

Yukon Energy Corporation

GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON

ISSUED FOR USE

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EXECUTIVE SUMMARY

Yukon Energy Corporation (YEC) retained EBA Engineering Consultants Ltd. (EBA) to carry out a ground-based geothermal reconnaissance program at three areas in central and southern Yukon:

- McArthur Hot Springs area (south of Mayo);
- Volcano Mountain area (near Fort Selkirk); and
- Haines Junction-Jarvis River area (Shakwak Valley).

These areas were suggested by Mr. Tim Sadlier-Brown, P.Ge., an independent technical advisor to YEC who collaborated with EBA on this project.

EBA completed the following tasks for this study:

- Geological background review and search area definition;
- Air photo interpretation to identify key targets in each search area;
- Reconnaissance-level ground geological survey with helicopter support to explore each area for evidence of existing or past hot spring or hydrothermal activity;
- Surface water and well survey (combined with the geological survey) to monitor and sample surface waters, springs and the warm Haines Junction municipal water well to gather hydrochemical and environmental isotope data;
- Geochemical and isotopic analysis to characterize the waters in the search areas and apply geothermometer formulas to infer temperatures that the spring/well waters had been exposed to in the subsurface;
- Conceptual geological models showing the hypothetical occurrence and movement of geothermal fluids in each search area;
- Preliminary assessment of geothermal potential and recommended follow-up work for each search area.

Fieldwork was carried out between September 8 and 16, 2008 by a team of three EBA staff, with field observations and monitoring at a total of 275 field stations in the three areas. Water parameters that EBA considered to be potentially useful to indicate the presence and character of geothermal waters (electrical conductivity, pH, temperature, and chloride) were measured in the field at selected field stations. A total of 13 water samples were collected (seven from McArthur Hot Springs area, three from Volcano Mountain area, and three from Haines Junction/Jarvis River area). These samples were analysed for physical parameters, cations/anions, dissolved metals, silicon, and environmental isotopes (oxygen-18 and deuterium). These parameters were chosen to characterize the water types, determine if the waters were of meteoric origin, and provide input data for geothermometer formulas.

Principal Field Observations

The prominent geothermal feature in the McArthur area is the McArthur Hot Spring complex, which was shown to be larger than previously mapped (area of about 150 m x 150 m) with 18 distinct spring outlets. Spring outlet temperatures there ranged from 12.5 to 51.9°C. Opal mineral crusts near outlets indicate historically higher flows (possibly seasonal or multi-year variations).

The prominent geological feature in the Volcano Mountain area is a cinder cone volcano with lava dome in its crater, and conspicuous blocky lava flows extending for kilometres to the south and north-northwest. Surface water temperatures were low (0 to 6°C), with one reading of 11.3°C (at Lava Lake). There was no direct evidence found for hydrothermal features (past or present) around Volcano Mountain.

The prominent geothermal features in the Haines Junction–Jarvis River area are a series of warm spring pools near the Jarvis River and the warm water, artesian municipal well at Haines Junction. Water temperatures at the warm springs ranged from 8.6 to 17.9°C, and was 15.6°C at the Haines Junction well.

Water Chemistry and Geothermometry Temperatures

A tri-linear plot of major ion water chemistry shows clear groupings for sodium-bicarbonate type geothermal waters and calcium-bicarbonate type cool surface waters. A few sample points fall outside these fields, and one sample (from surface drainage near Volcano Mountain) may be transitional between these fields.

Isotope results plotted with a meteoric water line show that all of the samples were likely of meteoric origin, which is consistent with other hot springs in western Canada. One sample (from Lava Lake, Volcano Mountain) is slightly enriched in oxygen-18 which may simply be due to evaporation and not an indicator of geothermal water.

Alkali- and silica-based geothermometer formulas were applied to the warm- and hot-geothermal water samples with the following results (all temperatures in °C):

Location ->	McArthur	McArthur	McArthur	McArthur	McArthur	Haines Junction Well	Jarvis River Warm Springs
Sample ID ->	M08S-2	M08S-4	M08S-6	M08S-12	Average	H08K-36	H08J-33
Geothermometer							
Alkali (Na-K-Ca)	117.5	129.2	117.4	118.7	120.7	65.5	100.1
Silica (SiO ₂)	163.7	154.7	159.8	149.6	156.9	110.4	110.5

The silica-based temperatures for McArthur Hot Springs are a lower bound to potential subsurface temperatures, due to (unquantified) loss of silicon due to rapid precipitation during sampling. Geothermal reservoir temperatures of at least 150°C are typically needed for commercial power generation, although power can be generated (less efficiently) with source water temperatures as low as 75°C.

Conceptual Geological Models

Conceptual geological models for the search areas all relate to structural geological controls on the downward infiltration of meteoric water, heating in the subsurface and upward migration along geological faults and discontinuities to the surface.

Preliminary Assessment of Geothermal Potential

This program shows evidence for medium- to high-temperature geothermal resources in both the McArthur Hot Springs and the Haines Junction-Jarvis River areas. Active warm or hot springs and a warm well were documented and sampled, with moderately high geothermometric temperatures (65.5 to 163.7°C) which compare with other geothermal occurrences currently being exploited for geothermal power generation in western North America.

The surface geothermal expression in the McArthur area shows the highest temperatures, but is focused at the hot springs complex. In contrast, warm waters in the Haines Junction-Jarvis River area occur over a larger area spanning tens of km. Geothermal resources may occur in fault-controlled settings elsewhere within the Shakwak Valley (from southeast of Haines Junction, to the northwest past Burwash Landing). There was no direct evidence of warm or hot water springs in the Volcano Mountain area, although the young geological history of this volcano suggests there may well be remnant heat within or near it.

Other candidate geological search areas (the Tintina Trench, south of the McArthur Hot Springs area, and the Alligator Lake/Takhini Hot Springs zone west of the City of Whitehorse) could also be investigated in a phased reconnaissance program.

Recommendations

1. For the McArthur Hot Springs area, clarify land ownership and access for further work, conduct satellite thermal image survey, low-level flying infrared survey, air-borne geophysics survey, and resample hot springs waters (including isotopes of helium, hydrogen and chlorine for further characterizing and age-dating geothermal waters).
2. Even though the Volcano Mountain area did not show direct evidence of hydrothermal activity, we recommend follow-up work to further explore fault-controlled drainage near Lava Lake, and elsewhere in the Selkirk Volcanic terrain south of Ft. Selkirk and on the Yukon River upstream of the mouth of Pelly River. This work should include a satellite thermal image survey, low-level flying infrared survey, resampling of hot springs waters (as described for McArthur Hot Springs), and air-borne geophysics survey.
3. For the Shakwak Valley area (southeast of Haines Junction northwest past Burwash Landing), conduct satellite thermal image survey, local knowledge survey, low-level flying infrared survey, air-borne geophysics survey, and resampling of warm springs and other target waters (as described for the McArthur Hot Springs above).
4. Consider a phased approach to geothermal resource exploration in other areas (e.g., the Tintina Trench area in central Yukon, Nash Creek north of Mayo, Alligator Lake/Takhini area west of the City of Whitehorse, and Swift River/Watson Lake area in south-eastern Yukon).

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1.0 INTRODUCTION

1.1 GENERAL

EBA Engineering Consultants Ltd. (EBA) is pleased to present this report issued for use to Yukon Energy Corporation (YEC) for the ground-based geothermal reconnaissance program at three separate areas in Yukon. We (EBA) understand that YEC is interested in pursuing a phased approach to identifying and assessing medium- and high-temperature geothermal resources in selected areas in Yukon. This is with a view of potentially generating electrical power within an economical distance from existing and proposed power grids to offset the need for additional capacity from conventional hydroelectric sources.

YEC has retained Mr. Tim Sadlier-Brown, P.Geo., an independent geological consultant from Vancouver, BC, as technical advisor for geothermal resource assessment. Mr. Sadlier-Brown has been involved to help guide this project and we understand will assist YEC in reviewing this report.

1.2 BACKGROUND

To put this effort in context, EBA has identified five phases for evaluating geothermal resources:

- Phase 1 - Satellite Imagery Assessment
- Phase 2 - Low-Level Flying Infrared Survey
- Phase 3 - Ground-based Geothermal Reconnaissance Assessment
- Phase 4 - Detailed Geophysical and Geological Confirmatory Assessment
- Phase 5 - Test Drilling Program.

In an earlier proposal to YEC, EBA presented a separate program for Phases 1 and 2. We understand funding for Phase 1 and 2 work is under review. This current work represents Phase 3. Phase 1 and 2 work can be used to supplement and compliment this ground-based work when funding is approved.

This sequence of work starting with Phase 3 is supported by substantial past geological assessment for geothermal resources carried out by Mr. Sadlier-Brown. From this past work, he has identified a series of specific search areas for potential geothermal resources in economically-favourable locations within Yukon. For budgetary reasons, only the top three most promising search areas were included in this program. These search areas (shown on Figure 1) are:

- McArthur Hot Springs area;
- Volcano Mountain (Fort Selkirk) area; and

- Haines Junction- Jarvis River area (Shakwak Valley).

More detailed site location plans for these areas are presented as Figures 2, 3 and 4.

Two other areas which could be considered in future are the Tintina Trench geological zone (southeast of McArthur Hot Springs area) and the Alligator Lake/Takhini Hot Springs area (west and northwest of Whitehorse).

1.3 PURPOSE AND SCOPE

The key objective of this study was to conduct a geological and hydrogeochemical investigation of the three search areas to characterize their potential for geothermal resources. In addition, we have identified a range of next steps useful for further understanding geothermal resources in these three areas, and for other search areas listed above.

The scope of this work involved a range of preparatory office activities (geological and geothermal background review, and air photo interpretation), followed by reconnaissance-level fieldwork (including geological and hydrogeochemical observations, field measurements and water sampling), laboratory analysis of water chemistry and environmental isotopes (oxygen-18 and deuterium), estimates of deep ground temperature (using hydrochemical geothermometer formulas), and a discussion of the results and next steps. The same level of effort was applied to each of the three search areas, with two field days in each area supported by helicopter (and ground vehicle for Haines Junction-Jarvis River area). No intrusive fieldwork (e.g., drilling) or geophysics was conducted for this program; these will be part of recommended future work.

After EBA's fieldwork was complete and preliminary water chemistry results were obtained, Tim Sadlier-Brown made a trip to Yukon to discuss the preliminary results and make a day-trip visit to selected warm spring sites in the Jarvis River area. Jack Dennett of EBA in Whitehorse met with Mr. Sadlier-Brown for this meeting and accompanied him on the site visit. This scope was beyond our original proposal, but was incorporated in our contingency budget for this work.

This report contains all of the findings, results, analysis, discussion, conclusions and recommendations for this assignment.

2.0 METHODS

2.1 GEOLOGICAL BACKGROUND AND TARGET DEFINITION

To better understand the location, size and geological characteristics of the three search areas, Scott Schillereff and Jack Dennett of EBA met with Tim Sadlier-Brown on August 29, 2008 in EBA's offices in Vancouver, BC. During this half-day meeting, this team discussed the geological and geothermal setting of the three areas, the results of past

scientific studies and reports on geothermal resources in Yukon, and identified specific search area limits using 1:50,000 topographic maps.

We discussed and confirmed our field approach for gathering reconnaissance geological information in and around the search areas, for monitoring field parameters for water and for obtaining and analysing water samples.

2.2 AIR PHOTO INTERPRETATION

EBA carried out a stereoscopic air photo interpretation (API) using the best available air photos for each search area. The currently available air photos were black and white, 1:46,000-scale photos, flown in the 1950s.

The API was used to identify the following:

- Fault traces and morphological lineaments that might indicate underlying geological structures or lithologic contacts;
- Gross features of bedrock lithology and erosion;
- Existing hot springs or seeps;
- Vegetation lineaments potentially related to underlying structural bedrock;
- Anomalous or dead vegetation areas potentially indicating warm/hot water seeps or springs (or former springs);
- Details useful for accessing and traversing the target areas;
- Areas of potential hazard from natural features or wildlife areas;
- Primary and backup helicopter landing zones (for field planning in case of emergency); and
- Stream survey target reaches, including helicopter set down and pick up points.

These features were marked on air photos and copied for the field team, along with blowups of 1:50,000 NTS topographic maps for orientation and field navigation.

2.3 GEOLOGICAL GROUND RECONNAISSANCE

The geological reconnaissance included the following:

- Initial helicopter fly-over for site overview and safety reasons (spotting active wildlife);
- Traverses along routes confirmed in the field between suitable helicopter landing spots to identify and map key geological features or hydrothermal areas of interest;
- Identify and map any active hydrothermal features found in the target areas (warm/hot springs or seeps);

- Identify and map rock staining or mineral precipitation potentially related to past hydrothermal activity. This included documenting surface encrustation (e.g., opal or travertine);
- Map main rock types, key geological structures and other geological features where exposed to help define the geological setting in each search area; and,
- Photograph and obtain GPS coordinates for all field stations (using hand held GPS unit).

For safety reasons and effective ground coverage, two geologists were deployed along with the water sampling technician (see below) in each search area. For speed and efficiency with a tight weather window, field programs were carried out with helicopter support in all areas (4WD vehicle also used in the Haines Junction-Jarvis River area). Helicopter support was provided by Trans North Turbo Air of Whitehorse, Yukon, using a Bell Jet Ranger III helicopter.

Prior to fieldwork every day, the EBA team held a tailgate-style safety meeting to discuss safety, weather and field logistics issues, including a helicopter safety check with the helicopter pilot.

