Yukon

Environment | Water Resources Branch

Water Licence Audit Report

Dates of site visits: August 30, September 5, October 30, 31, and November 2, 2018

Licence number: MN93-001-13 (Expired)

Site contact: Arcadio Rodriguez

Date of report: March 14, 2019

Team: Nicole Novodvorsky, Brendan Mulligan, Amelie Janin, Norbert Botca, Claire Gough, Troy Searson, and Emily Sessford

Licensee: City of Whitehorse

Prepared by: Nicole Novodvorsky, Norbert Botca, and Amelie Janin

Distribution List: Government of Yukon – Environment (EC&I, EA, S&A), City of Whitehorse, Hemmera, Yukon Spring, Environment and Climate Change Canada, and Core Geoscience Services

Executive Summary

- The purpose of the audit was to understand the City of Whitehorse wastewater treatment facilities in anticipation of a water licence renewal and verify compliance with the current water licence.
- Water quality samples were collected in and around the Livingston Trail Environmental Control Facility (LTECF) and the Crestview Wastewater Treatment Facility (CWTF) for compliance sampling, to understand the flow paths of wastewater using artificial sweeteners, and to see if petroleum hydrocarbons are entering/exiting the LTECF.
- Conclusions:
    - At the time of the investigation, discharge from the LTECF was in compliance with EQS in water licence MN93-001-13, however the licence expired on November 1, 2018.
- Recommendations:
    - A surface water monitoring location should be added in Yukon River upstream of WH10 and upstream of all potential effects from affected groundwater seepage.

- A monitoring location for surface water quality should be added in the Yukon River downstream of the Crestview lagoon;
- Upstream and downstream monitoring locations should be established for surface water quality in the creek downgradient and south of the Crestview lagoon
- Hydrocarbons and metals in water should be monitored as per the Contaminated Sites Regulations (CSR) to ensure the potential receiving environments (e.g., the Yukon River) are not adversely impacted by discharge activities or upset conditions such as seepage containing contamination.
- Adequate characterization of the groundwater flow regime should be conducted and should include determination of the direction and rate of groundwater flow, identification of potential receiving environments, and assessment of travel times for potential contaminant pathways
- Groundwater level and quality around the Crestview Lagoons should be monitored
- The monitoring well GW-4 at the LTECF should be rehabilitated or replaced.
- Samples from existing groundwater monitoring wells at the LTECF and surface water bodies with water derived from wastewater (detectable concentrations of sweeteners) should be analyzed for the suite of petroleum hydrocarbon parameters
- MW2-08d at the CWTF should be rehabilitated or replaced, MW1-08 should be renamed MW1-08s, and a deeper well should be installed at the same location to create a nested pair similar to MW2-08s and MW2-08d
- Revise the analysis and discussion of stratigraphy and hydrogeology at the CWTF presented in EBA (2009) based on new information generated by rehabilitating or replacing MW2-08d, and installing a deeper well at the location of MW1-08.
- Water quality of all seeps downgradient of the LTECF, Pot Hole Lake, and Crestview Lagoon should be collected and monitored.

Background

- Licence MN93-001-13 expired on November 1, 2018. The licensee submitted an application for an 18-month renewal licence to better prepare for the submission of a proposal for a 25 year water licence.
- The purpose of the audit was to understand the City of Whitehorse wastewater treatment facilities in anticipation of their water licence renewal and ensure compliance.
- The LTECF discharged treated wastewater into the Yukon River via Pot Hole Lake commencing on August 1st, 2018 until the direct discharge line was repaired, where discharge commenced on September 6th, 2018; 12.5% through Pot Hole Lake and 87.5% through the discharge line. All discharge was again redirected into Pot Hole Lake on October 16, 2018. Discharge ceased on October 18, 2018.
- Artificial sweeteners (acesulfame, sucralose, saccharin, and cyclamate) were used as tracers of wastewater in this audit to understand possible flow paths and receptors. Artificial sweeteners are widespread in products consumed by humans such as diet beverages, pharmaceuticals, and toothpaste, and therefore are ubiquitous in human wastewater. The use of artificial sweeteners as tracers of wastewater is advantageous because these four artificial sweeteners are found in relatively high concentrations in human wastewater, they are very source specific, and degrade at relatively slow rates.
- The use of artificial sweeteners is a novel approach in a regulatory context, however as Spoelstra et al. (2017) states: "*Numerous studies have now demonstrated that artificial sweeteners are powerful tracers of wastewater in the environment*." Peer-reviewed studies have been published over the last 10 years demonstrating the efficacy of using artificial sweeteners as a tracer of domestic wastewater. Refer to Spoelstra et al. (2017) and references therein.
- Artificial sweetener results are reported in ng/L. Some results are reported as <MDL or MDL<PQL. MDL is the method detection limit, and the PQL is the practical quantitation limit. Results below the MDL indicates no detectable concentrations of the parameter. Results between the MDL and PQL indicate there is a small concentration detected, but it is so low that it may not be as accurate as reported.

Audit objectives

1. Ensure that discharge from the Livingston Trail Environmental Control Facility (LTECF) is in compliance with the Effluent Quality Standards (EQS) in water licence MN93-001-13.
2. Determine whether additional stations or parameters should be added to the monitoring requirements of MN93-001-13.
3. Determine if the following potential receptors are impacted by the LTECF: the Yukon River, groundwater seeps on the banks of the Yukon River, and presumed to be downgradient of the LTECF, and surface water bodies, including an apparent seepage pond and several pothole lakes.
4. Determine if the following potential receptors are impacted by the Crestview Wastewater Treatment Facility (CWTF): the Yukon River, a creek that is a tributary of the Yukon River and is presumed to be downgradient of the CWTF, and the Yukon Spring bottled water facility.
5. Search for groundwater seeps potentially downgradient of the LTECF in an area not typically surveyed by the City of Whitehorse (CoW) or its consultant.
6. Determine if influent or effluent from the LTECF contains detectable concentrations of petroleum hydrocarbons (PHCs) and, if so, if either contains concentrations of PHCs that exceed the aquatic life standards of the *Contaminated Sites Regulation* (CSR-AW).

Audit conditions

Date	Weather	Site Conditions
August 30, 2018	Overcast, no precipitation.	Conducted reconnaissance site visit to LTECF. Roads to and around site are navigable. Access around north side of storage pond may not be possible. Visited the CWTF and Yukon Springs water bottling plant to collect water quality samples; accessed sites from Alaska Highway. Sites surrounding the CWTF were accessed by foot.
September 5, 2018	Overcast, no precipitation.	Accessed the LTECF by vehicle and the areas to the south and west of the lagoon via vehicle. Road to and around site were navigable. Lakes sampled to the west of the LTECF were accessed by foot. Yukon River samples collected via boat launched at Rotary Park.
October 30, 2018	Mostly sunny, light snow on the ground	Accessed Yukon River bank (river right) via Long Lake Road and south from the LTECF, parking near well MW-4a. Walked along the Yukon River by foot.
October 31, 2018	Mostly sunny, light snow on the ground	Accessed Yukon River bank (river right) via Long Lake Road and south from the LTECF, parking near well MW-4a. Walked along the Yukon River by foot. Some banks downstream were narrow/difficult to traverse.
November 2, 2018	Overcast, snow on the ground, banks starting to freeze	Access Yukon River bank (river left) via the CWTF off the Alaska highway. Gained access to lagoons and parked, then walked on foot to bank.

Field notes

Note: Photos of sampling stations are available in Appendix A for reference. Descriptions and locations of sampling stations are available in Appendix B. Station locations are displayed on a map in Figure 1.

August 30, 2018

Team

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Brendan Mulligan, Senior Scientist – Groundwater, Government of Yukon
Amelie Janin, Senior Scientist – Water Quality, Government of Yukon
Claire Gough, Environmental Assessment Analyst, Government of Yukon
Troy Searson, Environmental Compliance Officer, Government of Yukon

Sampling Summary

Conducted a site visit of the City of Whitehorse (CoW) Livingston Long Term Environmental Control Facility (LTECF) and conducted an audit of the Crestview Lagoons wastewater treatment facility (CWTF) and area.

Station Code	Station Description	Field Notes	WQ Parameters Sampled
CC-DS	Crestview Creek downstream of Crestview Lagoon	Sampled channel downstream of beaver dam, approximately 150m upstream of Yukon River confluence. Area is very flooded upstream and downstream. Sampled where water flows the most on the north channel of creek.	Field parameters, artificial sweeteners
CL-3	Crestview Lagoon first secondary lagoon, north bank	Sampled at north end from shore near the water gate. Daphnia in water. Didn't record H20 temp.	Field parameters, artificial sweeteners
CL-1	Crestview Lagoon first primary lagoon, north bank	Water light brown. Sampled from bank.	Field parameters, artificial sweeteners
CC-US	Crestview Creek Upstream Crestview Lagoon, above culvert	Sampled upstream of culvert on road access to lagoons.	Field parameters, artificial sweeteners
YS	Yukon Springs water from tap at bottling plant	Sampled from tap within bottling plant.	Field parameters, artificial sweeteners
MW-1-08	Crestview monitoring well SW corner of lagoons	Dry at the time of the site visit.	None

MW-2-08	Crestview monitoring well S end of lagoons	Dry at the time of the site visit.	None
MW-3-08	Crestview Lagoon, NW corner well	Approximately 65 cm of groundwater column measured inside the monitoring well. Sampled using bailer.	Field parameters, artificial sweeteners
MW-4-08	Crestview Lagoon, east side well	Approximately 142 cm of groundwater column measured inside the monitoring well. Sampled using bailer.	Field parameters, artificial sweeteners

September 5, 2018

Team

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Amelie Janin, Senior Scientist – Water Quality, Government of Yukon
Emily Sessford, Environmental Compliance Officer, Government of Yukon
Katie Pfeifer, Groundwater Intern, Government of Yukon

Sampling Summary

This field event was conducted to collect surface and ground water samples from stations located at and in the vicinity of the LTECF. Samples obtained from LTECF were collected to ascertain the wastewater chemistry at the entrance and exit point of the LTECF. Samples collected upstream and downstream of the LTECF outfall (LTECF-US and CL-DS) were sampled to ascertain whether the water quality in Yukon River is affected by the water discharged from LTECF lagoon. The samples collected from the lakes and monitoring wells located south and west of the lagoon were sampled to ascertain if the water from the lagoon is discharging into subsurface.

Station Code	Station Description	Field Notes	WQ Parameters Sampled
CL-DS	Yukon River downstream of Crestview Lagoon mid-channel	-	Field parameters, routine, metals, major ions, nutrients, BOD5, fecal coliforms, oil & grease, hydrocarbons, artificial sweeteners
LTECF-US	Yukon River upstream of LTECF mid-channel	Upstream of seeps and all potential wastewater discharge. Strong sulphur odour.	
GW-1	Monitoring well 30m SE primary cells @ LTECF.	Sample clear	Field parameters, artificial sweeteners
GW-2	Monitoring well SW of facultative cells @ LTECF.	-	
GW-3	Monitoring well SW of long term storage pond	-	

GW-4	Monitoring well near northern margin of long term storage pond	Well is damaged; could not sample.	None
Lake1	Lake west of LTECF	Strong sulphur odour.	Field parameters, artificial sweeteners
Lake2	Lake west of LTECF	Replicate collected.	
Lake3	Lake west of LTECF	-	
Lake4	Lake west of LTECF	-	
Lake5	Lake west of LTECF	Relatively difficult to filter.	
Lake6	Lakes west of LTECF	-	
Lake7	Lake west of LTECF	-	
MW-1	Monitoring well 500m SSE of PHL.	Sample light brown.	Field parameters, artificial sweeteners
MW-2	Monitoring well 300m SSE of PHL.	Sample clear	
MW-4a	Monitoring well 30m NW of Yukon R to PHL.	Sample clear	
PHL	Pot hole lake	Smell of organic decomposition. Many active insects (Daphnia?) observed.	Field parameters, artificial sweeteners
Wetland	Wetland west of LTECF	Shallow water; limited open water, lots of debris and algae.	
WH-10	Yukon R u/s Whse Lagoon outfall mid-channel.	-	Field parameters, routine, nutrients, fecal coliforms
WH-11	Yukon R mid channel, 300 m d/s Whse Lagoon outfall	-	
WH-12	Yukon R mid channel, 750m d/s Whse Lagoon outfall.	Too much current to obtain turbidity.	Field parameters, fecal coliforms, artificial sweeteners
WH-6c	Combined Marwell and Porter Cr influent @ LTECF.	Turbidity unstable moving between 40-90NTU.	Field parameters, hydrocarbons, artificial sweeteners
WH-9b	LTECF discharge to effluent manhole.	Lots of filamentous algae; tried to avoid as much as possible.	Field parameters, routine, metals, major ions, nutrients, BOD5, fecal coliforms, oil & grease, LC50, hydrocarbons, artificial sweeteners

October 30, 2018

Team

Nicole Novodvorsky, Water Quality Technologist, Government of Yukon
Ethan Allen, Environmental Geochemist, Core Geoscience Services
Durand Cornett, Senior Environmental Technologist, Core Geoscience Services

Sampling Summary

Seepage samples were collected opportunistically during the Core Geosciences seep survey to identify any wastewater discharge. Monitoring well MW-4A near the bank was also sampled.

Station Code	Station Description	Field Notes	WQ Parameters Sampled
LL-Seep1	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 1	Small seep with low flow,	Field parameters, artificial sweeteners
YRB-1	Formerly monitoring well, Yukon R edge, 850m south of PHL. Now seep as sampling location.	Biggest seep observed, lots of green filamentous algae. CoreGeo Seep 4.	Field parameters, nutrients, dissolved metals, artificial sweeteners
LL-Seep11	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 11	Small channel, had to try hard to not get sediment in sample.	Field parameters, artificial sweeteners
LL-Seep2	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 2	Algae in seep water. No defined channel, just slow flow wet area. Had to create a pool area to sample the water.	Field parameters, artificial sweeteners
MW-4a	Monitoring well 30m NW of Yukon R to PHL.	Sampled with a hydrasleeve.	Field parameters, artificial sweeteners

October 31, 2018

Team

Nicole Novodvorsky, Water Quality Technologist, Government of Yukon
Norbert Botca, Groundwater Technologist, Government of Yukon

Sampling Summary

Yukon River bank, river right, was surveyed for seeps. No seeps were observed and therefore no samples were collected.

November 2, 2018

Team

Nicole Novodvorsky, Water Quality Technologist, Government of Yukon
Norbert Botca, Groundwater Technologist, Government of Yukon

Sampling Summary

Yukon River bank, river left, was surveyed for seeps downgradient of CWTF, and 2 seeps that were flowing were sampled.

Station Code	Station Description	Field Notes	WQ Parameters Sampled
CL-Seep1	Seep downgradient of CWTF along Yukon River	Seep was on the verge of freezing	Artificial Sweeteners
CL-Seep2	Seep downgradient of CWTF along Yukon River	Seep was on the verge of freezing	

Field Data

A summary of the field data collected during the site visit is presented in Table 1, below.

Table 1: Field parameters summary for surface water and groundwater stations

Station Name	T° C	DO	SPC (µS/cm)	pH	ORP (mV)	Turbidity (NTU)	Date (yymmdd)	Time (24 h)	Location
Wetland	11.9	16.35	838	6.91	-0.2	20.91	180905	13:17	LTECF
WH6c	10.1	1.09	715	7.94	-	40	180905	12:45	LTECF
WH9b	13.2	13.58	616	8.52	-	11.6	180905	12:06	LTECF
PHL	13.3	12.14	1159	9.08	-	1.95	180905	10:14	LTECF
Lake 1	12.4	13.09	-	9.44	-	14	180905	14:35	LTECF
Lake 2	12.7	12.23	2854	9.37	69.5	1.45	180905	14:48	LTECF
Lake 3	13.6	13.73	1915	9.03	82.2	7.2	180905	14:20	LTECF
Lake 4	11.9	9.14	807	7.68	94.1	1.1	180905	13:46	LTECF
Lake 5	11.2	8.42	1085	8.88	-	0.9	180905	11:00	LTECF
Lake 6	13.3	12.14	1159	9.08	-	1.95	180905	10:32	LTECF
Lake 7	12	10.88	861	8.32	-	3.35	180905	9:50	LTECF
MW1	8.26	5.73	608	7.65	222.1	75.13	180905	10:30	LTECF
MW2	7.6	5.69	605	7.66	223.7	7.62	180905	11:32	LTECF
MW4A	4.98	2.75	362.8	8.29	-1.3	4.03	180905	9:43	LTECF
MW4A	5.5	3.63	322.8	8.53	-	-	180830	13:21	LTECF

GW1	6.34	3.84	666	7.54	250.2	122.5	180905	12:35	LTECF
GW2	4.72	4.86	890	7.61	241.5	>35,000	180905	13:55	LTECF
GW3	4.1	5.24	853	7.54	244.6	94.26	180905	13:00	LTECF
MW1-08	Only 0.3 m of GW column; DRY						180830	-	Crestview
MW2-08D	DRY						180830	-	Crestview
MW2-08S	DRY						180830	-	Crestview
MW3-08	8.83	3.98	1119	6.71	243	-	180830	15:45	Crestview
MW4-08	4.27	6.75	1108	7.03	266.7	-	180830	16:19	Crestview
LTECF-US	12.6	10.37	95.3	7.3	138.9	0.47	180830	10:41	Yukon River
CC-DS	7.6	10.5	414.12	7.95	143.3	2.44	180830	15:07	Yukon River
CL-1	13.3	0.9	730	6.7	-147.3	>35,000	180830	16:28	Yukon River
CL-3	-	1.59	454.4	7.32	-132.5	72.3	180830	15:44	Yukon River
CC-US	8.6	10.65	233.7	7.95	38.3	0.67	180830	16:49	Yukon River
CL-DS	12.5	10.46	95.6	7.79	91.8	0.51	180830	9:57	Yukon River
WH10	12.5	10.42	88.6	7.24	134.7	0.7	180830	10:32	Yukon River
WH11	12.5	10.43	95.4	7.23	127.5	0.51	180830	10:23	Yukon River
WH12	12.5	10.4	92.2	7.44	130.4	OR	180830	10:15	Yukon River
YS	8.5	7.71	546	7.37	105.4	1.28	180830	16:57	Yukon Springs
LL-Seep1	4.7	9.13	583	7.62	-	-	181030	10:37	LTECF
YRB-1	6.3	3.85	591	7.70	-	-	181030	11:11	LTECF
LL-Seep2	5.7	6.77	591	8.02	-	-	181030	13:56	LTECF
LL-Seep11	5.2	7.11	584	7.61	-	-	181030	11:58	LTECF

DO = dissolved oxygen
ORP = oxidation-reduction potential
SPC = specific conductance
LTECF = Livingstone Trail Environmental Control Facility

Figure 1: Map of water sampling stations for the 2018 audit

Quality assurance and control

Quality assurance was ensured through following standard protocols for water quality sampling and using trained water collectors. An accredited laboratory was used for sample analysis to ensure data quality and reliability. Deviations from the protocol include not collecting replicate and field/trip blanks, although a replicate sweetener sample was collected.

Quality control was conducted by using a functioning and calibrated field meter, and calculating relative differences between field and lab results, and between replicates and duplicates.

The results of the quality control show that there was good concordance (<25% relative percent difference (RPD)) between field and laboratory parameters (conductivity and pH). LL-Seep2 had 26% RPD, but may be attributed to the difficulty in obtaining a clear sample of water since flow was very slow. A replicate was collected for artificial sweeteners at Lake 2; and the RPD was zero for all artificial sweeteners signifying confidence in the results. Duplicates were analyzed in the lab for artificial sweeteners and resulted in RPD's of <5%, showing good concordance between lab duplicates and therefore further strengthen reliability of sweetener results. Lastly, samples were collected around the same time as the licensee and compared to see any major deviations in results. Conductivity, NH4, pH, and fecal coliforms were below 14% RPD. Total phosphorus (as PO4) RPD was high between samples, however differences between samples are amplified as concentrations approach the MDL and phosphorus is known to vary significantly even between replicates & duplicates. The QC results are reported in Appendix E.

Compliance

Objective 1: Ensure that discharge from the Livingston Trail Environmental Control Facility (LTECF) is in compliance with the Effluent Quality Standards (EQS) in water licence MN93-001-13.

Samples were collected to identify any exceedances of water licence effluent quality standards. At the time of the investigation, none of the parameters exceeded the EQS, but total suspended solids was not analyzed in error and therefore could not be compared (Table 2). Licence MN93-001-13 expired on November 1, 2018, and therefore the licensee is operating without a licence. The City of Whitehorse is currently in the process of obtaining an 18 month licence, in order to prepare for a 25-year licence application.

Table 2: Audit results compared to water licence effluent standards at WH9b

Parameter	Effluent Quality Standard	Station	Result
Fecal Coliforms	2000 MPN/100mL	WH9b	<1
CBOD5	25 mg/L	WH9b	2.6
pH	6-9	WH9b	8.52
Total suspended solids	25 mg/L	WH9b	N/A
Oil and Grease	5 mg/L	WH9b	<2.0
Un-ionized Ammonia	1.25 mg/L	WH9b	0.391
LC50	Non-toxic (>96 hours)	WH9b	>96 hrs

Water Quality Results

Objective 2: Determine whether additional stations or parameters should be added to the monitoring requirements of MN93-001-13.

Surface water

The now expired water licence MN9-001-13 required monitoring of the Yukon River in three locations, namely WH10, WH11, and WH12 (Figure 2). WH10 is described as "immediately upstream of outfall from the LTECF", however, the "Yukon River Seepage Discharge Monitoring Study" conducted in November 2017 (Core Geoscience Services, 2017) identified the location of seeps downgradient of the LTECF. Noteworthy, one of the seeps identified in this report, "Seep #1", was located upstream of WH10, hence WH10 is no longer upstream of all potential project effects (see Figure 2). In addition, WH10 is located within an eddy. Hence, WRB recommends adding a water quality monitoring station upstream of WH10.

In addition, the Water Licence MN93-001-13 does not currently require monitoring of the Yukon River downstream of Crestview Lagoon. The lagoon receives wastewater effluent from the City and the treatment of this effluent occurs through two sewage lagoons followed by evaporation and infiltration into ground. Potential downgradient receptors from the Crestview Lagoons include the creek south and downgradient of the Crestview facility and the Yukon River which is located downgradient from the site (EBA 2009). WRB recommends to monitor water quality in the Yukon River downstream of the facility to ensure that a potential impact to Yukon River's water quality will be detected and possibly in the creek south of the Crestview facility.

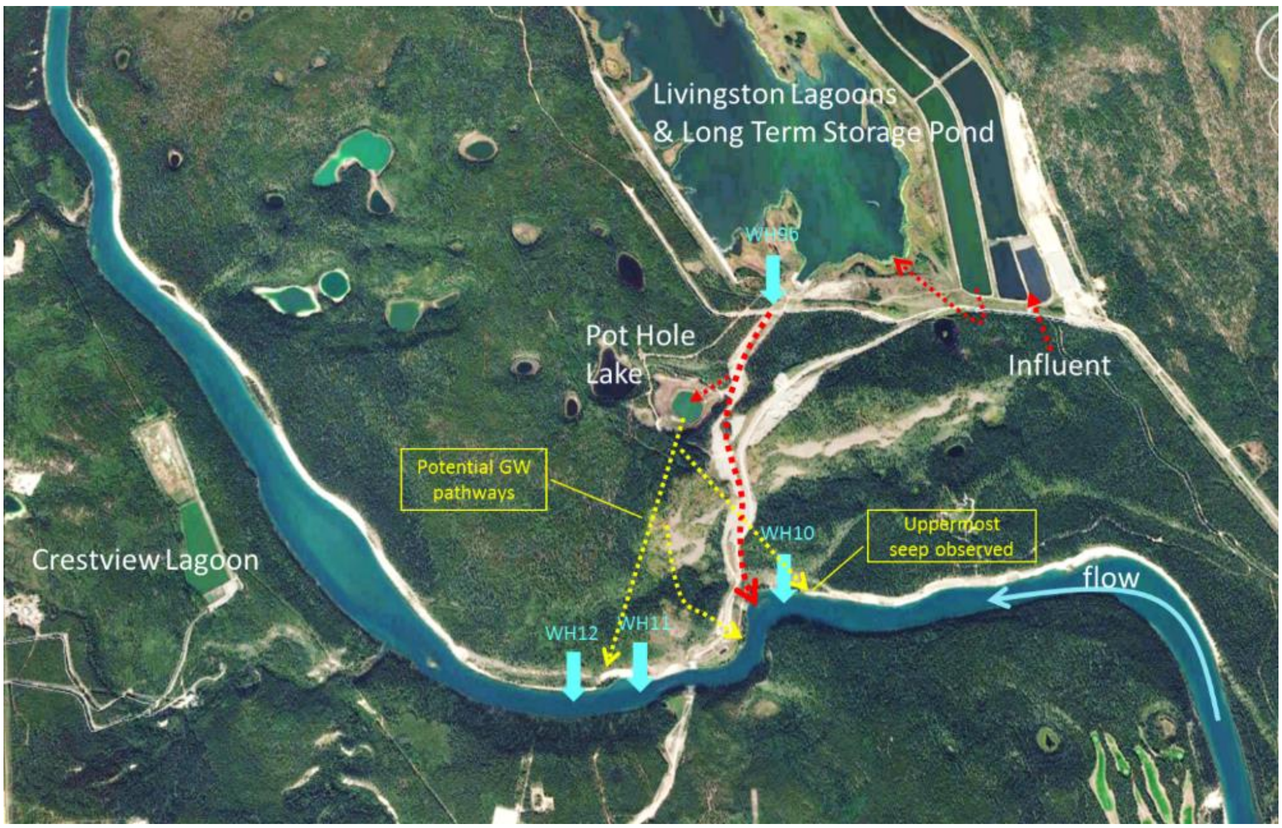

Figure 2: Location of the three Yukon River monitoring stations required under WL MN93-001-13.

