0.00034	0.00023
Total Metals	Arsenic, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Barium, total	mg/L	0.005	0.0225	0.0207	0.0198	0.0207	0.0176	0.0135	0.0138
Total Metals	Beryllium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.0234	0.028	0.0198	0.0158	0.0226	0.027	0.0192
Total Metals	Cadmium, total	mg/L	1E-05	0.00204	0.000957	0.0023	0.000863	0.00141	0.000386	0.000388
Total Metals	Calcium, total	mg/L	0.2	132	121	121	131	136	97.9	109
Total Metals	Chromium, total	mg/L	0.0005	0.00055	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Cobalt, total	mg/L	0.0001	0.00075	0.00043	0.00065	0.00027	0.00067	0.00021	0.0002
Total Metals	Copper, total	mg/L	0.0004	0.0378	0.0235	0.0352	0.0185	0.0191	0.0107	0.0105
Total Metals	Iron, total	mg/L	0.01	0.159	0.149	0.123	0.148	0.063	0.035	0.044
Total Metals	Lead, total	mg/L	0.0002	0.00339	0.00322	0.00159	0.00132	0.00124	0.00783	0.0007
Total Metals	Lithium, total	mg/L	0.0001	0.00326	0.00256	0.00233	0.00258	0.00276	0.00261	0.0019
Total Metals	Magnesium, total	mg/L	0.01	11.7	12.3	11	10.1	7.26	12.9	10.1
Total Metals	Manganese, total	mg/L	0.0002	0.173	0.0751	0.0973	0.0507	0.117	0.0455	0.0294
Total Metals	Molybdenum, total	mg/L	0.0001	0.00081	0.0005	0.0005	0.00054	0.00052	0.00047	0.00042
Total Metals	Nickel, total	mg/L	0.0004	0.00187	0.00095	0.00108	0.00058	0.00109	0.00047	0.0004
Total Metals	Phosphorus, total	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Metals	Potassium, total	mg/L	0.1	1.09	0.99	0.9	0.93	0.97	1.01	0.87
Total Metals	Selenium, total	mg/L	0.0005	0.0006	0.0005	0.00056	0.00058	0.0005	0.00081	0.0005
Total Metals	Silicon, total	mg/L	1	2.5	2.5	2.4	2.2	3.1	2.8	2.5
Total Metals	Silver, total	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Metals	Sodium, total	mg/L	0.1	6.42	4.81	4.67	5.1	6.1	6.54	6.36
Total Metals	Strontium, total	mg/L	0.001	0.445	0.397	0.383	0.424	0.435	0.335	0.324
Total Metals	Sulfur, total	mg/L	3	129	119	116	132	117	120	97.1
Total Metals	Tellurium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Thallium, total	mg/L	2E-05	0.00002	0.00002	0.000022	0.00002	0.00002	0.00002	0.000022

Total Metals	Thorium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Metals	Uranium, total	mg/L	2E-05	0.000046	0.000034	0.00004	0.00003	0.00002	0.00002	0.00002
Total Metals	Vanadium, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.0011	0.001	0.0011
Total Metals	Zinc, total	mg/L	0.004	0.528	0.289	0.474	0.213	0.336	0.124	0.127
Total Metals	Zirconium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9030242-01	9030732-01	9031295-01	9031832-02	9040077-01	9040523-02	9041136-01
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-02-27	2019-03-06	2019-03-13	2019-03-20	2019-03-27	2019-04-03	2019-04-10
DATE RECEIVED				2019-03-01	2019-03-08	2019-03-14	2019-03-22	2019-03-29	2019-04-04	2019-04-11
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	270	271	269	256	253	227	240
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.16	0.126	0.173	0.167	0.159	0.132	0.198
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.00027	0.00031	0.00021	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0106	0.0112	0.0115	0.0101	0.0103	0.0099	0.0117
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0194	0.022	0.022	0.0182	0.0176	0.0176	0.0163
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000088	0.000081	0.000046	0.000089	0.000156	0.000287	0.000063
Dissolved Metals	Calcium, dissolved	mg/L	0.2	90.4	91.9	94.6	85.4	85.2	74.9	81.2
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00126	0.00116	0.00069	0.00085	0.00097	0.0166	0.001
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00201	0.00204	0.00226	0.00209	0.00212	0.00207	0.00205
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	10.8	9.98	7.87	10.2	9.79	9.79	9.12
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.0163	0.00693	0.00255	0.0178	0.0052	0.0108	0.00278
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00049	0.00056	0.00039	0.00038	0.00041	0.00043	0.0004
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.85	0.92	0.9	0.87	0.88	0.85	0.81
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Silicon, dissolved	mg/L	1	2.8	2.1	2.8	2.6	2.8	2.4	2.6
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Sodium, dissolved	mg/L	0.1	5.37	5.86	6.11	5.61	5.78	5.47	5.32
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.323	0.388	0.337	0.331	0.331	0.309	0.317
Dissolved Metals	Sulfur, dissolved	mg/L	3	93	104	100	95	91.9	81	78.7
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.00002	0.00002	0.00002	0.000021	0.00002	0.00002	0.00002
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.0011	0.001	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0229	0.0155	0.0074	0.0162	0.0144	0.0463	0.0111
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	24.4	20.8	23	20.2	23.4	30.3	25.2
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	24.4	20.8	23	20.2	23.4	30.3	25.2
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	4	3	4	2	6.8	10.2	4
General Parameters	pH	pH units	0.1	6.55	6.73	7.35	7.47	7.85	7.65	8.03
General Parameters	Conductivity (EC)	uS/cm	2	604	620	580	603	562	511	521
Total Metals	Aluminum, total	mg/L	0.005	0.225	0.216	0.235	0.228	0.27	0.268	0.231
Total Metals	Antimony, total	mg/L	0.0002	0.00026	0.00028	0.0002	0.0002	0.0002	0.0002	0.0002
Total Metals	Arsenic, total	mg/L	0.0005	0.00104	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Barium, total	mg/L	0.005	0.0133	0.0144	0.014	0.0129	0.0131	0.0163	0.013
Total Metals	Beryllium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.022	0.0274	0.0273	0.0215	0.02	0.0193	0.0165
Total Metals	Cadmium, total	mg/L	1E-05	0.000548	0.000457	0.000314	0.000352	0.000988	0.00139	0.000413
Total Metals	Calcium, total	mg/L	0.2	96.7	105	100	94.2	91.7	86	82.3
Total Metals	Chromium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Cobalt, total	mg/L	0.0001	0.00028	0.00026	0.00016	0.00022	0.00046	0.0006	0.00019
Total Metals	Copper, total	mg/L	0.0004	0.0153	0.015	0.0102	0.0109	0.0296	0.2	0.0127
Total Metals	Iron, total	mg/L	0.01	0.059	0.084	0.097	0.058	0.149	0.169	0.066
Total Metals	Lead, total	mg/L	0.0002	0.00106	0.00179	0.00163	0.00116	0.00266	0.0103	0.00144
Total Metals	Lithium, total	mg/L	0.0001	0.00203	0.00215	0.00221	0.00235	0.00205	0.00209	0.00207
Total Metals	Magnesium, total	mg/L	0.01	11.5	11.2	7.96	11.4	10.6	9.72	9
Total Metals	Manganese, total	mg/L	0.0002	0.0581	0.0395	0.0274	0.047	0.0717	0.0934	0.0287
Total Metals	Molybdenum, total	mg/L	0.0001	0.00049	0.00056	0.00048	0.00039	0.00044	0.00039	0.00039
Total Metals	Nickel, total	mg/L	0.0004	0.0005	0.0004	0.0004	0.0004	0.0007	0.00094	0.00045
Total Metals	Phosphorus, total	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Metals	Potassium, total	mg/L	0.1	0.9	1.1	0.85	0.9	0.92	0.85	0.79
Total Metals	Selenium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Silicon, total	mg/L	1	3	2.7	2.9	2.8	2.9	2.7	2.6
Total Metals	Silver, total	mg/L	5E-05	0.000058	0.00005	0.000075	0.00005	0.00005	0.00005	0.00005
Total Metals	Sodium, total	mg/L	0.1	5.7	6.49	6.06	6.57	6.36	5.52	5.23
Total Metals	Strontium, total	mg/L	0.001	0.353	0.385	0.333	0.366	0.338	0.311	0.299
Total Metals	Sulfur, total	mg/L	3	93.5	101	89.4	100	88.9	84.3	75.3
Total Metals	Tellurium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Metals	Thallium, total	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002