2.4 SURFACE AND WATER WELL SURVEY

Surface water bodies (rivers, streams, ponds and lakes) and springs (hot, warm and cold) were identified from the air photo interpretation or encountered in the field. These sites along with the Haines Junction warm municipal water well were visited by an EBA water sampling technician who recorded the following information:

- Unique station label and UTM coordinates;
- Description and photograph (where useful);
- Water temperature;
- pH and Electrical Conductivity (EC); and
- Chloride (Cl) (using an ion-selective probe and meter).

Water temperature was a direct indicator of the presence of geothermal waters, or a mix of cool surface and hotter subsurface water. We anticipated that EC would be higher for geothermal waters, so measuring EC along streams can indicate where higher-conductivity geothermal waters are entering the stream. pH was measured in the field, as this was easy to do and field pH values are typically more reliable than laboratory-measured values. Typically, chloride (Cl) is higher in geothermal waters than in non-geothermal surface waters. For this reason, we included an ion-specific chloride probe in our field monitoring suite, in an effort to locate abrupt changes in surface water chloride content that could indicate a point where geothermal waters were entering a stream.

In this report, the field stations are identified using a convention so that each station label is unique. The generic labelling convention is as follows:

[Search area ID letter] [08] [Field staff ID letter] – [sequential number]

Where:

Search area ID = **M** (McArthur Hot Spring), **V** (Volcano Mountain) or **H** (Haines Junction- Jarvis River)

08 = **2008** (anticipating that additional work may take place in later years)

Field staff ID = **S** (Scott Schillereff), **J** (Jack Dennett), **K** (Katherine Johnston) or **D** (Dave Desmarais)

Sequential number = **1, 2, 3, ...** for each field person.

For example, M08S-2 refers to Schillereff's station no. 2 in the McArthur Hot Spring search area in 2008. This labelling convention provides unique labels for each station by each field person in all three search areas, and is used on all figures and data tables.

Field parameters for water were measured with portable instruments which were calibrated daily and checked against each other in the field. The instruments used are summarized in Table 1 below along with their resolution and accuracy data.

TABLE 1: SUMMARY OF FIELD WATER CHEMISTRY INSTRUMENTS			
Parameter	Instrument	Resolution	Accuracy
UTM Coordinates	Garmin handheld GPS	1 m	~7 m
pH	Hanna HI 98129 / Hanna HI 991300	0.01 pH units	0.01
EC	HI 98129/ HI 991300/ Oakton Instruments ECTestr 11	0.01 $\mu\text{S}/\text{cm}$	2% full scale
Temperature	Hanna HI 98129/ Hanna HI 991300/ Oakton Instruments ECTestr 11	0.1°C	0.5°C
Chloride	Cole-Parmer ion-selective electrode (for chloride)	0.1 mV	Variable (depends on concentration read off calibration graph)

The geology team members also carried hand-held pocket field meters for measuring water temperature/EC or temperature/EC/pH during their fieldwork. However, these readings were semi-quantitative and used mainly to document the general water character and determine if readings by the more accurate instruments were warranted. Measurements of pH, EC, and temperature using field pens were corrected where possible to be consistent with duplicate readings at the same station location by the water sampling technician using the more precise portable field instruments.

2.5 WATER CHEMISTRY AND ISOTOPE ANALYSIS

EBA collected 13 water samples from springs, creeks, and lakes within the three search areas (including the Haines Junction municipal well). Field station locations (for field observations and samples locations) are shown on Figures 2, 3 and 4. The water samples for each area are summarized below:

- MacArthur Hot Springs area (seven samples; Figure 2): Five at hot spring itself (M08S-2, M08S-4, M08S-6, M08S-11, M08S-12), and M08D-3 and M08D-10;
- Volcano Mountain (three samples, Figure 3): V08D-10, V08D-12 and V08D-17;
- Haines Junction – Jarvis River (three samples, Figure 4): H08J-33 (Jarvis River Warm Springs), H08D-39 (Jarvis River upstream of Warm Springs), H08K-36 (Haines Junction Municipal Supply Well).

Water samples were analyzed for hardness, alkalinity, cations and anions, dissolved metals and environmental isotopes of oxygen (oxygen-18) and hydrogen (deuterium). The major ion chemistry was included in order to classify the waters and determine their general chemical character. The metals analyses were used to support geothermometer calculations, specifically using sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and silicon (Si). Silicon was used to calculate the equivalent silica (SiO_2) concentration for use in the silica-based geothermometer formula. The environmental isotopes were included in order to plot them against a meteoric water line, to determine if the sample waters were of meteoric origin, or were fractionated to enriched oxygen-18 values which can be an isotopic characteristic of geothermal waters.

Water samples were collected in new, laboratory-supplied sample containers in accordance with laboratory recommended sampling procedures. Dissolved metals samples were field-filtered through a 0.45 μm filter and preserved with nitric acid (HNO_3). EBA field-diluted a sample from each location (1 part sample, 9 parts de-ionized water) for a diluted silicon analysis. This dilution retards silicon precipitation prior to analysis. Using this ratio, the laboratory result for the diluted sample can be multiplied by 10 to get the original concentration prior to dilution.

The water sample from the Haines Junction well (H08K-36) was collected from a pre-treatment hose bib located in the pump house. The other samples were collected directly from the spring or creek. A full backup set of samples was collected in case of shipping problems

Water samples were shipped on ice by air cargo to the laboratory. Inorganic water chemistry was analyzed by Cantest Environmental in Burnaby, British Columbia. Isotope analyses were conducted by the University of Waterloo Environmental Isotope Laboratory in Waterloo, Ontario. Due to an inadvertent miscommunication about the alkalinity analysis, our backup set of water samples was required for alkalinity analysis. When received, these backup samples had exceeded the nominal maximum holding time.

However, we still included the alkalinity results in this report and consider them useable for this reconnaissance-level assessment.

2.6 CONCEPTUAL GEOLOGICAL MODELS

Extensive research exists to evaluate thermal spring sources throughout the world, much of which is associated with potential geothermal development. In particular, considerable effort has been applied to investigate the geological environment of thermal springs in the Cordillera Region of North America, from the Rocky Mountains to the west coast. Geological models have been developed in the literature to represent the theoretical origin of thermal springs at many specific sites. A number of these models were reviewed and compared to the geological setting of the three study areas investigated for this project.

Reports and mapping of bedrock and structural geology for each of the three search areas were studied and compared to thermal system models that have been developed for hot springs in other regions. Research was focused on thermal sites of the Cordilleran region of western Canada. Conceptual models for each study area were constructed to represent a hypothetical thermal system with a geological setting that would correlate with known site geology. Section 4.4.1 provides a more detailed discussion of thermal system models. Conceptual geological models are reproduced as Figures 10, 12 and 14.

Since bedrock exposures and clear structural controls were sparse in all three search areas, the conceptual geological models presented here are necessarily simplistic and uncertain. With additional remote sensing, field and geophysical information (see recommendations), these conceptual models could be refined and improved.

3.0 RESULTS

3.1 FIELD OBSERVATIONS AND DATA

A summary of field observations and data is compiled and presented as Table A1 in Appendix A. A total of 275 field stations were documented in all three areas during this program. Representative photos subdivided for each search area are also attached at the end of this report.

3.1.1 McArthur Hot Springs Area

The McArthur Hot Springs search area (Figure 2) spanned 5.6 km east-west and 2.2 km north-south. A total of 78 field stations were documented in this area during fieldwork on September 9 and 11, 2008.

The key geothermal feature in this area is the McArthur Hot Spring complex itself (Figure 5, Photos M1 and M2). This complex had 18 distinguishable spring vents or seeps over an area approximately 150 m x 150 m. This size and number of vents is larger than previously documented (van Everdingen 1973). Water temperatures at the hot spring complex range from 12.5 to 51.9°C. The hottest spring outlet is at M08S-2 (Figure 5, Photo M5) which

corresponds with van Everdingen's spring outlet No. 1 which he reported had a temperature in 1973 of 54°C. There was a faint hydrogen sulphide (H₂S) smell at M08S-2, but was not noted at the other spring outlets. At the hot springs complex, electrical conductivity (EC) ranged from 149 to 298 µS/cm, pH ranged from 7.13 to 7.34 (with one anomalous value of 9.18 at M08S-6A), and chloride measured by ion-selective probe in the field ranged all below discernable values. For the hottest spring outlets, water sample field filtering was difficult, with clear gelatinous precipitate building up on the disposable filter membranes. This is interpreted to be amorphous hydrous silicate (opal) precipitating as the samples cooled in the cool fall air temperatures (typically 5-10°C air temperature).

A conspicuous white mineral crust was present on cobbles and boulders downstream of the vents (e.g., Photos M7, M11 and M16). X-ray diffraction studies of earlier samples from this spring show this to be primarily opal (amorphous hydrated silica mineral) (Photo M21). The white opaline bands show the height of past spring discharges. Importantly, numerous vents showed opal crusts up to 13 cm above the current water level (Photo M16). This indicates that past spring discharges have been much higher. One location, downstream of M08S-12 (Photo M18), shows two sets of opal bands, one lower and pronounced, and the other higher and less distinct. These two bands suggest different historical ranges of flow (perhaps a seasonal or short multi-year variation for the lower band and an older historic high flow for the upper band with its opal crust largely weathered away).

Hot water vents also showed a variation in the type and distribution of algae and mineral precipitates in outflowing water (e.g., Photo M13). Typically, dark green filaments of algae marked the hottest water nearest the vents (Photos M10 and M11), with other more clumping masses of green and pink algae forming in cooler water several meters away (Photo M12). Irregular masses of orange-brown iron hydroxide precipitate (Photo M14) form from 5-10 m downstream of the hottest vents (temperatures above about 40°C), attributed to cooling and oxygenation of the discharging waters.

Ferns, water cress, mint species, grasses and other warm climate vegetation (Photos M3, M4 and M8) are present within the open area of the McArthur Hot Spring complex (Figure 5). These can be considered as signature plants in looking for other hot water spring occurrences in the Yukon boreal forest.

In other parts of the search area there were abundant cold springs both along Hotspring Creek and along the higher tributary valleys. These springs were typically cold with temperatures less than 5°C, with EC 200 µS/cm or less and near-neutral pH. These field parameters are typical of shallow groundwater discharge from local meteoric sources.

Although vast talus deposits are present along upper valley slopes to the east of the McArthur Hot Spring complex (Photo M22), actual bedrock exposures are sparse. A granodiorite outcrop was documented at M08J-22, a granodiorite/diabase contact was noted 50 m northeast of M08J-24, and an outcrop of foliated, jointed metasedimentary rocks was observed at M08J-26 (refer to Figure 2). An important observation is that the intrusive granitoid/metasedimentary geological contact could be closer to the hot spring

occurrences than is shown on regional geological maps (Roots, 1993). In addition, the orientation of the linear valley at the hot springs is consistent with a cross fault, at a 60° angle to the regional fault trend. The hot spring complex discharges through unconsolidated valley fill overburden deposits (till, colluvium and alluvial sediments), but the bedrock float is conspicuously bimodal with about 70% metasedimentary rocks and 30% granitoid clasts (Photo M15; tan rocks are granitoids and dark grey rocks are metasediments).

3.1.2 Volcano Mountain Area

The Volcano Mountain search area (Figure 3) spanned 8 km east-west and 11 km north-south. A total of 54 field stations were documented in this area during fieldwork on September 8 and 10, 2008.

The conspicuous geological feature in this area is the cinder cone of Volcano Mountain (Photo V1) and the blocky lava flows (Photo V8) that have spread to the southwest and north of the volcano (Figure 3). A well-formed lava dome is present within the volcanic crater (Photo V2 and V8). While there was thin soil and sparse vegetation within the crater, we found no sign of surface water bodies, running water or evidence of hydrothermal vents at or near the summit of Volcano Mountain. Cold water springs and intermittent streams were observed on the flanks of the volcano below about 3,000 feet elevation.

A small stream south of Volcano Mountain has been dammed by a lava flow and impounded to a small lake (“Lava Lake” on Figure 3). This water overflows from the lake along the southern boundary of the lava flow, back into the original water course. A promontory of lava into this lake (V08D-10) was used for a water sampling point and a useful helicopter landing spot.

The drainages northeast of Volcano Mountain (V08D-11 to V08D-16) are a string of slow-moving channels, pools and wetlands (sample taken at V08D-12). This near-stagnant water bears on the interpretation of isotope results (discussed in Section 4.2).

An interesting feature of the area is absence of water in a large grassy depression, about 30 m deep, located 1.5 km east of Volcano Mountain (“Jack’s Pond” on Figure 3, Photo V5). This depression was shown as being full on a 1950 vintage air photo, and was only 1/3 full on a 1989 air photo. It is now grass-filled, but no succession of major shrubs or trees (Photo V6), suggesting the complete draining has been recent. (since 1989).

In the Volcano Mountain search area, electrical conductivities mostly ranged from 76 to 263 $\mu\text{S}/\text{cm}$ (with one anomalous reading of 1,496 $\mu\text{S}/\text{cm}$ at V08D-1), pH readings mostly ranged from 7.04-7.54 (with one anomalous value of 5.87 at V08D-2), and temperature observations mostly ranged from 0 to 6°C. The warmest recorded temperature in this area was 11.3°C at V08D-10 (Lava Lake).

3.1.3 Haines Junction-Jarvis River Area

The Haines Junction-Jarvis River search area (Figure 4) spanned 13 km east-west and ~8 km north-south. A total of 145 field stations were documented in this area during fieldwork on September 15 and 16, 2008.