Figure 3: Suggested monitoring locations downgradient of the Crestview facility

Groundwater

The current Water Licence MN093-001 does not require the City to conduct monitoring of groundwater around the Crestview Lagoon; however, the City is doing some monitoring in the area. In 2009, EBA conducted a hydrogeological investigation at the Crestview Lagoon and drilled four groundwater monitoring wells around the facility (see Figure *4: Location of Monitoring wells around the Crestview sewage lagoon facility (copied from EBA 2009).* 4 and EBA 2009). Unfortunately, EBA was not able to install bedrock wells at these locations. These wells are generally dry according to personal communications with the City. EBA had recommended a new bedrock monitoring well between the sewage lagoon and the Yukon Springs bottled water facility. WRB recommends monitoring of the quality and level of groundwater around of the sewage lagoon and implementation of EBA's recommendations.

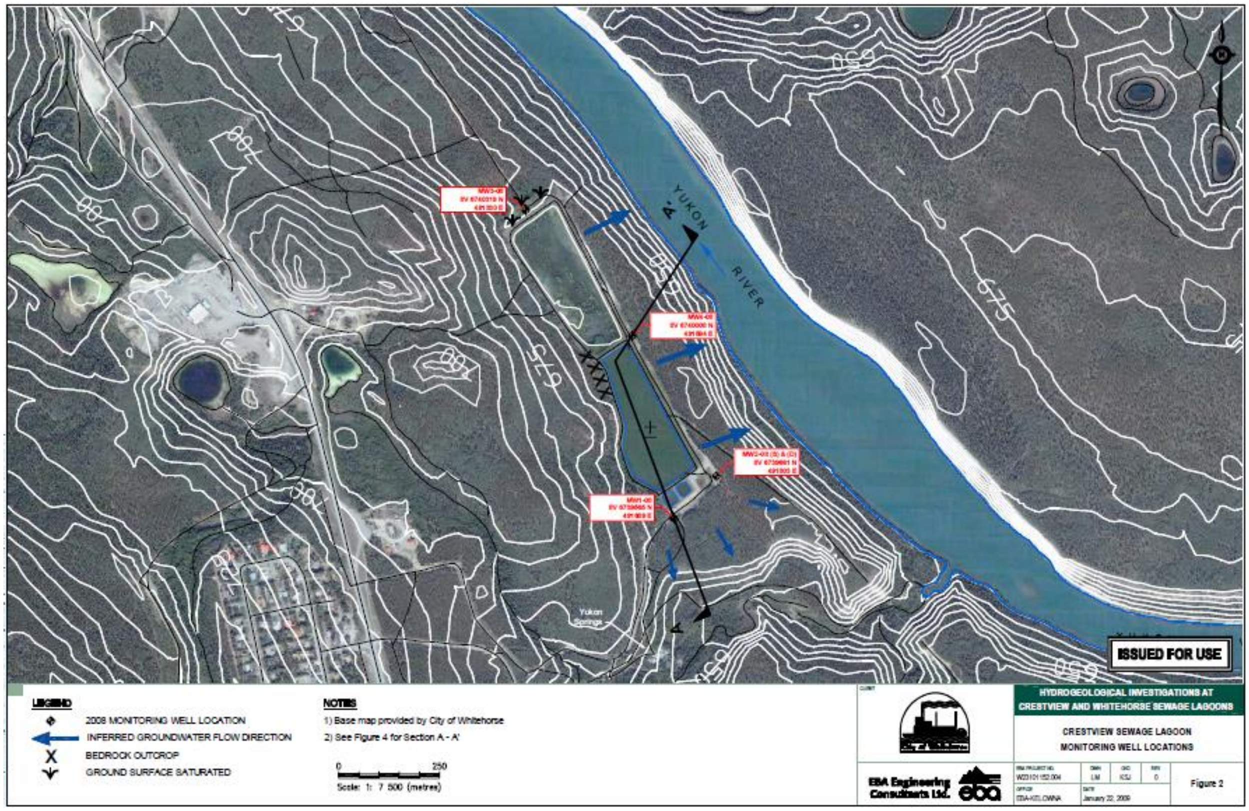

Figure 4: Location of Monitoring wells around the Crestview sewage lagoon facility (copied from EBA 2009).

Objective 3: Determine if the following potential receptors are impacted by the LTECF: the Yukon River, groundwater seeps on the banks of the Yukon River (and presumed to be downgradient of the LTECF), and surface water bodies, including an apparent seepage pond and several pothole lakes.

Current receptors of wastewater were identified using artificial sweeteners as a tracer. The results suggest that there is a significant presence of water derived from wastewater surrounding the long-term storage pond. Figure 5 illustrates the extent of the presence of water derived from wastewater using the relative percent of acesulfame relative to the concentrations observed at the discharge points (WH9b and PHL). Acesulfame was used as an indicator of the presence of water derived from wastewater due to its longer persistence in water compared to other sweeteners as well as its presence in samples collected where other sweeteners were not detected. The results suggest that wastewater is exfiltrating to groundwater and travelling outward to Lakes 3, 5, 6, and 7, the wetland (seepage pond), and groundwater wells GW1, 2, and 3. Lakes 1 and 2 appear to have no wastewater influence. Although it is known that the long-term storage pond is not lined, WRB is not aware of the extent of impact being previously evaluated.

Sweeteners were also detected in significant concentrations along the assumed flow path from Pot Hole lake south and into the Yukon River near MW-4a. There were no sweeteners detected in the Yukon River, likely due to dilution.

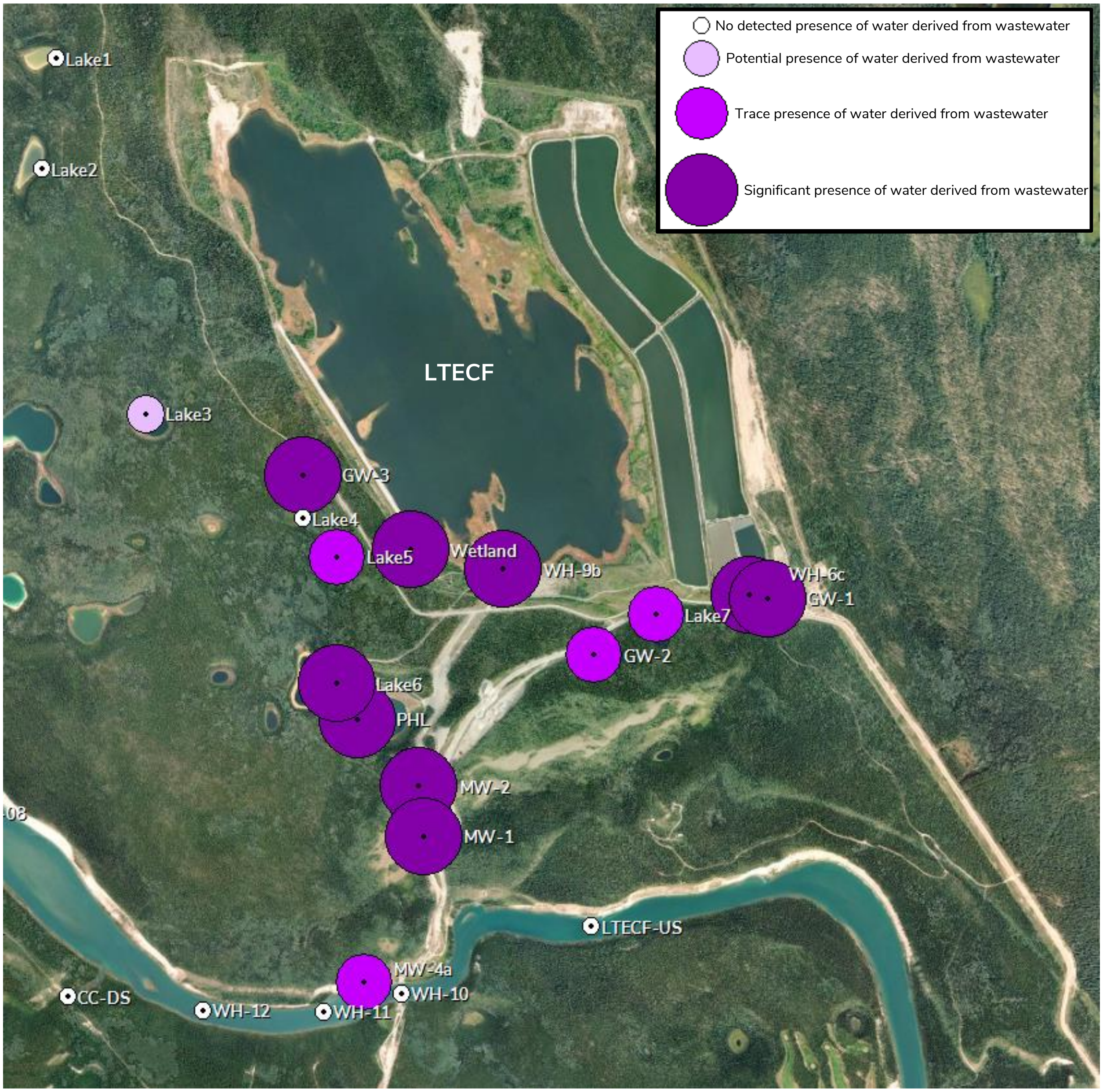

Figure 5: Summary of the presence of water derived from wastewater at stations sampled around the City of Whitehorse wastewater lagoons. The presence of water derived from wastewater is quantified by the relative percent concentration of artificial sweetener acesulfame divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the LTECF is defined as the average of acesulfame concentrations at WH-9b and PHL. The categories are defined as: No detected presence of water derived from wastewater = below method detection limit (<2 ng/L); Potential presence of water derived from wastewater = between method detection limit and practical quantitation limit (2-6 ng/L); Trace presence of water derived from wastewater = below 15% concentration relative to the concentration observed at the source; Significant presence of water derived from wastewater = >16% concentration relative to the concentration observed at the source.

To highlight differences between receptors influenced more recently by water derived from wastewater to those less recently, the ratio of saccharin to acesulfame concentrations relative to source concentrations were calculated and presented in Figure 3. Saccharin and acesulfame concentrations were used as a proxy for the age of wastewater and/or the degree of degradation of the sweetener. Artificial sweeteners will degrade over time due to a variety of factors, but overall acesulfame is known to degrade slower than saccharin. Therefore, a greater proportion of saccharin compared to acesulfame represents a greater presence of water derived from newer/untreated wastewater compared to older/treated wastewater. Artificial sweeteners are more susceptible to degradation in surface water compared to groundwater due to factors such as exposure to air and sunlight. Therefore, in the case of groundwater, greater saccharin concentrations relative to acesulfame indicate a more recent presence of water derived from wastewater and proximity to the wastewater source (Spoelstra et al. 2017). The results presented are not confirmatory since the sampling event was conducted one time, and therefore does not capture the temporal, seasonal, or spatial variability that may exist in the system.

The results in Figure 6 illustrate that GW-1, GW-3, and Lake7 are likely more recently influenced by the presence of water derived from wastewater. Stations GW-1, Lake7, and GW-3 have higher concentrations of saccharin compared to WH9b and PHL (approximately 7 times), which may indicate that samples collected at WH9b and PHL are not representative of the entire long-term storage pond, or wastewater is flowing subsurface from the storage pond and saccharin is not degrading as quickly as surrounding surface water bodies. A higher contribution of saccharin at GW-1 and Lake7 could also potentially be the result of the primary lagoons leaking.

Station MW-4a appears to also have a greater relative concentration of saccharin (newer, less degraded wastewater). The concentrations of saccharin at MW-4a are similar to source concentrations (203 and 302 ng/L respectively), whereas acesulfame concentrations decrease significantly compared to the source (494 and 3819ng/L, respectively). It would be expected that the flow path (MW1 and MW2) would also have a similar results, however concentrations of acesulfame are similar to source concentrations and saccharin is within the MDL<PQL. These results may suggest that the groundwater at MW1 and MW2 may not have been influenced by wastewater recently, and that there is a preferential wastewater pathway flowing due south to MW-4a and further west where the majority of seeps were observed. As discussed previously, temporal variability is not captured and therefore the sweetener results discussed above with respect to the relative age and degradation of water derived from wastewater are not conclusive, merely speculative. However, the artificial sweetener results overall do indicate the presence of water derived from wastewater.

A survey of seeps was conducted on the banks of the Yukon River to identify additional flow paths, and where possible samples were collected. The results are pending from the laboratory, and will be appended to this report once available.

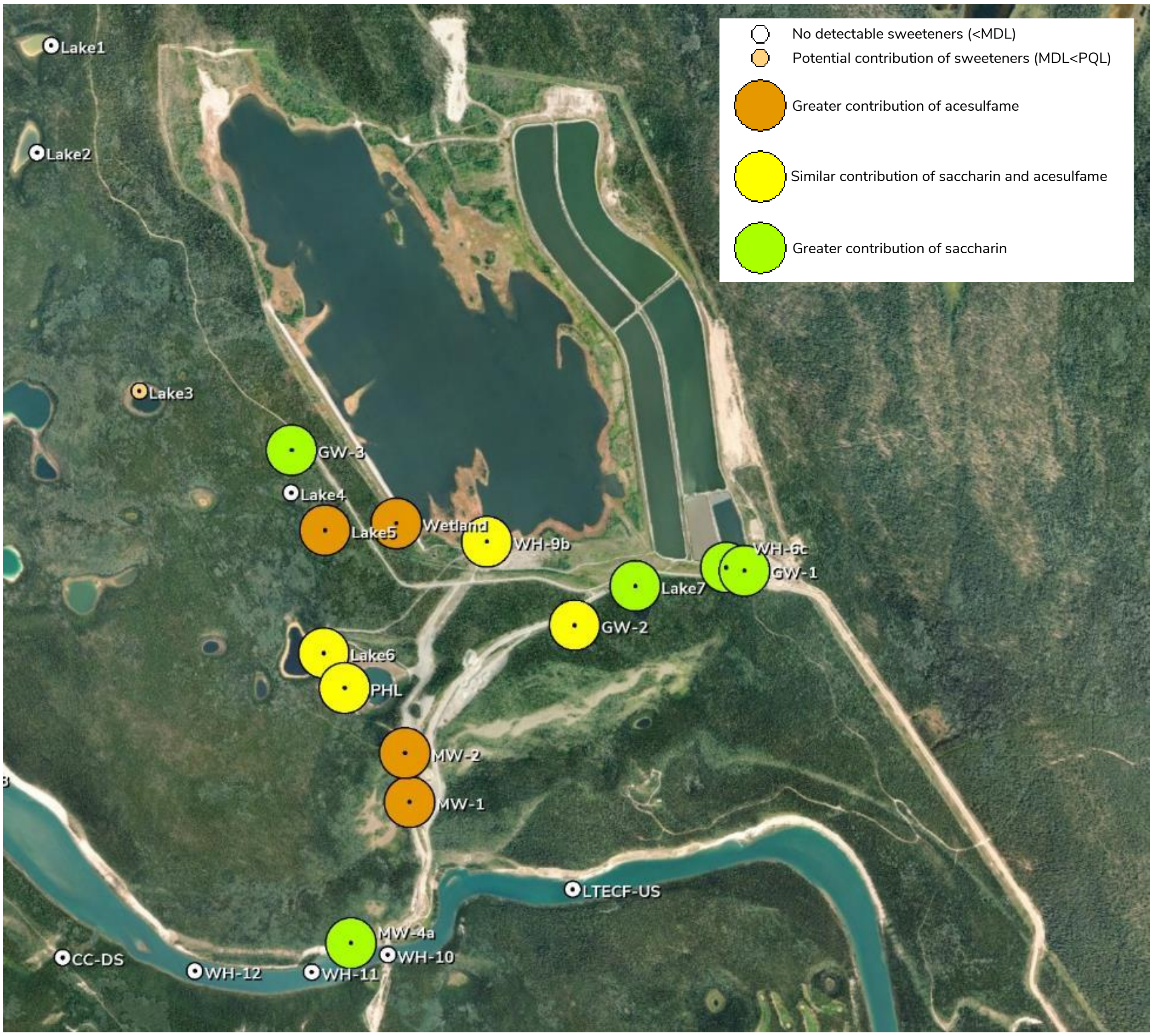

Figure 6: A representation of the ratio of the relative percent concentration of saccharin (more degradable artificial sweeteners) to the relative percent contribution of acesulfame (less degradable artificial sweeteners) surrounding the LTECF. The relative percent concentration of the artificial sweeteners was calculated as the concentration at a station divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the LTECF is defined as the average of acesulfame concentrations at WH-9b and PHL. The categories are defined as: No detected sweeteners = below method detection limit (<2 ng/L); Potential contribution of sweeteners = between method detection limit and practical quantitation limit (2-6 ng/L); Greater contribution of acesulfame = <0.8 ratio of relative concentrations of saccharin to acesulfame; Similar contribution of saccharin and acesulfame = 0.8-1.4 ratio of relative concentrations of saccharin to acesulfame; and Greater contribution of saccharin = >1.4 ratio of relative concentrations of saccharin to acesulfame. A greater ratio of degradable sweeteners (saccharin) is a proxy for newer and/or un- or under-treated wastewater. A greater ratio of less degradable sweeteners (acesulfame) represents older and/or treated wastewater.

A suite of conventional parameters were collected on the Yukon River such as metals, major ions, nutrients, fecal coliforms, and PHCs to assess any impacts and compare with receiving environment standards in water licence MN93-001-13. Water licence MN93-001-13 does not define 'negligible increase' for metals and therefore an RPD of 5% was used. The results indicate neglible (<5% RPD) changes in parameters from upsteam compared to downstream concentrations, with the exception of pH, ORP (oxidation reduction potential), total copper, and total phosphorus with RPD's between 7-118%. The changes as shown in Table 3 are not necessarily indicative of the impacts of the LTECF and CWWTF on Yukon River water, as more sampling events would be required to ascertain potential impacts. However, to estimate potential impacts from the discharge from the LTECF, the expected downstream concentrations were calculated based on available data of discharge and concentrations at the time of the audit at WH9b and the Yukon River. The lack of available data at the CWWTF precluded assessing impacts from this facility.

The following assimilative capacity equation was used to calculate the expected downstream concentration of parameters listed in Table 3: **C3 = Q1C1 + Q2C2 / Q3**, where:

Q1 = Yukon River discharge rate upstream (m^3/s),
C1 = Yukon River Concentration upstream,
Q2 = Wastewater discharge rate at WH9b (average rate in 2018) (m^3/s),
C2 = Parameter concentration at WH9b,
Q3 = Combined discharge downstream of LTECF (m^3/s),
C3 = Estimated concentration downstream LTECF.

The results suggest that the concentrations observed downstream for phosphorus and copper could be related to discharge from the LTECF with an expected concentration similar or higher than the observed concentrations.

Table 3: Summary of parameters on the Yukon River exceeding >5% RPD for samples collected on September 5, 2018. The expected downstream concentration was calculated using an assimilative capacity equation using the average discharge between the months of August to October between 2015-2017 (438m^3/s) and the estimated discharge from the LTECF on September 5, 2018 (0.25m^3/s). A more recent discharge value for the Yukon River was not available in 2018 to present.

Parameter	WH9b	LTECF-US (upstream)	CL-DS (downstream)	Expected downstream concentration
pH (field)	8.52	7.24	7.79	7.24
Oxidation Reduction Potential (mV)	N/A	138.9	91.8	N/A
Copper, total (mg/L)	0.00177	0.00046	0.00064	0.002
Total Phosphorus (as PO4) (mg/L)	2.31	<0.002	0.0034	0.0026

The data from WH9b was also compared to receiving environment standards from the Canadian Council of Ministers of the Environment's Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME's CWQG-PAL) and the Contaminated Sites Regulations for the Protection of Aquatic Life (CSR-AW). During the 2018 discharge, five water quality parameters exceeded CCME's CWQG-PAL and CSR-AW at station WH9b. To understand the potential impacts to the Yukon River, the assimilative capacity equation was used to estimate the expected 'worst case' downstream concentration using the lowest observed mean discharge in the Yukon River (317m³/s) between 2015-2017 in the months of August to October (when discharge from the LTECF occurs) and the highest discharge rate observed at WH9b in 2018 (1.97m³/s). More recent discharge values at the Yukon River were not available.

The results show that the Yukon River's high discharge rate compared to the LTECF discharge rate results in enough dilution to lower the concentration to below receiving environment standards, but could still increase the concentrations observed in the Yukon River. With ambiguous (no negligible increase) and limited parameters for recieving environment standards in water licence MN93-001-13, it is difficult to regulate the acceptable amount of contaminants in the Yukon River. New receiving environment standards should be developed to provide clarity in the new upcoming 25 year licence.

Table 4: Summary of the maximum observed concentrations of parameters exceeding receiving environment quality standards (CCME's CWQG-PAL and CSR-AW) for samples collected in 2018. The expected 'worst case' downstream concentration was calculated using the lowest observed discharge in the Yukon River (317m³/s) between 2015-2017 in the months of August to October (when discharge from the LTECF occurs) and the highest discharge rate observed at WH9b in 2018 (1.97m³/s).

Parameter (mg/L)	Receiving Environment Standard	WH9b maximum 2018	Upstream (WH-10/LTECF-US) Maximum 2018	Expected 'worst case' downstream concentration
Arsenic, total	0.005 (CCME & CSR)	0.00701	0.00052	0.00056
Iron, total	0.3 (CCME)	0.587	0.092	0.095
Nitrite	0.06 (CCME)	0.229	<0.01	0.0064
Ammonia, total	0.21,1.31 (CCME,CSR)	4.41	0.032	0.059
Unionized Ammonia	0.019 (CCME)	0.17	<0.0005	0.0013

Objective 4: Determine if the following potential receptors are impacted by the Crestview Wastewater Treatment Facility (CWTF): the Yukon River, a creek that is a tributary of the Yukon River and is presumed to be downgradient of the CWTF, and the Yukon Spring bottled water facility.

At the CWTF, the sweetener results suggest that wastewater is detected in both shallow and deep wells (MW3-08 and MW4-08, respectively), and therefore likely flowing subsurface into the Yukon River (Figure 7). Artificial sweeteners (acesulfame and saccharin) were also detected at the Yukon Springs bottled water facility. The results are above the minimum detection limit but less than the practical quantitation limit. These results suggest that there is minimal wastewater influence on Yukon Springs' water, however this suggestion should be confirmed with conventional parameters (i.e. fecal coliforms, nutrients, etc). It should be noted that the presence of artificial sweeteners themselves in drinking water is not of concern since artificial sweeteners are approved for human consumption under the federal *Food and Drug Act and Regulations*.

Figure 7: Summary of the presence of water derived from wastewater at stations sampled around the City of Whitehorse wastewater lagoons. The presence of water derived from wastewater is quantified by the relative percent concentration of artificial sweetener acesulfame to the average concentrations at the source of wastewater discharge. The source of wastewater discharge at Crestview lagoons is defined as the average of acesulfame concentrations at CL-1 and CL-3. The categories are defined as: No detected presence of water derived from wastewater = below method detection limit (<2 ng/L); Potential presence of water derived from wastewater = between method detection limit and practical quantitation limit (2-6 ng/L); Trace presence of water derived from wastewater = below 15% concentration relative to the concentration observed at the source; Significant presence of water derived from wastewater = >16% concentration relative to the concentration observed at the source.

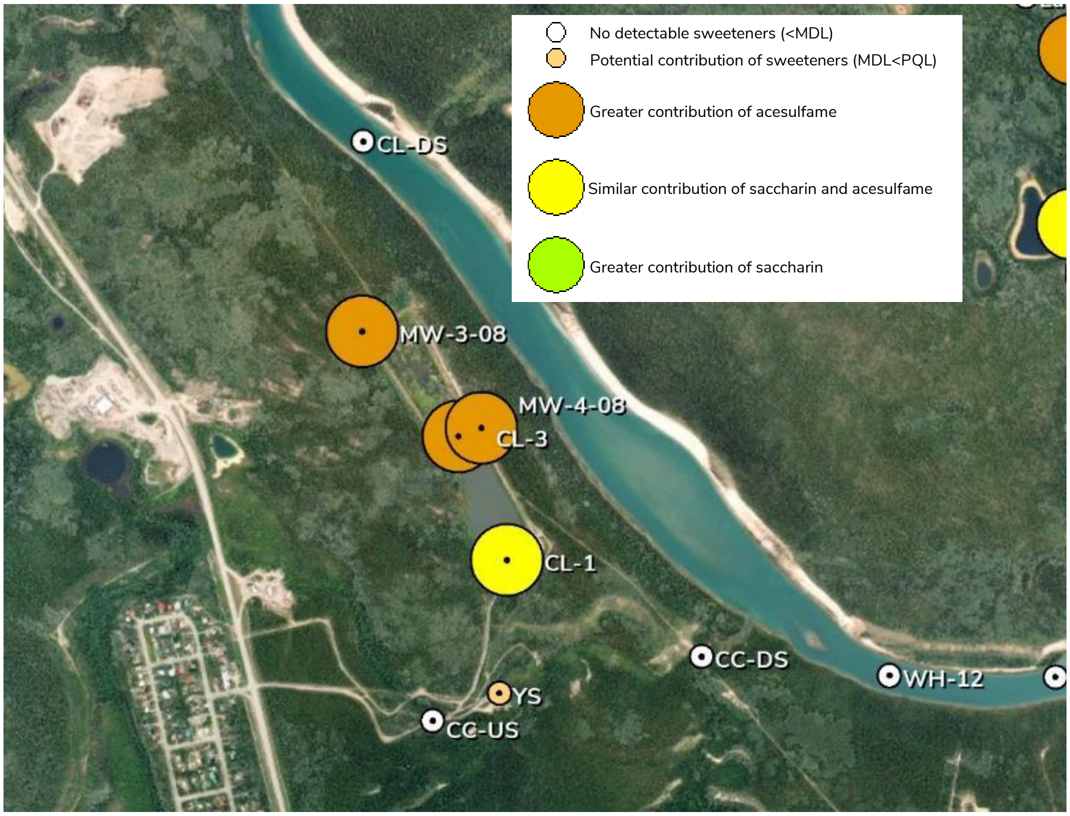

Figure 8: A representation of the ratio of the relative percent concentration of saccharin (more degradable artificial sweeteners) to the relative percent contribution of acesulfame (less degradable artificial sweeteners) surrounding the CWTF. The relative percent concentration of the artificial sweeteners was calculated as the concentration at a station divided by the average concentrations at the source of wastewater discharge. The source of wastewater discharge at the CWTF is defined as the average of acesulfame concentrations at CL-1 and CL-3. The categories are defined as: No detected sweeteners = below method detection limit (<2 ng/L); Potential contribution of sweeteners = between method detection limit and practical quantitation limit (2-6 ng/L); Greater contribution of acesulfame = <0.8 ratio of relative concentrations of saccharin to acesulfame; Similar contribution of saccharin and acesulfame = 0.8-1.4 ratio of relative concentrations of saccharin to acesulfame; and Greater contribution of saccharin = >1.4 ratio of relative concentrations of saccharin to acesulfame. A greater ratio of degradable sweeteners (saccharin) is a proxy for newer and/or un- or under-treated wastewater. A greater ratio of less degradable sweeteners (acesulfame) represents older and/or treated wastewater.