Total Metals	Thorium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Metals	Uranium, total	mg/L	2E-05	0.000025	0.00002	0.00002	0.000026	0.000026	0.000034	0.00002
Total Metals	Vanadium, total	mg/L	0.001	0.0017	0.0012	0.0014	0.0014	0.0015	0.0011	0.001
Total Metals	Zinc, total	mg/L	0.004	0.191	0.159	0.092	0.128	0.326	0.437	0.13
Total Metals	Zirconium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9041916-01	9042447-01	9050222-01	9050975-01	9051614-01	9052055-01	9052948-01
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-04-17	2019-04-24	2019-05-01	2019-05-08	2019-05-15	2019-05-22	2019-05-29
DATE RECEIVED				2019-04-20	2019-04-25	2019-05-02	2019-05-10	2019-05-17	2019-05-23	2019-05-31
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	238	229	205	218	218	225	257
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.142	0.263	0.21	0.183	0.158	0.144	0.0284
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.000161	0.000171	0.0002	0.000172	0.000154	0.000225	0.000956
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.000055	0.000126	0.0005	0.00005	0.00005	0.00005	0.000201
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0106	0.012	0.0113	0.0101	0.0117	0.0143	0.0204
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0154	0.014	0.0166	0.0175	0.0144	0.0171	0.0224
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.0000443	0.0001	0.000068	0.0000533	0.0000938	0.0000607	0.000044
Dissolved Metals	Calcium, dissolved	mg/L	0.2	83.4	77.8	68.1	71.6	76.5	79.1	95.4
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.00024	0.00021	0.0005	0.00013	0.00019	0.00085	0.0002
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0000135	0.0000368	0.0001	0.000054	0.000023	0.000019	0.0000329
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00069	0.00125	0.00135	0.00094	0.00124	0.00081	0.0009
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.0023	0.0055	0.01	0.002	0.0071	0.0039	0.0042
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.00005	0.000543	0.0002	0.00005	0.00005	0.00005	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00183	0.00185	0.00152	0.00208	0.00178	0.00165	0.00171
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	7.2	8.42	8.52	9.44	6.47	6.72	4.4
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00185	0.0102	0.00565	0.00706	0.00331	0.00223	0.00333
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.0004	0.000416	0.00038	0.000469	0.000441	0.000888	0.00484
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.000064	0.000157	0.0004	0.000399	0.00045	0.000088	0.000087
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.01	0.01	0.05	0.01	0.01	0.01	0.01
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.83	0.803	0.77	0.879	0.836	1.03	3.18
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.00037	0.00035	0.0005	0.0003	0.00027	0.00038	0.00101
Dissolved Metals	Silicon, dissolved	mg/L	1	2.73	2.5	2.5	2.75	2.88	2.56	2.33
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00001	0.00001	0.00005	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Sodium, dissolved	mg/L	0.1	5	4.87	4.7	5.59	5.07	5.17	5.91
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.34	0.316	0.252	0.295	0.288	0.315	0.381
Dissolved Metals	Sulfur, dissolved	mg/L	3	81.1	84.6	72.6	77.7	73.3	78.5	87.4
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.00005	0.00005	0.0005	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.0000083	0.000008	0.00002	0.0000082	0.000007	0.0000083	0.0000136
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.00005	0.00005	0.0002	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.00039
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.0000069	0.0000198	0.00002	0.0000168	0.0000112	0.0000084	0.0000056
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.00086	0.001	0.00107	0.00108	0.00107	0.00085
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0068	0.021	0.0119	0.009	0.0193	0.0103	0.0037
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.00002	0.00002	0.0001	0.00002	0.00002	0.00002	0.00002
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	23.6	21.2	23.7	21.8	27.9	28.8	34.7
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	23.6	21.2	23.7	21.8	27.9	28.8	34.7
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	4.2	4.6	4.4	5.4	6.2	5.4	10.6
General Parameters	pH	pH units	0.1	7.54	8.22	7.66	7.82	7.81	8.45	8.15
General Parameters	Conductivity (EC)	uS/cm	2	564	546	473	522	523	518	623
Total Metals	Aluminum, total	mg/L	0.005	0.182	0.307	0.263	0.382	0.197	0.19	0.142
Total Metals	Antimony, total	mg/L	0.0002	0.000185	0.00016	0.0002	0.000231	0.000155	0.00025	0.000968
Total Metals	Arsenic, total	mg/L	0.0005	0.000171	0.000177	0.0005	0.000419	0.000117	0.000131	0.000316
Total Metals	Barium, total	mg/L	0.005	0.013	0.014	0.0131	0.0341	0.0123	0.0158	0.0242
Total Metals	Beryllium, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Total Metals	Bismuth, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Total Metals	Boron, total	mg/L	0.005	0.0168	0.0163	0.0157	0.019	0.0171	0.0182	0.0267
Total Metals	Cadmium, total	mg/L	1E-05	0.000335	0.000446	0.000354	0.000397	0.000392	0.000273	0.000238
Total Metals	Calcium, total	mg/L	0.2	85.4	76.8	78.6	80.5	77.9	83	105
Total Metals	Chromium, total	mg/L	0.0005	0.00021	0.00024	0.0005	0.00046	0.00016	0.00105	0.00017
Total Metals	Cobalt, total	mg/L	0.0001	0.000172	0.000236	0.00021	0.000356	0.000235	0.000157	0.000123
Total Metals	Copper, total	mg/L	0.0004	0.0112	0.0144	0.0133	0.0155	0.0138	0.00882	0.00765
Total Metals	Iron, total	mg/L	0.01	0.0595	0.0793	0.055	0.355	0.0393	0.0808	0.0251
Total Metals	Lead, total	mg/L	0.0002	0.00125	0.00135	0.00329	0.0063	0.000724	0.00113	0.00203
Total Metals	Lithium, total	mg/L	0.0001	0.00243	0.00206	0.0017	0.00215	0.0019	0.00186	0.0019
Total Metals	Magnesium, total	mg/L	0.01	7.6	8.31	9.83	9.66	6.87	7.06	5.11
Total Metals	Manganese, total	mg/L	0.0002	0.0273	0.0384	0.0332	0.0442	0.0405	0.0268	0.0184
Total Metals	Molybdenum, total	mg/L	0.0001	0.00043	0.000432	0.00039	0.000521	0.000463	0.000935	0.00484
Total Metals	Nickel, total	mg/L	0.0004	0.00029	0.000495	0.00041	0.000874	0.000365	0.000294	0.000195
Total Metals	Phosphorus, total	mg/L	0.05	0.01	0.01	0.05	0.013	0.011	0.01	0.01
Total Metals	Potassium, total	mg/L	0.1	0.858	0.766	1.1	0.878	0.864	1.02	3.34
Total Metals	Selenium, total	mg/L	0.0005	0.00035	0.00037	0.00054	0.00036	0.00033	0.00044	0.00105
Total Metals	Silicon, total	mg/L	1	2.92	2.5	2.8	2.89	2.94	2.84	2.66
Total Metals	Silver, total	mg/L	5E-05	0.00001	0.00001	0.00005	0.000036	0.00001	0.00001	0.00001
Total Metals	Sodium, total	mg/L	0.1	5.26	4.75	4.83	5.63	5.44	5.3	6.3
Total Metals	Strontium, total	mg/L	0.001	0.345	0.317	0.261	0.303	0.278	0.328	0.396
Total Metals	Sulfur, total	mg/L	3	84.6	83.7	79.6	76.9	74.2	82.7	94.3
Total Metals	Tellurium, total	mg/L	0.0005	0.00005	0.00005	0.0005	0.00005	0.00005	0.00005	0.00007
Total Metals	Thallium, total	mg/L	2E-05	0.000159	0.0000101	0.00002	0.0000092	0.0000062	0.0000097	0.0000144

Total Metals	Thorium, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001
Total Metals	Tin, total	mg/L	0.0002	0.00021	0.00005	0.0002	0.00005	0.00005	0.00005	0.00005
Total Metals	Titanium, total	mg/L	0.005	0.00037	0.00042	0.005	0.00972	0.00037	0.00023	0.0002
Total Metals	Tungsten, total	mg/L	0.001	0.0002	0.0002	0.001	0.0002	0.0002	0.0002	0.00041
Total Metals	Uranium, total	mg/L	2E-05	0.0000121	0.0000227	0.000026	0.0000254	0.0000154	0.000013	0.0000104
Total Metals	Vanadium, total	mg/L	0.001	0.00103	0.00093	0.0012	0.00139	0.00098	0.00087	0.00084
Total Metals	Zinc, total	mg/L	0.004	0.0982	0.134	0.131	0.13	0.13	0.0913	0.0803
Total Metals	Zirconium, total	mg/L	0.0001	0.00002	0.00002	0.0001	0.000039	0.00002	0.00002	0.00002