The key geothermal features in this area are warm springs encountered along the Jarvis River about 4 km south of Sulphur Lake, and the warm water artesian well at Haines Junction (inset on Figure 4). A second warm water occurrence was noted along the Jarvis River about 3 km east of the main warm springs (at location H08D-39).

In the entire area, electrical conductivities ranged from 54 to >4,000 $\mu\text{S}/\text{cm}$, pH readings ranged from 6.20 to 9.26, and temperature observations ranged from 2.7 to 17.9 °C (at the Jarvis River warm springs). In general, water in this overall area had higher electrical conductivity and pH (more basic) compared with waters in the other search areas.

An aerial overview photograph of the Jarvis River warm springs (Figure 6) shows it is located at the base of lacustrine silt-clay cliffs. A total of six separate spring outlets are documented which are connected by surface water channels. The area includes two major pools (H08J-33 to the east and H08D-20 to the west). The eastern pool (Photo H6) is about 4 m in diameter and up to about 1.5 m deep. The western pool is about 3 m in diameter and up to about 0.6 m deep. Temperatures at the warm springs range from 8.6 to 17.9°C. These mild water temperatures have not been enough to support exotic vegetation (e.g., ferns) such as are found at the McArthur Hot Springs. At the warm springs, electrical conductivity mostly ranged from 595 to 690 $\mu\text{S}/\text{cm}$ (with one anomalous value of 1,343 $\mu\text{S}/\text{cm}$ at H08D-23), pH ranged from 6.97 to 7.92, and chloride determined from field measurements ranged from 1 to 2 mg/L. This was the highest field-determined chloride values in any of the three search areas.

Groundwater discharge at the warm springs is accompanied by an audible bubbling sound as the discharging groundwater degasses through the silty bottom of the warm springs. Water from the warm springs drains to a series of ponds approximately 150 south west of the main pools which in turn discharge to the Jarvis River.

3.2 WATER CHEMISTRY AND ISOTOPE ANALYSIS

3.2.1 Water Chemistry

Table 2 presents a summary of water chemistry and isotope analytical results. A tri-linear plot of major ions is shown in Figure 7.

McArthur Hot Spring Area

Table 2 shows water samples from the McArthur Hot Springs complex are sodium-bicarbonate type and soft (hardness 14 mg/L or less). On Figure 7, these hot spring waters cluster together and are within a group labelled warm-hot geothermal waters. Fluoride concentrations from the hot water samples ranged from 7.3 to 7.61 mg/L. Diluted silicon

results for these waters ranged from 2.63 to 7.28 mg/L. Applying the 10-fold correction due field dilution, the corrected silicon concentrations at the spring outlets was calculated to range from 26.3 to 72.8 mg/L. Note all silicon values in this report were used to calculate equivalent silica (SiO_2) values for purposes of applying the silica geothermometer (see Section 4.3.2).

The water sample from South Brook (M08D-10) is a calcium-sulphate type water and harder (44 mg/L) than the hot spring samples. On Figure 7 it plots separately from other samples.

The water sample from the headwaters of Hotspring Creek (M08D-3) is calcium-bicarbonate type water with low hardness (6 mg/L). On Figure 7, this sample plots with a cluster of cool surface water samples. Corrected silicon concentrations for M08D-3 and M08D-10 were low (2.7 and 8.0 mg/L, respectively).

Volcano Mountain Area

Table 2 shows that the samples from Lava Lake (V08D-10) and the near-stagnant drainage northeast of Volcano Mountain (V08D-12) were calcium-bicarbonate type waters, with moderate hardness (both 51 mg/L). Corrected silicon concentration for these samples was low (6.3 mg/L for V08D-10 and 9.2 mg/L for V08D-12).

The sample from the drainage north of Volcano Mountain (V08D-17) was sodium-bicarbonate water, with moderate hardness (57 mg/L) and moderate chloride (4.33 mg/L). On Figure 7, this sample appeared to be transitional between the cool surface water field and the warm-hot geothermal waters field. This is supported by a corrected silicon (Si) concentration of 18.7 mg/L, also transitional between the low values of cool surface waters and higher Si values of the geothermal waters.

Haines Junction-Jarvis River Area

Table 2 shows that the sample from the Haines Junction warm water well (H08K-36) was a sodium bicarbonate type water, with low hardness (9 mg/L). This sample plots within the warm-hot geothermal water field on Figure 7. Corrected silicon for this sample was 27.7 mg/L.

The sample from the Jarvis River warm spring (H08J-33) was a sodium bicarbonate type water, with moderate hardness (66 mg/L) and the highest chloride concentration of any of the samples (26.6 mg/L). Corrected silicon for this sample was 27.8 mg/L.

The sample from the Jarvis River east of the warm springs (H08D-39) was a calcium-bicarbonate type water, with the highest hardness of all the samples (95 mg/L). The corrected silicon for this sample was low (7.3 mg/L).

3.2.2 Isotope Analysis

Figure 8 presents the results of the oxygen-18 and deuterium environmental isotope analyses along with meteoric water lines (global, average Whitehorse, and range for Whitehorse). Laboratory isotope data are presented at the back of Appendix B. The oxygen-18 and deuterium results are expressed in per mil units (parts per thousand) in relation to standard mean ocean water (SMOW). The bars adjacent to each point represent the uncertainties in the analysis. The error bars appear to be compressed for deuterium, but this is simply a function of the large range of deuterium.

Oxygen-18 values for the samples ranged from -25.61 to -16.63 per mil. Laboratory replicates (3) were within 0.32 per mil. Deuterium values ranged from -197.97 to -147.59 per mil. Laboratory replicates (13) were within 0.71 per mil.

Figure 8 shows that all of the samples plot within the potential range of the Whitehorse meteoric water line. Most samples plot close to the average Whitehorse meteoric water line, which is shifted to the right (toward heavier oxygen-18 values) by about 0.5 per mil compared with the global mean water line.

One sample (V08D-10) is noticeably fractionated toward heavier oxygen-18 values compared with the trend of the other samples. This fractionation is not strong though (only about 1.5 per mil).

4.0 ANALYSIS AND DISCUSSION

4.1 NATURE AND SIGNIFICANCE OF WATER CHEMISTRY

The low chloride concentrations and electrical conductivity at the McArthur Hot Spring complex are consistent with earlier field and laboratory studies at the spring site, and makes this spring rare if not unique in Canada (van Everdingen 1973). This water chemistry suggests that dilute meteoric waters are infiltrating, heating up and discharging at the hot springs without long residence time to acquire a stronger ionic content (including chloride). This, along with the physiographic setting high in an intermontane valley, suggests that source waters are local, probably derived from local recharge at adjacent mountain slopes and ridges.

In contrast with the McArthur Hot Spring waters, the Jarvis River warm springs waters have higher Cl and EC, which are more typical of far-travelled geothermal waters with longer travel times. The different inorganic chemistry of McArthur Hot Spring and Jarvis River warm spring waters suggests either different conceptual models of geothermal fluid movement or markedly different rock-water interaction during transit. The Jarvis River warm springs, situated in the Shawkak Valley, with high relief mountains (Kluane Range) adjacent, may also be in a discharge zone for intermediate and regional groundwater flow systems (i.e., longer travel paths and residence times).

The high fluoride concentration in McArthur Hot Spring waters is typical of waters in contact with granitoid rocks (which typically contain fluorite). This chemical signature supports a concept that the McArthur Hot Spring waters are in direct contact with granitoid rocks in the subsurface.

Cool surface water samples all plot in a diffuse cluster within the calcium-bicarbonate field on Figure 7. This is useful for differentiating these waters, typical of shallow groundwater of meteoric origin, from geothermal waters.

The transitional water on Figure 7 (V08D-17) may be due to mixing of cool surface waters with warmer geothermal waters. However, this sample may simply have been in contact with more sodium-rich soils leading to its transitional plot location. We do not have enough supporting data at this reconnaissance level to confirm if this sample represents a warm water sample diluted with cool surface water.

The hot waters discharging at McArthur Hot Spring complex are supersaturated with respect to Si, causing what we interpreted to be opal precipitation as the sample cooled during field-filtering. Such Si precipitation means there was a degree of silicon loss during sample handling. This in turn means that the corrected laboratory Si values reported for these samples is likely lower than the actual Si concentrations at the spring outlets. Thus the temperatures calculated below using a silica geothermometer, for which temperature is proportional to silica and in turn silicon concentration, should be considered as a lower bound of actual subsurface temperatures. We expect such silicon loss (and resulting underestimated geothermometer temperatures) would be reduced if sampling procedures could be revised to inhibit precipitation in the field.

On Figure 7, all the warm-hot geothermal waters cluster compactly in the sodium-bicarbonate field. The strong Na-K content of these waters supports using an alkali-based geothermometer formula in estimating their subsurface temperature. In addition, the lack of substantial magnesium (Mg) content in the geothermal water samples means that there should not be a Mg bias in the alkali-based geothermometer results.

4.2 NATURE AND SIGNIFICANCE OF ISOTOPE RESULTS

The predominance of samples falling along or near the Whitehorse average meteoric water line on Figure 8 strongly suggests that all of these waters were of meteoric origin. This is borne out by the fact that the data point for the hottest geothermal water sample collected (M08S-2), sits squarely on the meteoric water line, and shows no fractionation compared with cold, meteoric water from the headwaters of Hotspring Creek (M08D-3).

Typically, high-temperature geothermal waters are enriched in oxygen-18 due to mixing with strongly enriched magmatic waters (e.g., Garcher and Arehart 2008). However, oxygen-18 enrichment can also occur from rock-water interaction (contact with enriched oxygen-18 in rock-forming minerals) due to prolonged residence time underground, or simply due to evaporative fractionation of the surface water body where the sample was collected. Sample V08D-10 was collected as a surface dip sample from Lava Lake

(Figure 3). This lake impounds a minor stream and would have very little throughput and long water residence time before overflow. Thus, a simple explanation for the oxygen-18 enrichment at V08D-10 is that it represents surface water evaporation, rather than evidence for geothermally-affected surface water.

4.3 GEOTHERMOMETRY

4.3.1 Choice of Geothermometers

There are a wide range of empirical chemical geothermometer formulas in the literature. One group is based on the equilibrium reached among alkali elements (sodium (Na), potassium (K) and calcium (Ca)) where reservoir rocks contain abundant quartz and feldspar (Fournier and Truesdell 1973). Another group is based on the solubility of various mineralogical forms of silica (SiO₂) in hot geothermal waters. Silica solubility is rate-dependent, so waters that gain silica at elevated temperatures only slowly release that silica as the waters cool (i.e., as they move upwards and discharge at the surface). For this reason, the silica content of discharging geothermal waters can be used to calculate the approximate maximum subsurface temperature at which the water acquired the silica content.

Some of the prominent formulas are presented in Table 3.

TABLE 3: COMMON GEOTHERMOMETER FORMULAS			
#	Formula	Source	Comment
Alkali-based formulas			
1	$T^{\circ}\text{C} = \{1647 / [(\log(\text{Na}/\text{K}) + B(\log(\sqrt{\text{Ca}}/\text{Na}) + 2.06) + 2.47)]\} - 273.15$	Fournier and Truesdell, 1973	B = 4/3 below 100°C and 1/3 above 100°C; useable for T > 70°C, best 180-300°C
2	$T^{\circ}\text{C} = [1217 / (\log(\text{Na}/\text{K}) + 1.483)] - 273.15$	Fournier 1981	Alkali formula using Na and K only
3	$T^{\circ}\text{C} = [876.3 / (\log(\text{Na}/\text{K}) + 0.8775)] - 273.15$	Diaz-Gonzalez and Santoyo, 2008	Updated using world database of geothermal fluids
4	$T^{\circ}\text{C} = [1289 / (\log(\text{Na}/\text{K}) + 1.635)] - 273.15$	Verma and Santoyo 1995	Updated using an error propagation method, with Fournier's original data
Silica-based formulas			
5	$T^{\circ}\text{C} = [1309 / (5.19 - \log\text{SiO}_2)] - 273.15$	Fournier 1981	Silica form is quartz with no steam loss; best for T > 180°C
6	$T^{\circ}\text{C} = [1522 / (5.75 - \log\text{SiO}_2)] - 273.15$	Fournier 1981	Silica form is quartz with steam loss from reservoir; best for T > 180°C
7	$T^{\circ}\text{C} = [1032 / (4.69 - \log\text{SiO}_2)] - 273.15$	Garcher and Arehart 2008	Silica form is chalcedony; best for T = 180-140°C
8	$T^{\circ}\text{C} = [731 / (4.52 - \log\text{SiO}_2)] - 273.15$	Garcher and Arehart 2008	Form is amorphous silica; best for T < 140°C

TABLE 3: COMMON GEOTHERMOMETER FORMULAS			
#	Formula	Source	Comment
9	$T^{\circ}\text{C} = -44.119 + 0.24469(\text{SiO}_2) - 1.7414$ $E - 4(\text{SiO}_2)^2 + 79.305\log(\text{SiO}_2)$	Verma and Santoyo 1995	Updated using an error propagation method, with Fournier's original data; useful for T = 20-210°C

Note: all concentrations in molality (mg/kg). For water with density ~1 kg/L, concentrations of mg/L can be used.

Due to the dilute nature of McArthur Hot Springs water (which does contain measurable K and Ca along with the dominant Na) and the Ca-K-Na mix in Jarvis River warm spring water, we have chosen to use the classic alkali formula no. 1 (Fournier and Truesdell 1973) with the constant term B = 1/3 (assuming subsurface temperatures are over 100°C).