To highlight differences between receptors influenced more recently by water derived from wastewater to those less recently, the ratio of saccharin to acesulfame concentrations relative to source concentrations were calculated and presented in Figure 8. This figure illustrates that the ratio of saccharin to acesulfame changes from CL-1 to CL-3, but maintains the same ratio in the wells. This result shows that saccharin is likely degrading in the secondary ponds, but water derived from wastewater is or has influenced the wells significantly. When the samples from the seeps are analyzed, this may provide an indication of the direction and the contribution of water derived from wastewater to the Yukon River.

Objective 5: Search for groundwater seeps potentially downgradient of the LTECF in an area not typically surveyed by the City of Whitehorse (CoW) or its consultant.

WRB conducted a survey for potential seeps along the Yukon River on both the LTECF and Crestview sides to identify whether there are potential groundwater pathways from the LTECF and/or Crestview. Beyond the CoW seep survey, there were no seeps observed along the banks of the Yukon River on the LTECF side. Along the Crestview side, seeps were observed downgradient of the lagoons, however the source water has yet to be confirmed with artificial sweetener analysis (Figure 10). Only two seeps were sampled, the others were frozen.

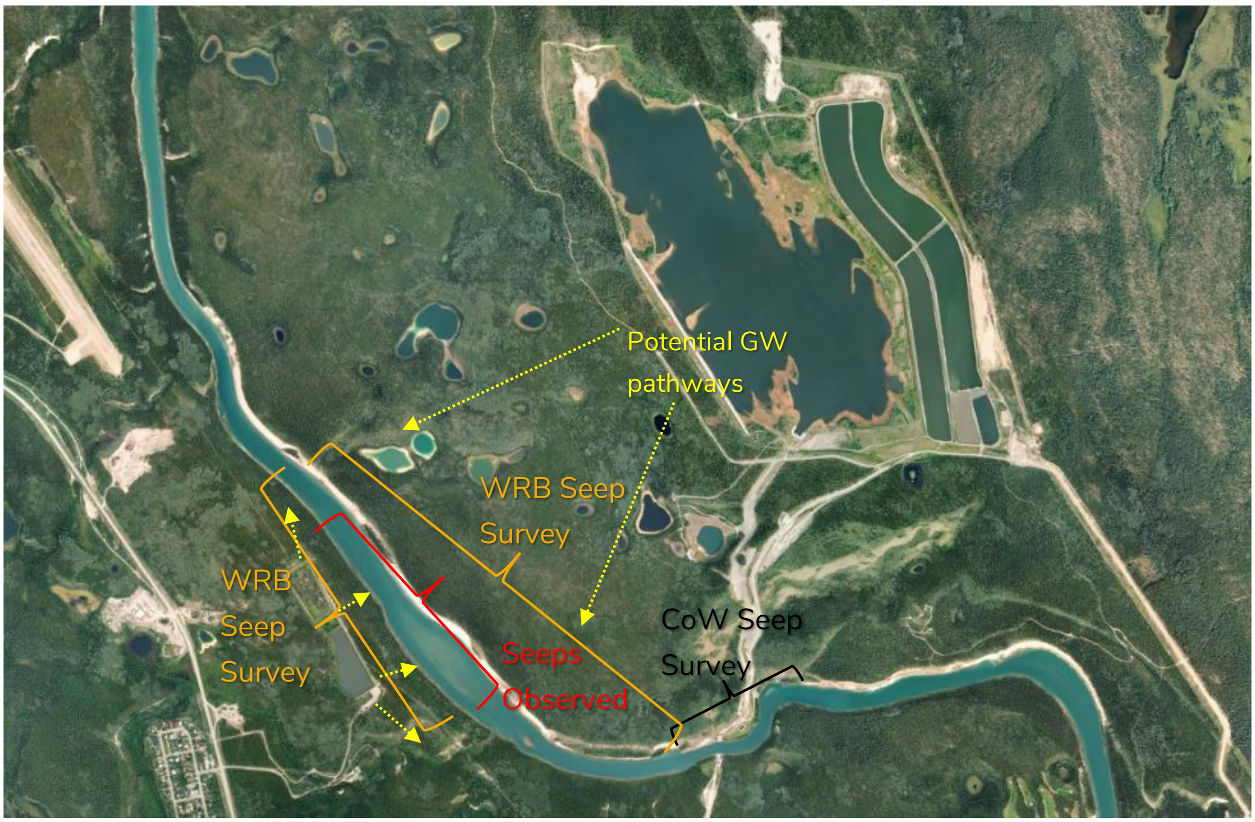

Figure 9: Summary of areas surveyed for seeps and seep locations.

Objective 6: Determine if influent or effluent from the LTECF contains detectable concentrations of petroleum hydrocarbons (PHCs) and, if so, if either contains concentrations of PHCs that exceed the aquatic life standards of the *Contaminated Sites Regulation* (CSR-AW).

PHCs sampled at the LTECF were detected at the influent and effluent, including various Polycyclic Aromatic Hydrocarbons (PAHs), and a small concentration of toluene in the influent (Table 5). Concentrations of light extractable petroleum hydrocarbons (LEPH) at the influent (WH6c) was 1320ug/L, which is above the CSR-AW maximum concentration of 500ug/L (see Table 4). This suggests that significant concentrations are likely entering the City's wastewater system. PHC concentrations in the influent are likely significantly temporally variable; it is acknowledged that the results observed are representative only of the influent quality at the time of sampling. The Yukon River stations (upstream and downstream of LTECF) had no detectable PHCs. None of the detectable results in the receiving environment exceeded the CSR-AW.

Table 5: Summary of hydrocarbon results at 4 stations sampled at the LTECF on September 5, 2018.

Parameter		CSR-AW	CL-DS	LTECF-US	WH-6c	WH-9b
			Yukon River downstream of Crestview Lagoon mid-channel	Yukon River upstream of LTECF mid-channel	Combined Marwell and Porter Cr influent @ LTECF.	LTECF discharge to effluent manhole.
			9/5/2018 9:57	9/5/2018 10:41	9/5/2018 12:45	9/5/2018 12:06
1-Methylnaphthalene	ng/L	n/a	<100	<100	<100	<100
2-Chloronaphthalene	ug/L	n/a	<0.100	<0.100	<0.100	<0.100
2-Methylnaphthalene	ng/L	n/a	<100	<100	220	114
Acenaphthene	ng/L	n/a	<50	<50	77	<50
Acenaphthylene	ng/L	n/a	<200	<200	<200	<200
Acridine	ng/L	500	<50	<50	<50	<50
Anthracene	ng/L	1000	<10	<10	<10	<10
Benzene	ug/L	4000	<0.5	<0.5	<0.5	<0.5
Benz-a-anthracene	ng/L	1000	<10	<10	<10	46
Benzo-a-pyrene	ng/L	100	<10	<10	<289	50
Benzo-bj-fluoranthene	ng/L	n/a	<50	<50	<50	118
Benzo-ghi-perylene	ng/L	n/a	<50	<50	<50	60
Benzo-k-fluoranthene	ng/L	n/a	<50	<50	<50	<50
Chrysene	ng/L	n/a	<50	<50	<50	<50
Dibenz-ah-anthracene	ng/L	n/a	<10	<10	<10	60
Ethylbenzene	ug/L	2000	<1.0	<1.0	<1.0	<1.0
EPH10-19	ug/L	n/a	<250	<250	1320	328
EPH19-32	ug/L	n/a	<250	<250	4220	377
Fluoranthene	ng/L	2000	<30	<30	<30	<30
Fluorene	ng/L	120000	<50	<50	<50	<50
HEPH	ug/L	n/a	<250	<250	4220	377
Indeno-123-cd-pyrene	ng/L	n/a	<50	<50	<50	58
LEPH	ug/L	**500**	<250	<250	1320	328
MTBE	ug/L	n/a	<1.0	<1.0	<1.0	<1.0
Naphthalene	ng/L	10000	<200	<200	253	<200
Phenanthrene	ng/L	3000	<100	<100	<100	<100
Pyrene	ng/L	200	<20	<20	<132	22
Quinoline	ng/L	34000	<50	<50	<50	<50
Styrene	ug/L	720	<1.0	<1.0	<1.0	<1.0
Toluene	ug/L	390	<1.0	<1.0	2	<1.0
Total Xylenes	ug/L	n/a	<2.0	<2.0	<2.0	<2.0

Conclusions and recommendations

The results of this audit provided a novel approach to uncovering pathways and receptors of wastewater in a regulatory context, as well as insight into other parameters not monitored for such as PHCs. In light of the results, the following items are recommended to provide better protection of the receiving environment. These recommendations were put forward in ENV's intervention to YESAB (Project 2018-0146) and to the Yukon Water Board (Application MN18-059). Further information and rationale for these recommendations are presented in Appendix G and H.

Recommendations:

The following recommendations are summarized from the two interventions noted above:

- Surface water:
    - A surface water monitoring location should be added in the Yukon River upstream of WH10 and upstream of all potential effects from affected groundwater seepage.
    - A monitoring location for surface water quality should be added in the Yukon River downstream of the Crestview lagoon;
    - Upstream and downstream monitoring locations should be established for surface water quality in the creek downgradient and south of the Crestview lagoon
    - Hydrocarbons and metals in water should be monitored as per the Contaminated Sites Regulations (CSR) to ensure the potential receiving environments (e.g., the Yukon River) are not adversely impacted by discharge activities or upset conditions such as seepage containing contamination.
- Groundwater:
    - Adequate characterization of the groundwater flow regime should be conducted and should include determination of the direction and rate of groundwater flow, identification of potential receiving environments and assessment of travel times for potential contaminant pathways
    - Groundwater level and quality around the Crestview Lagoons should be monitored
    - The monitoring well GW-4 at the LTECF should be rehabilitated or replaced.

- Samples from existing groundwater monitoring wells at the LTECF and surface water bodies with water derived from wastewater (detectable concentrations of sweeteners) should be analyzed for the suite of petroleum hydrocarbon parameters
- MW2-08d at the CWTF should be rehabilitated or replaced, MW1-08 should be renamed MW1-08s, and a deeper well should be installed at the same location to create a nested pair similar to MW2-08s and MW2-08d
- Revise the analysis and discussion of stratigraphy and hydrogeology at the CWTF presented in EBA (2009) based on new information generated by rehabilitating or replacing MW2-08d, and installing a deeper well at the location of MW1-08.
- Water quality of all seeps downgradient of the LTECF, Pot Hole Lake, and Crestview Lagoon should be collected and monitored.

Attachments: Appendix A: Audit Photo Log
Appendix B: Sampling Station Details
Appendix C: CARO Analytical Report
Appendix D: Artificial Sweetener Data
Appendix E: Quality Control Results
Appendix F: References
Appendix G: YG Environment's intervention to YESAB in project 2018-0146
Appendix H: YG Environment's intervention to YWB on application MN18-059

Appendix A: Audit Photo Log

August 30, 2018

Photo 1 – Secondary cell #4 at the LTECF lagoon, looking northwest.

Photo 2 – Long-term storage pond at the LTECF lagoon; looking east.

Photo 3 – LTECF: Effluent discharge from the long-term storage pond (W9Hb).

Photo 4 – Pothole Lake, located southwest of LTECF lagoon. View looking east.

Photo 5 – The manhole on the LTECF outfall in the foreground, with the area where the outfall discharge in the Yukon River (background). View looking southeast.

Photo 6 – Crestview secondary cell 1, looking southeast.

Photo 7 – Crestview secondary cell 2, looking northwest.

Photo 8 – Effluent transfer control structure at the Crestview facility.

Photo 9 – Crestview West primary cell, looking southeast

Photo 10 – Crestview East primary cell, looking northwest

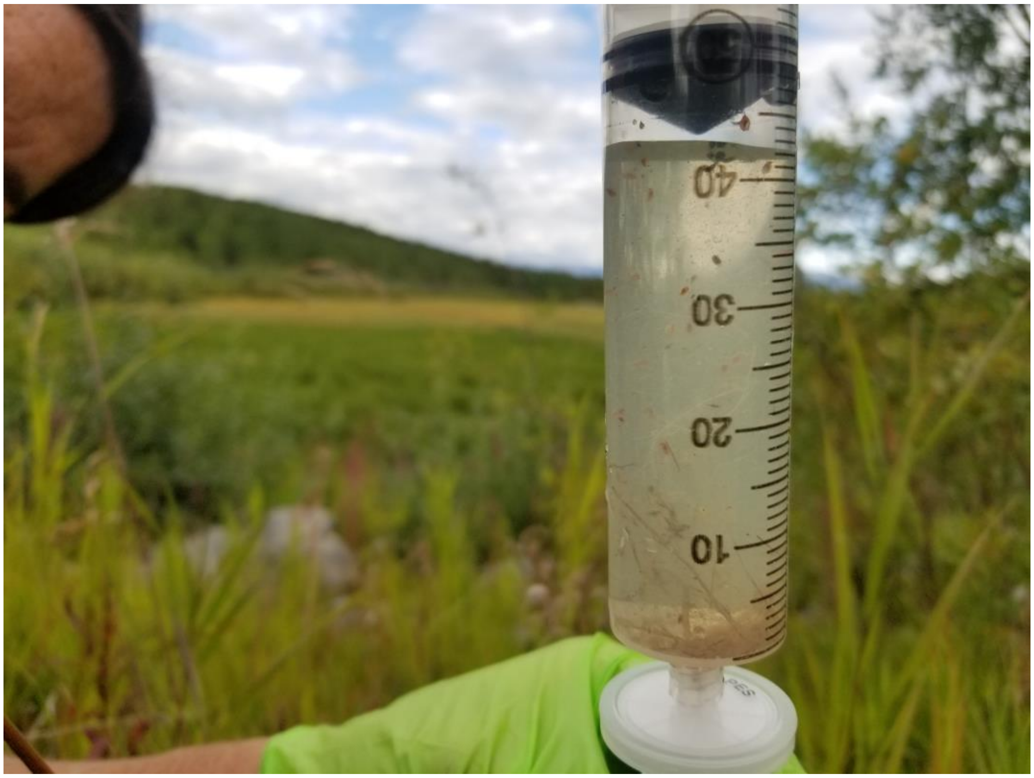

Photo 11 – Daphnia floating in water sample from the West primary cell at Crestview lagoon

Photo 12 – Monitoring well MW4-08, located northeast of the Crestview secondary cell.

Photo 13 – Monitoring well MW3-08, located north of the Crestview secondary cell 2.

Photo 14 – Monitoring well MW2-08, located southeast of the Crestview primary storage cells.

September 5, 2018

Photo 15 – Lake 1, located west of the LTECF. View looking southwest.

Photo 16 – Lake 7, located south of the LTECF. View looking south.

Photo 17– Collecting water sample from the long-term storage pond at LTCEF

Photo 18 – Collecting water sample from the influent coming in the LTCEF, south of the LTCEF lagoon.

Photo 19 – Sampling the Wetland located adjacent to the west of LTCEF lagoon.

Photo 20 – Lake 4, located west of the LTECF. View looking west.

Photo 21 – Lake 3, located west of the LTECF. View looking west.

Photo 22 – Lake 2, located northwest of the LTECF. View looking northwest.

Photo 23 – Monitoring well GW-1, located approximately 950 m south of the LTECF primary storage cell.

Photo 24 – Monitoring Well GW-2, located approximately 1200 m south of the LTECF lagoon.

Photo 25 – Monitoring Well GW-3, located west of the LTECF lagoon.

Photo 26 – Monitoring well MW1, located between Pothole Lake and Yukon River.

Photo 27 – Monitoring well MW2, located between Pothole Lake and Yukon River.

Photo 28 – Monitoring well MW4a, located south of LTECF, by the Yukon River bank.

Photo 29 – WH10, from the Yukon River looking north.

Photo 30 – WH11, looking toward the north bank.

October 30, 2018

Photo 31 – LL-Seep1 with low flow; downgradient of the LTECF

Photo 32 – LL-Seep2 with visible algae growth; downgradient of the LTECF

Photo 33 – LL-Seep11 flowing over clay soil; downgradient of the LTECF

Photo 34 – YRB-1 (CoreGeo Seep 4) is the most extensive seep; downgradient of the LTECF

October 31, 2018

Photo 35 – Suspected seepage area on the Yukon River shoreline, west of the LTCEF; view looking southeast.

November 2, 2018

Photo 36 – Seepage area #1 on the Yukon River shoreline, east of the Crestview lagoon; view looking southeast.

Photo 37 – Seepage area #2 on the Yukon River shoreline, east of the Crestview lagoon; view looking southeast.

Photo 38 – Seep sampling location #2. Although the seep started to freeze, flow was observed at this location.

Appendix B: Sampling Station Details

Station	Station Name	Station Description	Latitude NAD83	Longitude NAD83
CC-DS	Crestview Creek Downstream	Crestview Creek downstream of Crestview Lagoon	60.78939	-135.143
CC-US	Crestview Creek Upstream	Crestview Creek Upstream Crestview Lagoon, above culvert	60.78773	-135.157
CL-1	Crestview Lagoon 1	Crestview Lagoon first primary lagoon, north bank	60.79189	-135.153
CL-3	Crestview Lagoon 3	Crestview Lagoon first secondary lagoon, north bank	60.79508	-135.155
CL-DS	Yukon River d/s Crestview Lagoon	Yukon River downstream of Crestview Lagoon mid-channel	60.8027	-135.16
CL-Seep1	Crestview Seep 1	Seep1 at Yukon River downgradient from Crestview lagoon	N/A	N/A
CL-Seep2	Crestview Seep 2	Seep2 at Yukon River downgradient from Crestview Lagoon	N/A	N/A
GW-1	Monitoring well GW-1.	Monitoring well 30m SE primary cells @ LTECF.	60.8036	-135.091
GW-2	Monitoring well GW-2.	Monitoring well SW of facultative cells @ LTECF.	60.8016	-135.104
GW-3	Monitoring well GW-3.	Monitoring well SW of long term storage impoundment	60.80802	-135.125
Lake1	Lake 1	Lake west of LTECF	60.82286	-135.143
Lake2	Lake 2	Lake west of LTECF	60.81894	-135.144
Lake3	Lake 3	Lake west of LTECF	60.81019	-135.137
Lake4	Lake 4	Lake west of LTECF	60.80646	-135.125
Lake5	Lake 5	Lake west of LTECF	60.80508	-135.123
Lake6	Lake 6	Lake west of LTECF	60.80057	-135.123
Lake7	Lake 7	Lake west of LTECF	60.80303	-135.099
LL-Seep1	Livingston Seep 1	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 1	60.79245	-135.111
LL-Seep11	Livingston Seep 11	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 11	60.78976	-135.117
LL-Seep2	Livingston Seep 2	Seep along Yukon River downgradient of Livingston, corresponds with CoreGeo Seep Survey Seep 2	60.79206	-135.114
LTECF-US	Yukon River u/s LTECF	Yukon River upstream of LTECF mid-channel	60.7919	-135.104

Station	Station Name	Station Description	Latitude NAD83	Longitude NAD83
MW-1	Monitoring well MW-1.	Monitoring well 500m SSE of PHL.	60.79511	-135.116
MW-2	Monitoring well MW-2.	Monitoring well 300m SSE of PHL.	60.79691	-135.117
MW-3-08	MW-3-08	Crestview Lagoon, NW corner well	60.7978	-135.161
MW-4-08	MW-4-08	Crestview Lagoon, east side well	60.7953	-135.154
MW-4a	Monitoring well MW-4a.	Monitoring well 30m NW of Yukon River to PHL.	60.78992	-135.121
PHL	Pot Hole Lake.	Pot hole lake	60.79929	-135.121
Wetland	Wetland	Wetland/seepage pond west of LTECF	60.80534	-135.117
WH-10	Yukon R u/s LTECF discharge outfall	Yukon R u/s LTECF discharge outfall mid-channel.	60.7895	-135.118
WH-11	Yukon R d/s 300m LTECF discharge outfall	Yukon R mid channel, 300 m d/s LTECF discharge outfall	60.78886	-135.124
WH-12	Yukon R d/s 750m LTECF discharge outfall	Yukon R mid channel, 750m d/s LTECF discharge outfall	60.7889	-135.133
WH-6c	Combined Marwell and Porter Creek	Combined Marwell and Porter Creek influent @ LTECF.	60.80372	-135.093
WH-9b	LTECF discharge.	LTECF discharge to effluent manhole.	60.80466	-135.111
YRB-1	Monitoring well YRB-1.	Monitoring well, Yukon River edge, 850m south of PHL.	60.79175	-135.117
YS	Yukon Spring	Yukon Spring water from tap at bottling plant	60.78844	-135.153

Appendix C: CARO Analytical Reports

See below.

CARO
ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Yukon Government - Water Resources Suite 203, 1191 Front Street Whitehorse, YT Y1A 0K5		
ATTENTION	John Minder	**WORK ORDER**	8090545
PO NUMBER		**RECEIVED / TEMP**	2018-09-07 10:30 / 5°C
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07
PROJECT INFO	YK Water Resources - C00043458		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO 17025:2005 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at bshaw@caro.ca

Authorized By:

Bryan Shaw, Ph.D., P.Chem.
Client Service Coordinator

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Analyzed	Qualifier
2018149 (8090545-01) | Matrix: Water | Sampled: 2018-09-05 10:23					
BCMOE Aggregate Hydrocarbons					
VHw (6-10)	< 100	100	µg/L	2018-09-07	
VPHw	< 100	100	µg/L	N/A	
EPHw10-19	**1320**	250	µg/L	2018-09-11	
EPHw19-32	**4220**	250	µg/L	2018-09-11	
LEPHw	**1320**	250	µg/L	N/A	
HEPHw	**4220**	250	µg/L	N/A	
Surrogate: 2-Methylnonane (EPH/F2-4)	*81*	*60-140*	%	*2018-09-11*	
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	**0.077**	0.050	µg/L	2018-09-10	
Acenaphthylene	< 0.200	0.200	µg/L	2018-09-10	
Acridine	< 0.050	0.050	µg/L	2018-09-10	
Anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benz(a)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benzo(a)pyrene	< 0.289	0.010	µg/L	2018-09-10	RA1
Benzo(b+j)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(g,h,i)perylene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(k)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
2-Chloronaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Chrysene	< 0.050	0.050	µg/L	2018-09-10	
Dibenz(a,h)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Fluoranthene	< 0.030	0.030	µg/L	2018-09-10	
Fluorene	< 0.050	0.050	µg/L	2018-09-10	
Indeno(1,2,3-cd)pyrene	< 0.050	0.050	µg/L	2018-09-10	
1-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
2-Methylnaphthalene	**0.220**	0.100	µg/L	2018-09-10	
Naphthalene	**0.253**	0.200	µg/L	2018-09-10	
Phenanthrene	< 0.100	0.100	µg/L	2018-09-10	
Pyrene	< 0.132	0.020	µg/L	2018-09-10	RA1
Quinoline	< 0.050	0.050	µg/L	2018-09-10	
Surrogate: Acridine-d9	*90*	*50-140*	%	*2018-09-10*	
Surrogate: Naphthalene-d8	*82*	*50-140*	%	*2018-09-10*	
Surrogate: Perylene-d12	*59*	*50-140*	%	*2018-09-10*	
Volatile Organic Compounds (VOC)					
Benzene	< 0.5	0.5	µg/L	2018-09-07	
Ethylbenzene	< 1.0	1.0	µg/L	2018-09-07	
Methyl tert-butyl ether	< 1.0	1.0	µg/L	2018-09-07	
Styrene	< 1.0	1.0	µg/L	2018-09-07	
Toluene	**2.0**	1.0	µg/L	2018-09-07	
Xylenes (total)	< 2.0	2.0	µg/L	2018-09-07	
Surrogate: Toluene-d8	*119*	*70-130*	%	*2018-09-07*	
Surrogate: 4-Bromofluorobenzene	*96*	*70-130*	%	*2018-09-07*	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Analyzed	Qualifier
2018155 (8090545-02) | Matrix: Water | Sampled: 2018-09-05 10:15					
Anions					
Chloride	**36.1**	0.10	mg/L	2018-09-08	
Nitrate (as N)	**1.13**	0.010	mg/L	2018-09-08	
Nitrite (as N)	**0.229**	0.010	mg/L	2018-09-08	
Sulfate	**32.5**	1.0	mg/L	2018-09-08	
BCMOE Aggregate Hydrocarbons					
VHw (6-10)	< 100	100	µg/L	2018-09-08	
VPHw	< 100	100	µg/L	N/A	
EPHw10-19	**328**	250	µg/L	2018-09-11	
EPHw19-32	**377**	250	µg/L	2018-09-11	
LEPHw	**328**	250	µg/L	N/A	
HEPHw	**377**	250	µg/L	N/A	
Surrogate: 2-Methylnonane (EPH/F2-4)	*87*	*60-140*	%	*2018-09-11*	
Calculated Parameters					
Hardness, Total (as CaCO3)	**244**	0.500	mg/L	N/A	
General Parameters					
Alkalinity, Total (as CaCO3)	**232**	1.0	mg/L	2018-09-10	
Alkalinity, Phenolphthalein (as CaCO3)	**1.5**	1.0	mg/L	2018-09-10	
Alkalinity, Bicarbonate (as CaCO3)	**229**	1.0	mg/L	2018-09-10	
Alkalinity, Carbonate (as CaCO3)	**3.0**	1.0	mg/L	2018-09-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Ammonia, Total (as N)	**4.41**	0.020	mg/L	2018-09-13	
BOD, 5-day Carbonaceous	**2.6**	2.0	mg/L	2018-09-12	
Conductivity (EC)	**618**	2.0	µS/cm	2018-09-11	
Oil & Grease, Total	< 2.0	2.0	mg/L	2018-09-14	
pH	**8.09**	0.10	pH units	2018-09-12	HT2
Phosphorus, Total (as P)	**2.31**	0.0020	mg/L	2018-09-13	
Microbiological Parameters					
Coliforms, Fecal	< 1	1	CFU/100 mL	2018-09-08	HT1
Oncorhynchus mykiss Bioassay					
LC50, 96 h Trout	**>100**	1	% v/v	2018-09-10	
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	< 0.050	0.050	µg/L	2018-09-10	
Acenaphthylene	< 0.200	0.200	µg/L	2018-09-10	
Acridine	< 0.050	0.050	µg/L	2018-09-10	
Anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benz(a)anthracene	**0.046**	0.010	µg/L	2018-09-10	
Benzo(a)pyrene	**0.050**	0.010	µg/L	2018-09-10	
Benzo(b+j)fluoranthene	**0.118**	0.050	µg/L	2018-09-10	