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9060569-01	9061285-02	9062033-01	9063048-01	9070597-01	9071269-01	9072764-01
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-06-05	2019-06-12	2019-06-19	2019-06-26	2019-07-03	2019-07-10	2019-07-24
DATE RECEIVED				2019-06-06	2019-06-13	2019-06-20	2019-06-28	2019-07-05	2019-07-11	2019-07-26
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	255	282	276	227	209	215	227
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.209	0.165	0.345	0.152	0.16	0.164	0.147
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.000865	0.00116	0.00241	0.000978	0.000229	0.000252	0.00187
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.000198	0.0005	0.00057	0.000165	0.00006	0.000063	0.00017
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.016	0.0228	0.0238	0.0156	0.0127	0.0145	0.0213
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.026	0.043	0.039	0.0217	0.0163	0.0169	0.0332
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.0000701	0.000014	0.0000898	0.0000491	0.0000677	0.0000573	0.000114
Dissolved Metals	Calcium, dissolved	mg/L	0.2	89.7	101	98.6	79.5	71.3	74.9	81.6
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.00018	0.00128	0.00088	0.00016	0.00015	0.00029	0.00102
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0000308	0.0001	0.000102	0.0000297	0.0000244	0.0000195	0.0000346
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00141	0.0006	0.00314	0.00143	0.00097	0.00095	0.00199
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.002	0.01	0.002	0.0024	0.002	0.0041	0.0029
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.00005	0.0002	0.00005	0.000089	0.00005	0.000095	0.000162
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00206	0.00241	0.00163	0.00186	0.00194	0.00198	0.00179
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	7.44	7.13	7.27	6.95	7.43	6.84	5.53
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00437	0.00112	0.0245	0.00381	0.00348	0.00335	0.0052
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00364	0.00388	0.01	0.00353	0.000916	0.000551	0.00456
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.000085	0.0004	0.000376	0.0001	0.000069	0.000142	0.000141
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.01	0.05	0.01	0.01	0.01	0.01	0.01
Dissolved Metals	Potassium, dissolved	mg/L	0.1	2.5	2.8	4.9	2.05	1.05	1.05	3.08
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.00076	0.00078	0.00237	0.00083	0.0003	0.00034	0.00091
Dissolved Metals	Silicon, dissolved	mg/L	1	2.89	3.1	2.69	2.75	2.97	2.69	3.11
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.000019	0.00005	0.00001	0.000012	0.00001	0.00001	0.000028
Dissolved Metals	Sodium, dissolved	mg/L	0.1	6.51	7.58	7.63	6.15	5.69	5.65	6.34
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.351	0.372	0.372	0.323	0.297	0.3	0.318
Dissolved Metals	Sulfur, dissolved	mg/L	3	91.7	98.8	110	82.7	76.5	76.2	80.6
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.00005	0.0005	0.000077	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.0000119	0.00002	0.0000067	0.0000051	0.0000086	0.0000074	0.0000131
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.00005	0.0002	0.00005	0.00005	0.00005	0.00005	0.00005
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.0002	0.005	0.0002	0.0002	0.0002	0.0002	0.0002
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.00034	0.001	0.00093	0.00031	0.0002	0.0002	0.00036
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.000015	0.00002	0.0000324	0.0000079	0.0000101	0.0000085	0.0000245
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.00142	0.0016	0.00068	0.00087	0.00094	0.00083	0.00086
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0146	0.004	0.0217	0.0148	0.0128	0.0078	0.027
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.00002	0.0001	0.00002	0.00002	0.00002	0.00002	0.00002
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	25.8	22.6	21.7	11.3	20.2	15.1	30.4
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	25.8	22.6	21.7	11.3	20.2	15.1	30.4
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	3.8	8.8	3.8	5.8	4.2	3.4	2
General Parameters	pH	pH units	0.1	7.86	7.59	8.36	8.35	8.46	8.76	7.83
General Parameters	Conductivity (EC)	uS/cm	2	587	569	689	560	515	543	435
Total Metals	Aluminum, total	mg/L	0.005	0.25	0.184	0.43	0.175	0.224	0.208	0.18
Total Metals	Antimony, total	mg/L	0.0002	0.00088	0.00121	0.00257	0.00119	0.000325	0.000258	0.00212
Total Metals	Arsenic, total	mg/L	0.0005	0.000302	0.00067	0.000675	0.000253	0.000153	0.000202	0.000364
Total Metals	Barium, total	mg/L	0.005	0.0181	0.0433	0.0273	0.0197	0.0161	0.0204	0.0271
Total Metals	Beryllium, total	mg/L	0.0001	0.00001	0.0001	0.000011	0.00001	0.00001	0.00001	0.00001
Total Metals	Bismuth, total	mg/L	0.0001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001
Total Metals	Boron, total	mg/L	0.005	0.0308	0.0426	0.047	0.0224	0.0176	0.0176	0.0373
Total Metals	Cadmium, total	mg/L	1E-05	0.000332	0.000178	0.000407	0.000242	0.000263	0.000309	0.000305
Total Metals	Calcium, total	mg/L	0.2	95.4	101	107	89.7	80	82.5	95.4
Total Metals	Chromium, total	mg/L	0.0005	0.00028	0.001	0.00107	0.00025	0.00032	0.00026	0.00022
Total Metals	Cobalt, total	mg/L	0.0001	0.000205	0.0001	0.00031	0.000131	0.000161	0.000149	0.000163
Total Metals	Copper, total	mg/L	0.0004	0.0119	0.00647	0.0138	0.00715	0.00903	0.00883	0.00863
Total Metals	Iron, total	mg/L	0.01	0.0291	0.049	0.045	0.0302	0.0614	0.0693	0.0342
Total Metals	Lead, total	mg/L	0.0002	0.000493	0.00387	0.00117	0.00165	0.0011	0.00348	0.00344
Total Metals	Lithium, total	mg/L	0.0001	0.00223	0.00218	0.00188	0.00202	0.00205	0.00194	0.00181
Total Metals	Magnesium, total	mg/L	0.01	7.95	6.46	7.98	7.44	8.54	7.3	5.88
Total Metals	Manganese, total	mg/L	0.0002	0.0318	0.0135	0.0631	0.0197	0.0255	0.0235	0.0277
Total Metals	Molybdenum, total	mg/L	0.0001	0.00377	0.00354	0.0109	0.00386	0.000909	0.000564	0.005
Total Metals	Nickel, total	mg/L	0.0004	0.000355	0.0004	0.000706	0.000284	0.000344	0.000255	0.000264
Total Metals	Phosphorus, total	mg/L	0.05	0.01	0.05	0.011	0.01	0.01	0.01	0.01
Total Metals	Potassium, total	mg/L	0.1	2.63	2.62	5.28	2.24	1.27	1.1	3.18
Total Metals	Selenium, total	mg/L	0.0005	0.00078	0.0016	0.00284	0.00089	0.00033	0.0004	0.00104
Total Metals	Silicon, total	mg/L	1	3.06	3.1	2.95	2.63	3.16	2.92	3.24
Total Metals	Silver, total	mg/L	5E-05	0.00001	0.00005	0.00001	0.00001	0.00001	0.00001	0.000015
Total Metals	Sodium, total	mg/L	0.1	6.93	6.8	8.41	6.62	6.14	6.07	6.67
Total Metals	Strontium, total	mg/L	0.001	0.355	0.343	0.396	0.347	0.304	0.328	0.338
Total Metals	Sulfur, total	mg/L	3	98.8	91.5	116	77.3	82.5	80.8	81.2
Total Metals	Tellurium, total	mg/L	0.0005	0.00005	0.0005	0.000127	0.00005	0.00005	0.00005	0.00005
Total Metals	Thallium, total	mg/L	2E-05	0.0000125	0.00002	0.0000085	0.0000081	0.0000081	0.0000075	0.0000139

Total Metals	Thorium, total	mg/L	0.0001	0.00001	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001
Total Metals	Tin, total	mg/L	0.0002	0.00005	0.0002	0.00005	0.00005	0.00005	0.00005	0.00005
Total Metals	Titanium, total	mg/L	0.005	0.0002	0.005	0.0004	0.00026	0.00034	0.0007	0.00027
Total Metals	Tungsten, total	mg/L	0.001	0.00037	0.001	0.00103	0.00035	0.0002	0.0002	0.0004
Total Metals	Uranium, total	mg/L	2E-05	0.0000192	0.00002	0.0000368	0.0000131	0.0000134	0.0000132	0.0000141
Total Metals	Vanadium, total	mg/L	0.001	0.00139	0.0018	0.00057	0.00094	0.00114	0.00095	0.00091
Total Metals	Zinc, total	mg/L	0.004	0.112	0.0408	0.133	0.0669	0.0817	0.0877	0.0906
Total Metals	Zirconium, total	mg/L	0.0001	0.00002	0.0001	0.000022	0.00002	0.00002	0.00002	0.000038