For a silica geothermometer, we chose to use formula No. 9 (Verma and Santoyo 1995) since this is an update of Fournier's original formula and is applicable for temperatures ranging from 20 to 210°C. These formulae fit the hydrochemical setting and temperature ranges expected for the three search areas, and provide a reasonable estimate of subsurface temperatures for purposes of this reconnaissance study.

In applying the silica geothermometer, we assumed that for the waters sampled in this program, silicon (Si) is always bound as silica (SiO₂). In this study, the dilute sample silicon (Si) concentrations reported by the laboratory were first multiplied by 10 to determine the undiluted silicon concentration at the sampling point. The corrected silicon concentrations were then multiplied by 2.14 which is the ratio of atomic weights of Si and SiO₂. This calculated SiO₂ value was then used in the silica geothermometer formula. For example, the diluted Si concentration for sample M08S-2 was 7.28 mg/L. The corrected Si concentration was 72.8 mg/L and the calculated SiO₂ concentration was 155.8 mg/L.

4.3.2 Calculated Temperatures

Table 4 shows the calculated subsurface temperatures using the alkali (Na-K-Ca) and silica geothermometer formulas for waters that fell within the warm-hot geothermal water field on Figure 7 (McArthur Hot Spring samples (M08S-2, -4, -6 and -12), Haines Junction warm water well (H08K-36), and the Jarvis River warm spring (H08J-33)).

TABLE 4: SUMMARY OF CALCULATED SUBSURFACE TEMPERATURES							
Location ->	McArthur	McArthur	McArthur	McArthur	McArthur	Haines Junction Well	Jarvis River Warm Springs
Sample ID ->	M08S-2	M08S-4	M08S-6	M08S-12	Average	H08K-36	H08J-33
Geothermometer							
Alkali (Na-K-Ca)	117.5	129.2	117.4	118.7	120.7	65.5	100.1
Silica (SiO ₂)	163.7	154.7	159.8	149.6	156.9	110.4	110.5

Note: all temperatures in degrees Celcius (°C).

4.3.3 Nature and Significance of the Geothermometer Temperatures

For the McArthur Hot Springs complex, the alkali-based geothermometer temperatures (117.4 to 129.2°C; spread of 11.8°C) were very similar to the silica-based temperatures (149.6 to 163.7°C; spread of 14.1°C). These temperatures are somewhat higher than the silica-based temperatures (116 to 130°C) reported for the McArthur Hot Springs by Crandall and Sadlier-Brown (1978). [Note: the alkali-based temperatures they reported were much lower (75 to 76°C). However, those results are suspect, since the Na-K-Ca geothermometer formula they used was missing a constant (2.06) in the denominator.]

Since there may have been some silicon lost at the time of sampling at McArthur Hot Springs (due to silica gel precipitating on the filter apparatus), we consider these silica-based temperatures to be a lower bound of actual temperatures. Without knowing the amount of silicon loss, there is no way to determine how much this bias might be or to correct for it. Future sampling methods should be adjusted to avoid silicon loss in order to obtain more certain silica-based geothermometer results.

In the Haines Junction-Jarvis River samples, the geothermometer results were more variable and mixed. For the Haines Junction well and Jarvis River warm springs samples, the silica-based temperatures were higher than the alkali-based temperatures. In general, the results indicate that the subsurface waters in the Haines Junction-Jarvis River area appear to be about 20 to 55°C cooler than the average temperatures at McArthur Hot Springs.

4.4 CONCEPTUAL GEOLOGICAL MODELS

4.4.1 Geological Setting of Hot Springs in Western and Northern Canada

The processes that can occur in hydrothermal systems are perhaps the most complex and dynamic of any fluid resource. Geologic models of hydrothermal systems are typically simplified in order to better understand the source and transport mechanism, but the complexity of hydrothermal occurrences should not be underestimated.

Geological models of hot springs have three main components: downward mobility of surface (meteoric) water to depth, a sub-surface heat source, and a suitable conduit back to the surface. Heat sources are primarily epithermal (shallow volcanism) or magmatic (deep heat from the earth's molten core). Primary permeability of host rocks and secondary permeability of faults and other discontinuities act as conduits to the surface (Grasby and Hutcheon, 2001). Deep circulation of meteoric water to reach a suitable heat source requires pervasive, high porosity, fracturing or faulting in the bedrock. A high angle fault is typically required to rapidly transport heated water to the surface. Each of the three search areas evaluated for this project have a geological setting consistent with these conditions.

Generally, the temperature of rocks in the earth increases with depth (according to a geothermal gradient). This temperature gradient is variable and is affected by rock type,

porosity, depth to magma, proximity to plate tectonic features (e.g., subduction zones) and recent volcanism. Typically, the geothermal gradient is assumed to be about 1°C per 30 m (or 33°C per km) below ground surface. At this rate, 0°C water flowing through deep fractures would reach 100°C at a depth of 3 km. Geothermal gradients in southern BC range from 20 to 50°C per km, with an average value of 31°C per km (Grasby and Hutcheon, 2001). Temperature is controlled by the depth of circulation, which is influenced by fault plane geometry. Hydraulic permeability within the fault zone controls the rate of fluid circulation. Calculated circulation depths for meteoric water involved in thermal spring systems of the Canadian Cordillera range from 1.6 to 4.8 km.

If water percolates deeply enough into the crust, it will be heated simply by coming into contact with hot rocks. The water from hot springs in non-volcanic areas is heated in this manner. Underground water, both meteoric (originating at the surface) or magmatic (ancient water stored deep underground in a porous rock reservoir) can also be heated by an intrusive body (magma). Some hot springs in the Kootenay region of southeast BC are thought to be heated by a near-surface intrusive, as the apparent temperature gradient in this area is reported by underground miners to be greater than normal (McDonald, 1981). In volcanic zones such as Yellowstone National Park, water may be heated by coming into contact with magma (molten rock).

The source of most thermal springs is meteoric water percolating down through fractures and super-heated to be forced up a sealed route in a deep, high angle fault to emerge at the surface. Heated water may also accumulate in a sub-surface reservoir of porous rock, where it is tapped by faults that provide a conduit to the surface. Stable isotope compositions of waters from thermal springs across the Canadian Cordillera are consistent with a meteoric origin (Grasby and Hutcheon, 2001).

Key to the successful upward migration of thermal water to the surface is the development of a sealed conduit within a fault system that forms an express route to the surface. If the water moves slowly from depth to the surface, it will cool down before emerging as a spring. Where springs occur in limestone formations, water flow paths may be enlarged by dissolution creating a virtual pipeline to the surface. This can cause rapid upward flow and higher water temperature of thermal springs at the surface.

Favourable conditions may result from lithology and/or fault geometry that act to seal a section of a fault system to inhibit lateral distribution of thermal fluids. Deposition of minerals dissolved in thermal fluids due to changes in temperature, pressure or mixing with other fluids is the most likely process in the formation of a sealed conduit to carry thermal fluids to the surface. Thermal springs commonly develop large tufa deposits; however, deposition of tufa may eventually seal off the flow to the surface.

Hot springs of Western Canada can be classified in two broad groups, one associated with deformed sedimentary strata and faulting (between the coast and the Rocky Mountain Trench), and another following the coastal areas and into the Yukon (associated with intrusives, crustal-scale faulting and areas of recent volcanic activity). Formation of many of

the larger thermal springs in the Rockies tends to be quite consistent and follow fractures in the folded and uplifted sedimentary rocks of the Rockies that penetrate deep into the earth.

The primary control on the distribution of thermal springs in the southern Canadian Cordillera appears to be the existence of brittle faults that provide a high-permeability flow path for deep-circulating meteoric water. Infiltration rate or heat flux does not appear to have a significant influence on the distribution of springs (Grasby and Hutcheon, 2001).

The local geological setting of thermal springs varies considerably. In most cases a thermal spring consists of several vents of varying temperature that may be in close proximity or widely-spaced. Where bedrock is at surface, thermal springs may be observed to vent directly from jointing and provide direct evidence of the host rock and clues to the thermal model. In many cases, springs well up through unconsolidated material such as colluvium at the base of a slope or glacial till

Advanced exploration of geothermal targets should include detailed mapping of major geological structures in the study area to determine the attitude of faults. Fault attitude and location plays a crucial role in the function of geothermal systems. They act as effective conduits for fluid flow along the fault but they may also be effective barriers to fluid flow across the fault. The circulation depth of geothermal systems may be a function of the depth to the fault plane below the recharge area. The dip of the fault appears to play a significant role in the depth to which water circulates (Grasby and Hutcheon, 2001).

4.4.2 Geological Model for McArthur Hot Springs Area

McArthur Hot Springs is a series of at least 18 vents with active flows emanating through valley fill overburden deposits (alluvial and/or glacial deposits and colluvium). The geological setting at the hot spring site is modern with no apparent fossil precipitates and no travertine deposits. Some white opaline silica (Crandall and Sadlier-Brown, 1978) sinter occurs on pebbly gravels next to vents and along vent outflows. Cobbles and boulders of altered siltstone and mudstone and granitoid rocks are common at the site but the nearest exposed bedrock was observed about 1.5 km to the east.

McArthur Hot Springs lies within the Selwyn Basin at the northern edge of the Selwyn Fold Belt. A Cretaceous Age (135 my) intrusive body, the McArthur Pluton, is a significant geological feature in the McArthur Hot Springs area. The thermal springs are located at the southwest margin of the pluton, where it intrudes sedimentary and meta-sedimentary rocks ranging in age from Late Cambrian (> 500 my) to Lower Devonian (350 my). Units include black siltstone, mudstone and chert of the Road River Group and mudstone, siltstone, interbedded sandstone and schist of the Hyland Group (Figure 9). Fold axes, geological contacts and major faults are oriented in a southeast/northwest direction. The McArthur Pluton itself is similarly oriented, parallel to a prominent linear geomorphological feature in the Yukon region, the Tintina Trench (located 8 km south of the thermal springs).

A regional, high-angle fault is mapped about 5 km southwest of the hot springs. Parallel folding and associated fracturing of the metasediments presents a suitable environment for

deep sub-surface migration of meteoric water. The proximity of the hot springs and the alteration and structure associated with the intrusive pluton contact could provide a pathway from a geothermal reservoir at depth to the surface (Figure 10). Residual heat of the McArthur Pluton may also elevate the regional temperature gradient.

McArthur Hot Spring is located along a reach of Hotspring Creek that follows a linear valley which is at a 60° angle with the trend of regional faulting. Cross (or subsidiary) faults typically form angles of 60° with a main fault. Enhanced permeability of such cross-faults would provide conduits for a rapid ascent of heated water to the surface. There may also be convective water circulation within a fault zone, where water recharges at one location, percolates downward and finds its way to hot springs within the same fault. In addition (and applicable to any hot springs), the full discharge of geothermal water may not occur at the hot springs; there may be some lateral leakage at depth along permeable zones or geological contact zones.

Evidence for changes in the range of historic hot spring discharge (different bands of opaline crusts on boulders near the vents), suggests that the rate of this hot spring circulation, or its discharge points has varied during the life of the hot spring complex. One explanation for flow path changes may be changes in rock mass permeability or flow paths in response to recent geological events (e.g., earthquakes).

4.4.3 Geological Model for Volcano Mountain Area

Volcano Mountain is the site of the youngest volcanic activity in the Yukon and the most northerly volcanic field in Canada. The Selkirk Series Volcanics cover the Volcano Mountain study area (Figure 11). These rocks consist of Modern (Early Pleistocene) basalt and andesite flows, breccias, volcanic ejecta, hyaloclastite and tuffs. These relatively young volcanic rocks are extensive and reach as far as the Yukon River 15 km to the south. Selkirk Volcanics also occur at a separate deposit located 30 km south of Volcano Mountain and at a small cone 4 km south of the Pelly River mouth. Cumulative basalt flow thicknesses are reported to be greater than 100 m where they have filled valleys (Jackson, 1997). Unconsolidated glacial deposits underlie and are interstratified with the volcanics. Slightly older Tertiary basalt, andesite, dacite and trachyte flows, breccias and tuffs of the Carmacks Volcanics fringe and underlie the Volcano Mountain area.

Volcano Mountain volcanic deposits are the youngest of the Selkirk Volcanics, range in age from Pleistocene to Recent. The deposits are less than 10,000 years old but the age of the most recent eruptions are unknown. The site is a suitable target for geothermal potential since the source of recent epithermal activity may be relatively shallow and the local geothermal gradient may be higher than normal. Next to Volcano Mountain, an unconformable (fault) contact juxtaposes Pre-Cambrian age Yukon Group metamorphic rocks with Tertiary Carmacks Volcanics. This contact is parallel to regional geomorphological trends (Figure 12) and could provide a permeable pathway for hot water at depth to flow quickly to the surface or into a sub-surface reservoir.

Thermal springs were not observed in the Volcano Mountain area during the limited 2008 fieldwork (only two days). The area is nonetheless a compelling target for exploration of underlying geothermal resources due to the recent volcanic activity and structural setting, as not all economically-significant geothermal reservoirs discharge directly to the surface. It may be discharging geothermal waters are dispersed within the highly porous and permeable volcanic deposits at the surface, or in relatively shallow porous and permeable bedrock. Although the scope of this project limited fieldwork to the Volcano Mountain deposit, other Selkirk Series volcanic deposits near Ft. Selkirk and south of the Pelly River are good candidates for follow-up work.

