City of Whitehorse

ISSUED FOR USE

GROUNDWATER TEMPERATURE, GEOTHERMOMETER AND GEOTHERMAL SIGNATURE ASSESSMENT CITY OF WHITEHORSE YUKON

W23101137

July 24, 2008

EBA Engineering Consultants Ltd.
p. 867.668.3068 • f. 867.668.4349
Calcite Business Centre • Unit 6, 151 Industrial Road • Whitehorse, Yukon Y1A 2V3 • CANADA

TABLE OF CONTENTS

PAGE

TABLES

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 INTRODUCTION

In accordance with our proposal dated April 1, 2008, EBA Engineering Consultants Ltd. (EBA) has carried out sampling and testing of groundwater from selected wells in Whitehorse, YT. Groundwater temperature was measured in the wells, and samples were collected and laboratory-tested for various parameters that can be used to infer exposure of the groundwater to higher temperatures. This work was funded by both the City of Whitehorse (City) and Yukon Energy Corporation (YEC)/Yukon Development Corporation, who share a common interest in these findings.

This report presents a summary of EBA's methods to conduct the study, a summary of field measurements and laboratory results, and an interpretation of the results in the context of geothermal resource potential in the City.

2.0 PURPOSE AND SCOPE

The purpose of this work was to collect groundwater temperature data by measuring temperature profiles in 10 existing water wells around the City. Target well locations were selected as part of a separate assignment that involved review of historical reports, well logs, and anecdotal information, along with consultation with City and YEC personnel. In addition, while each well was open for temperature profiling, a suite of water samples was collected and laboratory-tested for various geochemical and isotopic parameters that were used for subsequent geothermal interpretations.

3.0 BACKGROUND

3.1 GEOTHERMAL STUDIES

Various amounts of subsurface temperature data have been collected in and around the City since the 1970s. In the 1970s, the primary interest for finding a warm groundwater supply in Whitehorse was for tempering the City's municipal surface water supply to prevent water line freezing. In 1976, Hydrogeological Consultants Ltd. (HCL) conducted a study entitled "Warm Groundwater for the Northern Part of the City of Whitehorse" (HCL, 1976). This study involved the compilation of groundwater temperature and flow data from 13 locations (wells or springs) within and around the City, in addition to a low-level flight for remote heat sensing. Results of this study indicated thermal anomalies in and around Porter Creek and Riverdale. Out of the thirteen groundwaters tested, HCL classified seven as "warm" and one (Takhini Hot Springs) as "hot".

Depth-temperature profiles in the Riverdale area were collected by Stanley Associates Engineering (Stanley) in 1980 as part of an exploratory drilling program. The depth-temperature profiles showed a sharp (3°C) increase in temperature from the base of the gravel unit to the top of the basalt (at approximately 60 mbgl). Stanley concluded that the main source of heat in the Selkirk aquifer is geothermal.

EBA conducted a low-temperature geoexchange potential study for the City (EBA, 2007) that included compiling subsurface information collected from water well logs, borehole databases, and geological mapping. The subsurface information was used along with development characteristics (location, type and lot size) to produce geoexchange potential maps showing the possibility for applying closed- and open-loop geoexchange technology for developable areas of the City.

One intent of this present project is to supplement the existing geoexchange potential maps by documenting subsurface temperature data collected from water wells around the City. Deep ground temperature is an important parameter for the design of low temperature geoexchange systems, as it plays a significant role in the type and depth of ground heat exchanger selection.

3.2 GEOCHEMICAL AND ISOTOPIC ANALYSIS TECHNIQUES

Groundwater temperature is an obvious indicator of geothermal influence. However, a number of geochemical techniques can be applied to thermal and non-thermal waters to aid in reconnaissance exploration for higher-temperature geothermal reservoirs in a given area. Some of these geochemical techniques include major ion analysis, geothermometer calculations, and isotopic analysis. These techniques as applied to this present study are discussed below.

Major ion laboratory analyses of groundwater samples can be grouped to reveal different subsurface groundwater types. Piper (1944) developed a method to diagram water chemistry based on a trilinear plot (also called a Piper Trilinear Plot). This method is based on relative amounts of sodium and potassium (Na+K), magnesium (Mg), calcium (Ca), chloride (Cl), sulphate (SO_4), and bicarbonate (HCO_3), and carbonate (CO_3) in a fluid. A water sample plots on the diagram as a single point, based on its overall major ion chemistry. It can be subjectively inferred that groundwater samples falling within the same region on a Piper Trilinear Plot have similar origins.

Chemical geothermometry is a technique that can be used to estimate subsurface geothermal reservoir temperatures using concentrations of certain elements in groundwater. Chemical geothermometers were developed on the basis of temperature-dependent chemical equilibrium between the water and the minerals at the deep reservoir conditions. The two main types of chemical geothermometers that are commonly used in geothermal reconnaissance exploration are based on silica (SiO_2) equilibrium and alkali (Na-K-Ca) equilibrium. Geothermometer temperatures are determined by empirical equations that relate temperature to concentrations of elements in groundwater. A review of chemical geothermometers is given by Fournier (1981).

Isotopic analyses, similar to major ion analyses, can be used to infer origin of groundwater and give some insight into potential groundwater flow paths. In low-temperature geothermal system analyses, the isotopes most often useful are the stable isotopes (i.e., those that are not radioactive) of hydrogen and oxygen: hydrogen-2 or deuterium (D) and

oxygen-18 (O-18). These isotopes are part of the water molecule, and are present in differing proportions in meteoric waters (i.e., rain and snow), depending upon the temperature of precipitation. As meteoric water enters the subsurface and becomes groundwater, its isotopic signature is generally preserved unless the groundwater experiences a significant temperature change or mineral exchange with surrounding rock. By plotting deuterium versus O-18, this degree of change (or fractionation) can be determined and used to infer the relative nature of such temperature changes.

Finally, certain trace metals and dissolved gases commonly occur in high temperature geothermal waters. These trace metals include arsenic (As), boron (B), lithium (Li), and mercury (Hg). Dissolved gases include carbon dioxide (CO_2) and hydrogen sulphide (H_2S). Their presence in groundwater samples can be another indicator of hot subsurface conditions.

4.0 METHODS

4.1 WELL SELECTION

EBA compiled a list of candidate wells from information contained in City and Yukon Government well drilling reports and from the Yukon Water Well database. The candidate well list included the deepest and most accessible wells within the City. In consultation with the City, EBA selected 10 of the candidate locations for depth-temperature profiling and for groundwater sampling. Back-up wells were also selected at most of the locations in the event that the primary well was not accessible or available for profiling and sampling. A summary list including depth, location, static water level and well construction details (where available) is included as Table 1. Well locations are shown in Figure 1.

4.2 FIELD METHODS

The field work for this project was completed from May 15 to 26, 2008 by Cedric Schilder, with assistance from Katherine Johnston, P.Eng. of EBA.

4.2.1 Temperature Profiling

EBA collected depth-temperature data using a Heron Instruments Dipper-T 1000/300 water level and temperature meter. The method for depth-temperature profiling involved lowering the instrument to the bottom of the well (or as deep in the well as physically possible) and letting the probe equilibrate for 10 min. Following equilibration, the probe was raised through the water column and held at each depth interval for 1 min or until the temperature stabilized. Temperature data was collected at 2 – 10 m intervals. Well locations along with bottom well temperatures and depths are included in Figure 1. Depth temperature profiles for each well are included as Figure 2.

4.2.2 Groundwater Sampling

EBA collected groundwater samples from each well or spring location using either: a Grundfos Redi Flo-2 submersible pump, the existing domestic water well pump, or a disposable bailer. For samples collected using pumps, EBA pumped the water to waste until the field parameters of pH, electrical conductivity (EC) and temperature stabilized, and there was no noticeable improvement in water clarity. For water samples collected using bailers, EBA lowered the bailer into the screened portion of the well and collected the water sample while minimizing disturbance to the water column. EBA collected the McIntyre Creek sample directly from the creek, just above the pumphouse.

EBA collected the water samples in laboratory-supplied sampling containers in accordance with laboratory recommended sampling procedures. Dissolved metals samples were filtered in the field through a disposable 0.45 µm filter and preserved with nitric acid (HNO_3). Water samples were shipped on ice by air cargo to the respective laboratory within recommended holding times.

4.3 LABORATORY ANALYSIS

Analysis of major ions (Mg, Ca, Na, K, Cl, HCO_3 and SO_4), metals (As, B, F, Fe, Hg, Li, and Si), and dissolved gases (CO_2 and H_2S) was completed by CanTest Ltd. in Burnaby, BC. Isotope analysis of oxygen-18 and deuterium was completed by the University of Waterloo Environmental Isotope Lab in Waterloo, Ontario. Laboratory results are summarized in Table 2.

5.0 RESULTS AND DISCUSSION

5.1 GROUNDWATER TEMPERATURE IN WELLS

The groundwater temperature and corresponding depth of measurement (i.e., either well bottom or deepest accessible point in the well) are shown on Figure 1 and summarized in Table 2. Given that the wells are completed at varying depths and differing geologic units, a City-wide contour map of groundwater temperature is not appropriate until a larger database of groundwater temperatures is developed. For reference, the geotherm design manual prepared by EBA for the City in December 1998 (EBA, 1998) indicates that the depth of seasonal frost penetration varies between 2 and 5 mbgl, depending on soil type, density, moisture content and snow cover.