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9080191-01	9080697-01	9081523-02	9083048-01	9090514-01	9091289-02	9092100-01
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-07-31	2019-08-07	2019-08-14	2019-08-28	2019-09-04	2019-09-11	2019-09-18
DATE RECEIVED				2019-08-02	2019-08-09	2019-08-16	2019-08-30	2019-09-06	2019-09-13	2019-09-20
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	198	242	197	277	220	202	292
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.163	0.357	0.253	0.344	0.187	0.197	0.718
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.000334	0.00314	0.00213	0.00149	0.00131	0.00046	0.00231
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.000092	0.0005	0.0005	0.000652	0.000242	0.0005	0.000331
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0161	0.0247	0.0232	0.0197	0.0233	0.0193	0.0197
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0176	0.059	0.0371	0.0455	0.0226	0.0231	0.0482
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000049	0.000085	0.000117	0.0000888	0.000107	0.000093	0.0000551
Dissolved Metals	Calcium, dissolved	mg/L	0.2	68.7	85.1	67.3	94.4	74.8	66.6	110
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.00016	0.00096	0.001	0.00026	0.00109	0.001	0.00104
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0000148	0.0001	0.00011	0.0000863	0.0000729	0.0001	0.0000107
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00089	0.0033	0.00239	0.00236	0.00187	0.00197	0.00367
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.002	0.01	0.01	0.002	0.002	0.01	0.002
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.00009	0.0002	0.0002	0.00005	0.000108	0.0002	0.00005
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00198	0.00213	0.00173	0.00285	0.00209	0.0023	0.0027
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	6.43	7	7.06	10.1	8.14	8.67	4.22
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00252	0.00762	0.042	0.0172	0.0213	0.0119	0.00132
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.000582	0.00644	0.00499	0.0033	0.00499	0.00052	0.00399
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.000062	0.0004	0.00054	0.000131	0.000324	0.0004	0.000275
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.01	0.05	0.05	0.01	0.01	0.05	0.01
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.997	4.92	3.86	2.91	1.81	1.07	4.57
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.00037	0.00094	0.0006	0.00052	0.00048	0.0005	0.00111
Dissolved Metals	Silicon, dissolved	mg/L	1	2.98	2.6	2.7	3.41	3.11	2.7	1.43
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00001	0.00005	0.00005	0.00001	0.00001	0.00005	0.00001
Dissolved Metals	Sodium, dissolved	mg/L	0.1	5.43	7.88	6.65	10.5	6.92	6.63	7.73
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.298	0.325	0.262	0.335	0.342	0.28	0.41
Dissolved Metals	Sulfur, dissolved	mg/L	3	68.4	83.4	71.1	91.8	73.4	70.1	108
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.00005	0.0005	0.0005	0.00005	0.00005	0.0005	0.00005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.0000083	0.00002	0.00002	0.0000139	0.0000112	0.00002	0.0000117
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.00005	0.0002	0.0002	0.00005	0.00005	0.0002	0.00005
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.0002	0.005	0.005	0.0002	0.0002	0.005	0.0002
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.0002	0.001	0.001	0.0014	0.00026	0.001	0.00056
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.0000096	0.000027	0.000033	0.0000285	0.0000253	0.000049	0.0000086
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.00081	0.001	0.001	0.00074	0.0009	0.001	0.00038
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0093	0.0209	0.0177	0.0148	0.0161	0.0155	0.0016
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.00002	0.0001	0.0001	0.00002	0.00002	0.0001	0.00002
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	26.3	22.5	24	21.6	21.2	20.5	22
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	26.3	22.5	24	21.6	21.2	20.5	22
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	2.6	2	2	3.6	3.2	2.2	2.8
General Parameters	pH	pH units	0.1	8.47	7.59	7.57	7.47	7.7	7.67	7.41
General Parameters	Conductivity (EC)	uS/cm	2	406	554	499	576	490	439	660
Total Metals	Aluminum, total	mg/L	0.005	0.211	0.42	0.311	0.32	0.218	0.244	0.913
Total Metals	Antimony, total	mg/L	0.0002	0.00044	0.00336	0.00255	0.00177	0.00131	0.00047	0.00229
Total Metals	Arsenic, total	mg/L	0.0005	0.000234	0.00056	0.0006	0.000703	0.000347	0.0005	0.000595
Total Metals	Barium, total	mg/L	0.005	0.0255	0.0285	0.0374	0.0271	0.0391	0.0309	0.0289
Total Metals	Beryllium, total	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Total Metals	Bismuth, total	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Total Metals	Boron, total	mg/L	0.005	0.0221	0.0615	0.0412	0.0363	0.0287	0.0257	0.0586
Total Metals	Cadmium, total	mg/L	1E-05	0.000262	0.000246	0.000318	0.000279	0.000303	0.000323	0.000342
Total Metals	Calcium, total	mg/L	0.2	82.7	91.5	73.2	86.8	77.5	78.4	118
Total Metals	Chromium, total	mg/L	0.0005	0.00019	0.00099	0.00137	0.00111	0.00109	0.00089	0.00108
Total Metals	Cobalt, total	mg/L	0.0001	0.000129	0.00013	0.00024	0.000172	0.000193	0.00019	0.00015
Total Metals	Copper, total	mg/L	0.0004	0.00791	0.00892	0.0114	0.00852	0.00985	0.0118	0.0157
Total Metals	Iron, total	mg/L	0.01	0.0327	0.028	0.037	0.0161	0.0342	0.052	0.163
Total Metals	Lead, total	mg/L	0.0002	0.00257	0.0009	0.00275	0.00131	0.00444	0.0045	0.00472
Total Metals	Lithium, total	mg/L	0.0001	0.00229	0.00243	0.00192	0.00239	0.00224	0.00229	0.00266
Total Metals	Magnesium, total	mg/L	0.01	7.79	7.99	8.01	8.82	9.04	9.14	4.48
Total Metals	Manganese, total	mg/L	0.0002	0.0245	0.0256	0.0679	0.0364	0.0442	0.0364	0.0221
Total Metals	Molybdenum, total	mg/L	0.0001	0.000715	0.00644	0.00713	0.00324	0.00199	0.00052	0.00414
Total Metals	Nickel, total	mg/L	0.0004	0.000253	0.0004	0.00079	0.000452	0.000531	0.00098	0.000132
Total Metals	Phosphorus, total	mg/L	0.05	0.01	0.05	0.05	0.01	0.01	0.05	0.01
Total Metals	Potassium, total	mg/L	0.1	1.15	5.38	4.28	2.65	1.81	1.16	4.66
Total Metals	Selenium, total	mg/L	0.0005	0.00047	0.00092	0.00073	0.00052	0.00054	0.0005	0.00122
Total Metals	Silicon, total	mg/L	1	3.35	3.1	3	2.63	3.39	3.3	1.51
Total Metals	Silver, total	mg/L	5E-05	0.00001	0.00005	0.00005	0.00001	0.00001	0.00005	0.000052
Total Metals	Sodium, total	mg/L	0.1	6.63	8.66	7.61	9.6	7.73	5.88	7.97
Total Metals	Strontium, total	mg/L	0.001	0.342	0.353	0.282	0.34	0.328	0.282	0.409
Total Metals	Sulfur, total	mg/L	3	85.1	96.5	78.4	84.9	74.6	72.4	109
Total Metals	Tellurium, total	mg/L	0.0005	0.00005	0.0005	0.0005	0.00005	0.00005	0.0005	0.00005
Total Metals	Thallium, total	mg/L	2E-05	0.0000099	0.00002	0.00002	0.000014	0.0000134	0.00002	0.0000157

Total Metals	Thorium, total	mg/L	0.0001	0.00001	0.0001	0.0001	0.00001	0.00001	0.0001	0.00001
Total Metals	Tin, total	mg/L	0.0002	0.00005	0.0002	0.0002	0.00005	0.00005	0.0002	0.00005
Total Metals	Titanium, total	mg/L	0.005	0.00021	0.005	0.005	0.0002	0.0002	0.005	0.00317
Total Metals	Tungsten, total	mg/L	0.001	0.0002	0.001	0.001	0.00136	0.00027	0.001	0.00057
Total Metals	Uranium, total	mg/L	2E-05	0.0000154	0.000029	0.000042	0.000031	0.0000334	0.000033	0.0000176
Total Metals	Vanadium, total	mg/L	0.001	0.00083	0.0011	0.001	0.00063	0.00095	0.0013	0.00061
Total Metals	Zinc, total	mg/L	0.004	0.0707	0.0687	0.0986	0.07	0.0809	0.102	0.0866
Total Metals	Zirconium, total	mg/L	0.0001	0.00002	0.0001	0.0001	0.00002	0.00002	0.0001	0.000025