4.4.4 Geological Model for Haines Junction-Jarvis River Area

The Jarvis River Warm Springs (JRWS) are located in the Shakwak Valley, a broad valley that separates the St. Elias Mountains terrane from the Yukon Plateau. Thick glaciolacustrine and till deposits fill the Shakwak valley bottom.

The thermal springs are located about 100 m north of the Jarvis River at the base of an approximately 25 m high glaciolacustrine silt escarpment. The springs discharge at the stratigraphic contact of the glaciolacustrine unit with underlying till, close to the elevation of the present floodplain of the Jarvis River. The JRWS consists of six thermal ponds in an area of about 50 m by 70 m. Active gas expulsion at somewhat regular intervals was observed in most pools. Two of the thermal ponds cause active sloughing within the toe of the glaciolacustrine silt escarpment. The full extent of the thermal spring area is unknown, as the thick glaciolacustrine deposit could cover additional vents to the northeast.

Although large boulders of sub-rounded [till] float characterize the site, the nearest exposed bedrock (Mesozoic Era peridotite and serpentine) occurs about 2 km to the southwest. Bedrock underlying the warm springs is probably folded greenstone, greenschist, argillite and greywacke of Paleozoic/Mesozoic rocks that may contact Yukon Group metamorphic rocks to the east. Coast Plutonic Complex intrusions (mainly granodiorite and granite) are common throughout the area and are exposed on the east sides of the Shakwak Valley. They intrude the metasediments and could influence sub-surface geology near the warm springs (Figure 14). Throughout the area, Mesozoic volcanic and sedimentary successions are intruded by stocks and dykes of peridotite and serpentine. In addition, granite and granodiorite stocks and dykes intrude all of these rocks at widely scattered locations throughout the St. Elias Mountains (Kindle, 1953).

Regional structure includes northwest-southeast trending normal faults of the Shakwak system. The sharp, linear termination of the Kluane Range along the southwest boundary of the Shakwak Valley suggests that there is a major regional fault underlying the thick overburden deposits. Early mapping (Kindle, 1953) shows a probable regional fault along this southwest valley wall about 3 km west of the JRWS. This fault was identified in other mapping (Wheeler, 1963 and Bostock, 1952), which also indicated a cross fault in the Jarvis River Valley at the east edge of the Kluane Range. Two significant regional geological structures, the Denali Fault system and the parallel Duke River Fault, lie west of the

boundary of the Shakwak Valley and the Kluane Range. Recent mapping suggests that faults forming the broad physiographic expression of the Shakwak Trench are inactive and older than the active regional Denali Fault in the front ranges of the Kluane Mountains.

The geological setting of the JRWS supports a geothermal flow model in which older, brittle, folded and fractured metasedimentary rocks provide a medium for deep influx of meteoric water, and regional faults and smaller cross-faults provide conduits for hot water to reach the surface.

4.5 PRELIMINARY ASSESSMENT OF GEOTHERMAL RESOURCES FOR THE THREE SEARCH AREAS

Based on the findings of this program, there is evidence for medium- to high-temperature geothermal resources in both the McArthur Hot Springs and the Haines Junction-Jarvis River areas. Active warm or hot springs and a warm well were documented and sampled, with moderately high geothermometric temperatures (65.5 to 163.7°C). These calculated temperatures are comparable with other geothermal occurrences currently being exploited for geothermal power generation in western North America. For example, Garchar and Archart (2008) indicate that geothermal reservoir temperatures of 150°C or more are typically required to commercially exploit geothermal energy production. The silica-based temperatures for McArthur Hot Spring are marginally above this (average temperature 156.9°C). In addition, technology currently being applied at the Chena Hot Springs in Alaska is used to generate electricity (albeit with poor efficiency and total power <1 MW) with ~75°C source water by taking advantage of low cooling water temperatures.

The extent of potential geothermal resources in the McArthur area appears to be focused around the hot springs complex (currently estimated to extend about 150 m x 150 m on the surface). Subsurface sources at depth are not currently known, but may be controlled a few geological faults channelling hot water rising from the intrusive batholith contact.

In contrast, the warm water springs or wells appear to occur along a linear trend over kilometres of distance in the Haines Junction-Jarvis River area. The geological setting in this area indicates that geothermal resources are controlled by regional geological features (rock groups and major structures). Thus, the prospecting area for potential geothermal resources should be much larger than the area picked for this study, and could rightly include the entire Shakwak Valley (from southeast of Haines Junction, to the northwest past Burwash Landing). Even though the subsurface temperatures currently documented appear to be medium (nominally 65 to 100°C), it is possible that higher-grade geothermal resources might be found in such a large potential search area.

There was no direct evidence of warm or hot water springs in the Volcano Mountain area, although the young geological history of this volcano suggests there may well be remnant heat within or near it.

Beyond technical factors, there are other issues relating to suitable proximity to power grids, land use and ownership, and other social and economic factors that should be assessed at an early stage of geothermal resource assessment. That is outside the scope of this work.

Finally, there are other candidate geological search areas that could also be investigated at a reconnaissance level, as per this program. These areas include other areas along the length of the Tintina Trench (south of the McArthur Hot Springs area), Nash Creek (north of Mayo), Alligator Lake/Takhini Hot Springs zone (west of the City of Whitehorse), and Swift River/Watson Lake area (southeastern Yukon).

4.6 NEXT STEPS FOR GEOTHERMAL RESOURCES ASSESSMENT

4.6.1 McArthur Hot Springs Area

We suggest that the following steps be considered by YEC for the McArthur Hot Springs area:

- Clarify land ownership and access for purposes of more advanced geothermal exploration, and eventual possible energy exploitation. This would be aimed at identifying non-technical factors in YEC making business decisions on whether to proceed or not.
- Conduct a satellite infrared image assessment of the McArthur Hot Springs region, from the Tintina Trench up to and including the south side of the McArthur Range mountains. This would be aimed at locating other high-elevation mountain hot springs similar to the McArthur Hot Springs complex.
- Conduct a low-level flying infrared camera survey of the McArthur Hot Springs complex and adjacent valleys to better delineate the thermal boundaries of the spring complex, and prospect for smaller hot spring occurrences which may be hidden within dense forest cover. If cost-effective, also conduct suitable air-borne geophysics over the McArthur Hot Springs area, to provide additional evidence for the size and occurrence of hot springs in this area.
- Repeat water sampling at the Hot Spring complex with a focus on improved silicon sampling, field-based alkalinity measurements, and sampling for isotopes of helium ($^4\text{He}/^3\text{He}$ ratio can be an indicator of geothermal fluids), hydrogen (^3H (tritium) can be used for age-dating recently recharged water) and carbon (^{14}C has a half-life of 5,715 yrs and can be used for age-dating older waters).
- Complete a thermal gradient core hole to a nominal depth of 200-300 m to document rock type and subsurface temperature conditions at the hot springs.

4.6.2 Volcano Mountain Area

We suggest that the following steps be considered by YEC for the Volcano Mountain area:

- Conduct a satellite infrared image assessment of the entire Volcano Mountain area (including the extensive lava flows). This would be aimed at locating broad thermal anomalies that could focus further remote sensing or geophysical exploration.
- Conduct a low-level flying infrared camera survey of the Volcano Mountain area and adjacent linear drainages, and of the Selkirk Volcanics near Ft. Selkirk and south of the mouth of the Pelly River. This would be aimed at identifying remnant thermal heat in the volcano itself or the lava flows leading from it.
- Repeat water sampling in the Lava Lake drainage with a focus on improved silicon sampling, field-based alkalinity measurements, and sampling for isotopes of helium ($^4\text{He}/^3\text{He}$ ratio can be an indicator of geothermal fluids), hydrogen (^3H (tritium) can be used for age-dating recently recharged water) and carbon (^{14}C has a half-life of 5,715 yrs and can be used for age-dating older waters).
- Conduct a ground-based geophysical survey (e.g., horizontal loop EM) to better define geological structures which might be conduits for geothermal fluid migration.

4.6.3 Haines Junction-Jarvis River Area

We suggest that the following steps be considered by YEC for the Shakwak Valley area:

- Conduct a satellite infrared image assessment of the entire Shakwak Valley, from southeast of Haines Junction northwest beyond Burwash Landing. This would be aimed at locating broad thermal anomalies over this large area that could focus further remote sensing or geophysical exploration. Satellite image analysis is ideally suited for a first screening step over large search areas.
- Conduct a local knowledge survey (First Nations groups, trappers, and hunters) to gather information on warm or hot water occurrences within the Shakwak Valley. Local knowledge can be a tremendous asset to identify potential target areas for follow-up reconnaissance assessment.
- Conduct a low-level flying infrared camera survey of selected thermal anomaly areas identified by the satellite survey or the local knowledge survey. This would be aimed at identifying and delineating specific thermal anomalies for ground-based follow-up.
- Repeat water sampling at the Warm Springs, Haines Junction municipal well, and new targets identified by the satellite/low-level flying work with a focus on improved silicon sampling, field-based alkalinity measurements, and sampling for isotopes of helium ($^4\text{He}/^3\text{He}$ ratio can be an indicator of geothermal fluids), hydrogen (^3H (tritium) can be used for age-dating recently recharged water) and carbon (^{14}C has a half-life of 5,715 yrs and can be used for age-dating older waters).

- Conduct a ground-based geophysical survey (e.g., magnetometer) to better define geological structures which might be conduits for geothermal fluid migration.
- Complete a thermal gradient core hole to a nominal depth of 200-300 m to document rock type and subsurface temperature conditions at the warm springs

4.6.4 Other Search Areas in Yukon

Based on budget availability, YEC should consider phased geothermal exploration efforts in the Tintina Trench, Nash Creek, Alligator Lake/Takhini, and Swift River/Watson Lake areas. This should include consulting local government and private sector geologists to gather recent and reliable information on potential existing or past hydrothermal occurrences in these areas.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

1. There is evidence of medium- to high-temperature geothermal resources in both the McArthur Hot Springs and the Haines Junction-Jarvis River areas. Active warm or hot springs and the warm Haines Junction well show moderately high subsurface geothermometric temperatures (65.5 to 163.7°C). The upper range of these calculated temperatures is comparable with other geothermal occurrences currently being exploited for geothermal power generation in western North America (typically requiring geothermal reservoir temperatures of 150°C, although power can be produced with as low as 75°C source water).
2. We found no direct evidence of warm or hot water springs in the Volcano Mountain area. However, the young geological history of this volcano and the possible fault underlying the Lava Lake drainage suggests there may well be remnant subsurface heat in this area and a plausible conduit to the surface.
3. The extent of the geothermally-active area appears to be small in the McArthur Hot Springs area (on a scale of hundreds of meters), but may extend over much larger areas (potentially kilometres or tens of kilometres) in the Haines Junction-Jarvis River area (and elsewhere in the Shakwak Valley).

5.2 RECOMMENDATIONS

1. For the McArthur Hot Springs area, clarify land ownership and access for further work, conduct satellite thermal image survey, low-level flying infrared survey, air-borne geophysics survey, resampling of hot springs waters (including isotopes of helium, hydrogen and carbon for identifying and age-dating geothermal waters), and a thermal gradient core hole (nominally to 200-300 m depth).

2. Even though the Volcano Mountain area did not show direct evidence of hydrothermal activity, we recommend follow-up work to further explore fault-controlled drainage near Lava Lake, and elsewhere in the Selkirk Volcanic terrain south of Ft. Selkirk and on the Yukon River upstream of the mouth of Pelly River. This work should include satellite thermal image survey, low-level flying infrared survey, resampling of hot springs waters (including isotopes of helium, hydrogen and carbon for identifying and age-dating geothermal waters), and ground-based geophysics survey (to better define geological structures).
3. For the Shakwak Valley area (southeast of Haines Junction northwest past Burwash Landing), conduct satellite thermal image survey, local knowledge survey, low-level flying infrared survey, ground-based geophysics survey, resampling of warm springs and other target waters (including isotopes of helium, hydrogen and carbon for identifying and age-dating geothermal waters), and a thermal gradient core hole (nominally to 200-300 m depth).
4. Consider a phased approach (as presented here) to geothermal resource exploration in other potential areas (the Tintina Trench area in central Yukon, Nash Creek north of Keno, Alligator Lake/Takhini area west of the City of Whitehorse, and Swift River/Watson Lake area in southeastern Yukon).

6.0 CLOSURE

This report and its contents are intended for the sole use of Yukon Energy Corporation and their agents. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Yukon Energy Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Confirmation of Assignment and in the General Conditions provided in Appendix C of this report.

We trust this report issued for use is satisfactory. Please do not hesitate to call should you have any questions concerning this report.