The bottom well groundwater temperatures in the wells measured were found to range from 2.9°C to 8.8°C, with the highest observed temperature in the Vanier School test well (145 m deep) and the lowest at the Stevens Subdivision well (DH90-01). The warmest groundwater temperatures were observed in the Riverdale area. Excluding the Riverdale Area wells (i.e., the Vanier School test well and the TH1-80 well), the range of measured groundwater temperatures in the City was 2.9 °C to 4.6 °C, with an average of 3.9°C.

Temperature versus depth profiles are shown in Figure 2. The slope of the line connecting the points in the vertical profile for a given well indicates the geothermal gradient in that well. Excluding the Tank Farm well, the lowest geothermal gradient of 1.28°C/100 m was measured at the Wolf Creek monitoring well. The Tank Farm well has a relatively constant temperature with depth and essentially no geothermal gradient. The reason for this is uncertain, but may be due to vertical mixing of groundwater at different temperatures within the well. The highest geothermal gradient of 6.1°C/100 m was observed at the Porter Creek Well (4-76). It is premature to compare geothermal gradients between the wells until a more accurate geologic/geothermal model is developed for the City area that describes groundwater recharge areas, flow paths, and discharge areas. This is due to the fact that geothermal gradients are best compared where heat conduction is the primary heat transfer mechanism. With the influence of groundwater flow, geothermal gradients may change in zones of colder water influence and mixing. For example, warm water could be rising vertically along faults, and then flowing laterally in preferential permeable zones. A well intersecting these zones may exhibit multiple geothermal gradients.

A significant temperature increase (2.2°C) is observed in the Vanier School well profile between a depth of approximately 65 m and 87 m. This is consistent with the Stanley (1980) findings of a sharp temperature increase at the top of the basalt bedrock in the Riverdale Area.

5.2 GROUNDWATER GEOCHEMISTRY

5.2.1 Major Ions

Groundwater geochemistry results are summarized in Table 2 and plotted on a Piper Trilinear diagram in Figure 3.

A review of the data presented in Figure 3 shows distinct groupings of groundwater types. All samples except those from the Vanier School well, the Riverdale Well TH1-80, and the Wolf Creek Monitoring Well group together, and can be classified as calcium or magnesium – bicarbonate type water. The three groundwater samples (i.e., the Vanier School well, TH1-80, and the Wolf Creek Monitoring Well) that are chemically unique are completed in basalt. As mentioned previously, the Vanier School well and TH1-80 exhibit the highest groundwater temperature. However, without chemical comparison to a hot spring sample, it is inconclusive whether the geochemical signature of the groundwater in the basalt wells is attributable to geothermal activity or to normal rock-water interaction with minerals in the basalt.

5.2.2 Trace Metals and Dissolved Gases

Arsenic and mercury were not detected in any of the samples above the laboratory detection limits. Boron was found in the Vanier School and Stevens Subdivision samples. Lithium was found above detection limits in the 14 MacDonald Rd and the Vanier School samples.

No hydrogen sulphide (H_2S) was detected in any of the samples. Free carbon dioxide was detected in the 14 MacDonald Rd., Tank Farm and Cadet Camp water samples.

The presence of some trace metals and CO_2 indicate possible geothermal influence of the groundwater from these wells, but this evidence is not conclusive without comparison to a hot groundwater sample (i.e., from a local hot spring).

5.3 STABLE ISOTOPES IN GROUNDWATER

A plot of deuterium versus oxygen-18 for all water samples collected is shown in Figure 4. Also shown in Figure 4 are lines representing the global meteoric water line and average isotopic content of meteoric waters in Whitehorse, bracketed by a range (yellow shading) defined by Whitehorse precipitation sample measurements compiled by Birks et al. (2003). The isotope concentrations are expressed relative to a standard, referred to as Standard Mean Ocean Water (SMOW), and are presented as parts per thousand (‰). Negative sample results indicate depletion of the isotope relative to the standard. Less negative values (i.e., approaching zero) indicate a progressively warmer water origin. Groundwaters substantially derived from deep, hot geothermal sources are typically strongly enriched in oxygen-18, and plot well to the right of the local meteoric water line.

A review of the data presented in Figure 4 shows that all of the well samples possess oxygen-18 and deuterium concentrations that fall close to the average Whitehorse meteoric water line, within the range of Whitehorse meteoric water (yellow shaded area). The samples with the greatest oxygen-18 enrichment are those from the Vanier School and McIntyre Creek. This mild enrichment could be indicative of either a warmer environment or evaporation at the time of rainfall. None of the well samples show strong isotopic evidence of hot geothermal source water.

5.4 CHEMICAL GEOTHERMOMETERS

Alkali and silica geothermometers were calculated using a geothermometer spreadsheet tool (Coolbaugh, 2008). The spreadsheet calculates the Na-K-Ca/Mg, quartz, and chalcedony geothermometers using Na, K, Ca, Mg, and SiO_2 concentrations. The methodology and empirical equations are those employed by Mariner et. al. (1983).

The subsurface geothermal reservoir temperature is estimated from the alkali and silica geothermometers to range from 20°C to 52°C, with a sample average of 37°C. The higher estimate is from the Vanier School test well and the lower estimate is from the Porter Creek well. If a high-temperature geothermal reservoir exists in the Whitehorse area, the calculated chemical geothermometers indicate some degree of mixing and dilution of geothermal water with colder meteoric water.

6.0 CONCLUDING SUMMARY

EBA measured groundwater temperatures at ten locations (nine wells and one spring) around the City of Whitehorse. Groundwater samples were also collected and laboratory tested for various chemical and isotopic parameters for geothermal resource reconnaissance exploration. A summary of the findings and conclusions of this work are as follows:

- The warmest groundwater temperatures were observed in the Riverdale area, with the highest temperature of 8.8°C observed in the Vanier School test well (145 m deep), followed by 6.5°C observed in well TH1-80 (127 m deep).
- Excluding the Riverdale Area wells, the range of measured groundwater temperatures around the City was 2.9°C to 4.6°C, with an average of 3.9°C. The average depth of these measurements is 45 m.
- Geochemical analyses of major ions in groundwater indicate distinct groupings of groundwater types. Three groundwater samples (i.e. the Vanier School well, TH1-80, and the Wolf Creek Monitoring Well) are chemically unique from the others. All three of these wells are completed in basalt, and two of the three wells (the Vanier School well and TH1-80) exhibit the highest groundwater temperature of all samples. Without chemical comparison to a hot spring sample (i.e., Takhini Hot Springs), it is inconclusive whether the geochemical signature of the groundwater in the basalt wells is attributable to geothermal activity or to normal rock-water interaction with minerals in the basalt.
- The trace elements and dissolved gases commonly associated with high-temperature geothermal resources were not found to be pervasive in the groundwater samples tested. Boron, lithium, and CO_2 were found in some samples, but other dissolved constituents common to geothermal waters such as arsenic, mercury, and hydrogen sulphide were not found above detection limits in any samples. The presence of some trace constituents is indicative of possible geothermal influence of the groundwater from these wells, but this evidence is not conclusive without comparison to a hot groundwater sample.
- Analysis of stable isotopes in groundwater samples revealed that all possess oxygen-18 and deuterium concentrations that fall within the range representative of Whitehorse meteoric water. The samples with the greatest oxygen-18 enrichment are those from the Vanier School and McIntyre Creek. This mild enrichment could be indicative of either a warmer environment or evaporation.
- Chemical geothermometers (alkali and silica) estimate the subsurface geothermal temperature to range from 20°C to 52°C, with a sample average of 37°C. Thus, if a high-temperature geothermal reservoir exists in the Whitehorse area, the calculated chemical geothermometers indicate some degree of mixing and dilution of geothermal water with colder meteoric water.

- This work represents an initial step in geothermal reconnaissance exploration around the City of Whitehorse. The observations and data interpretation from this work could be enhanced by including similar field and laboratory measurements of groundwater from local hot springs.

7.0 CLOSURE

We trust this report, issued for use, is satisfactory. This report is to be read in conjunction with the General Conditions (Appendix C), which form part of this report.

If you have any questions, please contact the undersigned at your convenience.

Respectfully submitted,
EBA Engineering Consultants Ltd.

Andrew Chiasson, Ph.D., P.E.
Senior Geoexchange Engineer
Pacific Environment Practice
Direct Line: 250.862.4832 x268
email: achiasson@eba.ca

Reviewed by:
H. Scott Schillereff, Ph.D., P.Geo.
Principal Consultant
Pacific Environment Practice
Direct Line: 250.862.4832 x225
email: sschillereff@eba.ca

/tmkp

REFERENCES

Birks, S.J., Edwards, T.W.D., Gibson, J.J., Michel. F.A., Drimmie, R.J., and MacTavish, D., 2003. *Canadian Network for Isotopes in Precipitation*, University of Waterloo/Meteorological Service of Canada.

Craig, J., 1961. Isotopic variations in meteoric water. *Science*, 133, pp. 1702-1703.

Coolbaugh, M., 2008. Personal communication. Great Basin Center for Geothermal Energy, University of Nevada-Reno, Reno, NV.

EBA Engineering Consultants Ltd., 1998. *Geotherm Design Manual for The City of Whitehorse, YT.* Report prepared for the City of Whitehorse. December 1998.

EBA Engineering Consultants Ltd., 2007. *Geoexchange Potential in the City of Whitehorse, YT.* Report prepared for the City of Whitehorse. October 2007.

Fetter, C.W., 1994. *Applied Hydrogeology 2nd Ed.* Prentice Hall.

Fournier, R.O., 1981. Application of Water Geochemistry to Geothermal Exploration and Reservoir Engineering. *Geothermal Systems - Principles and Case Histories.* L. Ryback and L.J.P. Muffler, Eds., Wiley, NY, pp. 109-143.