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9092877-01	9100574-01	9101235-02	N000079-01	N000565-01	N001480-01	N001934-02
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-Runoff
DATE SAMPLED				2019-09-25	2019-10-02	2019-10-09	2019-10-16	2019-10-23	2019-11-06	2019-11-13
DATE RECEIVED				2019-09-27	2019-10-04	2019-10-11	2019-10-25	2019-10-31	2019-11-12	2019-11-15
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	242	214	209	231	276	195	197
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.29	0.283	0.12	0.365	0.47	0.136	0.343
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.00304	0.00286	0.001	0.000452	0.000966	0.00136	0.00722
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.000362	0.000477	0.0005	0.000115	0.000265	0.00025	0.00071
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0221	0.0211	0.022	0.0161	0.0189	0.0161	0.0251
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.000012	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0485	0.0496	0.0726	0.0178	0.0295	0.0248	0.0515
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000058	0.0000354	0.000119	0.000163	0.0000815	0.0000816	0.000062
Dissolved Metals	Calcium, dissolved	mg/L	0.2	89.5	77.2	77.5	82.7	104	65.4	68
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.00106	0.00082	0.00116	0.00111	0.00041	0.00013	0.00101
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0000223	0.0000221	0.0001	0.0000422	0.000017	0.00012	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00163	0.00177	0.00225	0.00148	0.00138	0.00227	0.00273
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.002	0.002	0.01	0.002	0.002	0.002	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.00005	0.00005	0.0002	0.000051	0.00005	0.00005	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00218	0.00209	0.00186	0.0023	0.00231	0.00191	0.00156
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	4.32	5.09	3.76	5.86	4.21	7.72	6.51
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00341	0.00414	0.0083	0.00911	0.00256	0.0278	0.0113
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00507	0.00599	0.00398	0.000827	0.0023	0.00203	0.006
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.00004	0.000126	0.0004	0.000198	0.000049	0.000445	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.01	0.01	0.058	0.01	0.01	0.01	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	4.79	4.54	3.43	1.17	2.39	1.96	3.69
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.00086	0.00177	0.00169	0.00053	0.00071	0.00041	0.00225
Dissolved Metals	Silicon, dissolved	mg/L	1	2.45	2.93	2.7	2.24	1.64	3.13	2.5
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00001	0.00002	0.00005	0.00001	0.00001	0.00001	0.000062
Dissolved Metals	Sodium, dissolved	mg/L	0.1	7.83	7.77	7.7	5.27	5.69	5.86	6.73
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.374	0.317	0.325	0.314	0.378	0.28	0.334
Dissolved Metals	Sulfur, dissolved	mg/L	3	91.3	91.3	71	83.4	96.5	68.3	69.1
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.00005	0.000252	0.0005	0.00005	0.00005	0.00005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.000012	0.0000083	0.00002	0.0000109	0.0000126	0.0000131	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.00005	0.00005	0.0002	0.00005	0.00005	0.00005	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.0002	0.0002	0.005	0.0002	0.0002	0.0002	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.00055	0.00078	0.001	0.0002	0.00022	0.00028	0.001
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.0000109	0.0000129	0.000024	0.0000146	0.0000054	0.0000398	0.00002
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.0007	0.00075	0.001	0.00051	0.00039	0.00071	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0085	0.0018	0.0133	0.0118	0.0046	0.0181	0.0219
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.00002	0.00002	0.0001	0.00002	0.00002	0.00002	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	20.6	23.8	32.4	17.2	20.1	23.9	25.4
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	20.6	23.8	32.4	17.2	20.1	23.9	25.4
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	5	3.2	4	7	3.8	2	3.2
General Parameters	pH	pH units	0.1	8.67	7.8	7.62	7.25	7.99	8.17	7.49
General Parameters	Conductivity (EC)	uS/cm	2	547	521	484	515	604	468	483
Total Metals	Aluminum, total	mg/L	0.005	0.393	0.328	0.205	0.474	0.554	0.169	0.482
Total Metals	Antimony, total	mg/L	0.0002	0.00352	0.00303	0.00098	0.00056	0.000993	0.0014	0.00749
Total Metals	Arsenic, total	mg/L	0.0005	0.000617	0.000629	0.0005	0.000366	0.000348	0.000351	0.0009
Total Metals	Barium, total	mg/L	0.005	0.0347	0.0255	0.0233	0.0258	0.0245	0.0193	0.0307
Total Metals	Beryllium, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.0846	0.0526	0.0879	0.0239	0.0369	0.0296	0.0459
Total Metals	Cadmium, total	mg/L	1E-05	0.000411	0.000139	0.000266	0.000748	0.000531	0.00026	0.000279
Total Metals	Calcium, total	mg/L	0.2	106	85.4	86.8	85.4	111	70.4	72.9
Total Metals	Chromium, total	mg/L	0.0005	0.00123	0.00092	0.00127	0.00111	0.00064	0.00019	0.00095
Total Metals	Cobalt, total	mg/L	0.0001	0.000221	0.0000911	0.00018	0.000369	0.000216	0.000219	0.00015
Total Metals	Copper, total	mg/L	0.0004	0.0121	0.00685	0.00903	0.0167	0.012	0.00901	0.0103
Total Metals	Iron, total	mg/L	0.01	0.115	0.0282	0.032	0.167	0.122	0.0203	0.045
Total Metals	Lead, total	mg/L	0.0002	0.00354	0.00142	0.00136	0.00436	0.00191	0.000834	0.00319
Total Metals	Lithium, total	mg/L	0.0001	0.00251	0.00223	0.002	0.00245	0.00258	0.00203	0.00177
Total Metals	Magnesium, total	mg/L	0.01	5.23	5.49	4.18	6.04	4.53	8.69	7.57
Total Metals	Manganese, total	mg/L	0.0002	0.0478	0.0189	0.0343	0.0532	0.0381	0.0493	0.0352
Total Metals	Molybdenum, total	mg/L	0.0001	0.00566	0.00668	0.00421	0.000867	0.00234	0.00213	0.00585
Total Metals	Nickel, total	mg/L	0.0004	0.000367	0.000253	0.00042	0.000756	0.00036	0.000615	0.00042
Total Metals	Phosphorus, total	mg/L	0.05	0.01	0.01	0.05	0.01	0.01	0.01	0.05
Total Metals	Potassium, total	mg/L	0.1	5.67	4.99	3.6	1.21	2.29	2.11	3.8
Total Metals	Selenium, total	mg/L	0.0005	0.00099	0.00219	0.00228	0.00058	0.00081	0.00047	0.00242
Total Metals	Silicon, total	mg/L	1	2.94	3.08	3	2.41	1.52	3.43	3.4
Total Metals	Silver, total	mg/L	5E-05	0.00001	0.00001	0.00005	0.00001	0.00001	0.00001	0.00005
Total Metals	Sodium, total	mg/L	0.1	9.29	8.17	6.92	5.4	5.81	6.59	7.75
Total Metals	Strontium, total	mg/L	0.001	0.425	0.349	0.337	0.325	0.369	0.29	0.338
Total Metals	Sulfur, total	mg/L	3	101	78.9	74.8	77.2	91.7	71	85
Total Metals	Tellurium, total	mg/L	0.0005	0.00005	0.000388	0.00082	0.00005	0.00005	0.00005	0.0005
Total Metals	Thallium, total	mg/L	2E-05	0.0000135	0.0000094	0.000023	0.0000105	0.0000142	0.0000102	0.00002

Total Metals	Thorium, total	mg/L	0.0001	0.00001	0.00001	0.0001	0.00001	0.00001	0.00001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.00005	0.00005	0.0002	0.00005	0.00005	0.00005	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.0004	0.0002	0.005	0.00203	0.00033	0.0002	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.00062	0.00082	0.001	0.0002	0.00024	0.00029	0.001
Total Metals	Uranium, total	mg/L	2E-05	0.0000212	0.0000162	0.00002	0.0000297	0.0000131	0.0000352	0.000023
Total Metals	Vanadium, total	mg/L	0.001	0.00083	0.00074	0.001	0.00075	0.0007	0.0007	0.0017
Total Metals	Zinc, total	mg/L	0.004	0.112	0.0341	0.0682	0.178	0.101	0.0833	0.08