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TABLES



TABLE 2 - SUMMARY OF WATER QUALITY RESULTS

Project Sample ID		M08S-4	M08S-4 diluted ¹	M08S-6	M08S-6 diluted	M08S-11	M08S-11 diluted	M08S-12	M08S-12 diluted	M08S-2	M08S-2 diluted	M08D-3	M08D-3 diluted	M08D-10	M08D-10 diluted	H08K-36	H08K-36 diluted	H08D-39	H08D-39 diluted	H08J-33	H08J-33 diluted	V08D-12	V08D-12 diluted	V08D-17	V08D-17 diluted	V08D-10	V08D-10 diluted
CanTest ID (a)		809250443	809250446	809250449	809250450	809250451	809250452	809250454	809250459	809250460	809250462	809250463	809250465	809250467	809250470	809250471	809250475	809250476	809250479	809250482	809250483	809250484	809250489	809250490	809250493	809250500	809250501
CanTest Group # (a)		90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103	90925103
CanTest ID (b)		811140345	-	811140348	-	811140349	-	811140350	-	811140351	-	81114352	-	811140353	-	811140354	-	811140355	-	811140356	-	811140357	-	811140358	-	811140359	-
CanTest Group # (b)		91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-	91114116	-
Lab Report Sample ID		MHS08-S4	MHS08-S4 diluted	MHS08-S6	MHS08-S6 diluted	MHS08-S11	MHS08-S11 diluted	MHS08-S12	MHS08-S12 diluted	MHS08-S2	MHS08-S2 diluted	MHS08-D3	MHS08-D3 diluted	MHS08-D10	MHS08-D10 diluted	HJ08-K36	HJ08-K36 diluted	H08-D39	H08-D39 diluted	H08-J33	H08-J33 diluted	VM08-D12	VM08-D12 diluted	VM08-D17	VM08-D17 diluted	VM08-D10	VM08-D10 diluted
Date Collected		9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	9-Sep-08	11-Sep-08	9-Sep-08	16-Sep-08	16-Sep-08	16-Sep-08	16-Sep-08	16-Sep-08	16-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	10-Sep-08	4-Sep-08
Parameter	Units																										
Total Alkalinity CaCO3	mg/L	70.7	- ²	71.4	-	37.8	-	70.3	-	72.0	-	10.6	-	4.8	-	107	-	97.0	-	293	-	40.5	-	81.9	-	57.5	-
Bicarbonate Alkalinity HCO3	mg/L	55.3	-	43.2	-	46.2	-	43.9	-	43.3	-	12.9	-	5.8	-	130.2	-	118	-	332	-	49.4	-	99.9	-	70.2	-
Carbonate Alkalinity CO3	mg/L	15.3	-	21.3	-	<0.5	-	20.6	-	21.9	-	<0.5	-	<0.5	-	8.3	-	<0.5	-	12.4	-	<0.5	-	<0.5	-	<0.5	-
Hydroxide Alkalinity OH	mg/L	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-	<0.5	-
Hardness (Total) CaCO3	mg/L	3	-	4	-	14	-	4	-	4	-	6	-	44	-	9	-	95	-	66	-	51	-	57	-	51	-
Dissolved Fluoride F	mg/L	7.3	-	7.41	-	3.51	-	7.7	-	7.61	-	< 0.05	-	0.1	-	0.28	-	< 0.05	-	0.31	-	< 0.05	-	< 0.05	-	0.13	-
Dissolved Chloride Cl	mg/L	0.88	-	0.8	-	0.61	-	1.12	-	0.86	-	< 0.2	-	< 0.2	-	0.43	-	0.2	-	26.6	-	< 0.2	-	4.33	-	0.26	-
Nitrate and Nitrite N	mg/L	< 0.05	-	< 0.05	-	< 0.05	-	0.1	-	< 0.05	-	< 0.05	-	0.16	-	< 0.05	-	< 0.05	-	0.09	-	< 0.05	-	0.31	-	< 0.05	-
Dissolved Nitrate N	mg/L	< 0.05	-	< 0.05	-	< 0.05	-	0.1	-	< 0.05	-	< 0.05	-	0.16	-	< 0.05	-	< 0.05	-	0.07	-	< 0.05	-	0.31	-	< 0.05	-
Nitrite N	mg/L	0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	0.022	-	< 0.002	-	< 0.002	-	< 0.002	-
Dissolved Sulphate SO4	mg/L	15.7	-	14.9	-	18.7	-	15.8	-	14.9	-	< 0.5	-	46.4	-	14.6	-	14.3	-	32.7	-	6.19	-	34.1	-	2.6	-
Metals Analysis																											
Dissolved Aluminum Al	mg/L	0.079	-	0.042	-	0.61	-	0.042	-	0.048	-	0.028	-	0.051	-	< 0.005	-	0.006	-	0.017	-	0.15	-	0.031	-	0.067	-
Dissolved Antimony Sb	mg/L	0.002	-	0.001	-	< 0.001	-	0.001	-	0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Arsenic As	mg/L	0.19	-	0.19	-	0.087	-	0.18	-	0.19	-	< 0.001	-	< 0.001	-	0.016	-	0.001	-	0.002	-	< 0.001	-	0.002	-	< 0.001	-
Dissolved Barium Ba	mg/L	0.008	-	0.007	-	0.068	-	0.005	-	0.004	-	0.003	-	0.11	-	0.014	-	0.028	-	0.053	-	0.029	-	0.013	-	0.011	-
Dissolved Beryllium Be	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Bismuth Bi	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 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	0.15	-	0.16	-	0.16	-	0.16	-	0.16	-	< 0.05	-	< 0.05	-	0.11	-	< 0.05	-	0.38	-	< 0.05	-	< 0.05	-	< 0.05	-
Dissolved Cadmium Cd	mg/L	< 0.0002	-	< 0.0002	-	0.0003	-	< 0.0002	-	< 0.0002	-	< 0.0002	-	0.0013	-	< 0.0002	-	< 0.0002	-	< 0.0002	-	< 0.0002	-	< 0.0002	-	< 0.0002	-
Dissolved Calcium Ca	mg/L	1.25	-	1.45	-	3.82	-	1.39	-	1.43	-	2.35	-	10.7	-	2.96	-	28.6	-	10.5	-	12.3	-	14.2	-	13.5	-
Dissolved Chromium Cr	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Cobalt Co	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Copper Cu	mg/L	< 0.001	-	< 0.001	-	0.007	-	< 0.001	-	< 0.001	-	0.001	-	< 0.001	-	< 0.001	-	0.002	-	< 0.001	-	0.002	-	0.003	-	0.003	-
Dissolved Iron Fe	mg/L	0.47	-	< 0.05	-	0.59	-	< 0.05	-	< 0.05	-	< 0.05	-	< 0.05	-	< 0.05	-	< 0.05	-	< 0.05	-	0.49	-	0.1	-	0.08	-
Dissolved Lead Pb	mg/L	< 0.001	-	< 0.001	-	0.003	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Lithium Li	mg/L	0.15	-	0.16	-	0.068	-	0.16	-	0.16	-	< 0.001	-	0.002	-	< 0.001	-	0.002	-	0.007	-	0.001	-	0.003	-	0.002	-
Dissolved Magnesium Mg	mg/L	0.06	-	< 0.05	-	1.12	-	< 0.05	-	< 0.05	-	0.12	-	4.28	-	0.35	-	5.76	-	9.59	-	4.91	-	5.23	-	4.1	-
Dissolved Manganese Mn	mg/L	0.007	-	< 0.001	-	0.016	-	< 0.001	-	< 0.001	-	0.001	-	0.003	-	0.001	-	< 0.001	-	0.011	-	0.084	-	0.012	-	0.002	-
Dissolved Mercury Hg	ug/L	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-	< 0.02	-
Dissolved Molybdenum Mo	mg/L	0.016	-	0.017	-	0.0097	-	0.017	-	0.017	-	< 0.0005	-	< 0.0005	-	0.0053	-	0.0006	-	0.017	-	0.0006	-	0.088	-	0.0027	-
Dissolved Nickel Ni	mg/L	< 0.001	-	< 0.001	-	0.002	-	< 0.001	-	< 0.001	-	< 0.001	-	0.004	-	< 0.001	-	< 0.001	-	< 0.001	-	0.003	-	0.001	-	0.002	-
Dissolved Phosphorus P	mg/L	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	< 0.15	-	0.2	-	< 0.15	-
Dissolved Potassium K	mg/L	1.4	-	1.1	-	1.2	-	1.1	-	1.1	-	0.2	-	0.4	-	0.3	-	1.6	-	1.9	-	0.5	-	9.3	-	1.8	-
Dissolved Selenium Se	mg/L	< 0.001	-	< 0.001	-	0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	0.002	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Silicon Si	mg/L	25.5	6.31	27.2	6.85	13.3	2.63	25.5	5.8	27.1	7.28	0.9	0.27	3.1	0.8	9.1	2.77	3.4	0.73	10.7	2.78	3.9	0.92	7.8	1.87	2.1	0.63
Dissolved Silver Ag	mg/L	< 0.00025	-	< 0.00025	-	0.031	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-	< 0.00025	-
Dissolved Sodium Na	mg/L	39.8	-	41	-	26.5	-	39.5	-	40.9	-	0.35	-	1.15	-	45.6	-	2.98	-	111	-	3.56	-	20.1	-	6.69	-
Dissolved Strontium Sr	mg/L	0.009	-	0.012	-	0.039	-	0.012	-	0.012	-	0.009	-	0.065	-	0.041	-	0.092	-	0.24	-	0.12	-	0.36	-	0.17	-
Dissolved Tellurium Te	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-
Dissolved Thallium Tl	mg/L	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-
Dissolved Thorium Th	mg/L	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-	< 0.0005	-
Dissolved Tin Sn	mg/L	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001	-	0.004	-	< 0.001	-	< 0.001	-	< 0.001	-	< 0.001									



FIGURES





LEGEND

- Communities
- Waterbodies
- Roads
- ▭ Political Boundaries

NOTES

Base data source: ESRI, Government of Yukon

ISSUED FOR USE

**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY**

Area Location Map

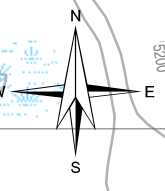
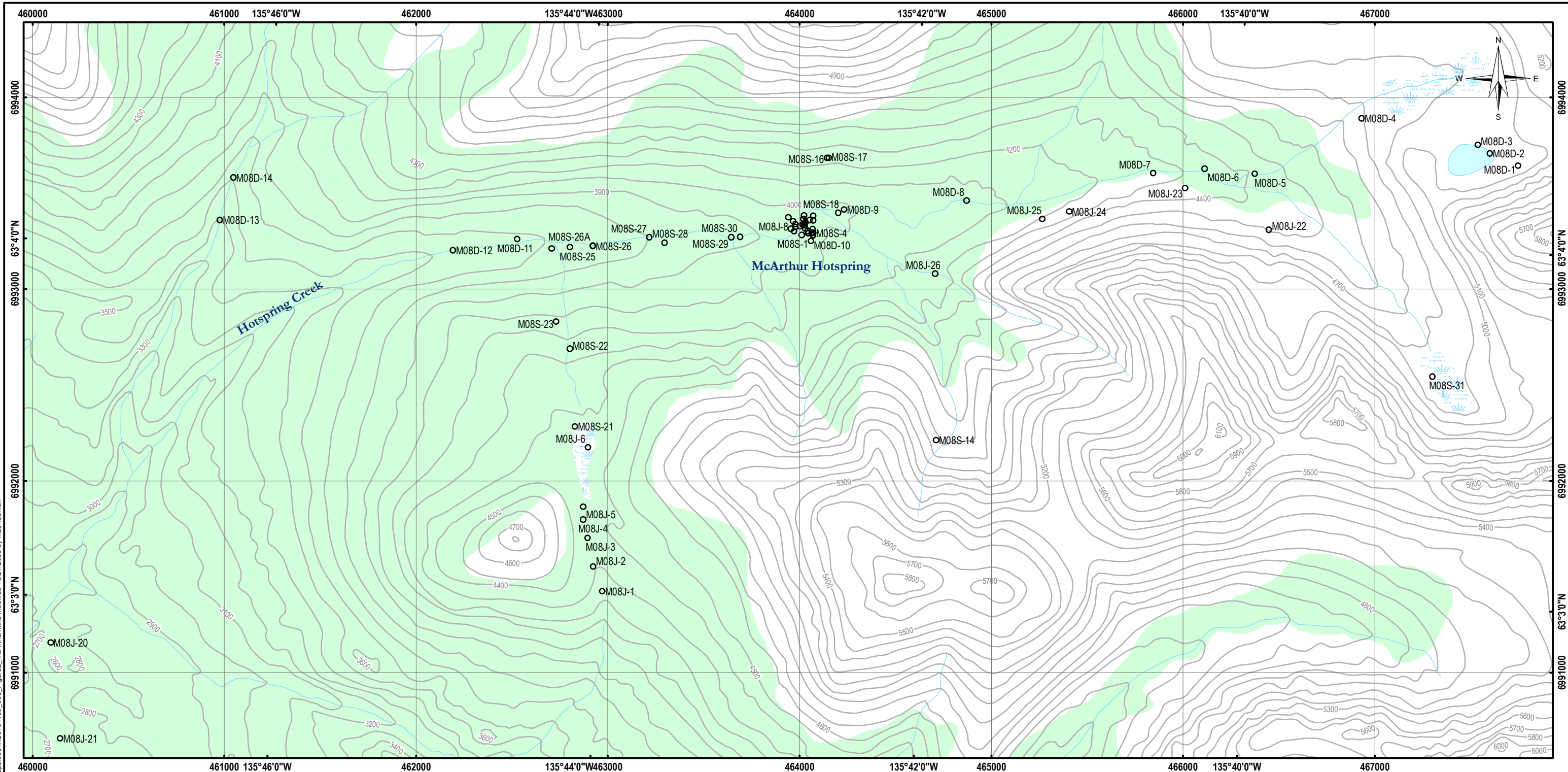
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Scale: 1:6,000,000			
100 50 0 100			
Kilometres			
FILE NO. W23101159_008_Figure1_SiteLocation.mxd			
PROJECT NO. W23101159.008	DWN MEZ	CKD HSS	REV 0
OFFICE EBA-VANC	DATE December 4, 2008		



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Figure 1



McArthur Hot Spring

Hot Spring Creek

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LEGEND

- Sample Location
- Contour (100 ft)
- Watercourse
- Waterbody
- Wetland
- Vegetation

NOTES
Base data source: NTDB 1:50,000 (105M04)