Analyte	Result	RL	Units	Analyzed	Qualifier
2018155 (8090545-02) | Matrix: Water | Sampled: 2018-09-05 10:15, Continued					
Polycyclic Aromatic Hydrocarbons (PAH), Continued					
Benzo(g,h,i)perylene	**0.060**	0.050	µg/L	2018-09-10	
Benzo(k)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
2-Chloronaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Chrysene	< 0.050	0.050	µg/L	2018-09-10	
Dibenz(a,h)anthracene	**0.060**	0.010	µg/L	2018-09-10	
Fluoranthene	< 0.030	0.030	µg/L	2018-09-10	
Fluorene	< 0.050	0.050	µg/L	2018-09-10	
Indeno(1,2,3-cd)pyrene	**0.058**	0.050	µg/L	2018-09-10	
1-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
2-Methylnaphthalene	**0.114**	0.100	µg/L	2018-09-10	
Naphthalene	< 0.200	0.200	µg/L	2018-09-10	
Phenanthrene	< 0.100	0.100	µg/L	2018-09-10	
Pyrene	**0.022**	0.020	µg/L	2018-09-10	
Quinoline	< 0.050	0.050	µg/L	2018-09-10	
Surrogate: Acridine-d9	*94*	*50-140*	%	*2018-09-10*	
Surrogate: Naphthalene-d8	*97*	*50-140*	%	*2018-09-10*	
Surrogate: Perylene-d12	*29*	*50-140*	%	*2018-09-10*	S02
Total Metals					
Aluminum, total	**0.0627**	0.0050	mg/L	2018-09-11	
Antimony, total	**0.00024**	0.00020	mg/L	2018-09-11	
Arsenic, total	**0.00701**	0.00050	mg/L	2018-09-11	
Barium, total	**0.0468**	0.0050	mg/L	2018-09-11	
Beryllium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Bismuth, total	< 0.00010	0.00010	mg/L	2018-09-11	
Boron, total	**0.0928**	0.0050	mg/L	2018-09-11	
Cadmium, total	< 0.000010	0.000010	mg/L	2018-09-11	
Calcium, total	**48.5**	0.20	mg/L	2018-09-11	
Chromium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Cobalt, total	**0.00032**	0.00010	mg/L	2018-09-11	
Copper, total	**0.00177**	0.00040	mg/L	2018-09-11	
Iron, total	**0.329**	0.010	mg/L	2018-09-11	
Lead, total	**0.00043**	0.00020	mg/L	2018-09-11	
Lithium, total	**0.00215**	0.00010	mg/L	2018-09-11	
Magnesium, total	**29.8**	0.010	mg/L	2018-09-11	
Manganese, total	**0.203**	0.00020	mg/L	2018-09-11	
Molybdenum, total	**0.00237**	0.00010	mg/L	2018-09-11	
Nickel, total	**0.00195**	0.00040	mg/L	2018-09-11	
Phosphorus, total	**2.62**	0.050	mg/L	2018-09-11	
Potassium, total	**11.4**	0.10	mg/L	2018-09-11	
Selenium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Silicon, total	**5.5**	1.0	mg/L	2018-09-11	
Silver, total	< 0.000050	0.000050	mg/L	2018-09-11	

Analyte	Result	RL	Units	Analyzed	Qualifier
2018155 (8090545-02) | Matrix: Water | Sampled: 2018-09-05 10:15, Continued					
Total Metals, Continued					
Sodium, total	**38.2**	0.10	mg/L	2018-09-11	
Strontium, total	**0.348**	0.0010	mg/L	2018-09-11	
Sulfur, total	**9.7**	3.0	mg/L	2018-09-11	
Tellurium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Thallium, total	< 0.000020	0.000020	mg/L	2018-09-11	
Thorium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Tin, total	< 0.00020	0.00020	mg/L	2018-09-11	
Titanium, total	< 0.0050	0.0050	mg/L	2018-09-11	
Tungsten, total	< 0.0010	0.0010	mg/L	2018-09-11	
Uranium, total	**0.00241**	0.000020	mg/L	2018-09-11	
Vanadium, total	**0.0024**	0.0010	mg/L	2018-09-11	
Zinc, total	< 0.0040	0.0040	mg/L	2018-09-11	
Zirconium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Volatile Organic Compounds (VOC)					
Benzene	< 0.5	0.5	µg/L	2018-09-08	
Ethylbenzene	< 1.0	1.0	µg/L	2018-09-08	
Methyl tert-butyl ether	< 1.0	1.0	µg/L	2018-09-08	
Styrene	< 1.0	1.0	µg/L	2018-09-08	
Toluene	< 1.0	1.0	µg/L	2018-09-08	
Xylenes (total)	< 2.0	2.0	µg/L	2018-09-08	
Surrogate: Toluene-d8	*115*	*70-130*	%	*2018-09-08*	
Surrogate: 4-Bromofluorobenzene	*97*	*70-130*	%	*2018-09-08*	
2018153 (8090545-03) | Matrix: Water | Sampled: 2018-09-05 10:41					
Anions					
Chloride	**0.15**	0.10	mg/L	2018-09-08	
Nitrate (as N)	< 0.010	0.010	mg/L	2018-09-08	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-09-08	
Sulfate	**7.6**	1.0	mg/L	2018-09-08	
BCMOE Aggregate Hydrocarbons					
VHw (6-10)	< 100	100	µg/L	2018-09-08	
VPHw	< 100	100	µg/L	N/A	
EPHw10-19	< 250	250	µg/L	2018-09-11	
EPHw19-32	< 250	250	µg/L	2018-09-11	
LEPHw	< 250	250	µg/L	N/A	
HEPHw	< 250	250	µg/L	N/A	
Surrogate: 2-Methylnonane (EPH/F2-4)	*77*	*60-140*	%	*2018-09-11*	
Calculated Parameters					
Hardness, Total (as CaCO3)	**43.2**	0.500	mg/L	N/A	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Analyzed	Qualifier
2018153 (8090545-03) | Matrix: Water | Sampled: 2018-09-05 10:41, Continued					
General Parameters					
Alkalinity, Total (as CaCO3)	**39.4**	1.0	mg/L	2018-09-10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Bicarbonate (as CaCO3)	**39.4**	1.0	mg/L	2018-09-10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Ammonia, Total (as N)	**0.032**	0.020	mg/L	2018-09-13	
BOD, 5-day Carbonaceous	< 2.0	2.0	mg/L	2018-09-12	BOD2
Conductivity (EC)	**95.3**	2.0	µS/cm	2018-09-11	
Oil & Grease, Total	< 2.0	2.0	mg/L	2018-09-14	
pH	**7.48**	0.10	pH units	2018-09-12	HT2
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L	2018-09-13	
Microbiological Parameters					
Coliforms, Fecal	**1**	1	CFU/100 mL	2018-09-08	HT1
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	< 0.050	0.050	µg/L	2018-09-10	
Acenaphthylene	< 0.200	0.200	µg/L	2018-09-10	
Acridine	< 0.050	0.050	µg/L	2018-09-10	
Anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benz(a)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benzo(a)pyrene	< 0.010	0.010	µg/L	2018-09-10	
Benzo(b+j)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(g,h,i)perylene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(k)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
2-Chloronaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Chrysene	< 0.050	0.050	µg/L	2018-09-10	
Dibenz(a,h)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Fluoranthene	< 0.030	0.030	µg/L	2018-09-10	
Fluorene	< 0.050	0.050	µg/L	2018-09-10	
Indeno(1,2,3-cd)pyrene	< 0.050	0.050	µg/L	2018-09-10	
1-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
2-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Naphthalene	< 0.200	0.200	µg/L	2018-09-10	
Phenanthrene	< 0.100	0.100	µg/L	2018-09-10	
Pyrene	< 0.020	0.020	µg/L	2018-09-10	
Quinoline	< 0.050	0.050	µg/L	2018-09-10	
Surrogate: Acridine-d9	*84*	*50-140*	%	*2018-09-10*	
Surrogate: Naphthalene-d8	*90*	*50-140*	%	*2018-09-10*	
Surrogate: Perylene-d12	*46*	*50-140*	%	*2018-09-10*	S02
Total Metals					
Aluminum, total	**0.0276**	0.0050	mg/L	2018-09-11	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Analyzed	Qualifier
2018153 (8090545-03) | Matrix: Water | Sampled: 2018-09-05 10:41, Continued					
Total Metals, Continued					
Antimony, total	< 0.00020	0.00020	mg/L	2018-09-11	
Arsenic, total	< 0.00050	0.00050	mg/L	2018-09-11	
Barium, total	**0.0249**	0.0050	mg/L	2018-09-11	
Beryllium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Bismuth, total	< 0.00010	0.00010	mg/L	2018-09-11	
Boron, total	< 0.0050	0.0050	mg/L	2018-09-11	
Cadmium, total	< 0.000010	0.000010	mg/L	2018-09-11	
Calcium, total	**13.4**	0.20	mg/L	2018-09-11	
Chromium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Cobalt, total	< 0.00010	0.00010	mg/L	2018-09-11	
Copper, total	**0.00046**	0.00040	mg/L	2018-09-11	
Iron, total	**0.029**	0.010	mg/L	2018-09-11	
Lead, total	< 0.00020	0.00020	mg/L	2018-09-11	
Lithium, total	**0.00069**	0.00010	mg/L	2018-09-11	
Magnesium, total	**2.36**	0.010	mg/L	2018-09-11	
Manganese, total	**0.00260**	0.00020	mg/L	2018-09-11	
Molybdenum, total	**0.00142**	0.00010	mg/L	2018-09-11	
Nickel, total	< 0.00040	0.00040	mg/L	2018-09-11	
Phosphorus, total	< 0.050	0.050	mg/L	2018-09-11	
Potassium, total	**0.64**	0.10	mg/L	2018-09-11	
Selenium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Silicon, total	< 1.0	1.0	mg/L	2018-09-11	
Silver, total	< 0.000050	0.000050	mg/L	2018-09-11	
Sodium, total	**1.07**	0.10	mg/L	2018-09-11	
Strontium, total	**0.0713**	0.0010	mg/L	2018-09-11	
Sulfur, total	< 3.0	3.0	mg/L	2018-09-11	
Tellurium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Thallium, total	< 0.000020	0.000020	mg/L	2018-09-11	
Thorium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Tin, total	< 0.00020	0.00020	mg/L	2018-09-11	
Titanium, total	< 0.0050	0.0050	mg/L	2018-09-11	
Tungsten, total	< 0.0010	0.0010	mg/L	2018-09-11	
Uranium, total	**0.000605**	0.000020	mg/L	2018-09-11	
Vanadium, total	< 0.0010	0.0010	mg/L	2018-09-11	
Zinc, total	< 0.0040	0.0040	mg/L	2018-09-11	
Zirconium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Volatile Organic Compounds (VOC)					
Benzene	< 0.5	0.5	µg/L	2018-09-08	
Ethylbenzene	< 1.0	1.0	µg/L	2018-09-08	
Methyl tert-butyl ether	< 1.0	1.0	µg/L	2018-09-08	
Styrene	< 1.0	1.0	µg/L	2018-09-08	
Toluene	< 1.0	1.0	µg/L	2018-09-08	

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Analyzed	Qualifier
2018153 (8090545-03) | Matrix: Water | Sampled: 2018-09-05 10:41, Continued					
Volatile Organic Compounds (VOC), Continued					
Xylenes (total)	< 2.0	2.0	µg/L	2018-09-08	
Surrogate: Toluene-d8	*117*	*70-130*	%	*2018-09-08*	
Surrogate: 4-Bromofluorobenzene	*96*	*70-130*	%	*2018-09-08*	
2018154 (8090545-04) | Matrix: Water | Sampled: 2018-09-05 09:57					
Anions					
Chloride	**0.15**	0.10	mg/L	2018-09-08	
Nitrate (as N)	< 0.010	0.010	mg/L	2018-09-08	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-09-08	
Sulfate	**7.7**	1.0	mg/L	2018-09-08	
BCMOE Aggregate Hydrocarbons					
VHw (6-10)	< 100	100	µg/L	2018-09-08	
VPHw	< 100	100	µg/L	N/A	
EPHw10-19	< 250	250	µg/L	2018-09-11	
EPHw19-32	< 250	250	µg/L	2018-09-11	
LEPHw	< 250	250	µg/L	N/A	
HEPHw	< 250	250	µg/L	N/A	
Surrogate: 2-Methylnonane (EPH/F2-4)	*82*	*60-140*	%	*2018-09-11*	
Calculated Parameters					
Hardness, Total (as CaCO3)	**44.8**	0.500	mg/L	N/A	
General Parameters					
Alkalinity, Total (as CaCO3)	**39.7**	1.0	mg/L	2018-09-10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Bicarbonate (as CaCO3)	**39.7**	1.0	mg/L	2018-09-10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-09-13	
BOD, 5-day Carbonaceous	< 2.0	2.0	mg/L	2018-09-12	BOD2
Conductivity (EC)	**96.8**	2.0	µS/cm	2018-09-11	
Oil & Grease, Total	< 2.0	2.0	mg/L	2018-09-14	
pH	**7.44**	0.10	pH units	2018-09-12	HT2
Phosphorus, Total (as P)	**0.0034**	0.0020	mg/L	2018-09-13	
Microbiological Parameters					
Coliforms, Fecal	< 1	1	CFU/100 mL	2018-09-08	HT1
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	< 0.050	0.050	µg/L	2018-09-10	
Acenaphthylene	< 0.200	0.200	µg/L	2018-09-10	
Acridine	< 0.050	0.050	µg/L	2018-09-10	

CARO ANALYTICAL SERVICES

TEST RESULTS

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Analyte	Result	RL	Units	Analyzed	Qualifier
2018154 (8090545-04) | Matrix: Water | Sampled: 2018-09-05 09:57, Continued					
Polycyclic Aromatic Hydrocarbons (PAH), Continued					
Anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benz(a)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Benzo(a)pyrene	< 0.010	0.010	µg/L	2018-09-10	
Benzo(b+j)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(g,h,i)perylene	< 0.050	0.050	µg/L	2018-09-10	
Benzo(k)fluoranthene	< 0.050	0.050	µg/L	2018-09-10	
2-Chloronaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Chrysene	< 0.050	0.050	µg/L	2018-09-10	
Dibenz(a,h)anthracene	< 0.010	0.010	µg/L	2018-09-10	
Fluoranthene	< 0.030	0.030	µg/L	2018-09-10	
Fluorene	< 0.050	0.050	µg/L	2018-09-10	
Indeno(1,2,3-cd)pyrene	< 0.050	0.050	µg/L	2018-09-10	
1-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
2-Methylnaphthalene	< 0.100	0.100	µg/L	2018-09-10	
Naphthalene	< 0.200	0.200	µg/L	2018-09-10	
Phenanthrene	< 0.100	0.100	µg/L	2018-09-10	
Pyrene	< 0.020	0.020	µg/L	2018-09-10	
Quinoline	< 0.050	0.050	µg/L	2018-09-10	
Surrogate: Acridine-d9	*64*	*50-140*	%	*2018-09-10*	
Surrogate: Naphthalene-d8	*85*	*50-140*	%	*2018-09-10*	
Surrogate: Perylene-d12	*45*	*50-140*	%	*2018-09-10*	S02
Total Metals					
Aluminum, total	**0.0275**	0.0050	mg/L	2018-09-11	
Antimony, total	< 0.00020	0.00020	mg/L	2018-09-11	
Arsenic, total	< 0.00050	0.00050	mg/L	2018-09-11	
Barium, total	**0.0260**	0.0050	mg/L	2018-09-11	
Beryllium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Bismuth, total	< 0.00010	0.00010	mg/L	2018-09-11	
Boron, total	< 0.0050	0.0050	mg/L	2018-09-11	
Cadmium, total	< 0.000010	0.000010	mg/L	2018-09-11	
Calcium, total	**14.0**	0.20	mg/L	2018-09-11	
Chromium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Cobalt, total	< 0.00010	0.00010	mg/L	2018-09-11	
Copper, total	**0.00064**	0.00040	mg/L	2018-09-11	
Iron, total	**0.030**	0.010	mg/L	2018-09-11	
Lead, total	< 0.00020	0.00020	mg/L	2018-09-11	
Lithium, total	**0.00070**	0.00010	mg/L	2018-09-11	
Magnesium, total	**2.39**	0.010	mg/L	2018-09-11	
Manganese, total	**0.00284**	0.00020	mg/L	2018-09-11	
Molybdenum, total	**0.00144**	0.00010	mg/L	2018-09-11	
Nickel, total	< 0.00040	0.00040	mg/L	2018-09-11	
Phosphorus, total	< 0.050	0.050	mg/L	2018-09-11	

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Analyte	Result	RL	Units	Analyzed	Qualifier
2018154 (8090545-04) | Matrix: Water | Sampled: 2018-09-05 09:57, Continued					
Total Metals, Continued					
Potassium, total	**0.64**	0.10	mg/L	2018-09-11	
Selenium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Silicon, total	< 1.0	1.0	mg/L	2018-09-11	
Silver, total	< 0.000050	0.000050	mg/L	2018-09-11	
Sodium, total	**1.08**	0.10	mg/L	2018-09-11	
Strontium, total	**0.0750**	0.0010	mg/L	2018-09-11	
Sulfur, total	< 3.0	3.0	mg/L	2018-09-11	
Tellurium, total	< 0.00050	0.00050	mg/L	2018-09-11	
Thallium, total	< 0.000020	0.000020	mg/L	2018-09-11	
Thorium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Tin, total	< 0.00020	0.00020	mg/L	2018-09-11	
Titanium, total	< 0.0050	0.0050	mg/L	2018-09-11	
Tungsten, total	< 0.0010	0.0010	mg/L	2018-09-11	
Uranium, total	**0.000629**	0.000020	mg/L	2018-09-11	
Vanadium, total	< 0.0010	0.0010	mg/L	2018-09-11	
Zinc, total	< 0.0040	0.0040	mg/L	2018-09-11	
Zirconium, total	< 0.00010	0.00010	mg/L	2018-09-11	
Volatile Organic Compounds (VOC)					
Benzene	< 0.5	0.5	µg/L	2018-09-08	
Ethylbenzene	< 1.0	1.0	µg/L	2018-09-08	
Methyl tert-butyl ether	< 1.0	1.0	µg/L	2018-09-08	
Styrene	< 1.0	1.0	µg/L	2018-09-08	
Toluene	< 1.0	1.0	µg/L	2018-09-08	
Xylenes (total)	< 2.0	2.0	µg/L	2018-09-08	
Surrogate: Toluene-d8	*116*	*70-130*	%	*2018-09-08*	
Surrogate: 4-Bromofluorobenzene	*93*	*70-130*	%	*2018-09-08*	

Sample Qualifiers:

BOD2	The sample dilutions set-up for the BOD analysis did not meet the oxygen depletion criterion of at least 2 mg/L.
HT1	The sample was prepared and/or analyzed past the recommended holding time.
HT2	The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.
RA1	The Reporting Limit has been raised due to matrix interference.
S02	Surrogate recovery outside of control limits. Data accepted based on acceptable recovery of other surrogates.

APPENDIX 1: SUPPORTING INFORMATION

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Analysis Description	Method Ref.	Technique	Location
Alkalinity in Water	SM 2320 B* (2011)	Titration with H2SO4	Kelowna
Ammonia, Total in Water	SM 4500-NH3 G* (2011)	Automated Colorimetry (Phenate)	Kelowna
Anions in Water	SM 4110 B (2011)	Ion Chromatography	Kelowna
Biochemical Oxygen Demand, Carbonaceous in Water	SM 5210 B (2011)	Dissolved Oxygen Meter	Richmond
BTEX in Water	EPA 5030B / EPA 8260D	Purge&Trap / GC-MSD (SIM)	Richmond
Coliforms, Fecal in Water	SM 9222 D (2006)	Membrane Filtration / m-FC Agar	Kelowna
Conductivity in Water	SM 2510 B (2011)	Conductivity Meter	Richmond
EPH in Water	EPA 3511* / BCMOE EPHw	Hexane MicroExtraction (Base/Neutral) / Gas Chromatography (GC-FID)	Richmond
Hardness in Water	SM 2340 B* (2011)	Calculation: 2.497 [total Ca] + 4.118 [total Mg] (Est)	N/A
HEPHw in Water	BCMOE LEPH/HEPH	Calculation	N/A
LEPHw in Water	BCMOE LEPH/HEPH	Calculation	N/A
Oil and Grease, Total in Water	EPA 1664A*	Liquid-Liquid Extraction with Hexane	Richmond
pH in Water	SM 4500-H+ B (2011)	Electrometry	Richmond
Phosphorus, Total in Water	SM 4500-P B.5* (2011) / SM 4500-P F (2011)	Persulfate Digestion / Automated Colorimetry (Ascorbic Acid)	Kelowna
Polycyclic Aromatic Hydrocarbons in Water	EPA 3511* / EPA 8270D	Hexane MicroExtraction (Base/Neutral) / GC-MSD (SIM)	Richmond
Total Metals in Water	EPA 200.2* / EPA 6020B	HNO3+HCl Hot Block Digestion / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	Richmond
Trout LC50 in Water	EPS 1/RM/13 B	Rainbow Trout Acute Lethality: Multi-concentration	Sublet
VH in Water	EPA 5030B / BCMOE VHw	Purge&Trap / Gas Chromatography (GC-FID)	Richmond
VPHw in Water	BCMOE VPH	Calculation: VH - (Benzene + Toluene + Ethylbenzene + Xylenes + Styrene)	N/A

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
% v/v	Percent volume per volume
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
>1	Greater than the specified Result
CFU/100 mL	Colony Forming Units per 100 millilitres
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, ph > 7 = basic
µg/L	Micrograms per litre
µS/cm	Microsiemens per centimetre
BCMOE	British Columbia Environmental Laboratory Manual, British Columbia Ministry of Environment
EPA	United States Environmental Protection Agency Test Methods
EPS	Environment Canada Biological Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

APPENDIX 1: SUPPORTING INFORMATION

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General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued unless otherwise agreed to in writing.