Hydrogeological Consultants Ltd., 1976. *Warm Groundwater for the Northern Part of the City of Whitehorse.* Report prepared for the City of Whitehorse. July 1976.

Mariner, R.H., Presser, T.S., and Evans, W.C., 1983, Geochemistry of active geothermal systems in the northern Basin and Range Province; Geothermal Resources Council Special Report No. 13.

Piper, A.M., 1944. Agraphic procedure in the geochemical interpretation of water analysis. *Transactions of the Geophysical Union*, pp. 914-923.

Stanley Associates Engineering Ltd., 1980 *City of Whitehorse 1979 Groundwater Exploration Program Selkirk Area.* Report prepared for the City of Whitehorse. January 1980.

Yukon Water Well Database.

TABLES

TABLE 1: Sites for Thermal Profiling and Water Quality Testing in Whitehorse

Location/ Desription	Well/ Spring ID	UTM Coordinates [2]		Depth (m)	SWL (mbtoc)[1]	Comments
		E	N			
Stevens Subdivision	DH90-01	486037	6743873	94.0	72.8	Temperature data only available between 90.5 and 95.5 mbgl
Porter Creek	4-76	492389	6739450	73.2	3.7	Maximum accessible depth of 36 m
14 MacDonald Rd	14 MacDonald Rd	492037	6738556	>40	37.9	Profiled to 40 mbgl (top of well pump)
Fish Lake Road	Icy Waters Well	490333	6731997	63.0	1.5	
McIntyre Creek	McIntyre Creek	494104	6734537	N/A	N/A	Spring
Tank Farm	No. 3-78	494652	6732026	73.2	26.0	
Riverdale	Vanier School	498231	6729697	146.5	7.8	
Riverdale	TH1-80	499294	6730203	121.9	6.9	
Wolf Creek	LTMW No 1	502004	6719000	49.1	16.5	
Cadet Camp	Cadet Camp - MW	502666	6717933	6.0	4.2	

1) SWL = Static Water Level, mbtoc = meters below top of casing
2) UTM coordinates using NAD 27 Datum (Zone 8)

TABLE 2: SUMMARY OF GEOCHEMICAL AND GEOTHERMAL PARAMETERS

Well ID		14 MacDonald Rd	Vanier School	TH1-80	McIntyre Creek	4-76	No. 3-78	LTMW No. 1	Icy Waters Well	Cadet Camp MW	DH90-01	Yukon River
Location/ Description		14 MacDonald Rd	Riverdale	Riverdale	McIntyre Creek	Porter Creek	Tank Farm	Wolf Creek	Fish Lake Road	Cadet Camp	Stevens Subdivison	Yukon River
CanTest Group No.		90520104	90520104	90520104	90520104	90520104	90526026	90527149	90527149	90527149	90523136	N/A
Date Sampled (m/dd/yyy)		5/15/2008	5/15/2008	5/15/2008	5/15/2008	5/16/2008	5/23/2008	5/26/2008	5/26/2008	5/26/2008	5/22/2008	5/15/2008
Sample Method		Installed Pump	Redi Flo-2	Redi Flo-2	Grab	Redi Flo-2	Redi Flo-2	Bailer	Redi Flo-2	Bailer	Bailer	Grab
Depth of Well (mbtoc)		40 [2]	145	127	N/A	36	71	51	63	6	95.5	N/A
Bottom of Well Temperature (deg C)		4	8.81	6.5	N/A	4.37	3.81	3.37	4.68	4.16	2.93	N/A
Geochemical Constituents												
Major Ions												
Dissolved Magnesium Mg	mg/L	14	21	7.78	7.72	14	21.2	5.25	16.2	9.48	27.1	-
Dissolved Calcium Ca	mg/L	99.9	60.6	3.59	36	77.9	41.7	6.64	26	38.4	63.4	-
Dissolved Sodium Na	mg/L	6.42	174	12.2	2.88	5.78	15.6	16	6.85	4.75	23.4	-
Dissolved Potassium K	mg/L	2	2.7	2.9	1.2	1.9	1.3	1.7	3.7	1.3	2.6	-
Dissolved Chloride Cl	mg/L	43.3	131	1.02	0.24	13.3	1.15	13.4	6.45	0.64	0.43	-
Bicarbonate Alkalinity HCO3	mg/L	261	160	62	130	253	215	38.6	169	125	25.4	-
Dissolved Sulphate SO4	mg/L	42.1	342	2.44	9.37	38.2	27	14.3	6.55	28.2	8.34	-
Other Ions and Dissolved Metals												
Dissolved Arsenic As	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	-
Dissolved Boron B	mg/L	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.12	-
Dissolved Flouride F	mg/L	<0.25	0.94	0.16	0.18	0.19	0.23	0.09	0.16	0.08	<0.05	-
Dissolved Iron Fe	mg/L	0.06	0.37	0.12	<0.05	0.61	0.77	0.12	0.06	0.21	0.37	-
Dissolved Mercury Hg	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Dissolved Lithium Li	mg/L	0.002	0.062	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Dissolved Silicon Si	mg/L	5.7	9.1	0.3	4.1	5	8.7	<0.25	7.7	6.1	10.1	-
Dissolved Gases												
Free Carbon Dioxide	mg/L	19.4	<2	<2	<2	<2	7	<2	<2	7.9	<2	-
Hydrogen Sulfide (H2S)	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	-
Stable Isotopes												
Oxygen-18 O-18	‰	-21.26	-21.55	-22.34	-19.51	-21.01	-22.12	-21.78	-20.89	-20.26	-21.6	-19.06
Deuterium D	‰	-168.2	-174.24	-176.99	-158.78	-165.18	-176.1	-170.96	-166.57	-162.71	-168.85	-151.47

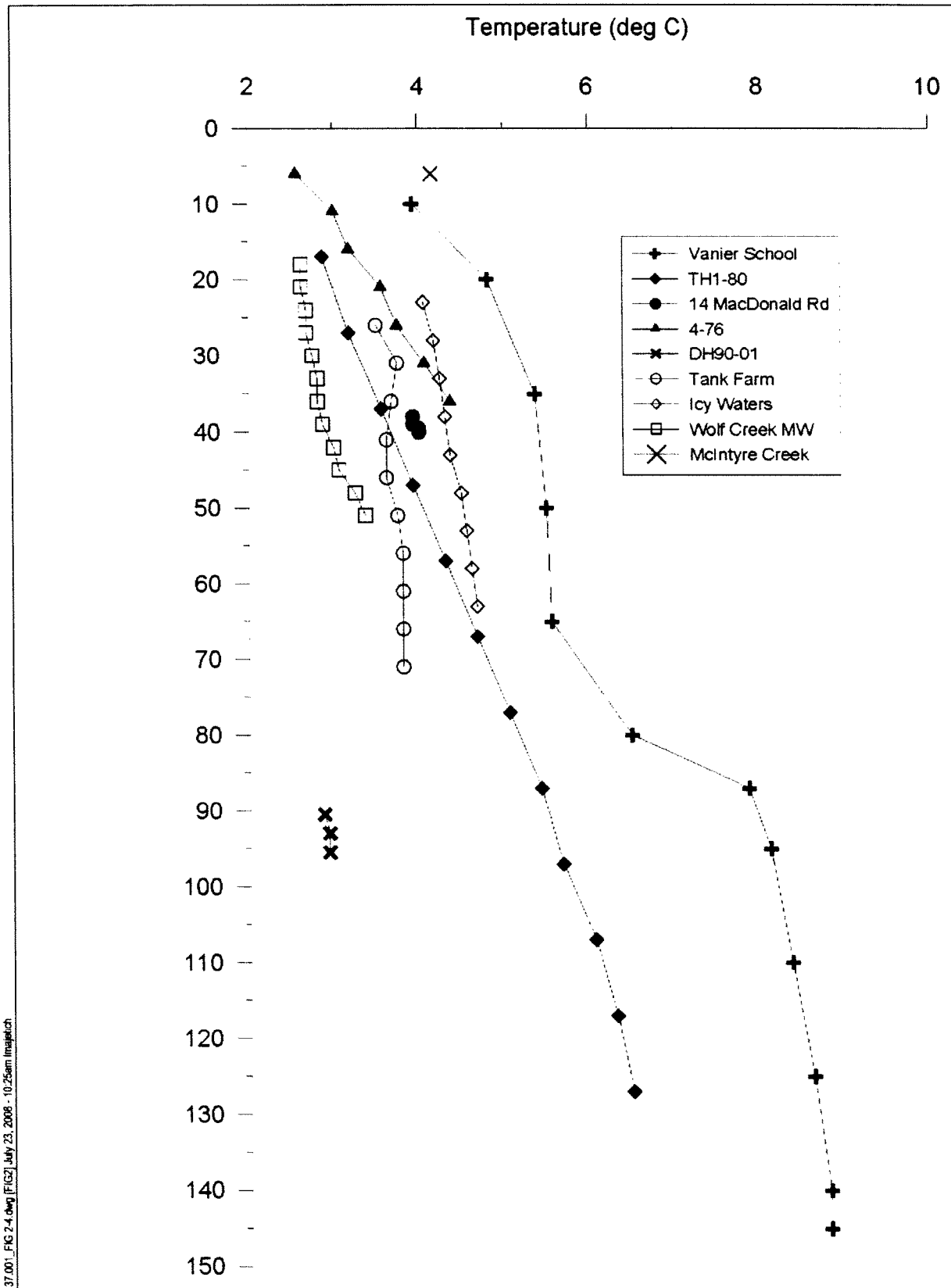
Notes:

1) "<" denotes less than detection limit

2) Depth to top of pump assembly, total well depth likely deeper

3) N/A denotes not applicable

FIGURES



CLIENT

City of Whitehorse

THERMAL PROFILES

GROUNDWATER TEMPERATURE, GEOTHERMOMETER AND GEOTHERMAL SIGNATURE ASSESSMENT
CITY OF WHITEHORSE, YUKON

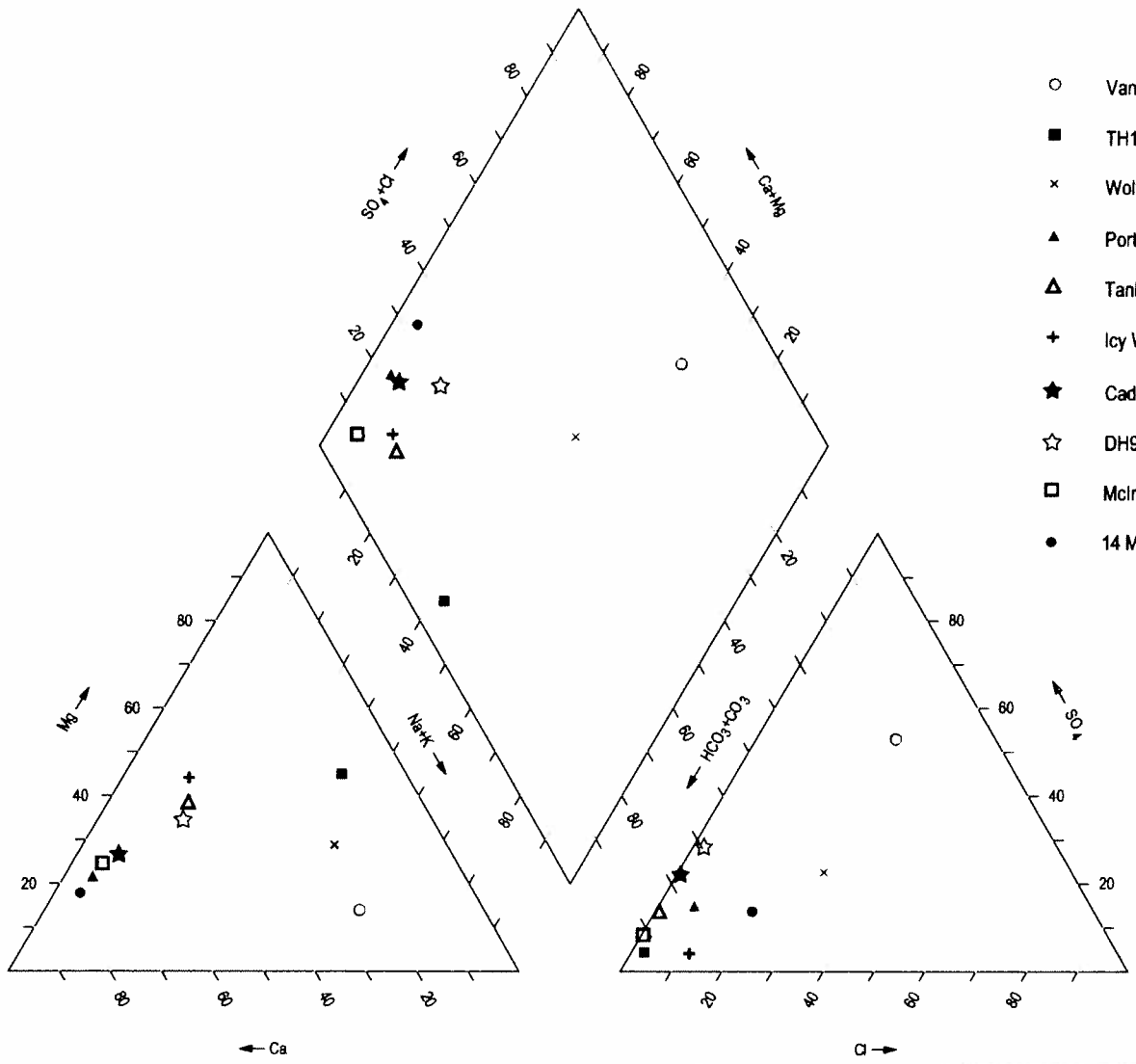
PROJECT NO	DWN	CKD	REV
W23101137.001	LM	KSJ	-

OFFICE: EBA-KELOWNA
DATE: JULY 21, 2008

FIGURE 2

EBA Engineering Consultants Ltd.

Q:\Kelowna\Drafting\W231\W23101137.001\W23101137.001_FIG 2-4.dwg [FIG3] July 23, 2008 - 10:04am lmajesich



- Vanier School
- TH1-80 Riverdale
- Wolf Creek Monitoring Well
- Porter Creek Well
- Tank Farm
- Icy Waters
- Cadet Camp
- DH90-01
- McIntyre Creek
- 14 MacDonald Rd

NOTES:
1) See Table 1 for laboratory results

CLIENT

City of Whitehorse

TRI-LINEAR PLOT OF MAJOR IONS IN GROUNDWATER SAMPLES

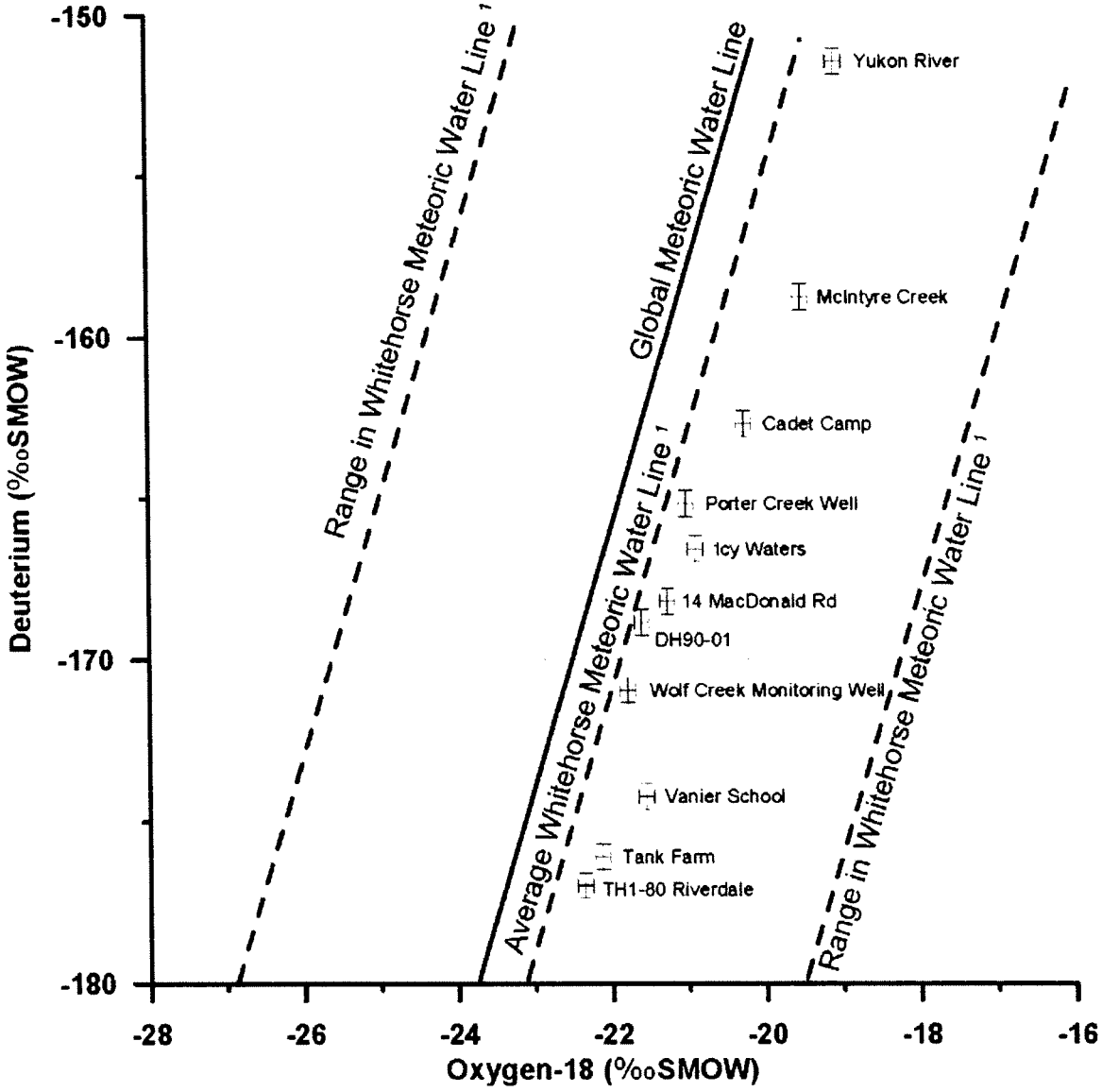
GROUNDWATER TEMPERATURE, GEOTHERMOMETER AND GEOTHERMAL SIGNATURE ASSESSMENT CITY OF WHITEHORSE, YUKON

PROJECT NO	DWN	CKD	REV
W23101137.001	LM	KSJ	-
OFFICE	DATE		
EBA-KELOWNA	JULY 21, 2008		

FIGURE 3

EBA Engineering Consultants Ltd.

eba



NOTES:

1) Whitehorse meteoric water line range from Birks, Edwards, Gibson, Michel, Drimmie, and MacTavish, Canadian Network for Isotopes in Precipitation, Univeristy of Waterloo/ Meteorological Service of Canada 2003.
2) Global meteoric water line from Fetter (1994) citing Craig (1961)
3) See Figure 1 for well locations
4) SMOW = Standard Mean Ocean Water
5) Crosses show range of uncertainty in lab measurements

CLIENT

City of Whitehorse

EBA Engineering Consultants Ltd.