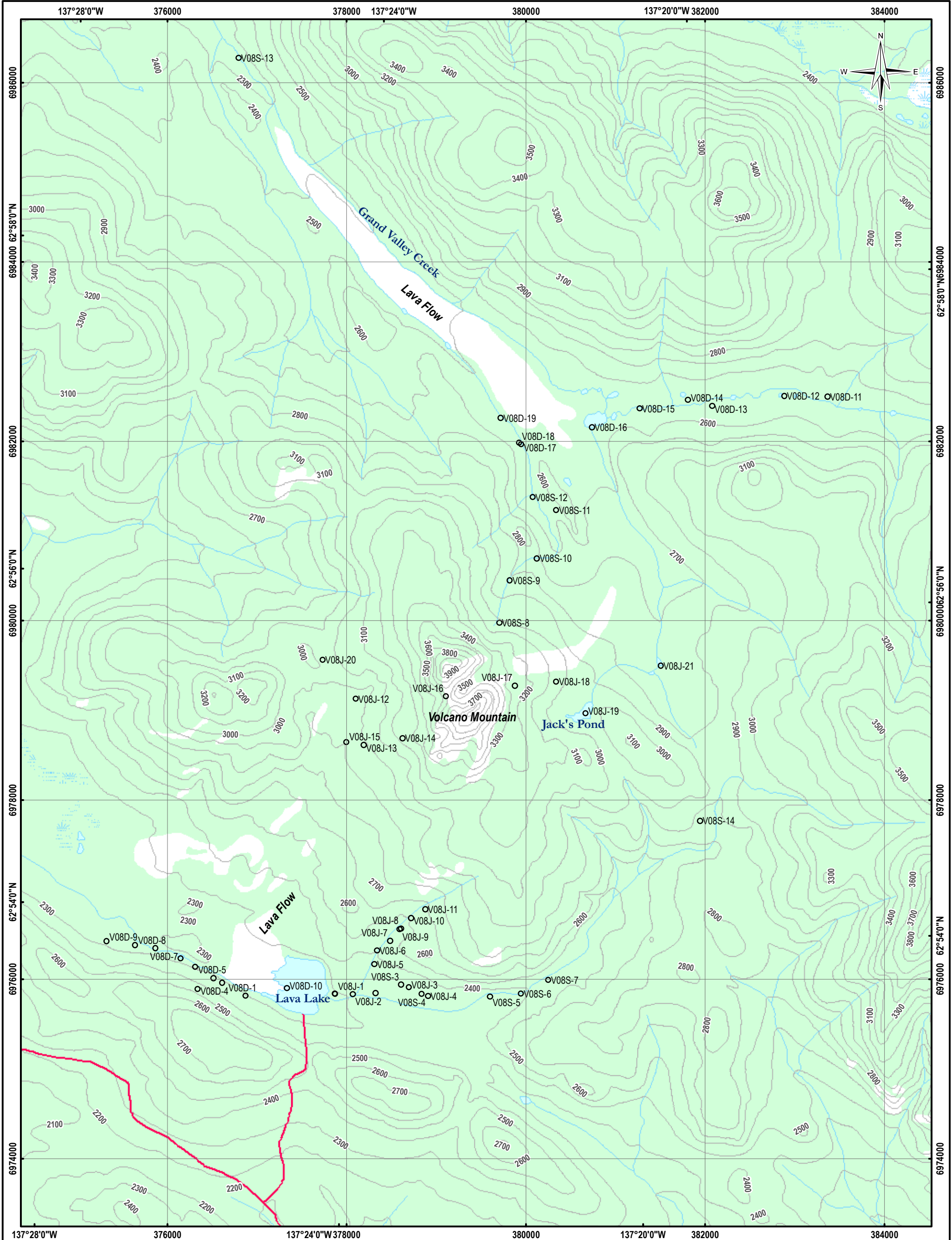
**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY**

Location Plan for McArthur Hot Springs Study Area

PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:20,000			
Meters			
FILE NO. W23101159_008_Figure2_McArthur.mxd			
PROJECT NO. W23101159.008	DWN MEZ	CKD HSS	REV 0
OFFICE EBA-VANC	DATE December 2, 2008		

Figure 2

G:\Vancouver\GIS\ENVIRONMENTAL\W23101159_008_Figure2_McArthur.mxd modified: 10/21/2008 by mzondevan



LEGEND

- Sample Location
- Trail
- Contour (100 ft)
- Watercourse
- Waterbody
- Wetland
- Vegetation

ISSUED FOR USE

NOTES

Base data source: NTDB 1:50,000 (115113, 115114, 115P03, 115P04)

**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY**

**Location Plan for
Volcano Mountain Study Area**

PROJECTION UTM Zone 8	DATUM NAD83
Scale: 1:40,000	
Meters	
FILE NO. W23101159_008_Figure3_Volcano.mxd	
PROJECT NO. W23101159.008	
OFFICE EBA-VANC	DATE December 2, 2008

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Figure 3



G:\Vancouver\GIS\ENVIRONMENTAL\W23101159_008_Figure4_Shakwak.mxd modified: 10/21/2008 by mzondevan

LEGEND

- Sample Location
- Waterbody
- Contour (40 m/100 ft)
- Wetland
- Road
- UTM Zone Boundary
- Major Road
- Vegetation
- Trail
- Watercourse

NOTES
Base data source: NTDB 1:50,000 (115B16, 115A13, 115A12, 115A11, 115A14)

**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY**

**Location Plan for
Haines Junction - Jarvis River
Study Area**

PROJECTION UTM Zone 7/Zone 8	DATUM NAD83		
Scale: 1:50,000			
FILE NO. W23101159_008_Figure4_Shakwak.mxd			
PROJECT NO. W23101159.008	DWN MEZ	CKD HSS	REV 0
OFFICE EBA-VANC	DATE December 4, 2008		

Figure 4

ISSUED FOR USE

SOUTH
↑



LEGEND
 — Water
 - - - Water (Approximate)
 ● Sample Location
 H08J-15 Sample ID
 12.9°C Sample Temperature

ISSUED FOR USE

NOT TO SCALE



**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
 MULTIPLE AREAS, YUKON TERRITORY**

**Detailed Location Plan
 McArthur Hot Springs**

EBA Engineering Consultants Ltd.

PROJECT NO. W23101159.008	DWN MEZ	CKD HSS	REV 0
OFFICE EBA-VANC	DATE December 2, 2008		

Figure 5

W23101159-008_Figure5.cdr



LEGEND

- Water
- Water (Approximate)
- Sample Location
- H08D-31** Sample ID
- 12.9°C** Sample Temperature

ISSUED FOR USE

NOT TO SCALE

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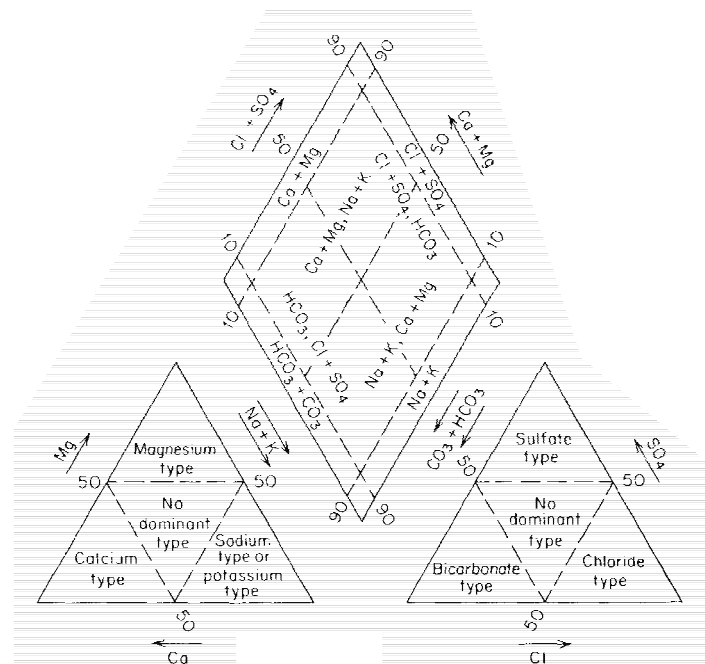


GROUND-BASED GEOTHERMAL
RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY

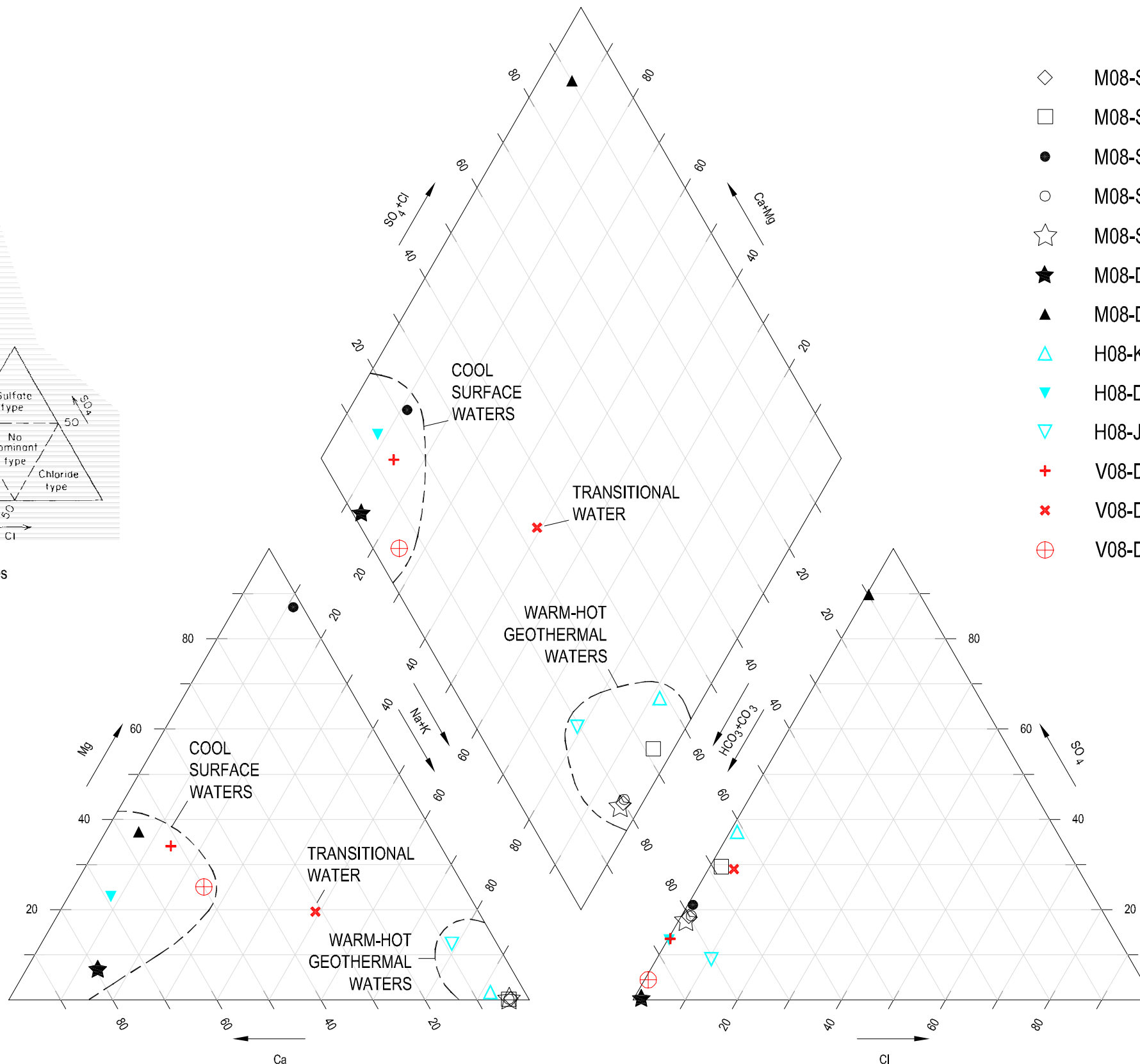
**Detailed Location Plan
Jarvis River Warm Springs**

PROJECT NO. W23101159.008	DWN MEZ	CKD JD	REV 0
OFFICE EBA-VANC	DATE December 4, 2008		

Figure 6



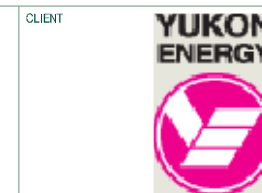
Trilinear classification of water types
(from Freeze and Cherry, 1979)



- ◇ M08-S4 McArthur Hot Spring
- M08-S6 McArthur Hot Spring
- M08-S11 Cool Spring by McArthur Hot Spring
- M08-S12 McArthur Hot Spring
- ☆ M08-S2 McArthur Hot Spring
- ★ M08-D3 Headwaters Hot Spring Creek
- ▲ M08-D10 South Brook by McArthur Hot Spring
- △ H08-K36 Haines Junction Well
- ▽ H08-D39 Jarvis River E of Warm Springs
- ▽ H08-J33 Jarvis River Warm Spring
- ⊕ V08-D12 Stream NE of Volcano Mountain
- ⊗ V08-D17 Stream N of Volcano Mountain
- ⊕ V08-D10 Lava Lake

NOTES
1) Data Plot from Piper Plot version 1.0
(EBA 1998 D.A. von Everdingen)
2) Water quality data summarized in Table 2