APPENDIX 2: QUALITY CONTROL RESULTS

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The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B8I0484										
Blank (B8I0484-BLK1)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
Blank (B8I0484-BLK2)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
LCS (B8I0484-BS1)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	16.3	0.10	mg/L	16.0		102	90-110			
Nitrate (as N)	4.21	0.010	mg/L	4.00		105	93-108			
Nitrite (as N)	2.05	0.010	mg/L	2.00		102	85-114			
Sulfate	17.0	1.0	mg/L	16.0		106	91-109			
LCS (B8I0484-BS2)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	16.4	0.10	mg/L	16.0		103	90-110			
Nitrate (as N)	4.17	0.010	mg/L	4.00		104	93-108			
Nitrite (as N)	2.00	0.010	mg/L	2.00		100	85-114			
Sulfate	16.6	1.0	mg/L	16.0		104	91-109			
Duplicate (B8I0484-DUP1)		**Source: 8090545-02**		Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	36.4	0.10	mg/L		36.1			< 1	10	
Nitrate (as N)	1.13	0.010	mg/L		1.13			< 1	10	
Nitrite (as N)	0.229	0.010	mg/L		0.229			< 1	6	
Sulfate	32.8	1.0	mg/L		32.5			1	6	
Matrix Spike (B8I0484-MS1)		**Source: 8090545-02**		Prepared: 2018-09-08, Analyzed: 2018-09-08						
Chloride	51.3	0.10	mg/L	16.0	36.1	95	75-125			
Nitrate (as N)	5.18	0.010	mg/L	4.00	1.13	101	75-125			
Nitrite (as N)	2.23	0.010	mg/L	2.00	0.229	100	80-120			
Sulfate	47.6	1.0	mg/L	16.0	32.5	95	75-125			

APPENDIX 2: QUALITY CONTROL RESULTS

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
BCMOE Aggregate Hydrocarbons, Batch B8I0436										
Blank (B8I0436-BLK1)				Prepared: 2018-09-07, Analyzed: 2018-09-07						
VHw (6-10)	< 100	100	µg/L							
LCS (B8I0436-BS2)				Prepared: 2018-09-07, Analyzed: 2018-09-07						
VHw (6-10)	3700	100	µg/L	3280		113	70-130			
BCMOE Aggregate Hydrocarbons, Batch B8I0497										
Blank (B8I0497-BLK1)				Prepared: 2018-09-09, Analyzed: 2018-09-11						
EPHw10-19	< 250	250	µg/L							
EPHw19-32	< 250	250	µg/L							
Surrogate: 2-Methylnonane (EPH/F2-4)	*277*		*µg/L*	444		*62*	*60-140*			
LCS (B8I0497-BS2)				Prepared: 2018-09-09, Analyzed: 2018-09-11						
EPHw10-19	15000	250	µg/L	15400		97	70-130			
EPHw19-32	21100	250	µg/L	22200		95	70-130			
Surrogate: 2-Methylnonane (EPH/F2-4)	*372*		*µg/L*	444		*84*	*60-140*			
General Parameters, Batch B8I0392										
Blank (B8I0392-BLK1)				Prepared: 2018-09-07, Analyzed: 2018-09-12						
BOD, 5-day Carbonaceous	< 2.0	2.0	mg/L							
LCS (B8I0392-BS1)				Prepared: 2018-09-07, Analyzed: 2018-09-12						
BOD, 5-day Carbonaceous	212	50.9	mg/L	198		107	85-115			
Reference (B8I0392-SRM1)				Prepared: 2018-09-07, Analyzed: 2018-09-12						
BOD, 5-day Carbonaceous	216	50.9	mg/L	198		109	66-136			
General Parameters, Batch B8I0575										
Blank (B8I0575-BLK1)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Blank (B8I0575-BLK2)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Blank (B8I0575-BLK3)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
LCS (B8I0575-BS1)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
Alkalinity, Total (as CaCO3)	96.9	1.0	mg/L	1000		10	92-106			

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8I0575, Continued										
LCS (B8I0575-BS2)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	95.4	1.0	mg/L	1000		10	92-106			
LCS (B8I0575-BS3)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	100	1.0	mg/L	1000		10	92-106			
General Parameters, Batch B8I0624										
Blank (B8I0624-BLK1)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Conductivity (EC)	< 2.0	2.0	µS/cm							
LCS (B8I0624-BS1)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Conductivity (EC)	148	2.0	µS/cm	147		100	90-110			
Reference (B8I0624-SRM1)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Conductivity (EC)	1010	2.0	µS/cm	1000		101	95-105			
General Parameters, Batch B8I0655										
Blank (B8I0655-BLK1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Oil & Grease, Total	< 2.0	2.0	mg/L							
LCS (B8I0655-BS1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Oil & Grease, Total	32.1	2.0	mg/L	41.7		77	71-106			
LCS Dup (B8I0655-BSD1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Oil & Grease, Total	32.7	2.0	mg/L	41.7		78	71-106	2	20	
General Parameters, Batch B8I0729										
Blank (B8I0729-BLK1)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
Blank (B8I0729-BLK2)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
Blank (B8I0729-BLK3)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
LCS (B8I0729-BS1)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.103	0.0020	mg/L	0.100		103	80-112			
LCS (B8I0729-BS2)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.0917	0.0020	mg/L	0.100		92	80-112			
LCS (B8I0729-BS3)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.0897	0.0020	mg/L	0.100		90	80-112			
General Parameters, Batch B8I0734										
Reference (B8I0734-SRM1)				Prepared: 2018-09-12, Analyzed: 2018-09-12						
pH	6.14	0.10	pH units	6.20		99	97.5-102.5			
General Parameters, Batch B8I0769										

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Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8I0769, Continued										
Blank (B8I0769-BLK1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK2)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK3)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK4)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
LCS (B8I0769-BS1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.04	0.020	mg/L	1.00		104	90-115			
LCS (B8I0769-BS2)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.03	0.020	mg/L	1.00		103	90-115			
LCS (B8I0769-BS3)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	0.999	0.020	mg/L	1.00		100	90-115			
LCS (B8I0769-BS4)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.01	0.020	mg/L	1.00		101	90-115			
Microbiological Parameters, Batch B8I0480										
Blank (B8I0480-BLK1)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Coliforms, Fecal	< 1	1	CFU/100 mL							
Duplicate (B8I0480-DUP1)	**Source: 8090545-03**			Prepared: 2018-09-08, Analyzed: 2018-09-08						
Coliforms, Fecal	< 1	1	CFU/100 mL		1				81	MIC29
Polycyclic Aromatic Hydrocarbons (PAH), Batch B8I0497										
Blank (B8I0497-BLK1)				Prepared: 2018-09-09, Analyzed: 2018-09-09						
Acenaphthene	< 0.050	0.050	µg/L							
Acenaphthylene	< 0.200	0.200	µg/L							
Acridine	< 0.050	0.050	µg/L							
Anthracene	< 0.010	0.010	µg/L							
Benz(a)anthracene	< 0.010	0.010	µg/L							
Benzo(a)pyrene	< 0.010	0.010	µg/L							
Benzo(b+j)fluoranthene	< 0.050	0.050	µg/L							
Benzo(g,h,i)perylene	< 0.050	0.050	µg/L							
Benzo(k)fluoranthene	< 0.050	0.050	µg/L							
2-Chloronaphthalene	< 0.100	0.100	µg/L							
Chrysene	< 0.050	0.050	µg/L							
Dibenz(a,h)anthracene	< 0.010	0.010	µg/L							
Fluoranthene	< 0.030	0.030	µg/L							
Fluorene	< 0.050	0.050	µg/L							
Indeno(1,2,3-cd)pyrene	< 0.050	0.050	µg/L							
1-Methylnaphthalene	< 0.100	0.100	µg/L							
2-Methylnaphthalene	< 0.100	0.100	µg/L							
Naphthalene	< 0.200	0.200	µg/L							
Phenanthrene	< 0.100	0.100	µg/L							
Pyrene	< 0.020	0.020	µg/L							
Quinoline	< 0.050	0.050	µg/L							
Surrogate: Acridine-d9	*3.22*		*µg/L*	*4.44*		*72*	*50-140*			

CARO ANALYTICAL SERVICES

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Polycyclic Aromatic Hydrocarbons (PAH), Batch B8I0497, Continued										
Blank (B8I0497-BLK1), Continued				Prepared: 2018-09-09, Analyzed: 2018-09-09						
Surrogate: Naphthalene-d8	*3.91*		*µg/L*	4.44		*88*	*50-140*			
Surrogate: Perylene-d12	*1.70*		*µg/L*	4.44		*38*	*50-140*			*S02*
LCS (B8I0497-BS1)				Prepared: 2018-09-09, Analyzed: 2018-09-09						
Acenaphthene	4.00	0.050	µg/L	4.40		91	58-125			
Acenaphthylene	4.17	0.200	µg/L	4.40		95	54-128			
Acridine	3.56	0.050	µg/L	4.44		80	50-112			
Anthracene	3.69	0.010	µg/L	4.44		83	66-125			
Benz(a)anthracene	4.89	0.010	µg/L	4.44		110	59-123			
Benzo(a)pyrene	4.24	0.010	µg/L	4.40		96	62-116			
Benzo(b+j)fluoranthene	8.35	0.050	µg/L	8.89		94	69-121			
Benzo(g,h,i)perylene	4.30	0.050	µg/L	4.40		98	58-129			
Benzo(k)fluoranthene	3.69	0.050	µg/L	4.44		83	67-128			
2-Chloronaphthalene	3.80	0.100	µg/L	4.44		86	50-140			
Chrysene	4.35	0.050	µg/L	4.42		98	58-125			
Dibenz(a,h)anthracene	4.51	0.010	µg/L	4.42		102	58-126			
Fluoranthene	3.68	0.030	µg/L	4.36		85	67-133			
Fluorene	3.96	0.050	µg/L	4.40		90	55-122			
Indeno(1,2,3-cd)pyrene	4.01	0.050	µg/L	4.44		90	62-126			
1-Methylnaphthalene	3.99	0.100	µg/L	4.38		91	53-125			
2-Methylnaphthalene	4.00	0.100	µg/L	4.36		92	52-122			
Naphthalene	4.08	0.200	µg/L	4.44		92	50-130			
Phenanthrene	3.84	0.100	µg/L	4.40		87	67-127			
Pyrene	3.64	0.020	µg/L	4.44		82	68-133			
Quinoline	5.00	0.050	µg/L	4.44		112	51-140			
Surrogate: Acridine-d9	*4.04*		*µg/L*	4.44		*91*	*50-140*			
Surrogate: Naphthalene-d8	*4.12*		*µg/L*	4.44		*93*	*50-140*			
Surrogate: Perylene-d12	*1.97*		*µg/L*	4.44		*44*	*50-140*			*S02*
LCS Dup (B8I0497-BSD1)				Prepared: 2018-09-09, Analyzed: 2018-09-09						
Acenaphthene	4.02	0.050	µg/L	4.40		91	58-125	< 1	16	
Acenaphthylene	4.24	0.200	µg/L	4.40		96	54-128	2	16	
Acridine	2.97	0.050	µg/L	4.44		67	50-112	18	26	
Anthracene	3.74	0.010	µg/L	4.44		84	66-125	1	14	
Benz(a)anthracene	4.72	0.010	µg/L	4.44		106	59-123	3	23	
Benzo(a)pyrene	4.12	0.010	µg/L	4.40		94	62-116	3	16	
Benzo(b+j)fluoranthene	8.22	0.050	µg/L	8.89		93	69-121	1	14	
Benzo(g,h,i)perylene	4.14	0.050	µg/L	4.40		94	58-129	4	25	
Benzo(k)fluoranthene	3.70	0.050	µg/L	4.44		83	67-128	< 1	18	
2-Chloronaphthalene	3.81	0.100	µg/L	4.44		86	50-140	< 1	30	
Chrysene	4.25	0.050	µg/L	4.42		96	58-125	2	24	
Dibenz(a,h)anthracene	4.16	0.010	µg/L	4.42		94	58-126	8	23	
Fluoranthene	3.60	0.030	µg/L	4.36		83	67-133	2	18	
Fluorene	4.04	0.050	µg/L	4.40		92	55-122	2	16	
Indeno(1,2,3-cd)pyrene	3.89	0.050	µg/L	4.44		87	62-126	3	22	
1-Methylnaphthalene	4.04	0.100	µg/L	4.38		92	53-125	1	16	
2-Methylnaphthalene	4.04	0.100	µg/L	4.36		93	52-122	< 1	17	
Naphthalene	4.07	0.200	µg/L	4.44		92	50-130	< 1	18	
Phenanthrene	3.75	0.100	µg/L	4.40		85	67-127	2	14	
Pyrene	3.56	0.020	µg/L	4.44		80	68-133	2	18	
Quinoline	5.21	0.050	µg/L	4.44		117	51-140	4	12	
Surrogate: Acridine-d9	*3.41*		*µg/L*	4.44		*77*	*50-140*			
Surrogate: Naphthalene-d8	*4.06*		*µg/L*	4.44		*91*	*50-140*			
Surrogate: Perylene-d12	*1.87*		*µg/L*	4.44		*42*	*50-140*			*S02*

CARO ANALYTICAL SERVICES

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Total Metals, Batch B8I0510										
Blank (B8I0510-BLK1)				Prepared: 2018-09-09, Analyzed: 2018-09-11						
Aluminum, total	< 0.0050	0.0050	mg/L							
Antimony, total	< 0.00020	0.00020	mg/L							
Arsenic, total	< 0.00050	0.00050	mg/L							
Barium, total	< 0.0050	0.0050	mg/L							
Beryllium, total	< 0.00010	0.00010	mg/L							
Bismuth, total	< 0.00010	0.00010	mg/L							
Boron, total	< 0.0050	0.0050	mg/L							
Cadmium, total	< 0.000010	0.000010	mg/L							
Calcium, total	< 0.20	0.20	mg/L							
Chromium, total	< 0.00050	0.00050	mg/L							
Cobalt, total	< 0.00010	0.00010	mg/L							
Copper, total	< 0.00040	0.00040	mg/L							
Iron, total	< 0.010	0.010	mg/L							
Lead, total	< 0.00020	0.00020	mg/L							
Lithium, total	< 0.00010	0.00010	mg/L							
Magnesium, total	< 0.010	0.010	mg/L							
Manganese, total	< 0.00020	0.00020	mg/L							
Molybdenum, total	< 0.00010	0.00010	mg/L							
Nickel, total	< 0.00040	0.00040	mg/L							
Phosphorus, total	< 0.050	0.050	mg/L							
Potassium, total	< 0.10	0.10	mg/L							
Selenium, total	< 0.00050	0.00050	mg/L							
Silicon, total	< 1.0	1.0	mg/L							
Silver, total	< 0.000050	0.000050	mg/L							
Sodium, total	< 0.10	0.10	mg/L							
Strontium, total	< 0.0010	0.0010	mg/L							
Sulfur, total	< 3.0	3.0	mg/L							
Tellurium, total	< 0.00050	0.00050	mg/L							
Thallium, total	< 0.000020	0.000020	mg/L							
Thorium, total	< 0.00010	0.00010	mg/L							
Tin, total	< 0.00020	0.00020	mg/L							
Titanium, total	< 0.0050	0.0050	mg/L							
Tungsten, total	< 0.0010	0.0010	mg/L							
Uranium, total	< 0.000020	0.000020	mg/L							
Vanadium, total	< 0.0010	0.0010	mg/L							
Zinc, total	< 0.0040	0.0040	mg/L							
Zirconium, total	< 0.00010	0.00010	mg/L							
LCS (B8I0510-BS1)				Prepared: 2018-09-09, Analyzed: 2018-09-11						
Aluminum, total	0.0224	0.0050	mg/L	0.0200		112	80-120			
Antimony, total	0.0192	0.00020	mg/L	0.0200		96	80-120			
Arsenic, total	0.0201	0.00050	mg/L	0.0200		100	80-120			
Barium, total	0.0201	0.0050	mg/L	0.0200		101	80-120			
Beryllium, total	0.0204	0.00010	mg/L	0.0200		102	80-120			
Bismuth, total	0.0194	0.00010	mg/L	0.0200		97	80-120			
Boron, total	0.0211	0.0050	mg/L	0.0200		106	80-120			
Cadmium, total	0.0200	0.000010	mg/L	0.0200		100	80-120			
Calcium, total	1.99	0.20	mg/L	2.00		100	80-120			
Chromium, total	0.0185	0.00050	mg/L	0.0200		93	80-120			
Cobalt, total	0.0197	0.00010	mg/L	0.0200		98	80-120			
Copper, total	0.0199	0.00040	mg/L	0.0200		100	80-120			
Iron, total	2.11	0.010	mg/L	2.00		105	80-120			
Lead, total	0.0198	0.00020	mg/L	0.0200		99	80-120			
Lithium, total	0.0222	0.00010	mg/L	0.0200		111	80-120			
Magnesium, total	2.03	0.010	mg/L	2.00		101	80-120			
Manganese, total	0.0207	0.00020	mg/L	0.0200		104	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090545
PROJECT	City of Whitehorse	**REPORTED**	2018-10-10 13:07

Total Metals, Batch B8I0510, Continued

LCS (B8I0510-BS1), Continued — Prepared: 2018-09-09, Analyzed: 2018-09-11

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Molybdenum, total	0.0187	0.00010	mg/L	0.0200		93	80-120			
Nickel, total	0.0213	0.00040	mg/L	0.0200		106	80-120			
Phosphorus, total	2.12	0.050	mg/L	2.00		106	80-120			
Potassium, total	2.07	0.10	mg/L	2.00		104	80-120			
Selenium, total	0.0214	0.00050	mg/L	0.0200		107	80-120			
Silicon, total	1.7	1.0	mg/L	2.00		85	80-120			
Silver, total	0.0193	0.000050	mg/L	0.0200		97	80-120			
Sodium, total	2.13	0.10	mg/L	2.00		107	80-120			
Strontium, total	0.0199	0.0010	mg/L	0.0200		99	80-120			
Sulfur, total	5.0	3.0	mg/L	5.00		100	80-120			
Tellurium, total	0.0198	0.00050	mg/L	0.0200		99	80-120			
Thallium, total	0.0199	0.000020	mg/L	0.0200		100	80-120			
Thorium, total	0.0170	0.00010	mg/L	0.0200		85	80-120			
Tin, total	0.0203	0.00020	mg/L	0.0200		102	80-120			
Titanium, total	0.0192	0.0050	mg/L	0.0200		96	80-120			
Tungsten, total	0.0188	0.0010	mg/L	0.0200		94	80-120			
Uranium, total	0.0186	0.000020	mg/L	0.0200		93	80-120			
Vanadium, total	0.0188	0.0010	mg/L	0.0200		94	80-120			
Zinc, total	0.0224	0.0040	mg/L	0.0200		112	80-120			
Zirconium, total	0.0177	0.00010	mg/L	0.0200		88	80-120			

Reference (B8I0510-SRM1) — Prepared: 2018-09-09, Analyzed: 2018-09-11

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Aluminum, total	0.343	0.0050	mg/L	0.303		113	82-114			
Antimony, total	0.0493	0.00020	mg/L	0.0511		96	88-115			
Arsenic, total	0.122	0.00050	mg/L	0.118		103	88-111			
Barium, total	0.797	0.0050	mg/L	0.823		97	83-110			
Beryllium, total	0.0508	0.00010	mg/L	0.0496		102	80-119			
Boron, total	3.43	0.0050	mg/L	3.45		99	80-118			
Cadmium, total	0.0505	0.000010	mg/L	0.0495		102	90-110			
Calcium, total	11.9	0.20	mg/L	11.6		102	85-113			
Chromium, total	0.235	0.00050	mg/L	0.250		94	88-111			
Cobalt, total	0.0384	0.00010	mg/L	0.0377		102	90-114			
Copper, total	0.539	0.00040	mg/L	0.486		111	90-117			
Iron, total	0.516	0.010	mg/L	0.488		106	90-116			
Lead, total	0.210	0.00020	mg/L	0.204		103	90-110			
Lithium, total	0.450	0.00010	mg/L	0.403		112	79-118			
Magnesium, total	3.95	0.010	mg/L	3.79		104	88-116			
Manganese, total	0.113	0.00020	mg/L	0.109		103	88-108			
Molybdenum, total	0.194	0.00010	mg/L	0.198		98	88-110			
Nickel, total	0.259	0.00040	mg/L	0.249		104	90-112			
Phosphorus, total	0.230	0.050	mg/L	0.227		101	72-118			
Potassium, total	7.83	0.10	mg/L	7.21		109	87-116			
Selenium, total	0.129	0.00050	mg/L	0.121		106	90-122			
Sodium, total	8.55	0.10	mg/L	7.54		113	86-118			
Strontium, total	0.384	0.0010	mg/L	0.375		102	86-110			
Thallium, total	0.0892	0.000020	mg/L	0.0805		111	90-113			
Uranium, total	0.0285	0.000020	mg/L	0.0306		93	88-112			
Vanadium, total	0.366	0.0010	mg/L	0.386		95	87-110			
Zinc, total	2.59	0.0040	mg/L	2.49		104	90-113			

Volatile Organic Compounds (VOC), Batch B8I0436

Blank (B8I0436-BLK1) — Prepared: 2018-09-07, Analyzed: 2018-09-07

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Benzene	< 0.5	0.5	µg/L							
Ethylbenzene	< 1.0	1.0	µg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier

Volatile Organic Compounds (VOC), Batch B8I0436, Continued

Blank (B8I0436-BLK1), Continued Prepared: 2018-09-07, Analyzed: 2018-09-07

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Methyl tert-butyl ether	< 1.0	1.0	µg/L							
Styrene	< 1.0	1.0	µg/L							
Toluene	< 1.0	1.0	µg/L							
Xylenes (total)	< 2.0	2.0	µg/L							
Surrogate: Toluene-d8	*30.7*		*µg/L*	26.2		*117*	*70-130*			
Surrogate: 4-Bromofluorobenzene	*21.0*		*µg/L*	25.0		*84*	*70-130*			

LCS (B8I0436-BS1) Prepared: 2018-09-07, Analyzed: 2018-09-07

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Benzene	18.6	0.5	µg/L	20.0		93	70-130			
Ethylbenzene	18.4	1.0	µg/L	20.0		92	70-130			
Methyl tert-butyl ether	18.7	1.0	µg/L	20.0		94	70-130			
Styrene	24.1	1.0	µg/L	20.0		121	70-130			
Toluene	19.6	1.0	µg/L	20.1		97	70-130			
Xylenes (total)	56.8	2.0	µg/L	60.1		94	70-130			
Surrogate: Toluene-d8	*29.0*		*µg/L*	26.2		*111*	*70-130*			
Surrogate: 4-Bromofluorobenzene	*26.8*		*µg/L*	25.0		*107*	*70-130*			

QC Qualifiers:

MIC29 The difference in logs is less than the R value.
S02 Surrogate recovery outside of control limits. Data accepted based on acceptable recovery of other surrogates.

NAUTILUS ENVIRONMENTAL

Acute Toxicity Test Results

Sample 8090545-02,
collected September 05, 2018

Final Report

September 24, 2018

Submitted to: **CARO Analytical Services**
Richmond, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

SAMPLE INFORMATION

Sample ID	Dates			Receipt temperature
	Collected	Received	Rainbow trout test initiation	
8090545-02	05-Sep-18 at 1015h	10-Sep-18 at 0915h	10-Sep-18 at 1400h	5.5°C

TESTS

- Rainbow trout 96-h LC50 test

RESULTS

Toxicity test results

Sample ID	LC50 (% v/v)
8090545-02	>100

LC = Lethal Concentration

QA/QC

QA/QC summary	Rainbow trout
Reference toxicant LC50 (95% CL)	65.9 (50.4 – 86.4) µg/L Zn[1]
Reference toxicant historical mean (2 SD range)	83.0 (34.6 – 198.9) µg/L Zn
Reference toxicant CV	46%
Organism health history	Acceptable
Protocol deviations	None
Water quality range deviations	None
Control performance	Acceptable
Test performance	Valid

[1] Test date: September 06, 2018, LC = Lethal Concentration, CL = Confidence Limits, SD = Standard Deviation, CV = Coefficient of Variation

Report By:
Richard Chea, B.Sc.
Laboratory Biologist

Reviewed By:
Edmund Canaria, R.P.Bio
Senior Analyst

APPENDIX A – Summary of test conditions

Table 1. Summary of test conditions: 96-h rainbow trout (*Oncorhynchus mykiss*) LC50 test.

Test species	*Oncorhynchus mykiss*
Organism source	Hatchery
Organism age	Juvenile
Test type	Static
Test duration	96 hours
Test vessel	20-L glass aquarium
Test volume	10 to 20 L (depending on size of fish)
Test solution depth	≥15 cm
Test concentrations	Five concentrations, plus laboratory control
Test replicates	1 per treatment
Number of organisms	10 per replicate
Control/dilution water	Dechlorinated Metro Vancouver municipal tapwater
Test solution renewal	None
Test temperature	15 ± 1°C
Feeding	None
Light intensity	100 to 500 lux
Photoperiod	16 hours light / 8 hours dark
Aeration	6.5 ± 1 mL/min/L
Test measurements	Temperature, dissolved oxygen and pH measured daily; salinity measured in the undiluted sample at test initiation; conductivity measured at test initiation and termination; survival checked daily
Test protocol	Environment Canada (2000), EPS 1/RM/13, with 2007 & 2016 amendments
Statistical software	CETIS Version 1.9.4
Test endpoint	Survival (96-hour LC50)
Test acceptability criterion for controls	Survival ≥90%
Reference toxicant	Zinc (added as $ZnSO_4$)

APPENDIX B – Toxicity test data

Rainbow Trout Summary Sheet

Client: CARO Analytical Services

Start Date/Time: 10Sep18 @ 1400h

Work Order No.: 181502

Test Species: *Oncorhynchus mykiss*

Test Validity Criteria:

≥ 90% control survival

WQ Ranges:

T (°C) = 15 ± 1; DO (mg/L) = 7.0 to 10.3; pH = 5.5 to 8.5

Sample Information:

Sample ID: 8090545-02

Sample Date: 05Sep18

Date Received: 10Sep18

Sample Volume: 1 × 20 L

Other: —

Dilution Water:

Type: Dechlorinated Municipal Tap Water

Hardness (mg/L $CaCO_3$): 13

Alkalinity (mg/L $CaCO_3$): 14

Test Organism Information:

Batch No.: 082018a

Source: Aqua Farms

No. Fish/Volume (L): 10/10L

Loading Density (g/L): 0.35

Mean Length ± SD (mm): 36 ± 2 Range: 33 – 40

Mean Weight ± SD (g): 0.35 ± 0.07 Range: 0.24 – 0.53

Zinc Reference Toxicant Results:

Reference Toxicant ID: RTZn134

Stock Solution ID: 18Zn06

Date Initiated: 06 September 2018

96-h LC50 (95% CL): 65.9 (50.4 - 86.4) µg/L Zn

Reference Toxicant Mean and Historical Range: 83.0 (34.6 - 198.9) µg/L Zn

Reference Toxicant CV (%): 46%

Test Results: The 96h LC50 is estimated to be > 100% (v/v).