Total Metals	Zirconium, total	mg/L	0.0001	0.00002	0.00002	0.0001	0.000029	0.00002	0.00002	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9010115
Report Date: 2019-01-10 15:09:09

Client Nyrstar Myra Falls
Attention Craig Schweitzer
Project WEEKLY
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9110493-01	9111123-01	9120582-01	9121477-01	9121871-01	8476164	
CLIENT ID				11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11A-RUNOFF	11-A-RUNOFF	11A-RUNOFF
DATE SAMPLED				2019-11-20	2019-11-27	2019-12-05	2019-12-11	2019-12-18	2019-12-23	12/30/2019
DATE RECEIVED				2019-11-21	2019-11-28	2019-12-06	2019-12-17	2019-12-20		
MATRIX				Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**							
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	214	226	179	163	316	278	296
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.21	0.112	0.246	0.167	0.649	0.201	0.267
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.00302	0.00505	0.000927	0.00169	0.00105	0.000873	0.00117
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.000477	0.000628	0.000212	0.000299	0.000136	0.000275	0.000284
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.021	0.0186	0.0171	0.0156	0.0183	0.0193	0.0183
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001	0.000005	0.000005
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0242	0.0437	0.0201	0.0198	0.0169	0.021	0.022
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000125	0.000297	0.0000363	0.0000576	0.000643	0.000284	0.000161
Dissolved Metals	Calcium, dissolved	mg/L	0.2	75	76.7	58.6	54.3	117	98.8	98.4
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.00017	0.00012	0.00013	0.00015	0.00019	0.00013	0.0001
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0000585	0.000116	0.0000563	0.0000409	0.000115	0.000146	0.0000674
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00328	0.00324	0.00436	0.0049	0.00276	0.00232	0.00352
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.0039	0.002	0.002	0.0023	0.002	0.0150	0.0023
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.000111	0.00005	0.000157	0.00005	0.00008	0.0000500	0.0000402
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00188	0.00194	0.00183	0.00159	0.00256	0.00209	0.00187
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	6.4	8.38	7.98	6.56	5.91	7.47	7.48
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.0147	0.0299	0.0144	0.00555	0.0356	0.0386	0.0103
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00303	0.00435	0.00108	0.00178	0.00205	0.00193	0.00243
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.000157	0.000239	0.000202	0.000161	0.000239	0.000365	0.000222
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.012	0.01	0.012	0.01	0.01		
Dissolved Metals	Potassium, dissolved	mg/L	0.1	2.44	3.62	1.22	1.75	2.25	2.09	2.41
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.00096	0.00108	0.00043	0.00048	0.00053	0.000673	0.000815
Dissolved Metals	Silicon, dissolved	mg/L	1	2.3	3.02	2.95	2.62	0.19	2.09	2.18
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00001	0.000025	0.00001	0.00001	0.00001	0.000005	0.000005
Dissolved Metals	Sodium, dissolved	mg/L	0.1	5.6	6.92	5.43	4.95	4.8	5.56	6.22
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.291	0.345	0.266	0.288	0.349	0.325	0.33
Dissolved Metals	Sulfur, dissolved	mg/L	3	77.7	90.5	68.3	60.3	118	88.4	91.2
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.00005	0.00005	0.00005	0.00005	0.00005		
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.0000092	0.0000085	0.0000088	0.000009	0.0000164	0.0000088	0.0000088
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.00001		
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.00005	0.00005	0.00005	0.00005	0.00005	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.00034	0.00057	0.0002	0.00025	0.0002		
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.0000183	0.0000262	0.0000314	0.0000149	0.0000228	0.0000175	0.0000154
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.0005	0.00062	0.00054	0.00061	0.0002	0.00021	0.0002
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.0263	0.0564	0.0077	0.0089	0.0235	0.0659	0.0504
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.00002	0.00002	0.00002	0.000074	0.00002	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	23.8	23.4	103	20.6	21.5	1	25
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	22	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	23.8	23.4	103	20.6	21.5	27	30
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1
General Parameters	Solids, Total Suspended	mg/L	2	4.8	4.4	5	4.4	54.2	10	7.2
General Parameters	pH	pH units	0.1	7.45	7.5	7.56	7.38	7.55	7.43	7.44
General Parameters	Conductivity (EC)	uS/cm	2	528	528	420	484	722	600	620
Total Metals	Aluminum, total	mg/L	0.005	0.286	0.312	0.293	0.227	1.68	0.305	0.342
Total Metals	Antimony, total	mg/L	0.0002	0.00345	0.0054	0.00102	0.00184	0.00214	0.000901	0.00119
Total Metals	Arsenic, total	mg/L	0.0005	0.000621	0.00102	0.000388	0.000509	0.00458	0.000528	0.000399
Total Metals	Barium, total	mg/L	0.005	0.0348	0.0272	0.0205	0.0214	0.376	0.0390	0.0229
Total Metals	Beryllium, total	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.000038	0.00001	0.00001
Total Metals	Bismuth, total	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.000106	0.000005	0.000005
Total Metals	Boron, total	mg/L	0.005	0.045	0.0391	0.0255	0.0326	0.0405	0.022	0.022
Total Metals	Cadmium, total	mg/L	1E-05	0.000577	0.000414	0.000217	0.000345	0.00588	0.00151	0.00071
Total Metals	Calcium, total	mg/L	0.2	90.5	83.8	66.4	79.3	134	103	106
Total Metals	Chromium, total	mg/L	0.0005	0.00018	0.00021	0.00062	0.00021	0.00147	0.00024	0.00017
Total Metals	Cobalt, total	mg/L	0.0001	0.000253	0.000271	0.000166	0.000199	0.00207	0.000567	0.000284
Total Metals	Copper, total	mg/L	0.0004	0.0186	0.0162	0.00798	0.0149	0.208	0.0340	0.0194
Total Metals	Iron, total	mg/L	0.01	0.092	0.0624	0.0467	0.0589	3.07	0.284	0.116
Total Metals	Lead, total	mg/L	0.0002	0.00447	0.00216	0.00666	0.002	0.0853	0.0128	0.00183
Total Metals	Lithium, total	mg/L	0.0001	0.00213	0.0018	0.00203	0.00204	0.00278	0.00203	0.00196
Total Metals	Magnesium, total	mg/L	0.01	7.38	8.64	8.84	7.93	6.45	7.77	7.6
Total Metals	Manganese, total	mg/L	0.0002	0.046	0.0452	0.0351	0.0379	0.223	0.106	0.046
Total Metals	Molybdenum, total	mg/L	0.0001	0.00335	0.00443	0.00131	0.00199	0.00219	0.00196	0.00249
Total Metals	Nickel, total	mg/L	0.0004	0.000453	0.000537	0.000482	0.000412	0.00337	0.000965	0.000466
Total Metals	Phosphorus, total	mg/L	0.05	0.01	0.016	0.013	0.01	0.033		
Total Metals	Potassium, total	mg/L	0.1	2.73	3.98	1.34	2.02	2.23	2.05	2.49
Total Metals	Selenium, total	mg/L	0.0005	0.00106	0.00088	0.00053	0.0006	0.00061	0.000729	0.000931
Total Metals	Silicon, total	mg/L	1	2.43	3.77	3.25	2.94	1.04	2.15	2.38
Total Metals	Silver, total	mg/L	5E-05	0.00001	0.00001	0.00001	0.00001	0.000319	0.0000170	0.000005
Total Metals	Sodium, total	mg/L	0.1	6.48	7.27	6.08	6.1	4.53	5.68	6.17
Total Metals	Strontium, total	mg/L	0.001	0.333	0.378	0.283	0.312	0.38	0.316	0.363
Total Metals	Sulfur, total	mg/L	3	84.8	84.7	74.7	78.6	89.7	88.1	91.9
Total Metals	Tellurium, total	mg/L	0.0005	0.00005	0.00005	0.00005	0.00005	0.00014		
Total Metals	Thallium, total	mg/L	2E-05	0.0000098	0.0000098	0.0000097	0.0000105	0.0000333	0.0000102	0.0000097