DEUTERIUM VERSUS OXYGEN-18

GROUNDWATER TEMPERATURE, GEOTHERMOMETER AND GEOTHERMAL SIGNATURE ASSESSMENT CITY OF WHITEHORSE, YUKON

PROJECT NO	DWN	CKD	REV
W23101137.001	LM	KSJ	-

OFFICE: EBA-KELOWNA

DATE: JULY 21, 2008

FIGURE 4

O:\Kelowna\Drafting\W2311\W23101137.001\W23101137.001_FIG 2-4.dwg [FIG4] July 23, 2008 - 9:49am lmpetch

APPENDIX

APPENDIX A CANTEST LABORATORY CERTIFICATES AND REPORTS

Analysis Report

CANTEST

REPORT ON: Analysis of Liquid, Water Samples

REPORTED TO: EBA Engineering
150-1715 Dickson Ave
Kelowna, BC
V1Y 9G6

Att'n: Katherine Johnston

CHAIN OF CUSTODY: 2111941
PROJECT NAME: COW
PROJECT NUMBER: W23101137.002

NUMBER OF SAMPLES: 2

REPORT DATE: May 29, 2008

DATE SUBMITTED: May 22, 2008

GROUP NUMBER: 90523136

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Anions in Water by Ion Chromatography - was determined based on Method 4110 in Standard Methods (21st Edition) and EPA Method 300.0 (Revision 2.1).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Hardness in Water - was calculated based on Method 2340 B in Standard Methods for the Examination of Water and Wastewater (21st Edition).

Conventional Parameters - analyses were performed using procedures based on those described in the most current editions of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials", (2005 edition) Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" (21st Edition), published by the American Public Health Association.

Mercury in Water - analysis was performed using procedures based on U. S. EPA Method 245.7, oxidative digestion using bromination, and analysis using Cold Vapour Atomic Fluorescence Spectroscopy.

Field Filtered Metals in Water - Samples were filtered in the field (e.g. at the time of sampling) and quantitatively determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) and/or Inductively Coupled Plasma-Mass Spectroscopy (ICP/MS).

(Continued)

CANTEST LTD.

Anna Becalska, PhD
Coordinator, Trace Metals

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 734 7276 Fax: 604 731 2386

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

CANTEST

GROUP NUMBER: 90523136

Sulfur Compounds - analysis was performed using procedures based on EPA Method 918 using gas chromatographic separation and flame photometric detection.

TEST RESULTS:

(See following pages)

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90523136

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Alaska Highway	
DATE SAMPLED:		May 20/08	DETECTION LIMIT
CANTEST ID:		805230420	
Hardness	CaCO3	270	1
Free Carbon Dioxide		<	2
Total Alkalinity	CaCO3	22.7	0.5
Bicarbonate Alkalinity	HCO3	25.4	0.5
Carbonate Alkalinity	CO3	1.12	0.5
Hydroxide Alkalinity	OH	<	0.5
Dissolved Fluoride	F	<	0.05
Dissolved Chloride	Cl	0.43	0.2
Dissolved Sulphate	SO4	8.34	0.5

Results expressed as milligrams per liter (mg/L)

< Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90523136

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Alaska Highway		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 20/08		
CANTEST ID:		805230420	DETECTION LIMIT	UNITS
Aluminum	Al	0.02	0.005	mg/L
Antimony	Sb	<	0.001	mg/L
Arsenic	As	0.001	0.001	mg/L
Barium	Ba	0.059	0.001	mg/L
Beryllium	Be	<	0.001	mg/L
Bismuth	Bi	<	0.001	mg/L
Boron	B	1.12	0.05	mg/L
Cadmium	Cd	<	0.0002	mg/L
Calcium	Ca	63.4	0.05	mg/L
Chromium	Cr	<	0.001	mg/L
Cobalt	Co	<	0.001	mg/L
Copper	Cu	<	0.001	mg/L
Iron	Fe	0.37	0.05	mg/L
Lead	Pb	<	0.001	mg/L
Lithium	Li	<	0.001	mg/L
Magnesium	Mg	27.1	0.05	mg/L
Manganese	Mn	0.88	0.001	mg/L
Mercury	Hg	<	0.02	µg/L
Molybdenum	Mo	0.0018	0.0005	mg/L
Nickel	Ni	<	0.001	mg/L
Phosphorus	P	<	0.15	mg/L
Potassium	K	2.6	0.1	mg/L
Selenium	Se	<	0.001	mg/L
Silicon	Si	10.1	0.25	mg/L
Silver	Ag	<	0.00025	mg/L
Sodium	Na	23.4	0.05	mg/L
Strontium	Sr	0.3	0.001	mg/L
Tellurium	Te	<	0.001	mg/L
Thallium	Tl	<	0.0001	mg/L
Thorium	Th	<	0.0005	mg/L
Tin	Sn	<	0.001	mg/L

(Continued on next page)

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90523136

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Alaska Highway		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 20/08	DETECTION LIMIT	UNITS
CANTEST ID:		805230420		
Titanium	Ti	<	0.001	mg/L
Uranium	U	<	0.0005	mg/L
Vanadium	V	<	0.001	mg/L
Zinc	Zn	0.008	0.005	mg/L
Zirconium	Zr	<	0.01	mg/L

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90523136

CANTEST

Analysis of Sulfur Components in Liquid

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Hydrogen Sulfide
Alaska Highway	May 20/08	B05230425	<
DETECTION LIMIT UNITS			10 µg/L

µg/L = micrograms per liter
< = Less than detection limit

CHAIN OF CUSTODY RECORD

CANTEST

2111941

4606 Canada Way
Burnaby, B.C.
V5G 1K5

Tel: 604.734.7276
Fax: 604.731.2386
Toll Free: 800.665.8566
www.cantest.com

Page 1 of 1

Client Name: EBA Engineering Consultants
Postal Code: V1Y 9G6
Street Address (including suite number): 150-1715 Dickson Ave
City: Kelowna BC
Telephone: 250 862 4832
Fax:
E-Mail Address (Required for Electronic Reporting): ksjohnston@eba.ca
Contact Name: Katherine Johnston (250-419-8583)
Sampler's Name: Cedric Schilder
Quotation Number:
Project Number: W2310.139.002
Project Name: COW
P.O. Number:

RESULTS REQUESTED BY: Day ___ Month ___ Year ___
(Surcharges May Apply)

Special Instructions: ☐ AutoFax ☐ AutoEmail ☐ Return Cooler ☐ Ship Sample Bottles (please specify)

straw Hold G+S-Soil
c M
1 raw

Sample(s) are from a Drinking Water source servicing multiple households — Yes ☐

Group Number	Sample Identification	Date/Time Sampled (D/M/Y & 24hr clock)	Sample Type	Total Metals*	Dissolved Metals*	Field Filtered Metals*	Soil Metals*	pH	Conductivity	TSS	TDS	Alkalinity (total / spec.)	BOD	COD	Coliform, Total & E.coli	Coliform, Fecal	F Cl SO4 NO3	Nitrite	Oil & Grease (Total / Mineral)	Oil & Grease (Special Waste)	PCP (Tri, Tetra and Penta)	PCP (Mono and Di)	BETX/VPH	VOC	EPH (not PAH corrected)	PAH	LEPH/HEPH (PAH corrected)	PCB	Asbestos	Ions (F, Cl, HCO3, SO4)	Dissolved Oxygen, CO2, H2S			HOLD - DO NOT ANALYZE	Number of Containers
9052313G																																			
8052304Z	Alaska Highway 425 AB	D: May 20 T: 3 45	H_2O		X																									(X)	(X)				

#WLAWFI

Cl-IC
SO4-IC
#ALK-T
CO2-water lab
H2S
Liquid matrix (1H) (1raw)
9 May 23 2008 All past

F- IC

Dissolved metals to include: Mg, Ca, Na, K, As, B, (F), Fe, Hg, Li, Si

LAB USE ONLY

Relinquished by:	Date	Time	Received by:
Relinquished by:	Date	Time	Received by:

Total Number of Containers:

Method of Shipment:	Waybill No.:	Received for Lab by:	Date MAY 22 2008	Time 2:20
Shipped by:	Shipment Condition:	Cooler opened by:	Date	Time

FOR LABORATORY USE ONLY
Sample State at Receipt: ☐ Ambient ☑ Cold ☐ Frozen ☐ N/A Comments:
Temperature 6.1 °C Custody Seal Intact? ☐ Yes ☐ No ☑ n/a Number of Coolers/Shipping Containers: 1

*Please indicate appropriate regulatory guidelines:

WATER	SOIL
☐ CCME	☐ CCME
☐ BC-CSR	☐ BC-CSR
☒ Other (please specify) EBA Pkg rate 02 485/sample	☐ Other (please specify)

Analysis Report

CANTEST

REPORT ON: Analysis of Liquid, Water Samples

REPORTED TO: EBA Engineering
150-1715 Dickson Ave
Kelowna, BC
V1Y 9G6

Att'n: Katherine Johnston

CHAIN OF CUSTODY: 2111942
PROJECT NAME: Cow
PROJECT NUMBER: W23101137.002

NUMBER OF SAMPLES: 2

REPORT DATE: June 3, 2008

DATE SUBMITTED: May 26, 2008

GROUP NUMBER: 90526026

SAMPLE TYPE: Water, Liquid

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Anions in Water by Ion Chromatography - was determined based on Method 4110 in Standard Methods (21st Edition) and EPA Method 300.0 (Revision 2.1).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Hardness in Water - was calculated based on Method 2340 B in Standard Methods for the Examination of Water and Wastewater (21st Edition).