Reviewed by: [signature]

Date reviewed: Sept. 18, 2018

96-Hour Rainbow Trout Toxicity Test Data Sheet

Client/Project#: Caro Analytical Services
Sample I.D. 8090545-02
W.O. # 181502
RBT Batch #: 082018a
Date Collected/Time: Sept 5/18 @ 1015h
Date Setup/Time: Sept 10/18 @ 1900h
CER #: 2
Sample Setup By: JD

Number Fish/Volume: 10/18L 10L
7-d % Mortality: 0.2%
Total Pre-aeration Time (mins): 30
Aeration rate adjusted to 6.5 ± 1 mL/min/L? (Y/N): Y

Thermometer: Cer2
D.O. meter/probe: 2 / D2
Cond./Salinity meter/probe: 2 / CP2
pH meter/probe: 2 / P2

Undiluted Sample WQ			
Parameters	Initial WQ	Adjustment	30 min WQ
Temp °C	14.0		14.0
D.O. (mg/L)	10.2		10.3
pH	8.4		8.5
Cond. (µS/cm)	617		617
Salinity (ppt)	0.3		0.3

Concentration	# Survivors							Temperature (°C)					Dissolved Oxygen (mg/L)					pH					Conductivity (µS/cm)	
(% v/v)	1	2	4	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
Ctrl				10	10	10	10	15.0	15.0	15.0	15.0	15.0	9.5	9.5	9.4	9.5	9.5	7.0	7.0	7.1	7.2	7.2	36	39
6.25				10	10	10	10	15.0	15.0	15.0	15.0	15.0	9.6	9.6	9.6	9.5	9.5	7.3	7.0	7.2	7.2	7.1	97	92
12.5				10	10	10	10	15.0	15.0	15.0	15.0	15.0	9.7	9.7	9.7	9.6	9.6	7.6	7.5	7.6	7.4	7.6	132	132
25				10	10	10	10	14.5	15.0	15.0	15.0	15.0	9.8	9.7	9.8	9.7	9.6	8.1	7.7	7.8	7.8	7.8	200	203
50				10	10	10	10	14.5	15.0	15.0	15.0	15.0	9.8	9.6	9.8	9.6	9.6	8.3	8.1	8.2	8.2	8.2	342	346
100				10	10	10	10	14.0	15.0	15.0	15.0	15.0	10.3	9.7	9.8	9.6	9.6	8.5	8.4	8.6	8.6	8.6	617	622
Initials				JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD	JD

Sample Description/Comments: Clear yellow liquid. Organic particulates. No odour.

Fish Description at 96 h: All fish appear normal Number of Stressed Fish at 96 h: 0

Other Observations:

Reviewed by: [signature] Date Reviewed: Sept 18, 2018

Version 2.5; Issued July 19, 2017

Nautilus Environmental Company Inc.

APPENDIX C – Chain-of-custody form

CARO
ANALYTICAL SERVICES

SUBCONTRACT REQUEST (WO# 8090545)

SENDING LABORATORY:
CARO Analytical Services
#110 4011 Viking Way
Richmond, BC V6V 2K9
Phone: (604) 279-1499

wo#
181502

Contact Eilish St.Clair, B.Sc.
sublet@caro.ca

RECEIVING LABORATORY:
Nautilus Environmental (Burnaby)
8664 Commerce Court
Burnaby, BC V5A 4K7
Phone: (604) 420-8773

~~Due Date: 2018-09-14 12:00~~

Reg TAT

Analysis / Method	Expires	Comments
CARO Sample ID: 8090545-02 | Matrix: Water | Sampled: 2018-09-05 10:15		
Container(s) Submitted: J = C33_20 L Plastic (Tox)		
Trout LC50 [EPS 1/RM/13 B]	2018-09-10	

TC — 09/07
Released By — Date

Tyrone Hamilton — Sept. 10/18 @09:15
Received By — Date

1x20L

5.5°C

END OF REPORT

CARO ANALYTICAL SERVICES

Caring About Results, Obviously.

CA... 846
#11 ... 2K9
#10 ... K 5C3
172 ... 1H7

* 8 0 9 0 5 4 5 *

CARO BC COC, Rev 2017-05

CHAIN OF CUSTODY RECORD

COC#: ______ PAGE 1 OF 1

RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
N. BOTCA	TIME:	Air North TC	09/07 TIME: 1030

TURNAROUND TIME REQUESTED:
Routine: (5-7 Days) [X]
Rush: 1 Day* [ ] 2 Day* [ ] 3 Day* [ ]
Other*
*Contact Lab To Confirm. Surcharge May Apply

REGULATORY APPLICATION: Show on Report [ ]
Canadian Drinking Water Quality [ ] BC WQG [ ] BC HWR [ ]
BC CSR Soil: WL [ ] AL [ ] PL [ ] RL-LD [ ] RL-HD [ ] CL [ ] IL [ ]
BC CSR Water: AW [X] IW [ ] LW [ ] DW [ ]
CCME: Other:

PROJECT NUMBER / INFO: City of Whitehorse

A: Biohazard D: Asbestos G: Strong Odour
B: Cyanide E: Heavy Metals H: High Contamination
C: PCBs F: Flammable I: Other (please specify*)

REPORT TO:
COMPANY: Yukon Government, Dept of ENV
ADDRESS: Water Resources Branch (V-310)
Box 2703, Whitehorse, YT Y1A 2C6
CONTACT:
TEL/FAX:
DELIVERY METHOD: EMAIL [X] MAIL [ ] OTHER* [ ]
DATA FORMAT: EXCEL [X] WATERTRAX [ ] ESdat [ ] EQuIS [ ] BC EMS [ ] OTHER* [X]
EMAIL 1: Collin.Remillard@gov.yk.ca
EMAIL 2: amelie.janin@gov.yk.ca
EMAIL 3: brendan.mulligan@gov.yk.ca

INVOICE TO: SAME AS REPORT TO [X]
COMPANY:
ADDRESS:
CONTACT: Holly Goulding
TEL/FAX:
DELIVERY METHOD: EMAIL [X] MAIL [ ] OTHER* [ ]
EMAIL 1: holly.goulding@gov.yk.ca
EMAIL 2: Collin.Remillard@gov.yk.ca
EMAIL 3: Troy.Searson@gov.yk.ca
PO #:

** If you would like to sign up for ClientConnect and/or EnviroChain, CARO's online service offerings, please check here: [ ]

COMMENTS:

SAMPLED BY: ~~Nicole Novodvorsky~~ A. JANIN; B. MULLIGAN

8090545

ANALYSES REQUESTED:

SAMPLE ID - SAMPLE CLASS - STATION CODE	DRINKING WATER	OTHER WATER	SOIL	OTHER	CONTAINER QTY	DATE YYYY-MM-DD	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	(e.g. flow/volume media ID/notes)	METALS - WATER TOTAL (Hg [ ])		pH, EC, Spec. Alkalinity	CBOD5	TIC, TOC, DIC, DOC	Chloride, Sulphate, Nitrite, Nitrate	Total Phosphorus, Total Ammonia - N	un-ionized ammonia	Hexavalent Chromium (Cr VI)	Fecal Coliforms	Total Oil & Grease	BTEX/VPH	LEPH/HEPH/PAH	LC50	EHw 10-19	VHw 6-10	HOLD	POSSIBLE SAMPLE HAZARD CODE(S)
2018149 - P - WH6C		X			3	2018/09/05	10:23		X	X													X	X		X	X		
2018155 - P - WH96		X			10	2018/09/05	1015		X	X		X		X	X		X	X			X	X	X	X	X	X	X		
2018153 - P - U/S LTECF		X			9	2018/09/05	10:41		X	X		X		X	X		X	X			X	X	X	X		X	X		
2018154 - P - D/S CL		X			9	2018/09/05	0957		X	X		X		X	X		X	X			X	X	X	X		X	X		

SHIPPING INSTRUCTIONS: Return Cooler(s) [ ]
Supplies Needed:

SAMPLE RETENTION:
30 Days (default) [ ]
60 Days [ ] 90 Days [ ]
Other (surcharges will apply):

*** OTHER INSTRUCTIONS:**
Ice packs ours, please return.

If you would like to talk to a real live Scientist about your project requirements, please check here: [ ]

SAMPLE RECEIPT CONDITION:
COOLER 1 (°C): 5.3 ICE: Y [X] N [ ]
COOLER 2 (°C): ICE: Y [ ] N [ ]
COOLER 3 (°C): ICE: Y [ ] N [ ]
CUSTODY SEALS INTACT: NA [ ] Y [ ] N [ ]

CARO ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

REPORTED TO	Yukon Government - Water Resources Suite 203, 1191 Front Street Whitehorse, YT Y1A 0K5		
ATTENTION	John Minder	**WORK ORDER**	8090548
PO NUMBER		**RECEIVED / TEMP**	2018-09-07 10:30 / 5°C
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32
PROJECT INFO	YK Water Resources - C00043458		

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO 17025:2005 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at bshaw@caro.ca

Authorized By:

Bryan Shaw, Ph.D., P.Chem.
Client Service Coordinator

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090548
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32

Analyte	Result	RL	Units	Analyzed	Qualifier
2018152 (8090548-01) | Matrix: Water | Sampled: 2018-09-05 10:15					
Microbiological Parameters					
Coliforms, Fecal	< 1	1	CFU/100 mL	2018-09-08	HT1
2018151 (8090548-02) | Matrix: Water | Sampled: 2018-09-05 10:23					
General Parameters					
Alkalinity, Total (as CaCO3)	**39.4**	1.0	mg/L	2018-09-10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Bicarbonate (as CaCO3)	**39.4**	1.0	mg/L	2018-09-10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Ammonia, Total (as N)	**0.020**	0.020	mg/L	2018-09-13	
Conductivity (EC)	**94.7**	2.0	µS/cm	2018-09-10	
pH	**7.50**	0.10	pH units	2018-09-10	HT2
Phosphorus, Total (as P)	**0.0037**	0.0020	mg/L	2018-09-13	
Microbiological Parameters					
Coliforms, Fecal	< 1	1	CFU/100 mL	2018-09-08	HT1
2018150 (8090548-03) | Matrix: Water | Sampled: 2018-09-05 10:32					
General Parameters					
Alkalinity, Total (as CaCO3)	**38.8**	1.0	mg/L	2018-09-10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Bicarbonate (as CaCO3)	**38.8**	1.0	mg/L	2018-09-10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-09-10	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-09-13	
Conductivity (EC)	**94.0**	2.0	µS/cm	2018-09-10	
pH	**7.48**	0.10	pH units	2018-09-10	HT2
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L	2018-09-13	
Microbiological Parameters					
Coliforms, Fecal	< 1	1	CFU/100 mL	2018-09-08	HT1

Sample Qualifiers:

HT1 The sample was prepared and/or analyzed past the recommended holding time.

HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090548
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32

Analysis Description	Method Ref.	Technique	Location
Alkalinity in Water	SM 2320 B* (2011)	Titration with H2SO4	Kelowna
Ammonia, Total in Water	SM 4500-NH3 G* (2011)	Automated Colorimetry (Phenate)	Kelowna
Coliforms, Fecal in Water	SM 9222 D (2006)	Membrane Filtration / m-FC Agar	Kelowna
Conductivity in Water	SM 2510 B (2011)	Conductivity Meter	Kelowna
pH in Water	SM 4500-H+ B (2011)	Electrometry	Kelowna
Phosphorus, Total in Water	SM 4500-P B.5* (2011) / SM 4500-P F (2011)	Persulfate Digestion / Automated Colorimetry (Ascorbic Acid)	Kelowna

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
CFU/100 mL	Colony Forming Units per 100 millilitres
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued unless otherwise agreed to in writing.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090548
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in “batches” and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8I0575										
Blank (B8I0575-BLK1)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	< 2.0	2.0	µS/cm							
Blank (B8I0575-BLK2)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	< 2.0	2.0	µS/cm							
Blank (B8I0575-BLK3)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	< 2.0	2.0	µS/cm							
LCS (B8I0575-BS1)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
Alkalinity, Total (as CaCO3)	96.9	1.0	mg/L	100		97	92-106			
LCS (B8I0575-BS2)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	95.4	1.0	mg/L	100		95	92-106			
LCS (B8I0575-BS3)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Alkalinity, Total (as CaCO3)	100	1.0	mg/L	100		100	92-106			
LCS (B8I0575-BS4)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
Conductivity (EC)	1390	2.0	µS/cm	1410		98	95-104			

CARO ANALYTICAL SERVICES

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090548
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8I0575, Continued										
LCS (B8I0575-BS5)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Conductivity (EC)	1390	2.0	µS/cm	1410		99	95-104			
LCS (B8I0575-BS6)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
Conductivity (EC)	1410	2.0	µS/cm	1410		100	95-104			
Reference (B8I0575-SRM1)				Prepared: 2018-09-10, Analyzed: 2018-09-10						
pH	7.02	0.10	pH units	7.00		100	80-120			
Reference (B8I0575-SRM2)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
pH	7.02	0.10	pH units	7.00		100	80-120			
Reference (B8I0575-SRM3)				Prepared: 2018-09-11, Analyzed: 2018-09-11						
pH	7.02	0.10	pH units	7.00		100	80-120			
General Parameters, Batch B8I0729										
Blank (B8I0729-BLK1)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
Blank (B8I0729-BLK2)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
Blank (B8I0729-BLK3)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	< 0.0020	0.0020	mg/L							
LCS (B8I0729-BS1)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.103	0.0020	mg/L	0.100		103	80-112			
LCS (B8I0729-BS2)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.0917	0.0020	mg/L	0.100		92	80-112			
LCS (B8I0729-BS3)				Prepared: 2018-09-12, Analyzed: 2018-09-13						
Phosphorus, Total (as P)	0.0897	0.0020	mg/L	0.100		90	80-112			
General Parameters, Batch B8I0769										
Blank (B8I0769-BLK1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK2)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK3)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8I0769-BLK4)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
LCS (B8I0769-BS1)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.04	0.020	mg/L	1.00		104	90-115			
LCS (B8I0769-BS2)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.03	0.020	mg/L	1.00		103	90-115			
LCS (B8I0769-BS3)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	0.999	0.020	mg/L	1.00		100	90-115			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Yukon Government - Water Resources	**WORK ORDER**	8090548
PROJECT	City of Whitehorse	**REPORTED**	2018-09-17 15:32

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8I0769, Continued										
LCS (B8I0769-BS4)				Prepared: 2018-09-13, Analyzed: 2018-09-13						
Ammonia, Total (as N)	1.01	0.020	mg/L	1.00		101	90-115			
Microbiological Parameters, Batch B8I0480										
Blank (B8I0480-BLK1)				Prepared: 2018-09-08, Analyzed: 2018-09-08						
Coliforms, Fecal	< 1	1	CFU/100 mL							

CARO ANALYTICAL SERVICES
Caring About Results, Obviously.

* 8 0 9 0 5 4 8 *

1-8846
C V6V 2K9
C V1X 5C3
B T5S 1H7

CARO BC COC, Rev 2017-05

CHAIN OF CUSTODY RECORD

COC# ______ PAGE 1 OF 1

RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
N. BOTCA	TIME:	Air North TL	09/07 TIME: 1030

TURNAROUND TIME REQUESTED:
Routine: (5-7 Days) [X]
Rush: 1 Day* [ ] 2 Day* [ ] 3 Day* [ ]
Other*
*Contact Lab To Confirm. Surcharge May Apply

REGULATORY APPLICATION: Show on Report [ ]
Canadian Drinking Water Quality [ ] BC WQG [ ] BC HWR [ ]
BC CSR Soil: WL [ ] AL [ ] PL [ ] RL-LD [ ] RL-HD [ ] CL [ ] IL [ ]
BC CSR Water: AW [X] IW [ ] LW [ ] DW [ ]
CCME: Other:

REPORT TO:
COMPANY: Yukon Government, Dept of ENV
ADDRESS: Water Resources Branch (V-310)
Box 2703, Whitehorse, YT Y1A 2C6
CONTACT:
TEL/FAX:
DELIVERY METHOD: EMAIL [X] MAIL [ ] OTHER* [ ]
DATA FORMAT: EXCEL [X] WATERTRAX [ ] ESdat [ ] EQuIS [ ] BC EMS [ ] OTHER* [X]
EMAIL 1: amelie.jamin@gov.yk.ca
EMAIL 2: brendan.mulligan@gov.yk.ca
EMAIL 3: nicole.novodvorsky@gov.yk.ca

INVOICE TO: SAME AS REPORT TO [X]
COMPANY:
ADDRESS:
CONTACT: Holly Goulding
TEL/FAX:
DELIVERY METHOD: EMAIL [X] MAIL [ ] OTHER* [ ]
EMAIL 1: holly.goulding@gov.yk.ca
EMAIL 2: nicole.novodvorsky@gov.yk.ca
EMAIL 3:
PO #:

PROJECT NUMBER / INFO:
City of Whitehorse

A: Biohazard D: Asbestos G: Strong Odour
B: Cyanide E: Heavy Metals H: High Contamination
C: PCBs F: Flammable I: Other (please specify*)

COMMENTS:

** If you would like to sign up for ClientConnect and/or EnviroChain, CARO's online service offerings, please check here: [ ]

SAMPLED BY: ~~Nicole Novodvorsky~~ A. Jamin; B. Mulligan

ANALYSES REQUESTED:

SAMPLE ID - SAMPLE CLASS - STATION CODE	DRINKING WATER	OTHER WATER	SOIL	OTHER	CONTAINER QTY	DATE YYYY-MM-DD	TIME HH:MM	CHLORINATED	FILTERED	PRESERVED	(e.g. flow/volume media ID/notes)	METALS - WATER TOTAL (Hg)	METALS - WATER DISSOLVED (Hg)	pH, EC, Spec. Alkalinity	TSS, TDS	TIC, TOC, DIC, DOC	Chloride, Sulphate, Nitrite, Nitrate	Total Phosphorus, Total Ammonia - N	un-ionized ammonia	Hexavalent Chromium (Cr VI)	Fecal Coliforms	Total Oil & Grease	BTEX/VPH	LEPH/HEPH/PAH	LC50			HOLD	POSSIBLE SAMPLE HAZARD CODE(S)
2018152 - M - WH 12		X			1	2018-09-05	10:15		X	X											X								
2018151 - M - WH 11		X			4	2018-09-05	10:23		X	X				X				X			X								
2018150 - M - WH 10		X			4	2018-09-05	10:32		X	X				X				X			X								

SHIPPING INSTRUCTIONS: Return Cooler(s) [ ]
Supplies Needed:

SAMPLE RETENTION:
30 Days (default) [ ]
60 Days [ ] 90 Days [ ]
Other (surcharges will apply):

*** OTHER INSTRUCTIONS:**
Ice packs ours, please return.

If you would like to talk to a real live Scientist about your project requirements, please check here: [ ]

SAMPLE RECEIPT CONDITION:
COOLER 1 (°C): 5.3 ICE: Y [✓] N [ ]
COOLER 2 (°C): ICE: Y [ ] N [ ]
COOLER 3 (°C): ICE: Y [ ] N [ ]
CUSTODY SEALS INTACT: NA [ ] Y [ ] N [ ]

Appendix D: Artificial Sweetener Data

Sample ID	Station ID	Sample Class	Date	Time	Parameter	Result	Units	MDL	PQL	Date Analy	LabSmplNo	Lab Name
2018149	(WH)WH-6c	M	5-Sep-18	12:45	Acesulfame	20395	ng/L	2	6	16-Oct-18	20181070	ECCC
2018149	(WH)WH-6c	M	5-Sep-18	12:45	Cyclamate	4701	ng/L	3	8	16-Oct-18	20181070	ECCC
2018149	(WH)WH-6c	M	5-Sep-18	12:45	Saccharin	14390	ng/L	2	6	16-Oct-18	20181070	ECCC
2018149	(WH)WH-6c	M	5-Sep-18	12:45	Sucralose	18222	ng/L	20	60	16-Oct-18	20181070	ECCC
2018150	(WH)WH-10	P	5-Sep-18	10:32	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181081	ECCC
2018150	(WH)WH-10	P	5-Sep-18	10:32	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181081	ECCC
2018150	(WH)WH-10	P	5-Sep-18	10:32	Saccharin	<2	ng/L	2	6	16-Oct-18	20181081	ECCC
2018150	(WH)WH-10	P	5-Sep-18	10:32	Sucralose	<20	ng/L	20	60	16-Oct-18	20181081	ECCC
2018151	(WH)WH-11	P	5-Sep-18	10:23	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181082	ECCC
2018151	(WH)WH-11	P	5-Sep-18	10:23	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181082	ECCC
2018151	(WH)WH-11	P	5-Sep-18	10:23	Saccharin	<2	ng/L	2	6	16-Oct-18	20181082	ECCC
2018151	(WH)WH-11	P	5-Sep-18	10:23	Sucralose	<20	ng/L	20	60	16-Oct-18	20181082	ECCC
2018152	(WH)WH-12	P	5-Sep-18	10:15	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181083	ECCC
2018152	(WH)WH-12	P	5-Sep-18	10:15	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181083	ECCC
2018152	(WH)WH-12	P	5-Sep-18	10:15	Saccharin	<2	ng/L	2	6	16-Oct-18	20181083	ECCC
2018152	(WH)WH-12	P	5-Sep-18	10:15	Sucralose	<20	ng/L	20	60	16-Oct-18	20181083	ECCC
2018153	(WH)LTECF-US	M	5-Sep-18	10:41	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181084	ECCC
2018153	(WH)LTECF-US	M	5-Sep-18	10:41	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181084	ECCC
2018153	(WH)LTECF-US	M	5-Sep-18	10:41	Saccharin	<2	ng/L	2	6	16-Oct-18	20181084	ECCC
2018153	(WH)LTECF-US	M	5-Sep-18	10:41	Sucralose	<20	ng/L	20	60	16-Oct-18	20181084	ECCC
2018154	(WH)CL-DS	M	5-Sep-18	9:57	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181080	ECCC
2018154	(WH)CL-DS	M	5-Sep-18	9:57	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181080	ECCC
2018154	(WH)CL-DS	M	5-Sep-18	9:57	Saccharin	<2	ng/L	2	6	16-Oct-18	20181080	ECCC
2018154	(WH)CL-DS	M	5-Sep-18	9:57	Sucralose	<20	ng/L	20	60	16-Oct-18	20181080	ECCC
2018155	(WH)WH-9b	P	5-Sep-18	12:06	Acesulfame	3322	ng/L	2	6	16-Oct-18	20181068	ECCC
2018155	(WH)WH-9b	P	5-Sep-18	12:06	Cyclamate	166	ng/L	3	8	16-Oct-18	20181068	ECCC
2018155	(WH)WH-9b	P	5-Sep-18	12:06	Saccharin	309	ng/L	2	6	16-Oct-18	20181068	ECCC
2018155	(WH)WH-9b	P	5-Sep-18	12:06	Sucralose	13043	ng/L	20	60	16-Oct-18	20181068	ECCC
2018181	(WH)CC-DS	M	30-Aug-18	15:07	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181055	ECCC
2018181	(WH)CC-DS	M	30-Aug-18	15:07	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181055	ECCC
2018181	(WH)CC-DS	M	30-Aug-18	15:07	Saccharin	<2	ng/L	2	6	16-Oct-18	20181055	ECCC
2018181	(WH)CC-DS	M	30-Aug-18	15:07	Sucralose	<20	ng/L	20	60	16-Oct-18	20181055	ECCC
2018182	(WH)CL-3	M	30-Aug-18	15:44	Acesulfame	9445	ng/L	2	6	16-Oct-18	20181056	ECCC
2018182	(WH)CL-3	M	30-Aug-18	15:44	Cyclamate	1382	ng/L	3	8	16-Oct-18	20181056	ECCC
2018182	(WH)CL-3	M	30-Aug-18	15:44	Saccharin	3867	ng/L	2	6	16-Oct-18	20181056	ECCC
2018182	(WH)CL-3	M	30-Aug-18	15:44	Sucralose	13206	ng/L	20	60	16-Oct-18	20181056	ECCC
2018183	(WH)MW-3-08	M	30-Aug-18	15:45	Acesulfame	5477	ng/L	2	6	16-Oct-18	20181057	ECCC
2018183	(WH)MW-3-08	M	30-Aug-18	15:45	Cyclamate	404	ng/L	3	8	16-Oct-18	20181057	ECCC
2018183	(WH)MW-3-08	M	30-Aug-18	15:45	Saccharin	621	ng/L	2	6	16-Oct-18	20181057	ECCC
2018183	(WH)MW-3-08	M	30-Aug-18	15:45	Sucralose	6364	ng/L	20	60	16-Oct-18	20181057	ECCC
2018184	(WH)MW-4-08	M	30-Aug-18	16:19	Acesulfame	12373	ng/L	2	6	16-Oct-18	20181058	ECCC
2018184	(WH)MW-4-08	M	30-Aug-18	16:19	Cyclamate	513	ng/L	3	8	16-Oct-18	20181058	ECCC
2018184	(WH)MW-4-08	M	30-Aug-18	16:19	Saccharin	899	ng/L	2	6	16-Oct-18	20181058	ECCC
2018184	(WH)MW-4-08	M	30-Aug-18	16:19	Sucralose	13433	ng/L	20	60	16-Oct-18	20181058	ECCC
2018185	(WH)CL-1	M	30-Aug-18	16:28	Acesulfame	15761	ng/L	2	6	16-Oct-18	20181059	ECCC
2018185	(WH)CL-1	M	30-Aug-18	16:28	Cyclamate	3738	ng/L	3	8	16-Oct-18	20181059	ECCC
2018185	(WH)CL-1	M	30-Aug-18	16:28	Saccharin	11078	ng/L	2	6	16-Oct-18	20181059	ECCC
2018185	(WH)CL-1	M	30-Aug-18	16:28	Sucralose	20122	ng/L	20	60	16-Oct-18	20181059	ECCC
2018186	(WH)CC-US	M	30-Aug-18	16:49	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181060	ECCC
2018186	(WH)CC-US	M	30-Aug-18	16:49	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181060	ECCC
2018186	(WH)CC-US	M	30-Aug-18	16:49	Saccharin	<2	ng/L	2	6	16-Oct-18	20181060	ECCC
2018186	(WH)CC-US	M	30-Aug-18	16:49	Sucralose	<20	ng/L	20	60	16-Oct-18	20181060	ECCC
2018187	(WH)YS	M	30-Aug-18	16:57	Acesulfame	3	ng/L	2	6	16-Oct-18	20181061	ECCC
2018187	(WH)YS	M	30-Aug-18	16:57	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181061	ECCC
2018187	(WH)YS	M	30-Aug-18	16:57	Saccharin	4	ng/L	2	6	16-Oct-18	20181061	ECCC
2018187	(WH)YS	M	30-Aug-18	16:57	Sucralose	<20	ng/L	20	60	16-Oct-18	20181061	ECCC
2018198	(WH)GW-1	M	5-Sep-18	12:35	Acesulfame	995	ng/L	2	6	16-Oct-18	20181067	ECCC
2018198	(WH)GW-1	M	5-Sep-18	12:35	Cyclamate	751	ng/L	3	8	16-Oct-18	20181067	ECCC
2018198	(WH)GW-1	M	5-Sep-18	12:35	Saccharin	484	ng/L	2	6	16-Oct-18	20181067	ECCC
2018198	(WH)GW-1	M	5-Sep-18	12:35	Sucralose	661	ng/L	20	60	16-Oct-18	20181067	ECCC