Total Metals	Thorium, total	mg/L	0.0001	0.00001	0.00001	0.00001	0.00001	0.000029		
Total Metals	Tin, total	mg/L	0.0002	0.00005	0.00005	0.00005	0.00005	0.00005	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.00033	0.0002	0.00022	0.00025	0.0133	0.0005	0.0005
Total Metals	Tungsten, total	mg/L	0.001	0.00038	0.00059	0.00022	0.00029	0.0002		
Total Metals	Uranium, total	mg/L	2E-05	0.0000287	0.000031	0.0000343	0.0000264	0.000163	0.0000344	0.0000216
Total Metals	Vanadium, total	mg/L	0.001	0.00049	0.00134	0.00056	0.00068	0.00112	0.0002	0.00025
Total Metals	Zinc, total	mg/L	0.004	0.177	0.14	0.0653	0.1	1.57	0.448	0.202
Total Metals	Zirconium, total	mg/L	0.0001	0.00002	0.00002	0.000052	0.00002	0.000204	0.0001	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9011446
Report Date: 2019-02-01 09:53:48

Client Nyrstar Myra Falls
Attention Nicole Pesonen
Project Monthly
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9011446-04	9031829-01	9040523-03	9050222-08	9061285-04	9072067-04	9080697-08	9091289-04	9101235-04	9110068-08	9120929-05
CLIENT ID				MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2	MC-M2
DATE SAMPLED				2019-01-16	2019-03-20	2019-04-03	2019-05-01	2019-06-12	2019-07-17	2019-08-07	2019-09-11	2019-10-09	2019-11-14	2019-12-10
DATE RECEIVED				2019-01-18	2019-03-22	2019-04-04	2019-05-02	2019-06-13	2019-07-19	2019-08-09	2019-09-13	2019-10-11	2019-11-18	2019-12-11
MATRIX				Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**											
Anions	Nitrate+Nitrite (as N)	mg/L	0.005	0.036	0.052	0.024	0.025	0.052	0.0391	0.402	0.211	0.134	0.209	0.164
Anions	Nitrite (as N)	mg/L	0.005	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Anions	Sulfate	mg/L	1	38.1	33.9	16.9	22.9	14.4	16.5	54.7	66.2	34.2	37.7	33.9
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	48.7	44.2	26.9	34.7	23.9	23	62	77.9	45.7	51.8	48.6
Calculated Parameters	Nitrate (as N)	mg/L	0.01	0.036	0.052	0.0245	0.0246	0.0523	0.039	0.402	0.211	0.134	0.209	0.164
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.0321	0.042	0.0464	0.0416	0.0256	0.0261	0.0717	0.0591	0.0268	0.0613	0.0373
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00005	0.00064	0.00021	0.00014	0.00103	0.00038
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00012	0.0005	0.0005	0.000108	0.0005	0.0005
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.007	0.0056	0.005	0.0056	0.005	0.00517	0.0111	0.0132	0.00803	0.0094	0.0076
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0074	0.007	0.005	0.005	0.005	0.0024	0.0158	0.0118	0.0067	0.0124	0.0071
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000366	0.00008	0.000101	0.000167	0.000033	0.0000412	0.000103	0.000147	0.0000784	0.000088	0.000015
Dissolved Metals	Calcium, dissolved	mg/L	0.2	16.9	15.3	9.34	12	8.65	8.27	22	26.2	16.9	18.1	17.2
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.00102	0.00091	0.001	0.0009	0.001	0.00117	0.0005
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000087	0.0001	0.0001	0.0000181	0.0001	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00339	0.00127	0.00737	0.00378	0.00067	0.0008	0.00187	0.00244	0.00145	0.00188	0.00215
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.0052	0.01	0.01	0.002	0.01	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.00218	0.0002	0.000081	0.0002	0.0002	0.000082	0.0002	0.00027
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00022	0.00028	0.00018	0.00016	0.00015	0.000151	0.00044	0.0007	0.000307	0.00031	0.00025
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	1.54	1.47	0.866	1.14	0.545	0.569	1.66	3.02	0.856	1.62	1.36
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00657	0.00463	0.00404	0.00889	0.00107	0.00159	0.00433	0.00684	0.00287	0.00526	0.00382
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00028	0.00032	0.00026	0.0003	0.00044	0.000369	0.00151	0.0005	0.000817	0.00113	0.0001
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.000059	0.0004	0.0005	0.000083	0.0004	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.05	0.01	0.05	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.12	0.14	0.11	0.15	0.13	0.111	0.98	0.43	0.536	0.59	0.5
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.0005	0.00028	0.00065	0.0005
Dissolved Metals	Silicon, dissolved	mg/L	1	1.3	1.4	1.2	1.2	1	0.96	1.2	1.6	1.52	2.1	1.5
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00001	0.00005	0.00005	0.00001	0.00005	0.00005
Dissolved Metals	Sodium, dissolved	mg/L	0.1	0.98	1.01	0.96	1.14	0.85	0.781	2.07	2.68	1.5	1.72	1.54
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.0433	0.0483	0.029	0.0332	0.0237	0.0283	0.0752	0.0961	0.0589	0.0656	0.0539
Dissolved Metals	Sulfur, dissolved	mg/L	3	12.4	10.7	5.9	8.6	4.3	5.66	17.1	24.1	12.1	13.3	11.4
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00005	0.0005	0.0005	0.00005	0.0005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.000004	0.00002	0.00002	0.000004	0.00002	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00005	0.0002	0.0002	0.00005	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.0002	0.005	0.005	0.0002	0.005	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.001	0.0002	0.001	0.001
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.000023	0.000024	0.000027	0.000021	0.00002	0.0000357	0.00002	0.000022	0.000014	0.000027	0.000026
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.001	0.0002	0.001	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.108	0.0298	0.0308	0.0537	0.0124	0.0104	0.033	0.0444	0.0205	0.0285	0.0285
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00002	0.0001	0.0001	0.00002	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	23.6	13.6	13.1	17.1	11.4	9.2	12.2	16.6	18	13.4	21
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3	mg/L	1	23.6	13.6	13.1	17.1	11.4	9.2	12.2	16.6	18	13.4	21
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	Ammonia, Total (as N)	mg/L	0.02	0.022	0.025	0.024	0.081	0.077	0.048	0.178	0.114	0.114	0.12	0.076
General Parameters	Phosphorus, Total (as P)	mg/L	0.002	0.021	0.002	0.0056	0.0023	0.0049	0.0094	0.002	0.0083	0.0032	0.0036	0.0052
General Parameters	Phosphorus, Total Dissolved	mg/L	0.002	0.0049	0.002	0.0043	0.002	0.0023	0.0093	0.002	0.0067	0.0021	0.002	0.002
General Parameters	Solids, Total Suspended	mg/L	2		2	2	2	2						
General Parameters	pH	pH units	0.1	7.33	7.07	7.15	7.2	7.12	7.02	7.06	7.25	7.27	7.15	7.23
General Parameters	Conductivity (EC)	uS/cm	2	133	110	69.2	87.8	58.6	60.6	157	189	118	130	123
Total Metals	Aluminum, total	mg/L	0.005	0.0512	0.0575	0.0614	0.055	0.0309	0.033	0.0883	0.074	0.0426	0.0751	0.048
Total Metals	Antimony, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.000053	0.00068	0.00022	0.000198	0.00119	0.00045
Total Metals	Arsenic, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.000153	0.0005	0.0005	0.000173	0.0005	0.0005
Total Metals	Barium, total	mg/L	0.005	0.0073	0.0065	0.0055	0.0069	0.0064	0.00602	0.0123	0.0145	0.00923	0.0115	0.0094
Total Metals	Beryllium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.0079	0.0091	0.0051	0.005	0.0054	0.0031	0.0161	0.0122	0.0071	0.0167	0.0148
Total Metals	Cadmium, total	mg/L	1E-05	0.00041	0.000094	0.000111	0.000097	0.000064	0.000049	0.00013	0.00018	0.0000912	0.000114	0.000032
Total Metals	Calcium, total	mg/L	0.2	19.6	16.4	10.3	14.1	9.14	9.28	22.6	31	18.1	18.4	19.5
Total Metals	Chromium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.00081	0.00087	0.00106	0.00103	0.00103	0.00135	0.0005
Total Metals	Cobalt, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000149	0.0001	0.0001	0.0000246	0.0001	0.0001
Total Metals	Copper, total	mg/L	0.0004	0.00607	0.00248	0.0116	0.00255	0.00124	0.00195	0.00284	0.00407	0.00207	0.00402	0.00335
Total Metals	Iron, total	mg/L	0.01	0.014	0.015	0.021	0.022	0.01	0.0101	0.01	0.013	0.0087	0.015	0.01
Total Metals	Lead, total	mg/L	0.0002	0.00021	0.00022	0.00056	0.00052	0.00037	0.000243	0.00025	0.00089	0.000295	0.00123	0.00067
Total Metals	Lithium, total	mg/L	0.0001	0.00025	0.00034	0.00026	0.0001	0.00017	0.000167	0.00051	0.0007	0.000336	0.0003	0.00029
Total Metals	Magnesium, total	mg/L	0.01	1.64	1.62	0.851	1.11	0.517	0.584	1.85	3.27	0.971	1.56	1.5
Total Metals	Manganese, total	mg/L	0.0002	0.0114	0.007	0.00703	0.00491	0.00158	0.00262	0.00585	0.00999	0.00559	0.0077	0.0075
Total Metals	Molybdenum, total	mg/L	0.0001	0.00027	0.00035	0.00028	0.00034	0.00092	0.000385	0.00156	0.00048	0.000887	0.00122	0.00045
Total Metals	Nickel, total	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.000322	0.0004	0.0004	0.000125	0.00054	0.0004
Total Metals	Phosphorus, total	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.05	0.01	0.05	0.05
Total Metals	Potassium, total	mg/L	0.1	0.17	0.14	0.11	0.2	0.22	0.126	1.06	0.47	0.575	0.67	0.53
Total Metals	Selenium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.00075	0.0001	0.0005	0.0005	0.00042	0.00079	0.0005
Total Metals	Silicon, total	mg/L	1	1.6	1.4	1.2	1.3	1	1.01	1.5	2	1.64	4.1	1.7
Total Metals	Silver, total	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00001	0.00005	0.00005	0.00001	0.00005	0.00005
Total Metals	Sodium, total	mg/L	0.1	1.08	1.47	0.97	1.65	0.95	0.829	2.28	1.94	1.65	1.68	1.63
Total Metals	Strontium, total	mg/L	0.001	0.0501	0.0519	0.0282	0.0348	0.0236	0.0299	0.0809	0.0986	0.0617	0.0698	0.0604
Total Metals	Sulfur, total	mg/L	3	13.2	12.4	6.5	9	7.3	6	20	25	12.3	10.6	12.9
Total Metals	Tellurium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00005	0.0005	0.0005	0.000078	0.0005	0.0005
Total Metals	Thallium, total	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.000004	0.00002	0.00002	0.000004	0.00002	0.00002
Total Metals	Thorium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.0001	0.00001	0.0001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00005	0.0002	0.0002	0.00005	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.0002	0.005	0.005	0.0002	0.005	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.001	0.0002	0.001	0.001
Total Metals	Uranium, total	mg/L	2E-05	0.000027	0.000029	0.000029	0.000023	0.00002	0.0000198	0.00002	0.000025	0.0000273	0.000028	0.00003
Total Metals	Vanadium, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.0013	0.00027	0.001	0.001	0.0002	0.001	0.001
Total Metals	Zinc, total	mg/L	0.004	0.128	0.0384	0.0391	0.0369	0.0114	0.0156	0.0395	0.0564	0.0269	0.0486	0.0397
Total Metals	Zirconium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00002	0.0001	0.0001	0.00002	0.0001	0.0001

CARO Analytical Services
FINAL Analytical Testing Report
Work Order: 9011446
Report Date: 2019-02-01 09:53:48

Client Nyrstar Myra Falls
Attention Nicole Pesonen
Project Monthly
Project Info [none]

Note: This is not the original data. Please refer to PDF / Hardcopy report.