Conventional Parameters - analyses were performed using procedures based on those described in the most current editions of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials", (2005 edition) Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" (21st Edition), published by the American Public Health Association.

Mercury in Water - analysis was performed using procedures based on U. S. EPA Method 245.7, oxidative digestion using bromination, and analysis using Cold Vapour Atomic Fluorescence Spectroscopy.

Field Filtered Metals in Water - Samples were filtered in the field (e.g. at the time of sampling) and quantitatively determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) and/or Inductively Coupled Plasma-Mass Spectroscopy (ICP/MS).

(Continued)

CANTEST LTD.

Anna Becalska, PhD
Coordinator, Trace Metals

4606 Canada Way, Burnaby, BC V5G 1K5
Tel: 604 [illegible] Fax: 604 [illegible]

Sulfur Compounds - analysis was performed using procedures based on EPA Method 918 using gas chromatographic separation and flame photometric detection.

TEST RESULTS:

(See following pages)

REPORTED TO: EBA Engineering

REPORT DATE: June 3, 2008

GROUP NUMBER: 90526026

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Tank Form	
DATE SAMPLED:		May 23/08	
CANTEST ID:		805260064	DETECTION LIMIT
Hardness	CaCO3	191	1
Free Carbon Dioxide		7.0	2
Total Alkalinity	CaCO3	176	0.5
Bicarbonate Alkalinity	HCO3	215	0.5
Carbonate Alkalinity	CO3	<	0.5
Hydroxide Alkalinity	OH	<	0.5
Dissolved Fluoride	F	0.23	0.05
Dissolved Chloride	Cl	1.15	0.2
Dissolved Sulphate	SO4	27.0	0.5

Results expressed as milligrams per liter (mg/L)
< Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: June 3, 2008

GROUP NUMBER: 90526026

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Tank Form		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 23/08	DETECTION LIMIT	UNITS
CANTEST ID:		805260064		
Aluminum	Al	0.012	0.005	mg/L
Antimony	Sb	<	0.001	mg/L
Arsenic	As	<	0.001	mg/L
Barium	Ba	0.033	0.001	mg/L
Beryllium	Be	<	0.001	mg/L
Bismuth	Bi	<	0.001	mg/L
Boron	B	<	0.05	mg/L
Cadmium	Cd	<	0.0002	mg/L
Calcium	Ca	41.7	0.05	mg/L
Chromium	Cr	<	0.001	mg/L
Cobalt	Co	<	0.001	mg/L
Copper	Cu	0.002	0.001	mg/L
Iron	Fe	0.77	0.05	mg/L
Lead	Pb	<	0.001	mg/L
Lithium	Li	<	0.001	mg/L
Magnesium	Mg	21.2	0.05	mg/L
Manganese	Mn	0.014	0.001	mg/L
Mercury	Hg	<	0.02	µg/L
Molybdenum	Mo	0.0036	0.0005	mg/L
Nickel	Ni	<	0.001	mg/L
Phosphorus	P	<	0.15	mg/L
Potassium	K	1.3	0.1	mg/L
Selenium	Se	0.001	0.001	mg/L
Silicon	Si	8.7	0.25	mg/L
Silver	Ag	<	0.00025	mg/L
Sodium	Na	15.6	0.05	mg/L
Strontium	Sr	0.44	0.001	mg/L
Tellurium	Te	<	0.001	mg/L
Thallium	Tl	<	0.0001	mg/L
Thorium	Th	<	0.0005	mg/L
Tin	Sn	<	0.001	mg/L

(Continued on next page)

REPORTED TO: EBA Engineering

REPORT DATE: June 3, 2008

GROUP NUMBER: 90526026

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Tank Form		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 23/08		
CANTEST ID:		805260064	DETECTION LIMIT	UNITS
Titanium	Ti	<	0.001	mg/L
Uranium	U	0.0061	0.0005	mg/L
Vanadium	V	0.003	0.001	mg/L
Zinc	Zn	<	0.005	mg/L
Zirconium	Zr	<	0.01	mg/L

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: June 3, 2008

GROUP NUMBER: 90526026

CANTEST

Analysis of Sulfur Components in Liquid

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Hydrogen Sulfide
Tank Form	May 23/08	805260065	<
DETECTION LIMIT			10
UNITS			µg/L

µg/L micrograms per liter

< Less than detection limit

CHAIN OF CUSTODY RECORD

CANTEST

4606 Canada Way
Burnaby, B.C.
V5G 1K5

Tel: 604.734.7276
Fax: 604.731.2386
Toll Free: 800.665.8566

www.cantest.com

2111942

Client Name: EBA Engineering Consulting
Postal Code: V1X 9G9

Page 1 of 1

Street Address (including suite number): 150 - 1715 Dickson Ave
City: Kelowna BC

Telephone: 250 862 4832
Fax:
E-Mail Address (Required for Electronic Reporting): ksjohnston@eba.ca

Contact Name: Katherine Johnston (250-719-9593)
Sampler's Name: Cedric Schilder

Quotation Number:
Project Number: W23101137001
Project Name: COW
P.O. Number:

RESULTS REQUESTED BY:

Day Month Year

(Surcharges May Apply)

Special Instructions: AutoFax AutoEmail

Return Cooler
Ship Sample Bottles (please specify)

1 Sraw
1 araw
1 DM
1 Hraw

Sample(s) are from a Drinking Water source servicing multiple households — Yes

Group Number	Sample Identification	Date/Time Sampled (D/M/Y & 24hr clock)	Sample Type	Total Metals*	Dissolved Metals* ALKALI	Field Filtered Metals*	Soil Metals*	pH	Conductivity	TSS	TDS	Alkalinity (total / spec.)	BOD	COD	Coliform, Total & E.coli	Coliform, Fecal	F Cl SO_4 NO_3	Nitrite	Oil & Grease (Total / Mineral)	Oil & Grease (Special Waste)	PCP (Tri, Tetra and Penta)	PCP (Mono and Di)	BETX/VPH	VOC	EPH (not PAH corrected)	PAH	LEPH/HEPH (PAH corrected)	PCB	Asbestos	Cl-22 CO2	Ions Cl- CO2 HCO3, SO4	Dissolved	gasses CO2 H2S	HOLD - DO NOT ANALYZE	Number of Containers
9052b026 8052b064 065	Tank Farm	D: May 23 T: 2:30	H_2O		X																										X	X			

Dissolved metals to include: Mg, Ca, Na, K, As, B, F, Fe, Hg, Li, Sr

LAB USE ONLY

Relinquished by: Date Time Received by:
Relinquished by: Date Time Received by:

Total Number of Containers:

Method of Shipment: Waybill No.: Received for Lab by: MB Date MAY 26 2008 Time 9:45
Shipped by: Shipment Condition: Cooler opened by: Date Time

***Please indicate appropriate regulatory guidelines:**

WATER	SOIL
CCME	CCME
BC-CSR	BC-CSR
X Other (please specify) EBA drkg rate of 485 kmpl	Other (please specify)

FOR LABORATORY USE ONLY

Sample State at Receipt: Ambient X Cold Frozen N/A Comments:

Temperature 3.3 °C Custody Seal Intact? Yes No X n/a Number of Coolers/Shipping Containers: 1

Analysis Report

CANTEST

REPORT ON: Analysis of Liquid, Water Samples

REPORTED TO: EBA Engineering
150-1715 Dickson Ave
Kelowna, BC
V1Y 9G6

Att'n: Katherine Johnston

CHAIN OF CUSTODY: 2111940
PROJECT NAME: COW
PROJECT NUMBER: W23101137.002

NUMBER OF SAMPLES: 10

REPORT DATE: May 29, 2008

DATE SUBMITTED: May 20, 2008

GROUP NUMBER: 90520104

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Anions in Water by Ion Chromatography - was determined based on Method 4110 in Standard Methods (21st Edition) and EPA Method 300.0 (Revision 2.1).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Hardness in Water - was calculated based on Method 2340 B in Standard Methods for the Examination of Water and Wastewater (21st Edition).

Conventional Parameters - analyses were performed using procedures based on those described in the most current editions of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials", (2005 edition) Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" (21st Edition), published by the American Public Health Association.

Mercury in Water - analysis was performed using procedures based on U. S. EPA Method 245.7, oxidative digestion using bromination, and analysis using Cold Vapour Atomic Fluorescence Spectroscopy.

Field Filtered Metals in Water - Samples were filtered in the field (e.g. at the time of sampling) and quantitatively determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) and/or Inductively Coupled Plasma-Mass Spectroscopy (ICP/MS).

(Continued)

CANTEST LTD.

Anna Becalska, PhD
Trace Metals Coordinator

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Sulfur Compounds - analysis was performed using procedures based on EPA Method 918 using gas chromatographic separation and flame photometric detection.