Sample ID	Station ID	Sample Class	Date	Time	Parameter	Result	Units	MDL	PQL	Date Analy	LabSmplNo	Lab Name
2018199	(WH)GW-2	M	5-Sep-18	13:55	Acesulfame	55	ng/L	2	6	16-Oct-18	20181062	ECCC
2018199	(WH)GW-2	M	5-Sep-18	13:55	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181062	ECCC
2018199	(WH)GW-2	M	5-Sep-18	13:55	Saccharin	6	ng/L	2	6	16-Oct-18	20181062	ECCC
2018199	(WH)GW-2	M	5-Sep-18	13:55	Sucralose	<20	ng/L	20	60	16-Oct-18	20181062	ECCC
2018200	(WH)GW-3	M	5-Sep-18	13:19	Acesulfame	3616	ng/L	2	6	16-Oct-18	20181064	ECCC
2018200	(WH)GW-3	M	5-Sep-18	13:19	Cyclamate	888	ng/L	3	8	16-Oct-18	20181064	ECCC
2018200	(WH)GW-3	M	5-Sep-18	13:19	Saccharin	735	ng/L	2	6	16-Oct-18	20181064	ECCC
2018200	(WH)GW-3	M	5-Sep-18	13:19	Sucralose	1431	ng/L	20	60	16-Oct-18	20181064	ECCC
2018201	(WH)MW-1	M	5-Sep-18	10:30	Acesulfame	1799	ng/L	2	6	16-Oct-18	20181066	ECCC
2018201	(WH)MW-1	M	5-Sep-18	10:30	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181066	ECCC
2018201	(WH)MW-1	M	5-Sep-18	10:30	Saccharin	5	ng/L	2	6	16-Oct-18	20181066	ECCC
2018201	(WH)MW-1	M	5-Sep-18	10:30	Sucralose	9819	ng/L	20	60	16-Oct-18	20181066	ECCC
2018202	(WH)MW-2	M	5-Sep-18	11:32	Acesulfame	3567	ng/L	2	6	16-Oct-18	20181063	ECCC
2018202	(WH)MW-2	M	5-Sep-18	11:32	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181063	ECCC
2018202	(WH)MW-2	M	5-Sep-18	11:32	Saccharin	6	ng/L	2	6	16-Oct-18	20181063	ECCC
2018202	(WH)MW-2	M	5-Sep-18	11:32	Sucralose	3568	ng/L	20	60	16-Oct-18	20181063	ECCC
2018203	(WH)MW-4a	M	5-Sep-18	9:43	Acesulfame	494	ng/L	2	6	16-Oct-18	20181065	ECCC
2018203	(WH)MW-4a	M	5-Sep-18	9:43	Cyclamate	21	ng/L	3	8	16-Oct-18	20181065	ECCC
2018203	(WH)MW-4a	M	5-Sep-18	9:43	Saccharin	203	ng/L	2	6	16-Oct-18	20181065	ECCC
2018203	(WH)MW-4a	M	5-Sep-18	9:43	Sucralose	88	ng/L	20	60	16-Oct-18	20181065	ECCC
2018204	(WH)PHL	M	5-Sep-18	10:14	Acesulfame	4316	ng/L	2	6	16-Oct-18	20181069	ECCC
2018204	(WH)PHL	M	5-Sep-18	10:14	Cyclamate	155	ng/L	3	8	16-Oct-18	20181069	ECCC
2018204	(WH)PHL	M	5-Sep-18	10:14	Saccharin	295	ng/L	2	6	16-Oct-18	20181069	ECCC
2018204	(WH)PHL	M	5-Sep-18	10:14	Sucralose	12452	ng/L	20	60	16-Oct-18	20181069	ECCC
2018205	(WH)Lake1	M	5-Sep-18	14:35	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181071	ECCC
2018205	(WH)Lake1	M	5-Sep-18	14:35	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181071	ECCC
2018205	(WH)Lake1	M	5-Sep-18	14:35	Saccharin	<2	ng/L	2	6	16-Oct-18	20181071	ECCC
2018205	(WH)Lake1	M	5-Sep-18	14:35	Sucralose	<20	ng/L	20	60	16-Oct-18	20181071	ECCC
2018206	(WH)Lake2	M	5-Sep-18	14:48	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181072	ECCC
2018206	(WH)Lake2	M	5-Sep-18	14:48	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181072	ECCC
2018206	(WH)Lake2	M	5-Sep-18	14:48	Saccharin	<2	ng/L	2	6	16-Oct-18	20181072	ECCC
2018206	(WH)Lake2	M	5-Sep-18	14:48	Sucralose	<20	ng/L	20	60	16-Oct-18	20181072	ECCC
2018207	(WH)Lake2	QR	5-Sep-18	14:48	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181073	ECCC
2018207	(WH)Lake2	QR	5-Sep-18	14:48	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181073	ECCC
2018207	(WH)Lake2	QR	5-Sep-18	14:48	Saccharin	<2	ng/L	2	6	16-Oct-18	20181073	ECCC
2018207	(WH)Lake2	QR	5-Sep-18	14:48	Sucralose	<20	ng/L	20	60	16-Oct-18	20181073	ECCC
2018208	(WH)Lake3	M	5-Sep-18	14:20	Acesulfame	5	ng/L	2	6	16-Oct-18	20181074	ECCC
2018208	(WH)Lake3	M	5-Sep-18	14:20	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181074	ECCC
2018208	(WH)Lake3	M	5-Sep-18	14:20	Saccharin	<2	ng/L	2	6	16-Oct-18	20181074	ECCC
2018208	(WH)Lake3	M	5-Sep-18	14:20	Sucralose	<20	ng/L	20	60	16-Oct-18	20181074	ECCC
2018209	(WH)Lake4	M	5-Sep-18	13:46	Acesulfame	<2	ng/L	2	6	16-Oct-18	20181075	ECCC
2018209	(WH)Lake4	M	5-Sep-18	13:46	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181075	ECCC
2018209	(WH)Lake4	M	5-Sep-18	13:46	Saccharin	<2	ng/L	2	6	16-Oct-18	20181075	ECCC
2018209	(WH)Lake4	M	5-Sep-18	13:46	Sucralose	<20	ng/L	20	60	16-Oct-18	20181075	ECCC
2018210	(WH)Lake5	M	5-Sep-18	11:00	Acesulfame	258	ng/L	2	6	16-Oct-18	20181076	ECCC
2018210	(WH)Lake5	M	5-Sep-18	11:00	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181076	ECCC
2018210	(WH)Lake5	M	5-Sep-18	11:00	Saccharin	<2	ng/L	2	6	16-Oct-18	20181076	ECCC
2018210	(WH)Lake5	M	5-Sep-18	11:00	Sucralose	133	ng/L	20	60	16-Oct-18	20181076	ECCC
2018211	(WH)Lake6	M	5-Sep-18	10:32	Acesulfame	1420	ng/L	2	6	16-Oct-18	20181077	ECCC
2018211	(WH)Lake6	M	5-Sep-18	10:32	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181077	ECCC
2018211	(WH)Lake6	M	5-Sep-18	10:32	Saccharin	109	ng/L	2	6	16-Oct-18	20181077	ECCC
2018211	(WH)Lake6	M	5-Sep-18	10:32	Sucralose	1397	ng/L	20	60	16-Oct-18	20181077	ECCC
2018212	(WH)Lake7	M	5-Sep-18	9:50	Acesulfame	430	ng/L	2	6	16-Oct-18	20181078	ECCC
2018212	(WH)Lake7	M	5-Sep-18	9:50	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181078	ECCC
2018212	(WH)Lake7	M	5-Sep-18	9:50	Saccharin	86	ng/L	2	6	16-Oct-18	20181078	ECCC
2018212	(WH)Lake7	M	5-Sep-18	9:50	Sucralose	<20	ng/L	20	60	16-Oct-18	20181078	ECCC
2018213	(WH)Wetland	M	5-Sep-18	13:17	Acesulfame	4390	ng/L	2	6	16-Oct-18	20181079	ECCC
2018213	(WH)Wetland	M	5-Sep-18	13:17	Cyclamate	<3	ng/L	3	8	16-Oct-18	20181079	ECCC
2018213	(WH)Wetland	M	5-Sep-18	13:17	Saccharin	15	ng/L	2	6	16-Oct-18	20181079	ECCC
2018213	(WH)Wetland	M	5-Sep-18	13:17	Sucralose	311	ng/L	20	60	16-Oct-18	20181079	ECCC

Appendix E: Quality Control Results

Quality control of available field data compared to laboratory data.

Station	Date	Cond-F	Cond-L	RPD (%)	pH-F	pH-L	RPD (%)
CL-DS	9/5/2018 9:57	95.6	96.8	1.2474012	7.79	7.44	4.59619
LTECF-US	9/5/2018 10:41	95.3	95.3	0	7.3	7.48	2.43572
WH-11	9/5/2018 10:23	95.4	94.7	0.7364545	7.23	7.5	3.66599
WH-9b	9/5/2018 12:06	616	618	0.3241491	8.52	8.09	5.1776
LL-Seep1	10/30/2018 10:37	583	542	7.2888889	7.62	8.12	6.35324
YRB-1	10/30/2018 11:11	591	589	0.3389831	7.7	8.1	5.06329
LL-Seep11	10/30/2018 12:00	584	553	5.4529464	7.61	8.06	5.74346
MW-4a	10/30/2018 13:21	322.8	314	2.7638191	8.53	8.45	0.94229
LL-Seep2	10/30/2018 13:56	591	452	26.653883	8.02	8.12	1.23916

Comparison between field replicates

Parameter	Lake 2 9/5/2018 Sample	Lake 2 9/5/2018 Replicate	RPD (%)
Acesulfame	<2	<2	0
Sucralose	<20	<20	0
Cyclamate	<3	<3	0
Saccharin	<2	<2	0

Comparison between lab duplicates

Station	Date	Sample/Duplicate	Acesulfame (ng/L)	Sucralose (ng/L)	Cyclamate (ng/L)	Saccharin (ng/L)
CC-US	9/5/2018	Sample	<2	<20	<3	<2
		Duplicate	2	<20	<3	<2
*RPD (%)**			0	0	0	0
CL-DS	9/5/2018	Sample	<2	<20	<3	<2
		Duplicate	<2	<20	<3	<2
*RPD (%)**			0	0	0	0
MW-2	9/5/2018	Sample	3567	3568	<3	6
		Duplicate	3513	3330	<3	6
*RPD (%)**			1.01	4.54	0	0

**RPD % (Relative percent difference (x,y)) = [|x - y| ÷ |(x + y)/2|] * 100*

Comparison of samples independently collected by WRB and licensee, but during similar time.

Station	Date Time	Sampler	Cond-L µS/cm	N-NH4 mg/L	pH-L pH units	PO4-T mg/L	Coli-T CFU/100mL
WH-10	9/5/2018 10:32	WRB	94	<0.020	7.48	<0.002	<1
WH-10	9/5/2018 10:40	Licensee	97.1	<0.020	7.57	0.0056	1
*RPD (%)**			*3.2443747*	0	*1.19601*	*94.737*	0
WH-11	9/5/2018 10:23	WRB	94.7	0.02	7.5	0.0037	<1
WH-11	9/5/2018 10:30	Licensee	97.3	0.023	7.60	0.0473	1
*RPD (%)**			*2.7083333*	*13.95349*	*1.3245*	*170.98*	0
WH-12	9/5/2018 10:15	WRB	-	-	-	-	<1
WH-12	9/5/2018 10:20	Licensee	-	-	-	-	1
*RPD (%)**			-	-	-	-	0

**RPD % (Relative percent difference (x,y)) = [|x - y| ÷ |(x + y)/2|] * 100*

Appendix F: References

Core Geoscience Services, 2017. Yukon River Seepage Discharge Monitoring Study. November 2017.

EBA. 2009. Hydrogeological investigations at Crestview and Whitehorse Sewage Lagoons. February 2009.

Spoelstra, J., Senger, N.D., and S.L. Schiff. 2017. Artificial Sweeteners Reveal Septic System Effluent in Rural Groundwater. Journal of Environmental Quality. 46:1434-1443.

Appendix G: Government of Yukon – Environment's intervention to YESAB in project 2018-0146

See below.

Yukon

Yukon Environmental & Socio-economic Assessment Act

Compiled Comments Log Generated by Community Services on 2018-

Project

Project Name City of Whitehorse Water **YESAB File Number** 2018-0146

Proponent Name null

Project Description

The Project is an 18-month renewal of Water License MN93-001-13, which authorizes the City of Whitehorse to operate and maintain its drinking water, wastewater, and stormwater systems. The Project is proposed to commence on November 1, 2018 when MN93-001-13 expires, and continue for 18 months. During those 18 months, the City of Whitehorse will complete the process for a new 25-year water use license. The Project is within the traditional territories of the Kwanlin Dün First Nation and the Ta’an Kwäch’än Council.
Project Activities:
Drinking Water Extraction, Treatment and Distribution:

- Extraction of up to 20 000 m3/day water from the Selkirk Aquifer and Schwatka Lake for drinking water use
  - Treatment and distribution of drinking water
  - Operation and maintenance of water distribution infrastructure

Stormwater Collection and Discharge:

- Operation and maintenance of storm mains, manhole sumps, and stormwater outfalls

Wastewater Collection, Treatment and Discharge:

- Operation and maintenance of the Livingston Trail Environmental Control Facility:
  - Sewage lagoons and storage ponds
  - Release of effluent into Yukon River or Pothole Lake
  - Operation and maintenance of major and minor lift stations, and a flush tank
- Operation and maintenance of the Crestview sewage lagoon
- Emergency use of the Whitehorse sewage lagoon

Monitoring and Reporting:

- Water quality monitoring for all aspects of the water system

Department Comments

Posted By: Environment

Contact: Claire Gough

Phone: 867-393-7038

Email: Claire.Gough@gov.yk.ca

Comments:

Please see ENV comments attached.

Attachments:

File

22555__2018-0146 ENV Comments Final.pdf

Yukon

Yukon Environmental & Socio-economic Assessment Act

Compiled Comments Log Generated by Community Services on 2018-

Department Comments

Posted By:	HPW-Transportation Engineering Branch
Contact:	John MacDougall
Phone:	867-633-7962
Email:	john.macdougall@gov.yk.ca

Comments:
HPW has no concerns.

Yukon

Yukon Environmental & Socio-economic Assessment Act

Compiled Comments Log Generated by Community Services on 2018-

Department Comments

Posted By: Health & Social Services

Contact: Sabrina Kinsella

Phone: 867-456-6133

Email: sabrina.kinsella@gov.yk.ca

Comments:

Values: Public Health and Safety; Health and Safety of Individuals; Safe drinking water
Sections: Project Proposal-1
Conclusion:
Health and Social Services is satisfied that the potential adverse effects of this project on public health will be sufficiently mitigated for the proposed project duration, through the proponent’s commitments to ongoing protection of drinking water resources; adequate and regular drinking water quality monitoring and appropriate methods for sewage treatment.
Rationale/Application:
Health risks may be associated with direct contact with sewage and/or contamination of current or future drinking water. Health and Social Services is concerned with ensuring that existing and future sources of drinking water are protected and monitored, to prevent the spread of water borne illness or other harmful effects on Human Health.
In addition to ensuring a safe and sufficient water supply, Health and Social Services is concerned with potential nuisance effects of sewage disposal systems in proximity to residential areas. The prevention or minimization of adverse effects on residents due to odours associated with sewage disposal is warranted. In the absence of direct effects on health, nuisance effects may impact health indirectly, based on the intensity and duration of the effect. Links between stress, mental health and physical health are well documented. Though there is some variation among income and demographic groups, residential proximity to industrial activity may increase feelings of personal powerlessness and psychological distress. (Downey & Willigen, 2005) Stress can lead to adoption of health-threatening coping behaviours such as tobacco use and alcohol consumption (Mikkonen & Raphael, 2010); with the potential to exacerbate existing conditions such as cardiovascular disease, diabetes and addictions.
Based on the limited duration of this project; the proponent’s commitment to ongoing monitoring of water quality and odors, and to ongoing treatment of water and sewage, Health and Social Services is satisfied that the project effects will be adequately mitigated for the time period in question. Additional discussion may be required for the subsequent application for the 25 year renewal of the water and sewage systems.

YESAA – ASSESSMENT COMMENT

Department:	Environment	Branch: Environmental Programs
Contact:	Claire Gough, A/ Environmental Assessment Analyst	
Phone:	867-667-5855	E-mail: claire.gough@gov.yk.ca
Project Title:	**City of Whitehorse Water Licence Renewal—MN93-001-13**	
YESAB Project #:	**2018-0146**	
Date:	August 23, 2018	

Outcome: Environment (ENV) has reviewed the proposal for an 18-month renewal of Water Licence MN93-001-13 authorizing the City of Whitehorse (the City) to operate and maintain its drinking water, wastewater and stormwater systems. The City's water systems include: the Livingstone Trail Environmental Control Facility (LTECF), Whitehorse Lagoon, Marwell Lift Station, and Crestview Lagoon.

If appropriate mitigations are applied, the proposed 18- month renewal is unlikely to result in significant adverse environmental effects to the environmental values identified by ENV including: water quality and aquatic resources.

ENV also shares recommendations to support the City's preparation of the 25-year water licence renewal application.

Values: Water Quality and Aquatic Resources

Recommended Mitigations:

- Monitoring for hydrocarbons and metals as per the *Contaminated Sites Regulations* (CSR) to ensure the potential receiving environments (e.g., the Yukon River) are not adversely impacted by discharge activities or upset conditions such as seepage containing contamination.
- Additional water quality monitoring to ensure that potential receiving environments (e.g., the Yukon River) are not being adversely impacted by discharge activities or upset conditions such as seepage with contamination. Key areas of concern include:
  - Crestview Lagoon, Pot Hole Lake, and LTECF; and
  - Yukon River seepage locations.
- Expansion of the annual seepage study area to ensure the protection of potential downgradient receptors (e.g., Yukon Springs bottled water facility).

Discussion

CSR Contaminate Monitoring

The Yukon Water Board (YWB) "conclude[ed] that the Licensee should consider determining the levels of hydrocarbons in groundwater before the next licence renewal" when approving the Water Use Licence MN 93-001 Amendment 13 (Exhibit 12.1 Reasons for Decision, 2016). YWB's suggestion was responding to the Yukon government's (YG's) recommendation that a leakage assessment of the high-density polyethylene (HDPE) liner beneath the facility sludge drying beds be completed in consideration of localized groundwater quality and groundwater levels. In addition, YG's Standards and Approvals unit is aware of wastewater containing hydrocarbon concentrations greater than in the CSR limits and metals concentrations greater than the Sewer and Storm Utility Bylaw limits being discharged into the City's sanitary sewer system. A January 2018 application for a Relocation Permit (23-752) in support of Wheeler Street municipal activities documents the hydrocarbon and metal exceedances noted above in up to 30,000 liters of excavation water authorized by the City to be discharged into the sanitary sewage system. Lastly, YG's Site Assessment and Remediation Unit treated hydrocarbon contaminated water from the FH Collins School remediation project to meet the CSR standards prior to discharging into the

City's sewage system. However, if the water treatment equipment had been selected to meet only the Sewer and Storm Utility Bylaw limits, the discharge water would have had hydrocarbons exceeding the CSR requirements, which may have impacted the receiving environment.

Due to the events outlined above, as well as the likelihood of additional unknown incidents where wastewater containing contaminants are being discharged to the City's sewage system, ENV recommends that monitoring for hydrocarbons and metals as per CSR requirements is conducted to ensure facility activities or upset conditions such as seepage do not result in significant adverse impacts to the facility's localized receiving environments.

Crestview Lagoon, Pot Hole Lake and LTECF—Surface Water Quality

Currently, the Water Licence MN93-001-13 does not require monitoring of the Yukon River downstream of Crestview Lagoon. The lagoon receives wastewater effluent from the City and the treatment of this effluent occurs through two primary and two secondary cells. According to the proposal (Section 5.2), the total effluent volume entering the facility is either evaporated or infiltrated to the ground. Potential downgradient receptors from the Crestview Lagoons include: i) the creek south and downgradient of the Crestview facility, ii) the Yukon Springs bottled water facility which is located down- to cross-gradient from the site, and iii) the Yukon River which is located downgradient from the site (EBA 2009).

ENV recommends to monitor water quality in the Yukon River downstream of the facility to ensure that a potential impact to Yukon River's water quality will be detected.

Based on the surficial geology and topography, water infiltrating underneath the Crestview Lagoon possibly flows south and is captured by the creek (see Figure 2). The potential impact of the Crestview Lagoon to this creek is not currently monitored under the Water Licence MN093-001. ENV recommends that two water quality monitoring stations, and annually reported data, be added in the creek including i) a background station located upstream of potential effects, and ii) a downstream station near the confluence with the Yukon River.

Lastly, ENV also recommends adding a monitoring location in the Yukon River upstream of the location of Seep #1 to measure water quality parameters upstream of the facility and enable interpretation of potential LTECF impacts. Seep #1 was identified in the "Yukon River Seepage Discharge Monitoring Study" conducted in November 2017 (Core Geoscience Services, 2017) and indicates that WH10 is likely no longer upstream of all potential project effects (see Figure 1).

To summarize, ENV recommends additional surface water monitoring including:

- A monitoring location for surface water quality in the Yukon River downstream of the Crestview lagoon;
- Upstream and downstream monitoring locations for surface water quality in the creek downgradient and south of the Crestview lagoon; and
- A surface water monitoring location in Yukon River upstream of WH10 and upstream of all potential effects from affected groundwater seepage.

Crestview Lagoon Pot Hole Lake and LTECF —Groundwater

The current Water Licence MN093-001 does not require the City to conduct monitoring of groundwater around the Crestview Lagoon; however, the City is doing some monitoring in the area. In 2009, EBA conducted a hydrogeological investigation at the Crestview Lagoon drilling four groundwater monitoring wells around the facility (see Figure 3). EBA recommended a new bedrock monitoring well between the sewage lagoon and the Yukon Springs bottled water facility. ENV recommends monitoring of the quality and level of groundwater around of the sewage lagoon and supports execution of the EBA recommendation.

To summarize, ENV recommends additional ground water monitoring including:

- Conduct adequate characterization of the groundwater flow regime and effective monitoring of potential impacts to groundwater quality downgradient of the Crestview Lagoon; and
- Monitoring groundwater level and quality around the Crestview Lagoons.

Yukon River Annual Seepage Discharge Monitoring Study with Water Quality Analysis

The Water Licence MN093-001 (s. 43) requires the City to conduct an annual seep survey "for evidence of seepage or instability relating to treated wastewater discharge to the Pothole Lake"; however, seepage sampling and water quality analysis is not required. As per Section 2.2.7 of the 2017 Annual Water Licence report (Appendix C of the proposal), the City is aware that seeps may contribute to discharge entering the Yukon River, but trend characterization is limited by the absence of seepage water quality data. ENV recommends water sampling of annually identified seeps to monitor for non-compliant contributions to the Yukon River.

ENV recommends:

- Collecting and monitoring water quality of all seeps downgradient of the LTECF, Pot Hole Lake, and Crestview Lagoon.

Annual Seepage Study Area Expansion

As identified in the EBA 2009 report:

> *Potential downgradient receptors from the Crestview Lagoons include the Yukon Springs bottled water facility which is located down- to cross-gradient from the site and the Yukon River which is located downgradient from the site.*
>
> *The potential flow path for infiltrating effluent at the site may be to migrate under the influence of perched groundwater flow along the interface of the upper sand and underlying silt unit… to the south towards the Yukon Springs bottled water facility. Effluent may also continue to migrate downwards to the regional groundwater table through permeable zones in the silt unit and/or bedrock fractures. This effluent may flow northeast along the bedrock interface to the Yukon River.*

Further, topographic interpretation suggests that groundwater infiltrating from Pot Hole Lake flows west and not south.

ENV recommends:

- Expanding the annual seepage survey to include the areas:
  - Downgradient and west of Pothole Lake; and
  - Downgradient of the Crestview Lagoon.

Water Licence 25-Year Renewal:

Due to the long history of the City's water system facilities, as well as the numerous water licence amendments and renewals, the pending application to support the 25-year water licence should be standalone and provide transparent rationale of current and proposed terms and conditions to ensure that the receiving environments are protected. For example, ENV recommends the selection of Water Licence MN093-001 water quality standards in the Yukon River downstream of the facility, locations 300 m and 750 m downstream of the discharge pipe, are discussed with supporting rationale. In addition, ENV suggests that new bedrock wells are drilled and/or current wells improved up-gradient and down-gradient of the Crestview facility to allow for the characterization of the flow regime.

ENV also recommends the inclusion of a water balance model for the LTECF. It is unclear how much water evaporates, infiltrates and circulates through the various cells and pond at the LTECF. We suggest measuring flows of water throughout the facility to enable the production of the mass balance (i.e. measuring not only water quality at WH6c, WH7, WH8 and WH9b—or other appropriate locations—but also water quantity).

<u>References</u>

Core Geoscience Services, 2017. Yukon River Seepage Discharge Monitoring Study. November 2017.