LAB ID				9011446-01	9031295-02	9040523-01	9050222-03	9061285-01	9072067-01	9080697-03	9091289-01	9101235-01	9110068-03	9120929-03
CLIENT ID				MC-TP4-M	MC-TP4-M	MC-TP4-M	MC-TP4	MC-TP4-M	MC-TP4-M	MC-TP4	MC-TP4-M	MC-TP4-M	MC-TP4	MC-TP4
DATE SAMPLED				2019-01-16	2019-03-13	2019-04-03	2019-05-01	2019-06-12	2019-07-17	2019-08-07	2019-09-11	2019-10-09	2019-11-14	2019-12-10
DATE RECEIVED				2019-01-18	2019-03-14	2019-04-04	2019-05-02	2019-06-13	2019-07-19	2019-08-09	2019-09-13	2019-10-11	2019-11-18	2019-12-11
MATRIX				Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
General Method	**Analyte**	**Units**	**MRL**											
Calculated Parameters	Hardness, Total (as CaCO3)	mg/L	0.5	51.4	93.9	26.8	34.5	23.9	28.4	63.3	74.4	46	49.3	48.5
Dissolved Metals	Aluminum, dissolved	mg/L	0.005	0.0356	0.0501	0.0467	0.045	0.029	0.0284	0.0845	0.0611	0.0314	0.0697	0.0441
Dissolved Metals	Antimony, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.000056	0.00067	0.000178	0.000156	0.00107	0.00042
Dissolved Metals	Arsenic, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.000121	0.0005	0.000134	0.000147	0.0005	0.0005
Dissolved Metals	Barium, dissolved	mg/L	0.005	0.0072	0.008	0.0052	0.0055	0.005	0.0057	0.0103	0.0122	0.00834	0.009	0.0077
Dissolved Metals	Beryllium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Dissolved Metals	Bismuth, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Dissolved Metals	Boron, dissolved	mg/L	0.005	0.0138	0.0105	0.005	0.005	0.0074	0.0026	0.0179	0.0107	0.0072	0.0202	0.0066
Dissolved Metals	Cadmium, dissolved	mg/L	1E-05	0.000368	0.000147	0.000093	0.00008	0.000034	0.0000472	0.000093	0.000141	0.0000819	0.000096	0.000013
Dissolved Metals	Calcium, dissolved	mg/L	0.2	18.1	33.2	9.29	12	8.65	10.3	22.5	25.4	17	17.1	17.1
Dissolved Metals	Chromium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00011	0.001	0.00011	0.00085	0.00129	0.0005
Dissolved Metals	Cobalt, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000099	0.0001	0.0000234	0.0000214	0.0001	0.0001
Dissolved Metals	Copper, dissolved	mg/L	0.0004	0.00356	0.00195	0.00853	0.00163	0.00071	0.001	0.00195	0.00207	0.00169	0.00198	0.00248
Dissolved Metals	Iron, dissolved	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.0023	0.01	0.002	0.0025	0.01	0.01
Dissolved Metals	Lead, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.000107	0.0002	0.000116	0.000174	0.0002	0.0002
Dissolved Metals	Lithium, dissolved	mg/L	0.0001	0.00024	0.00069	0.00018	0.00018	0.00017	0.000193	0.00049	0.000634	0.000335	0.00032	0.00029
Dissolved Metals	Magnesium, dissolved	mg/L	0.01	1.53	2.65	0.877	1.11	0.542	0.665	1.71	2.63	0.829	1.58	1.41
Dissolved Metals	Manganese, dissolved	mg/L	0.0002	0.00609	0.00366	0.00344	0.00204	0.00086	0.00161	0.00397	0.00621	0.00277	0.00532	0.00369
Dissolved Metals	Molybdenum, dissolved	mg/L	0.0001	0.00029	0.00044	0.00028	0.00034	0.00049	0.000383	0.00163	0.00223	0.000871	0.00112	0.0001
Dissolved Metals	Nickel, dissolved	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.00508	0.000095	0.0004	0.000117	0.000162	0.0004	0.0004
Dissolved Metals	Phosphorus, dissolved	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.01	0.01	0.05	0.05
Dissolved Metals	Potassium, dissolved	mg/L	0.1	0.13	0.32	0.11	0.14	0.15	0.146	1.04	0.358	0.603	0.58	0.54
Dissolved Metals	Selenium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.00013	0.00029	0.00065	0.0005
Dissolved Metals	Silicon, dissolved	mg/L	1	1.3	1.6	1.2	1.2	1	1.04	1.2	1.62	1.48	1.9	1.5
Dissolved Metals	Silver, dissolved	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00001	0.00005	0.00001	0.00001	0.00005	0.00005
Dissolved Metals	Sodium, dissolved	mg/L	0.1	0.98	2.31	0.97	1.16	0.91	0.941	2.13	2.25	1.59	1.71	1.63
Dissolved Metals	Strontium, dissolved	mg/L	0.001	0.0477	0.104	0.0298	0.0349	0.0253	0.0357	0.0784	0.0938	0.0633	0.066	0.0563
Dissolved Metals	Sulfur, dissolved	mg/L	3	12.8	28.6	5.1	8.3	4.4	7.2	18.2	20.3	12.3	13.6	12.2
Dissolved Metals	Tellurium, dissolved	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00005	0.0005	0.00005	0.00005	0.0005	0.0005
Dissolved Metals	Thallium, dissolved	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.000004	0.00002	0.000004	0.000004	0.00002	0.00002
Dissolved Metals	Thorium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Dissolved Metals	Tin, dissolved	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00005	0.0002	0.00005	0.00005	0.0002	0.0002
Dissolved Metals	Titanium, dissolved	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.0002	0.005	0.0002	0.0002	0.005	0.005
Dissolved Metals	Tungsten, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.0002	0.0002	0.001	0.001
Dissolved Metals	Uranium, dissolved	mg/L	2E-05	0.000024	0.000021	0.000027	0.000026	0.000024	0.0000181	0.00002	0.0000189	0.0000152	0.000026	0.000028
Dissolved Metals	Vanadium, dissolved	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.00036	0.0002	0.001	0.001
Dissolved Metals	Zinc, dissolved	mg/L	0.004	0.113	0.0519	0.0292	0.0265	0.0106	0.0114	0.0311	0.0345	0.0221	0.0251	0.0259
Dissolved Metals	Zirconium, dissolved	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00002	0.0001	0.00002	0.00002	0.0001	0.0001
General Parameters	Alkalinity, Total (as CaCO3)	mg/L	1	20.4	21.9	12.1	15.3	9.6	10.3	11	15.9	15.8	12.3	16.1
General Parameters	Alkalinity, Phenolphthalein (as Ca	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Bicarbonate (as CaCO3)	mg/L	1	20.4	21.9	12.1	15.3	9.6	10.3	11	15.9	15.8	12.3	16.1
General Parameters	Alkalinity, Carbonate (as CaCO3)	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	Alkalinity, Hydroxide (as CaCO3)	mg/L	1	1	1	1	1	1	1	1	1	1	1	1
General Parameters	pH	pH units	0.1	7.24	7.16	7.25	7.24	7.06	7	7.17	7.29	7.24	7.15	7.23
General Parameters	Conductivity (EC)	uS/cm	2	133	222	70.4	86.5	57.7	72.1	163	184	123	126	123
Total Metals	Aluminum, total	mg/L	0.005	0.0589	0.0753	0.0685	0.0579	0.0335	0.0376	0.102	0.0903	0.052	0.0825	0.0552
Total Metals	Antimony, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00007	0.00072	0.000211	0.000406	0.00118	0.0005
Total Metals	Arsenic, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.000162	0.0005	0.000218	0.000188	0.0005	0.0005
Total Metals	Barium, total	mg/L	0.005	0.0077	0.0087	0.0055	0.0078	0.0062	0.00668	0.0113	0.0226	0.00935	0.0116	0.0098
Total Metals	Beryllium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Total Metals	Bismuth, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Total Metals	Boron, total	mg/L	0.005	0.0122	0.0142	0.006	0.005	0.0076	0.0035	0.0193	0.0121	0.008	0.0361	0.0139
Total Metals	Cadmium, total	mg/L	1E-05	0.000464	0.000176	0.000121	0.000092	0.000039	0.0000562	0.000124	0.000167	0.0000915	0.000121	0.000035
Total Metals	Calcium, total	mg/L	0.2	20.1	34.9	10.3	13.3	8.65	10.8	24	31.2	19.2	17.8	20.2
Total Metals	Chromium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00013	0.00164	0.00094	0.00092	0.00123	0.0005
Total Metals	Cobalt, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000259	0.0001	0.0000646	0.000032	0.0001	0.0001
Total Metals	Copper, total	mg/L	0.0004	0.00682	0.00415	0.0156	0.00249	0.00095	0.00155	0.003	0.00486	0.00238	0.00277	0.00395
Total Metals	Iron, total	mg/L	0.01	0.018	0.025	0.022	0.015	0.01	0.0106	0.047	0.0378	0.0108	0.014	0.013
Total Metals	Lead, total	mg/L	0.0002	0.00021	0.00039	0.00069	0.00046	0.00025	0.00038	0.00029	0.00191	0.000273	0.00043	0.00038
Total Metals	Lithium, total	mg/L	0.0001	0.00029	0.00068	0.00023	0.0001	0.00018	0.000199	0.00064	0.000701	0.000374	0.00044	0.00033
Total Metals	Magnesium, total	mg/L	0.01	1.72	2.67	0.857	1.15	0.531	0.691	1.92	2.96	0.977	1.59	1.56
Total Metals	Manganese, total	mg/L	0.0002	0.0132	0.009	0.00774	0.00445	0.00139	0.0108	0.00635	0.0127	0.00653	0.00815	0.00896
Total Metals	Molybdenum, total	mg/L	0.0001	0.0003	0.00049	0.00027	0.00037	0.00049	0.000399	0.00165	0.000538	0.000968	0.0012	0.00055
Total Metals	Nickel, total	mg/L	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.000225	0.00107	0.000206	0.000137	0.0004	0.0004
Total Metals	Phosphorus, total	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.011	0.01	0.05	0.05
Total Metals	Potassium, total	mg/L	0.1	0.19	0.32	0.12	0.22	0.16	0.183	1.13	0.428	0.66	0.65	0.58
Total Metals	Selenium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005	0.00018	0.00038	0.00079	0.0005
Total Metals	Silicon, total	mg/L	1	1.6	1.9	1.2	1.3	1	1.06	1.5	1.78	1.65	3.1	1.8
Total Metals	Silver, total	mg/L	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00001	0.00005	0.00001	0.00001	0.00005	0.00005
Total Metals	Sodium, total	mg/L	0.1	1.15	2.38	0.99	1.17	0.93	0.97	2.4	2.59	1.76	1.74	1.73
Total Metals	Strontium, total	mg/L	0.001	0.053	0.108	0.0293	0.0362	0.0253	0.0365	0.085	0.102	0.0679	0.0698	0.0651
Total Metals	Sulfur, total	mg/L	3	15.5	28	6.3	10	6.5	7.2	21.8	22.2	13.3	15.2	14.3
Total Metals	Tellurium, total	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00005	0.0005	0.00005	0.000115	0.0005	0.0005
Total Metals	Thallium, total	mg/L	2E-05	0.00002	0.00002	0.00002	0.00002	0.00002	0.000004	0.00002	0.000004	0.000004	0.00002	0.00002
Total Metals	Thorium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00001	0.0001	0.00001	0.00001	0.0001	0.0001
Total Metals	Tin, total	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.00005	0.0002	0.00005	0.00005	0.0002	0.0002
Total Metals	Titanium, total	mg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.0002	0.005	0.00084	0.0002	0.005	0.005
Total Metals	Tungsten, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.001	0.0002	0.0002	0.001	0.001
Total Metals	Uranium, total	mg/L	2E-05	0.00003	0.000022	0.000032	0.000025	0.000021	0.0000174	0.000021	0.0000224	0.0000235	0.00003	0.000034
Total Metals	Vanadium, total	mg/L	0.001	0.001	0.001	0.001	0.001	0.0012	0.00028	0.001	0.00049	0.0002	0.0035	0.001
Total Metals	Zinc, total	mg/L	0.004	0.138	0.0605	0.0446	0.0353	0.0097	0.0177	0.0372	0.0565	0.0268	0.0336	0.0411
Total Metals	Zirconium, total	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00002	0.0001	0.00002	0.00002	0.0001	0.0001

APPENDIX E – Chain-of-Custody Forms

END OF REPORT