TEST RESULTS:

(See following pages)

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		14 MacDonald Rd	Vanier	Riverdale THI-80	McIntyre Creek	
DATE SAMPLED:		May 15/08	May 15/08	May 15/08	May 15/08	DETECTION LIMIT
CANTEST ID:		805200310	805200314	805200316	805200318	
Hardness	CaCO3	307	238	41	122	1
Free Carbon Dioxide		19.4	<	<	<	2
Total Alkalinity	CaCO3	214	131	54.2	107	0.5
Bicarbonate Alkalinity	HCO3	261	160	62.0	130	0.5
Carbonate Alkalinity	CO3	<	<	2.04	<	0.5
Hydroxide Alkalinity	OH	<	<	<	<	0.5
Dissolved Fluoride	F	< 0.25	0.94	0.16	0.18	0.05
Dissolved Chloride	Cl	43.3	131	1.02	0.24	0.2
Dissolved Sulphate	SO4	42.1	342	2.44	9.37	0.5

Results expressed as milligrams per liter (mg/L)
< = Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Porter Creek	
DATE SAMPLED:		May 16/08	DETECTION LIMIT
CANTEST ID:		805200321	
Hardness	CaCO3	252	1
Free Carbon Dioxide		9.7	2
Total Alkalinity	CaCO3	207	0.5
Bicarbonate Alkalinity	HCO3	253	0.5
Carbonate Alkalinity	CO3	<	0.5
Hydroxide Alkalinity	OH	<	0.5
Dissolved Fluoride	F	0.19	0.05
Dissolved Chloride	Cl	13.3	0.2
Dissolved Sulphate	SO4	38.2	0.5

Results expressed as milligrams per liter (mg/L)
< Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		14 MacDonald Rd	Vanier	Riverdale THI-80	McIntyre Creek		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		May 15/08	May 15/08	May 15/08	May 15/08		
CANTEST ID:		805200310	805200314	805200316	805200318	DETECTION LIMIT	UNITS
Aluminum	Al	0.007	0.006	0.008	0.008	0.005	mg/L
Antimony	Sb	<	<	<	<	0.001	mg/L
Arsenic	As	<	0.001	<	<	0.001	mg/L
Barium	Ba	0.048	0.01	0.004	0.028	0.001	mg/L
Beryllium	Be	<	<	<	<	0.001	mg/L
Bismuth	Bi	<	<	<	<	0.001	mg/L
Boron	B	<	0.09	<	<	0.05	mg/L
Cadmium	Cd	<	<	<	<	0.0002	mg/L
Calcium	Ca	99.9	60.6	3.59	36	0.05	mg/L
Chromium	Cr	<	<	<	<	0.001	mg/L
Cobalt	Co	<	<	<	<	0.001	mg/L
Copper	Cu	0.14	0.001	0.001	0.004	0.001	mg/L
Iron	Fe	0.06	0.37	0.12	<	0.05	mg/L
Lead	Pb	<	<	<	<	0.001	mg/L
Lithium	Li	0.002	0.062	<	<	0.001	mg/L
Magnesium	Mg	14	21	7.78	7.72	0.05	mg/L
Manganese	Mn	0.013	0.097	0.009	0.007	0.001	mg/L
Mercury	Hg	<	<	<	<	0.02	µg/L
Molybdenum	Mo	0.0026	0.088	0.011	0.0012	0.0005	mg/L
Nickel	Ni	0.009	<	<	<	0.001	mg/L
Phosphorus	P	<	<	<	<	0.15	mg/L
Potassium	K	2	2.7	2.9	1.2	0.1	mg/L
Selenium	Se	<	<	<	<	0.001	mg/L
Silicon	Si	5.7	9.1	0.3	4.1	0.25	mg/L
Silver	Ag	<	<	<	<	0.00025	mg/L
Sodium	Na	6.42	174	12.2	2.88	0.05	mg/L
Strontium	Sr	0.49	0.55	0.039	0.18	0.001	mg/L
Tellurium	Te	<	<	<	<	0.001	mg/L
Thallium	Tl	<	<	<	<	0.0001	mg/L
Thorium	Th	<	<	<	<	0.0005	mg/L
Tin	Sn	<	<	<	<	0.001	mg/L

(Continued on next page)

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		14 MacDonald Rd	Vanier	Riverdale THI-80	McIntyre Creek		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		May 15/08	May 15/08	May 15/08	May 15/08		
CANTEST ID:		805200310	805200314	805200316	805200318	DETECTION LIMIT	UNITS
Titanium	Ti	<	<	<	<	0.001	mg/L
Uranium	U	0.0025	0.0005	<	0.0009	0.0005	mg/L
Vanadium	V	<	<	<	<	0.001	mg/L
Zinc	Zn	0.006	<	<	<	0.005	mg/L
Zirconium	Zr	<	<	<	<	0.01	mg/L

mg/L = milligrams per liter

< = Less than detection limit

µg/L = micrograms per liter

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Porter Creek		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 16/08		
CANTEST ID:		805200321	DETECTION LIMIT	UNITS
Aluminum	Al	0.015	0.005	mg/L
Antimony	Sb	<	0.001	mg/L
Arsenic	As	<	0.001	mg/L
Barium	Ba	0.051	0.001	mg/L
Beryllium	Be	<	0.001	mg/L
Bismuth	Bi	<	0.001	mg/L
Boron	B	<	0.05	mg/L
Cadmium	Cd	<	0.0002	mg/L
Calcium	Ca	77.9	0.05	mg/L
Chromium	Cr	0.003	0.001	mg/L
Cobalt	Co	<	0.001	mg/L
Copper	Cu	0.003	0.001	mg/L
Iron	Fe	0.61	0.05	mg/L
Lead	Pb	<	0.001	mg/L
Lithium	Li	0.001	0.001	mg/L
Magnesium	Mg	14	0.05	mg/L
Manganese	Mn	0.009	0.001	mg/L
Mercury	Hg	<	0.02	µg/L
Molybdenum	Mo	0.004	0.0005	mg/L
Nickel	Ni	0.002	0.001	mg/L
Phosphorus	P	<	0.15	mg/L
Potassium	K	1.9	0.1	mg/L
Selenium	Se	0.001	0.001	mg/L
Silicon	Si	5	0.25	mg/L
Silver	Ag	<	0.00025	mg/L
Sodium	Na	5.78	0.05	mg/L
Strontium	Sr	0.39	0.001	mg/L
Tellurium	Te	<	0.001	mg/L
Thallium	Tl	<	0.0001	mg/L
Thorium	Th	<	0.0005	mg/L
Tin	Sn	<	0.001	mg/L

(Continued on next page)

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Porter Creek		
SAMPLE PREPARATION:		DISSOLVED		
DATE SAMPLED:		May 16/08		
CANTEST ID:		805200321	DETECTION LIMIT	UNITS
Titanium	Ti	<	0.001	mg/L
Uranium	U	0.0038	0.0005	mg/L
Vanadium	V	0.001	0.001	mg/L
Zinc	Zn	0.013	0.005	mg/L
Zirconium	Zr	<	0.01	mg/L

mg/L milligrams per liter

< Less than detection limit

µg/L = micrograms per liter

REPORTED TO: EBA Engineering

REPORT DATE: May 29, 2008

GROUP NUMBER: 90520104

CANTEST

Analysis of Sulfur Components in Liquid

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Hydrogen Sulfide
14 MacDonald Rd	May 15/08	805200313	<
Vanier	May 15/08	805200315	<
Riverdale THI-80	May 15/08	805200317	<
McIntyre Creek	May 15/08	805200319	<
Porter Creek	May 16/08	805200322	<
DETECTION LIMIT			10
UNITS			µg/L

µg/L = micrograms per liter
< Less than detection limit

Analysis Report

CANTEST

REPORT ON: Analysis of Water Samples

REPORTED TO: EBA Engineering
150-1715 Dickson Ave
Kelowna, BC
V1Y 9G6

Att'n: Katherine Johnston

RECEIVED
JUN 2 3 2008

CHAIN OF CUSTODY: 2111944
PROJECT NAME: COW
PROJECT NUMBER: W23101137.002

NUMBER OF SAMPLES: 6

REPORT DATE: June 4, 2008

DATE SUBMITTED: May 27, 2008

GROUP NUMBER: 90527149

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Anions in Water by Ion Chromatography - was determined based on Method 4110 in Standard Methods (21st Edition) and EPA Method 300.0 (Revision 2.1).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (21st Edition).

Hardness in Water - was calculated based on Method 2340 B in Standard Methods for the Examination of Water and Wastewater (21st Edition).

Conventional Parameters - analyses were performed using procedures based on those described in the most current editions of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials", (2005 edition) Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" (21st Edition), published by the American Public Health Association.

Mercury in Water - analysis was performed using procedures based on U. S. EPA Method 245.7, oxidative digestion using bromination, and analysis using Cold Vapour Atomic Fluorescence Spectroscopy.

Field Filtered Metals in Water - Samples were filtered in the field (e.g. at the time of sampling) and quantitatively determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) and/or Inductively Coupled Plasma-Mass Spectroscopy (ICP/MS).

(Continued)

CANTEST LTD.

Per

Anna Becalska, PhD
Coordinator, Trace Metals

9565 Cardinal Way, Burnaby, BC V5A 4N5
Tel: 604-[illegible] Fax: 604-[illegible]

Sulfur Compounds - analysis was performed using procedures based on EPA Method 918 using gas chromatographic separation and flame photometric detection.