EBA. 2009. Hydrogeological investigations at Crestview and Whitehorse Sewage Lagoons. February 2009.

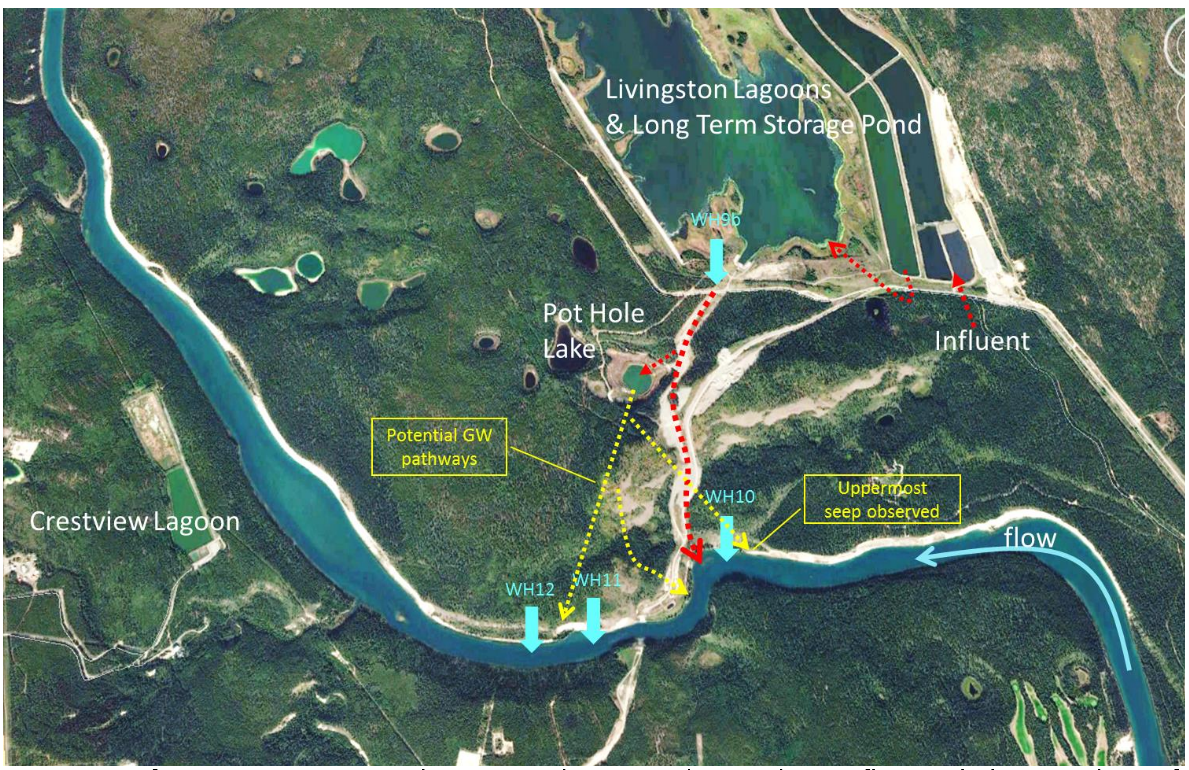


Figure 1. Surface water monitoring location and suspected groundwater flow path downgradient of the LTECF

Figure 2. Suspected groundwater flow path downgradient of the Crestview Lagoon and suggested WQ monitoring location

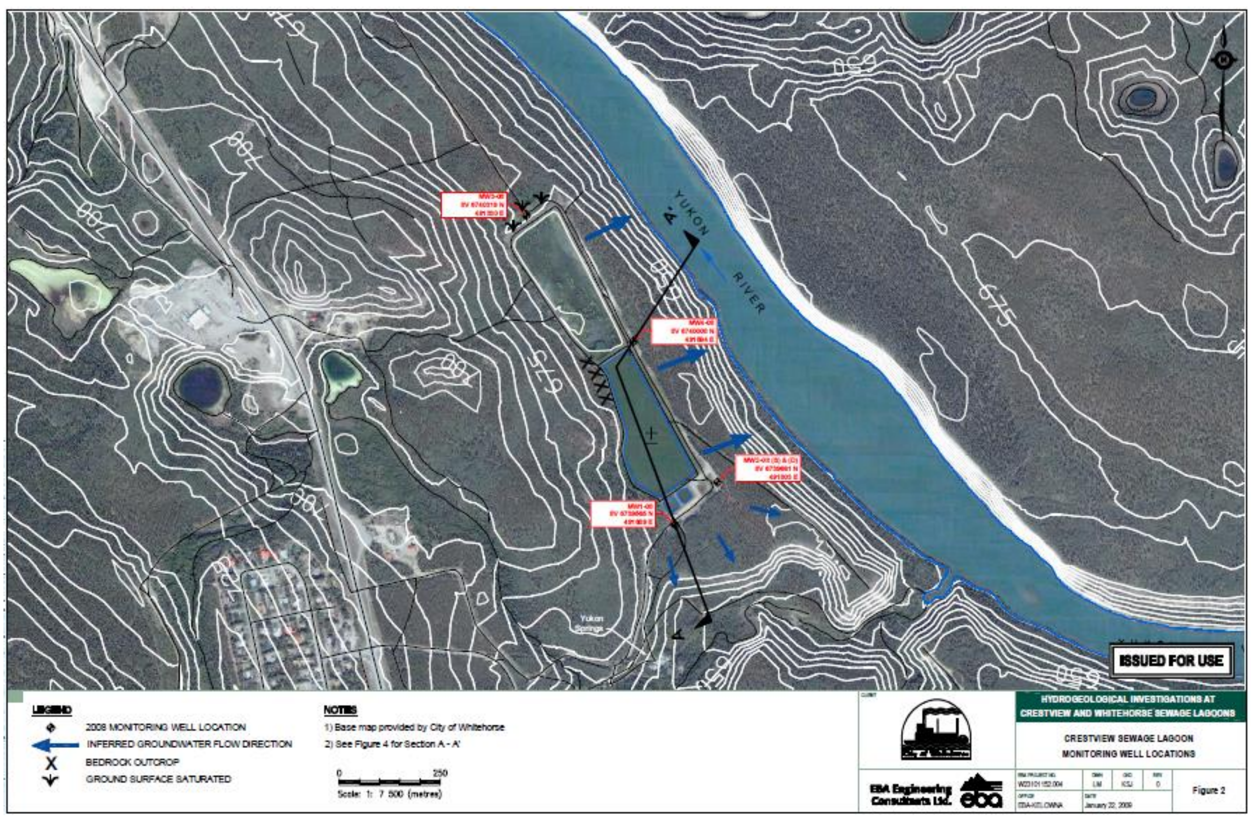


Figure 3. Location of Monitoring wells around the Crestview sewage lagoon facility (copied from EBA 2009).

YESAA – ASSESSMENT COMMENT

Appendix H: Government of Yukon – Environment's intervention to YWB on application MN18-059

See below.

Yukon

Box 2703, Whitehorse, Yukon Y1A 2C6

Date: January 18, 2019

Application Number: MN18-059
Applicant: City of Whitehorse

Yukon Water Board Secretariat
Suite 106, 419 Range Road
Whitehorse, Yukon
Y1A 3V1

Attn: Jean Beckerton
Licencing Officer

Re: Intervention for Application to Amend Type A Water Licence MN18-059, City of Whitehorse

1. Technical Review of Application

Yukon government (YG) has reviewed the above noted Application to Amend Type A water licence and has the following comments and recommendations for consideration by the Yukon Water Board (the Board). This submission includes references to a fall 2018 water quality sampling program conducted by the Department of Environment's Water Resource Branch. Sampling events include the City of Whitehorse (the City) wastewater treatment facilities and surrounding area, as well as piggybacking on the annual Yukon River seepage survey. The attached appendices include figures, tabled analytical results, and a redline version of the licence.

Surface Water Quality

1.1. Recommendation: Add hydrocarbons in the monitoring requirements listed for effluent from the Livingston Trail Environmental Control Facility (LTECF) (WH-9b) in Schedule A, Part 2, Table 2.

Rationale: YG recommends monitoring of WH-9b for the petroleum hydrocarbon parameters regulated pursuant to the Contaminated Sites Regulation (CSR) defined as: volatile petroleum hydrocarbons in water (VPHw), volatile hydrocarbons in water (VHw6-10), light extractable petroleum hydrocarbons in water (LEPHw), extractable petroleum hydrocarbons in water (EPHw10-19), monocyclic aromatic hydrocarbons (MAHs; benzene, ethylbenzene, styrene, and toluene), and polycyclic aromatic hydrocarbons (PAHs; acenapthene, acridine, anthracene, benz[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, fluorine, naphthalene, phenanthrene, pyrene, and quinoline). Maintaining a sampling frequency of three times during discharge as per other site parameter requirements.

To ensure standardized protection and monitoring of receiving environments potentially impacted by wastewater treatment systems, YG recommends that the petroleum hydrocarbon parameters listed above are included in the 18-month licence. The monitoring of hydrocarbons in 2019-2020 will also support the review and the licencing process for the 25-year renewal application. Monitoring results will inform the Board, YG, and the general public on the risks associated with potential release of hydrocarbons to the Yukon River. Further, these petroleum hydrocarbon parameters were recently requested to be included in the Town of Watson Type A Water Licence MN03-050-03 amendment.

In September 2018, the Department of Environment's Water Resources Branch conducted a water quality sampling program, with the permission of the City, at the wastewater treatment facilities, and surrounding areas. Hydrocarbons were detected at WH-6c (LTECF influent) and WH-9b (LTECF effluent) (see Appendix, Table 1). The analysed influent LEPH at WH-6c is 1,320 ug/L, 26 times the CSR maximum concentration. Given the volume of liquid entering the lagoon, the measured PHC concentrations further support the concern that significant amounts of petroleum products are routinely entering the facility and are potentially adversely impacting the Yukon River, and its receiving environments. The recommended monitoring of PHC concentrations as per CSR requirements is required to ensure wastewater treatment processes are sufficient prior to discharge.

Incidents involving the release of metals and hydrocarbons contaminants into municipal sewage effluents are common in the Yukon. For example, a January 2018 application for a Relocation Permit (23-752) in support of Wheeler Street municipal activities documents hydrocarbon and metal exceedances in up to 30,000 liters of excavation water, which was authorized by the City to be discharged into the sewage system. Another incident that raises this issue for YG is the Site Assessment and Remediation Unit treatment of hydrocarbon contaminated water from the FH Collins School remediation project. The wastewater was treated to meet the CSR standards prior to discharging into the sewage system. However, if the water treatment equipment had been selected to meet only the Sewer and Storm Utility Bylaw limits, the discharge water would have had hydrocarbons exceeding the CSR requirements, which may have impacted the receiving environment.

1.2. Recommendation: Add monitoring locations for surface water quality in the Yukon River downstream of the Crestview lagoon.

Rationale: Currently, the Water Licence MN93-001-13 does not require monitoring of the Yukon River downstream of Crestview Lagoon. The lagoon receives wastewater effluent from the City and the treatment of this effluent occurs through two primary and two secondary cells. According to the project proposal (Exhibit No. 1.2.1, Section 5.2), the total effluent volume entering the facility is either evaporated or infiltrated to the ground. Impacted groundwater will eventually reach the Yukon River downgradient (EBA 2009); therefore YG recommends to monitor water quality in the Yukon River downstream of the facility so that a potential impact to Yukon River's water quality would be detected. (see Appendix, Figure 1).

1.3. Recommendation: Add a surface water monitoring location in the Yukon River upstream of WH-10 and upstream of all potential effects from affected groundwater seepage.

Rationale: YG recommends adding a monitoring location in the Yukon River upstream of the location of Seep #1 that is not in an eddy to measure water quality parameters upstream of the facility and enables interpretation of potential LTECF impacts. Seep #1 was identified in the "Yukon River Seepage Discharge Monitoring Study" conducted in November 2017 (Core Geoscience Services, 2017) and indicates that WH-10 is likely no longer upstream of all potential project effects (see Appendix, Figure 2). Furthermore, WH-10 is located in an eddy (reverse water flow), and the location does not provide a sample representing water 'upstream' of the LTECF.

YG recommends the new monitoring location is assigned a new site code and monitored concurrently with WH-10 during the next two years. After two years of concurrent data has been collected, data should be compared between the two locations and sampling at WH-10 might not be required any longer.

Groundwater

1.4. Recommendation: The amended licence should include a condition that requires the City of Whitehorse to submit to the Board, before the expiry of the amended licence, a hydrogeological assessment of the LTECF that includes:

a) determination of the direction and rate of groundwater flow;
b) identification of potential receiving environments; and
c) assessment of travel times for potential contaminant pathways.

Rationale: Ongoing discussions with the City regarding their 18-month amendment submission indicate that a hydrogeological assessment of the LTECF has never been completed. A Trial Discharge Evaluation Report was prepared by Stantec in 2000 for the City. The report contains considerable hydrogeological information related to the discharge of treated effluent from the LTECF to the Pothole Lake; however, the report does not contain all of the elements required of a hydrogeological assessment of the entire facility. In particular, the report does not include borehole logs for the existing wells at the LTECF. These logs are not on Waterline and are still pending from City. Without the wells logs, subsurface conditions cannot be fully understood and a rudimentary cross-section from the LTECF to the Yukon River (i.e. along the groundwater flow path from source to receptor) cannot be constructed. This is of concern because the long-term storage impoundment at the LTECF is unlined. The LTECF is only authorized to discharge treated wastewater to the Yukon River (s. 18(h)) or to the Pothole Lake (s. 18(i)). It is critical to note that the current water licence authorizes the City to discharge to the Yukon River or to the Pothole Lake *only if the wastewater is treated to meet the effluent quality standards (EQS) listed in the licence (s. 26),* whereas the long-term storage impoundment discharges to groundwater whether or not the wastewater it contains is treated to the EQS listed in the licence.

Results from sampling conducted by Water Resources Branch on Sept. 5, 2018 clearly shows that groundwater and surface water receptors located east, southeast, or south of the LTECF are impacted by the facility, as demonstrated by the presence of artificial sweeteners (see Appendix Figure 3). Artificial sweeteners are widespread in products consumed by humans such as diet beverages, pharmaceuticals, and toothpaste, and therefore are ubiquitous in human waste. The use of artificial sweeteners as tracers of wastewater is advantageous because (a) artificial sweeteners are found in relatively high concentrations in human waste, (b) artificial sweeteners are not present in waters not impacted by human waste, and (c) artificial sweeteners degrade at relatively slow rates (Spoelstra *et al*., 2017).

A hydrogeological assessment of the LTECF will inform if additional groundwater monitoring wells are necessary to characterize the groundwater flow regime and/or to effectively monitor potential impacts to groundwater quality downgradient of the LTECF in advance of the 25-year licence renewal.

1.5. Recommendation: The monitoring well GW-4 at the LTECF should be rehabilitated or replaced.

Rationale: According to the current Water Licence, GW-4 is to be sampled three times per year. The licensee is presently non-compliant with this requirement because the well is compromised (see Appendix, Photo 1) and, according to reporting, has not been sampled since August 2015 (see Waterline for reports). GW-4 is a critical node in the groundwater monitoring network because it is the only well presumed to be upgradient of the LTECF and the location should be regularly monitored so that baseline groundwater chemistry can be adequately characterized, and potential downgradient impacts to groundwater can be adequately understood.

1.6. Recommendation: Samples from existing groundwater monitoring wells at the LTECF and surface water bodies known to be influenced by wastewater should be analyzed for the suite of petroleum hydrocarbon parameters listed in recommendation 1.1.

Rationale: The long-term storage impoundment at the LTECF has been found to be contain petroleum hydrocarbon contaminants (see rationale for Recommendation 1.1) and to be leaking (see rationale for Recommendation 1.4). To confirm if the LTECF has contaminated groundwater or surface water with petroleum hydrocarbons, it is necessary to assess the suite of petroleum hydrocarbon parameters regulated under the CSR (i.e., parameters listed in Recommendation 1.1) in samples collected from (a) all existing groundwater wells at the LTECF, and (b) surface water bodies (including four lakes and a wetland) known to be influenced by wastewater (see Appendix, Figure 3).

1.7. Recommendation: Add groundwater monitoring stations at the Crestview sewage treatment facility to Schedule A (Parts 1 and 2) of the licence.

Rationale: Section (s). 18(j) of the current Water Licence MN093-001 explicitly authorizes the City to *"discharge treated wastewater to groundwater from the Crestview wastewater treatment facility"* (CWTF). This discharge presents the potential for significant adverse impacts to groundwater quality downgradient of the facility, and to surface water quality if impacted groundwater is discharging to surface. Monitoring of groundwater should be required to ensure protection of the receiving environment and to ensure that future land use downgradient of the facility is not limited due to underlying contaminated groundwater. In 2009, EBA conducted a hydrogeological investigation at the CWTF, which resulted in the installation of four groundwater monitoring wells around the facility (see Appendix Figure 4). The City has been voluntarily monitoring these wells; however, such monitoring is not a requirement of the current licence.

1.8. Recommendation: MW2-08d at the CWTF should be rehabilitated or replaced, MW1-08 should be renamed MW1-08s, and a deeper well should be installed at the same location to create a nested pair similar to MW2-08s and MW2-08d.

Rationale: MW2-08d contained some water at installation but insufficient for sample collection. According to Water Resources Branch's database comprised of waterline submissions, MW2-08d has never been sampled (for comparison, MW4-08 has been sampled 22 times as of August 2018).

MW1-08 contained some water at installation but insufficient for sample collection. According to the Water Resources Branch's database, MW1-08 has been sampled only four times since its installation. It was installed to monitor perched groundwater at this location, which was foreseen to likely only be present during spring melt (EBA, 2009). A deeper well was not installed at this location in 2009 because the drilling rig was not equipped to drill through bedrock, which was encountered at 6.5 mbgs at this location (EBA, 2009)

The abovementioned wells are all inferred to be downgradient of the CWTF (EBA, 2009) (see Appendix Figure 4). In their report, EBA noted that *"The potential flow path for infiltrating effluent at the site may be to migrate under the influence of perched groundwater flow along the interface of the upper sand and underlying silt unit… to the south towards the Yukon Springs bottled water facility."* There are presently no monitoring wells that can effectively confirm the presence of potentially contaminated groundwater along this pathway. Sampling by the Water Resources Branch on Aug. 30, 2018 detected the presence of artificial sweeteners (albeit at concentrations below the practical quantification limit) at the Yukon Springs bottled water facility (see Appendix Figure 3). This result warrants further assessment of potential impacts from the CWTF on surrounding groundwater resources. Artificial sweeteners were not detected in the unnamed creek south of the CWTF in the samples collected by the Water Resources Branch on Aug. 30, 2018 (see Appendix Figure 3); however, that does not imply that potentially contaminated groundwater would not eventually travel from the CWTF to the unnamed creek.

Monitoring of water quality in the unnamed creek and at the Yukon Springs facility might be recommended as monitoring or as adaptive measures when the water licence is renewed for the full term.

1.9. Recommendation: Revise the analysis and discussion of stratigraphy and hydrogeology at the CWTF presented in EBA (2009) based on new information generated by rehabilitating or replacing MW2-08d, and installing a deeper well at the location of MW1-08.

Rationale: EBA (2009) includes an analysis and discussion of stratigraphy and hydrogeology at the CWTF that is supported by borehole logs and a cross-section. The well logs and groundwater information generated by rehabilitating or replacing MW2-08d, and installing a deeper well at the location of MW1-08 during the term of this licence will strongly support the licencing process for the 25 year renewal. The new information will support a refined analysis and discussion of stratigraphy and hydrogeology at the CWTF.

This information is critical because, as mentioned above, MW1-08 and MW2-08 are inferred to be downgradient of the CWTF (EBA, 2009) and this flow path must be better understood in order to ensure the protection of potential downgradient receptors, including the Yukon Springs bottled water facility and the unnamed creek south of the CWTF.

1.10. Recommendation: Modify Schedule A, Part 2, Table 3 of 5 to require monitoring of groundwater levels in GW-1, GW-2, GW-3, or GW-4 three times annually.

Rationale: The current Water Licence requires that GW-1, GW-2, GW-3, or GW-4 be sampled three times per year; however, it does not require monitoring of water levels in these wells (unlike MW1, MW2, and MW4A). Monitoring of groundwater levels prior to groundwater quality sampling is routine practise and required to understand hydraulic gradients and groundwater flow directions and velocities.

1.11. Recommendation: Add the following sentence to condition 15 of the existing licence; The annual report shall include groundwater equipotential maps for the CWTF and the LTECF that show the interpreted groundwater flow direction for each sampling event.

Rationale: Recommendation 1.4 (see above) is a hydrogeological assessment of the LTECF that includes determination of the directions of groundwater flow. Directions of groundwater flow at the CWTF were initially inferred by EBA in 2009 and requires re-evaluation. The direction of groundwater flows at the CWTF and the LTECF will be subject to temporal variation due to rising or falling groundwater levels, which is why ongoing monitoring of groundwater levels is recommended. Therefore, the direction of groundwater flow should be interpreted for each sampling event and reported annually. This is required to facilitate an evolving understanding of the fate and transport of contaminants from both the CWTF and LTECF.

1.12. Recommendation: Monitor the water quality of all seeps downgradient of the LTECF, Pot Hole Lake, and Crestview Lagoon.

Rationale: The Water Licence MN093-001 (s. 43) requires the City conduct an annual seep survey “for evidence of seepage or instability relating to treated wastewater discharge to the Pothole Lake”; however, seepage sampling and water quality analysis is not required. As per Section 2.2.7 of the 2017 Annual Water Licence report (Exhibit No 1.4.2 of the proposal), the City is aware that seeps may contribute to discharge entering the Yukon River, but the impact of the discharge on water quality in Yukon River is unknown since seepage water quality data is absent. The fall 2018 Water Resources Branch water sampling program included collection and analysis of water quality samples from the annual seepage sampling event. YG recommends that the City measure water quality in the seeps in the fall of 2019, the term of the renewal application. The information collected in 2018 and 2019 will support the licencing process for the 25-years renewal by providing an increased understanding of the pathway of discharge of contaminants infiltrating out of the Long-Term Storage pond.

1.13. Recommendation: Condition 43 of the current Water Licence should be amended to expand the annual seepage survey to include the following areas:

a) Downgradient and west of Pothole Lake; and

b) Downgradient of the Crestview Lagoon.

Rationale: Sampling conducted by Water Resources Branch on Sept. 5, 2018 demonstrates that the area potentially affected by the LTEFC is greater than previously considered. Samples collected from a wetland and five lakes located east, southeast, or south of the LTECF contain artificial sweeteners (see Appendix Figure 3). Artificial sweeteners were also detected in all groundwater monitoring wells sampled (GW-1, GW-2, GW-3, MW-1, MW-2, MW4a). Like the wetland and lakes, these wells are located east, southeast, or south of the LTECF (see Appendix Figure 5).The sweetener evidence indicates that the facility is releasing treated wastewater to groundwater. The LTECF is only authorized to discharge treated wastewater to the Yukon River (s. 18(h)) or to the Pothole Lake (s. 18(i)).

Furthermore, sampling conducted by Water Resources Branch on Aug. 30, 2018 demonstrates that the groundwater monitoring well located between the CWTF and the Yukon River (MW-4-08) contained artificial sweeteners. This is consistent with EBA's conclusion in their 2009 report that effluent from the CWTF *"may flow northeast along the bedrock interface to the Yukon River."*

Monitoring and Reporting

1.14. Recommendation: Revise condition 13 of the current licence to require water quality results are uploaded to WATERLINE using the 'Laboratory Data Submission Standards for Water Quality' as outlined on the Board's website.

Rationale: The standardized format improves the efficiency of data management and access to data for YG.

1.15. Recommendation: Revise Schedule A, part 1 (locations of monitoring stations) to include site coordinates.

Rationale: Inclusion of site coordinates will align with other water licences and promotes geo-specific data management, and enables the communication of monitoring information in a map format.

1.16. Recommendation: Remove the requirement to sample station YRB-1 in Schedule A, Part 2, Table 4.

Rationale: The City informed YG that YRB-1, which was at one point a shallow groundwater well along the edge of the Yukon River, is destroyed, and that sampling has continued from Yukon River surface water at the same location. Sampling of the river is not an appropriate substitute for the original intention of YRB-1. Any need to replace YRB-1 should be considered as part of our recommended hydrogeological assessment for the LTECF.

1.17. Recommendation: Alter the reference to station YRB-2.

Rationale: Monitoring station "YRB-2" is referenced in conditions 41 and 43 of the current licence; however, its location is not defined in the licence. Either the station should be defined in the locations table or the conditions should be revised. According to Stantec (2000), YRB-2 was destroyed in July 1999.

1.18. Recommendation: Revise station codes for existing WH13 and WH14 in Schedule A, Part 1.

Rationale: Station ID codes WH13 and WH14 were used in past Whitehorse licences (example: MN93-001) to represent the Yukon River sampling downstream from the Porter Creek lagoon. The sludge sampling codes should be revised to avoid confusion in data management.

2. Public Hearing

YG is not requesting a public hearing; however, should one be convened YG would consider making representations in connection with this application.

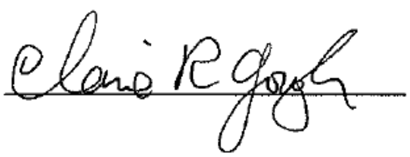
3. Review of Draft Water Licence

YG requests the opportunity to review the draft Water Licence prior to issuance.

4. Closing

Thank you for the opportunity to review and respond to this water licence application. As required by the Board, a copy of this intervention has been forwarded to the applicant and a copy in electronic format submitted to the Board. Should any aspect of this written submission require clarification, please do not hesitate to contact me.

Sincerely,



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Enclosure: Appendix: Figures and Table
Appendix: Yukon government Intervention Redline

References

Core Geoscience Services, 2017. Yukon River Seepage Discharge Monitoring Study. November 2017.

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