TEST RESULTS:

(See following pages)

REPORTED TO: EBA Engineering

REPORT DATE: June 4, 2008

CANTEST

GROUP NUMBER: 90527149

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Wolf Creek	Icy Waters	Cadet Camp	
DATE SAMPLED:		May 26/08	May 26/08	May 26/08	
CANTEST ID:		805270437	805270439	805270441	DETECTION LIMIT
Hardness	CaCO3	38	132	135	1
Free Carbon Dioxide		<	<	7.9	2
Total Alkalinity	CaCO3	31.7	148	103	0.5
Bicarbonate Alkalinity	HCO3	38.6	169	125	0.5
Carbonate Alkalinity	CO3	<	5.5	<	0.5
Hydroxide Alkalinity	OH	<	<	<	0.5
Dissolved Fluoride	F	0.09	0.16	0.08	0.05
Dissolved Chloride	Cl	13.4	6.45	0.64	0.2
Dissolved Sulphate	SO4	14.3	6.55	28.2	0.5

Results expressed as milligrams per liter (mg/L)
< = Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: June 4, 2008

GROUP NUMBER: 90527149

CANTEST

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Wolf Creek	Icy Waters	Cadet Camp		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		May 26/08	May 26/08	May 26/08		
CANTEST ID:		805270437	805270439	805270441	DETECTION LIMIT	UNITS
Aluminum	Al	0.023	<	0.048	0.005	mg/L
Antimony	Sb	<	<	<	0.001	mg/L
Arsenic	As	<	<	<	0.001	mg/L
Barium	Ba	0.003	0.028	0.048	0.001	mg/L
Beryllium	Be	<	<	<	0.001	mg/L
Bismuth	Bi	<	<	<	0.001	mg/L
Boron	B	<	<	<	0.05	mg/L
Cadmium	Cd	<	<	<	0.0002	mg/L
Calcium	Ca	6.64	26	38.4	0.05	mg/L
Chromium	Cr	<	<	<	0.001	mg/L
Cobalt	Co	<	<	<	0.001	mg/L
Copper	Cu	0.001	<	0.002	0.001	mg/L
Iron	Fe	0.12	0.06	0.21	0.05	mg/L
Lead	Pb	<	<	<	0.001	mg/L
Lithium	Li	<	0.001	<	0.001	mg/L
Magnesium	Mg	5.25	16.2	9.48	0.05	mg/L
Manganese	Mn	0.017	0.038	0.008	0.001	mg/L
Mercury	Hg	<	<	<	0.02	µg/L
Molybdenum	Mo	0.0028	0.0025	0.0012	0.0005	mg/L
Nickel	Ni	<	<	<	0.001	mg/L
Phosphorus	P	<	<	<	0.15	mg/L
Potassium	K	1.7	3.7	1.3	0.1	mg/L
Selenium	Se	<	<	<	0.001	mg/L
Silicon	Si	<	7.7	6.1	0.25	mg/L
Silver	Ag	<	<	<	0.00025	mg/L
Sodium	Na	16	6.85	4.75	0.05	mg/L
Strontium	Sr	0.037	0.27	0.27	0.001	mg/L
Tellurium	Te	<	<	<	0.001	mg/L
Thallium	Tl	<	<	<	0.0001	mg/L
Thorium	Th	<	<	<	0.0005	mg/L
Tin	Sn	<	<	<	0.001	mg/L

(Continued on next page)

REPORTED TO: EBA Engineering

REPORT DATE: June 4, 2008

CANTEST

GROUP NUMBER: 90527149

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		Wolf Creek	Icy Waters	Cadet Camp		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		May 26/08	May 26/08	May 26/08		
CANTEST ID:		805270437	805270439	805270441	DETECTION LIMIT	UNITS
Titanium	Ti	<	<	0.002	0.001	mg/L
Uranium	U	<	0.0016	0.0026	0.0005	mg/L
Vanadium	V	<	0.002	<	0.001	mg/L
Zinc	Zn	<	<	<	0.005	mg/L
Zirconium	Zr	<	<	<	0.01	mg/L

mg/L = milligrams per liter

μg/L = micrograms per liter

< = Less than detection limit

REPORTED TO: EBA Engineering

REPORT DATE: June 4, 2008

GROUP NUMBER: 90527149

CANTEST

Analysis of Sulfur Components in Liquid

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Hydrogen Sulfide
Wolf Creek (H2S)	May 26/08	805270438	<
Icy Waters (H2S)	May 26/08	805270440	<
Cadet Camp (H2S)	May 26/08	805270442	<
DETECTION LIMIT			10
UNITS			µg/L

µg/L = micrograms per liter
< = Less than detection limit

CHAIN OF CUSTODY RECORD

CANTEST

2111944

4606 Canada Way
Burnaby, B.C.
V5G 1K5

Tel: 604.734.7276
Fax: 604.731.2386
Toll Free: 800.665.8566

www.cantest.com

Page 1 of 1

Client Name: EBA Engineering Consultants
Postal Code: V1X 9G6
Street Address (including suite number): 150 - 1715 Dickson Ave.
City: Kelowna B.C.
Telephone: 250-862-4832
Fax:
E-Mail Address (Required for Electronic Reporting): ksjohnston@eba.ca
Contact Name: Katherine Johnston
Sampler's Name: Cedric Schilder
Quotation Number:
Project Number: N23101139.002
Project Name: COW
P.O. Number:

RESULTS REQUESTED BY:
Day Month Year
(Surcharges May Apply)

Special Instructions: ☐ AutoFax ☐ AutoEmail ☐ Return Cooler ☐ Ship Sample Bottles (please specify) 25

1x RAW, 2x SRAW, 6x TM, ~~3x DM~~
2x 1RAW, 1x 2RAW

Sample(s) are from a Drinking Water source servicing multiple households — Yes ☐

Group Number: 90527149

Sample Identification	Date/Time Sampled (D/M/Y & 24hr clock)	Sample Type	Total Metals*	Dissolved Metals*	Field Filtered Metals*	Soil Metals*	pH	Conductivity	TSS	TDS	Alkalinity (total / spec.)	BOD	COD	Coliform, Total & E.coli	Coliform, Fecal	F Cl SO4 NO3	Nitrite	Oil & Grease (Total / Mineral)	Oil & Grease (Special Waste)	PCP (Tri, Tetra and Penta)	PCP (Mono and Di)	BETX/VPH	VOC	EPH (not PAH corrected)	PAH	LEPH/HEPH (PAH corrected)	PCB	Asbestos	Ions, Cl⁻, CO3, HCO3, SO4	Diss. CO2, H2S	HOLD - DO NOT ANALYZE	Number of Containers
~~90527437~~ 425/438 Wolf Creek	D: May 26 T:	H2O		X																									X	X		
439/440 Icy Waters	D: May 26 T:	↓		X																									X	X		
441/442 Cockt Camp	D: May 26 T:	↓		X																									X	X		

USE ONLY

Dissolved metals to include: Mg, Ca, Na, K, As, B, I, Fe, Hg, Li, S

Relinquished by: Date Time Received by:
Relinquished by: Date Time Received by:
Total Number of Containers:

Method of Shipment: Waybill No.: Received for Lab by: UV Date MAY 27 2008 Time 2:30
Shipped by: Shipment Condition: Cooler opened by: Date Time

*Please indicate appropriate regulatory guidelines:
WATER ☐ CCME ☐ BC-CSR ☐ Other (please specify)
SOIL ☐ CCME ☐ BC-CSR ☐ Other (please specify)

FOR LABORATORY USE ONLY
Sample State at Receipt: ☐ Ambient ☑ Cold ☐ Frozen ☐ N/A Comments:
Temperature 7.9 °C Custody Seal Intact? ☐ Yes ☐ No ☑ n/a Number of Coolers/Shipping Containers: 1

EBA Per'g rate of $85/sample

CTT 119 Rev. 05/08 WHITE: FOLLOWS REPORT YELLOW: LAB COPY PINK: CLIENT COPY/GENERAL INFORMATION

APPENDIX

APPENDIX B UNVIERSITY OF WATERLOO LABORATORY REPORT

University of Waterloo

Department of Earth and Environmental Sciences
Faculty of Science

University of Waterloo
200 University Avenue West
Waterloo, Ontario, Canada
N2L 3G1

519-888-4567
Fax 519 746 7484

uwEILAB

June 24, 2008

Katherine Johnston, P.ENG
EBA Engineering
#150, 1715 Dickson Avenue
Kelowna, BC, V1Y 9G6

Dear Ms Johnston:

Enclosed please find the following:

1. Your Invoice EIL-0587
2. Your results from ISO file 2008394.

I hope you are happy with the results. As storage space is scarce, we can keep the samples here for two months, after which time we will empty and return them unless you have given us other instructions.

If you have any questions about this, please do not hesitate to call me at 519 888 4732 or e-mail me at mepatton@uwaterloo.ca.

Thank you for your support to uwEILAB.

Yours truly

Robert J. Drimmie
Manager, uwEILAB

Client: Johnston
EBA Engineering Consultants Ltd.

ISO# 2008394
Location:
11 for 18O, 2H

Environmental Isotope Lab
2008-06-19

#	Sample	Lab#	$\delta^{18}O$	Result	Repeat	$\delta^{2}H$	Result	Repeat
			H_2O	VSMOW		H_2O	VSMOW	
1	Alaska Highway 20-May	183629	X	-21.60		X	-168.85	-169.30
2	Tank Farm 23-May	183630	X	-22.12		X	-176.10	-175.53
3	Vanier 15-May	183631	X	-21.55		X	-174.24	-174.76
4	Riverdale TH1-80 15-May	183632	X	-22.34	-22.31	X	-176.99	-176.20
5	Yukon River 20-May	183633	X	-19.06		X	-151.47	-151.01
6	MacIntyre Creek 15-May	183634	X	-19.51		X	-158.78	-158.10
7	14 MacDonald Rd 15-May	183635	X	-21.26		X	-168.20	-168.29
8	Icy Waters 26-May	183636	X	-20.89		X	-166.57	-166.49
9	4-76 Porter Creek 16-May	183637	X	-21.01		X	-165.18	-164.98
10	Cadet Camp 26-May	183638	X	-20.26		X	-162.71	-161.96
11	Wolfe Creek 26-May	183639	X	-21.78	-21.82	X	-170.96	-170.29

To Contact uwEILAB:
519 888 4732

Robert J. Drimmie
uwEILAB Manager
rdrimmie@uwaterloo.ca
519 888 4567 ext 32580