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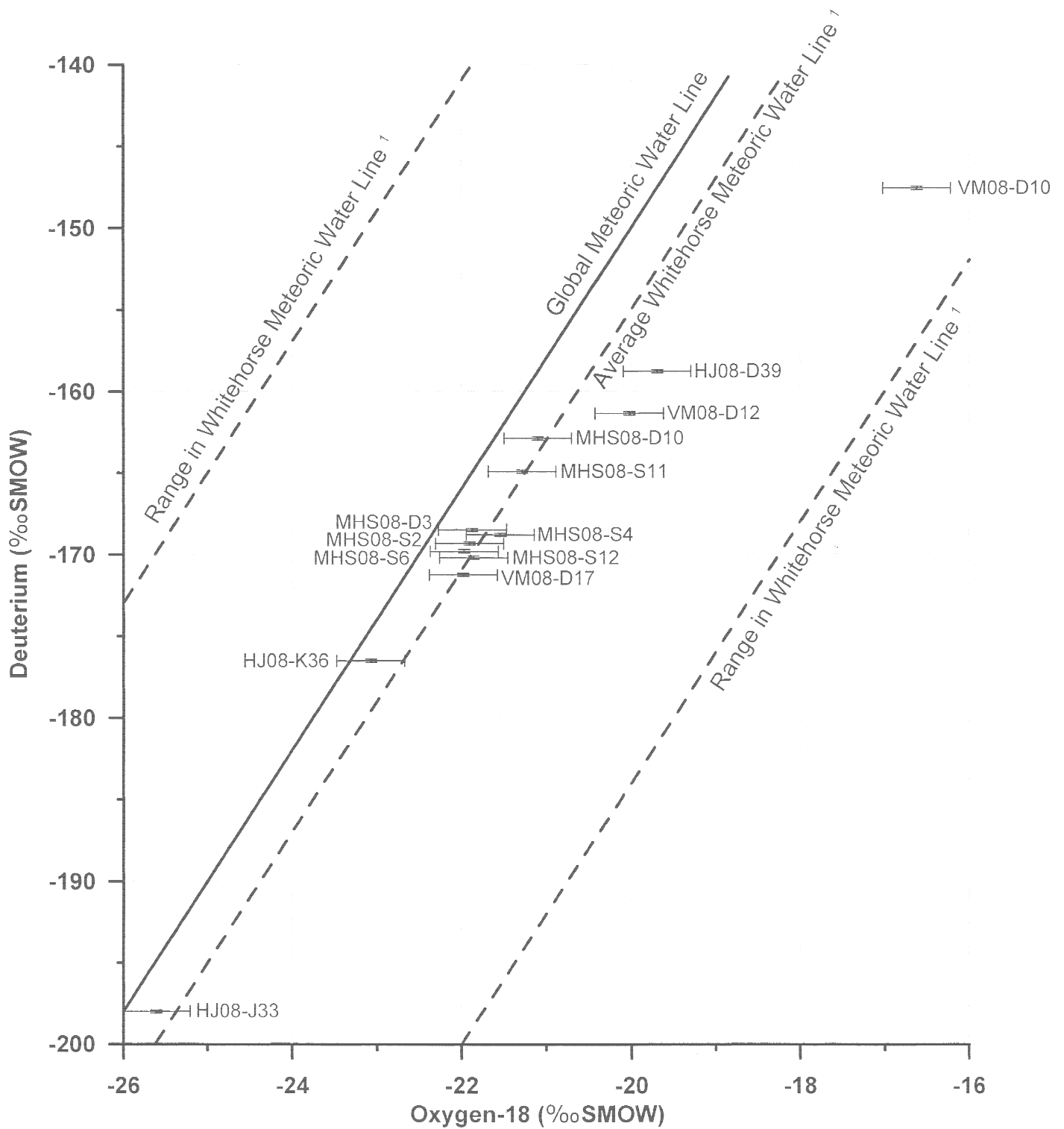


GROUND-BASED GEOTHERMAL
RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY

Tri-linear Plot of Major Ions

PROJECT NO. W23101159.006	DWN LM	CKD HSS	REV 0
OFFICE EBA-KELOWNA	DATE December 2, 2008		

Figure 7



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NOTES

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

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GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON TERRITORY

Plot of Isotope Data with Meteoric Water Line

EBA Engineering Consultants Ltd.



PROJECT NO.
W23101159.006

DWN
LM

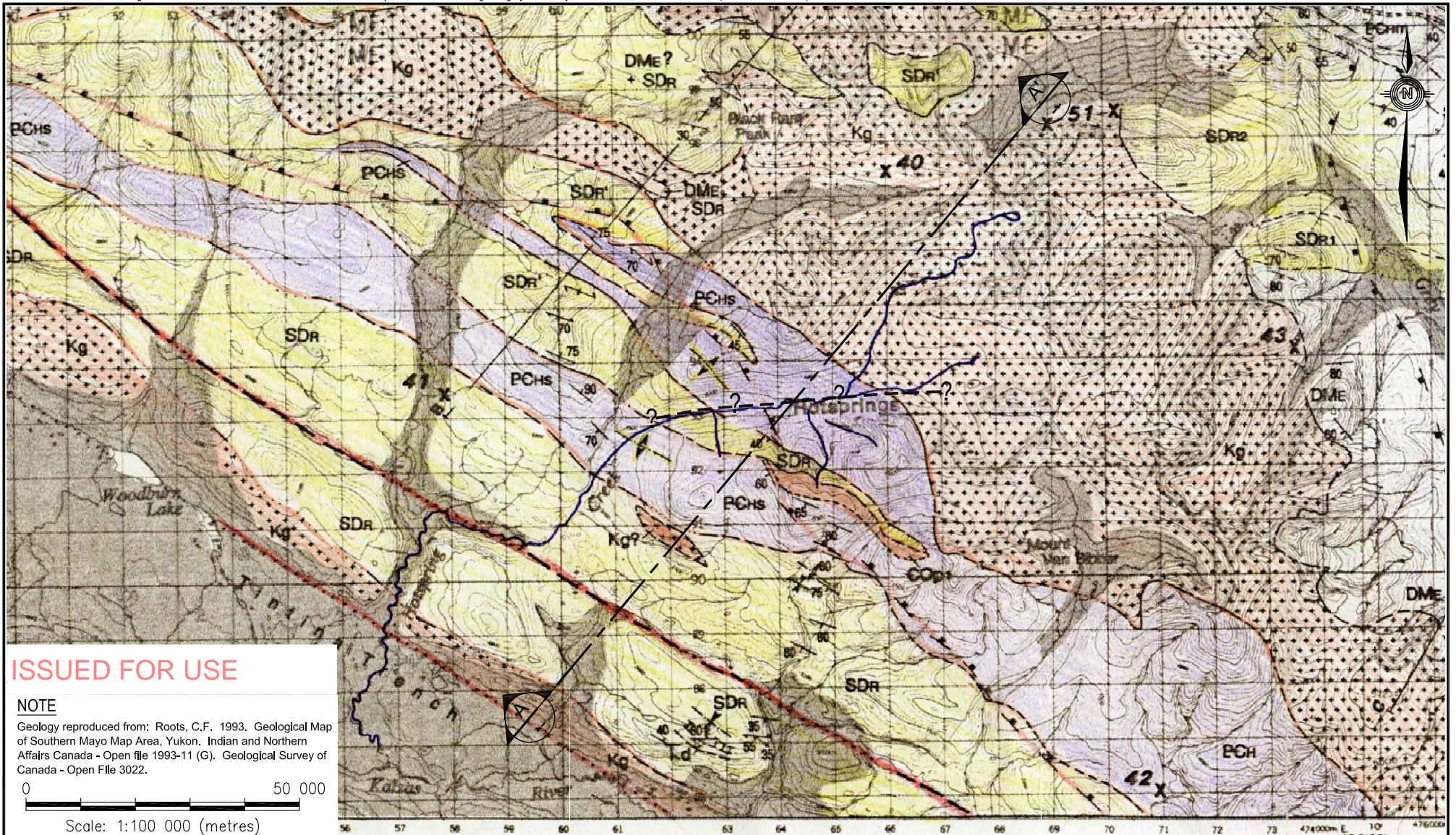
CKD
HSS

REV
0

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EBA-KELOWNA

DATE
December 2, 2008

Figure 8



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NOTE

Geology reproduced from: Roots, C.F. 1993. Geological Map of Southern Mayo Map Area, Yukon. Indian and Northern Affairs Canada - Open file 1993-11 (G). Geological Survey of Canada - Open File 3022.



Scale: 1:100 000 (metres)

LEGEND

- [Kg]** McArthur Pluton (Cretaceous): medium-grained, biotite-hornblende-phyric granite
- [SDR]** Road River Group (Silurian to Lower Devonian): undifferentiated black siltstone, mudstone and chert.
- [COP]** (Late Cambrian to Early Ordovician): olive and brown weathering siltstone with black laminae, brown sandstone with thin interbeds of black chert; purple and green-white nodular limy siltstone-schist
- [PCHS]** Hyland Group (PreCambrian-Lower Cambrian): undivided, maroon and green mudstone and siltstone, locally with white quartz sandstone interbeds; brown weathering med. to coarse-grained quartz mica schist and metasandstone with thin discontinuous white limestone
- Fault (defined, approximate, assumed)
- - -** Geological contact (defined, approximate, assumed)
- ↗ 60** Foliation, with dip angle and direction
- ↕** Syncline
- ↖** Anticline
- ⊙** Thermal alteration halo around McArthur Pluton
- ↘ 50** Bedding with dip angle

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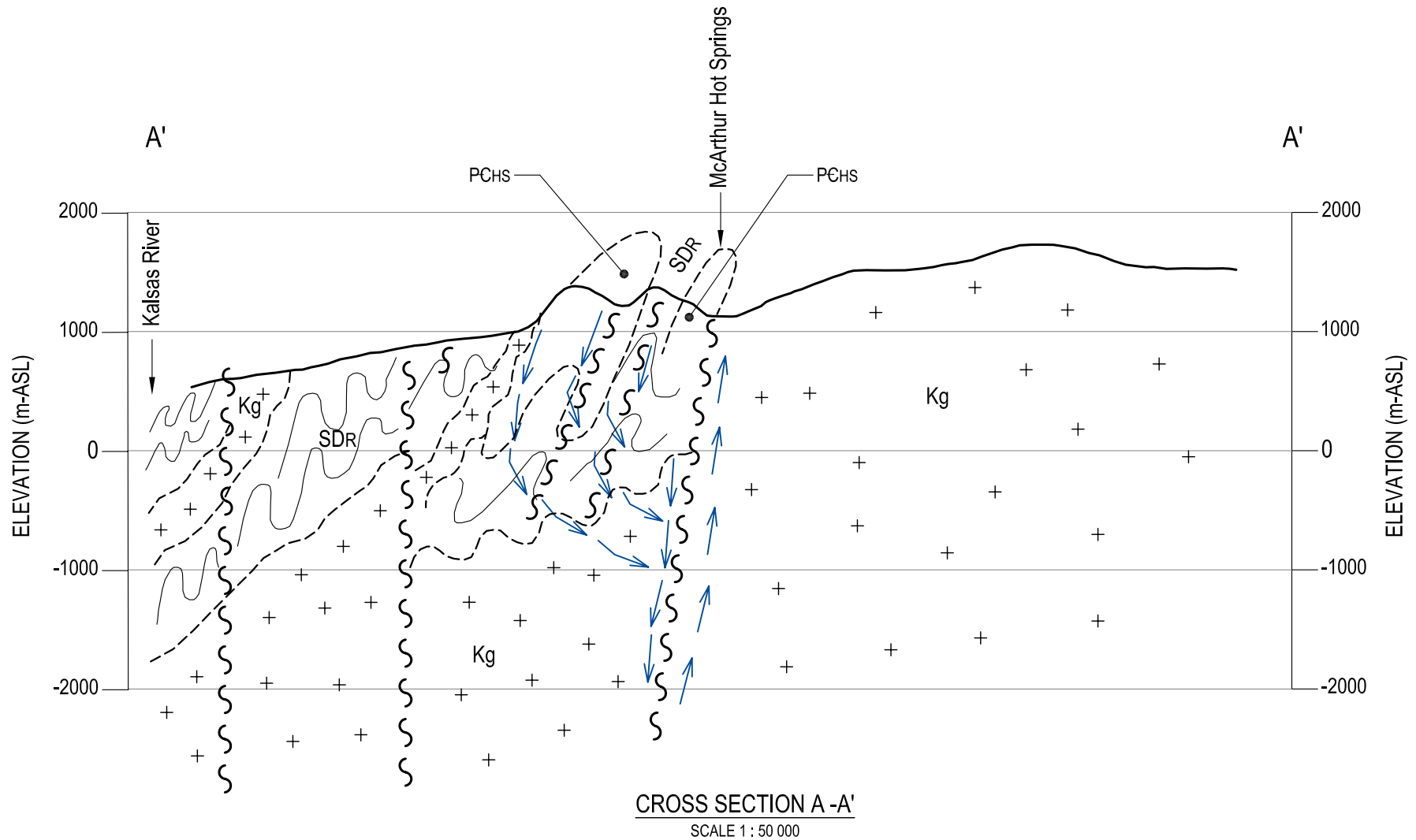
EBA Engineering Consultants Ltd.

**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON**

**McArthur Hot Springs Area
Site Plan Showing
Geology and Section A-A'**

PROJECT NO. W23101159.008	DWN JSB	CKD JTD	REV 0
OFFICE WHSE	DATE December 1, 2008		

Figure 9



LEGEND

- Meteoric Recharge Path
- Fault
- Geological Contact
- Folding

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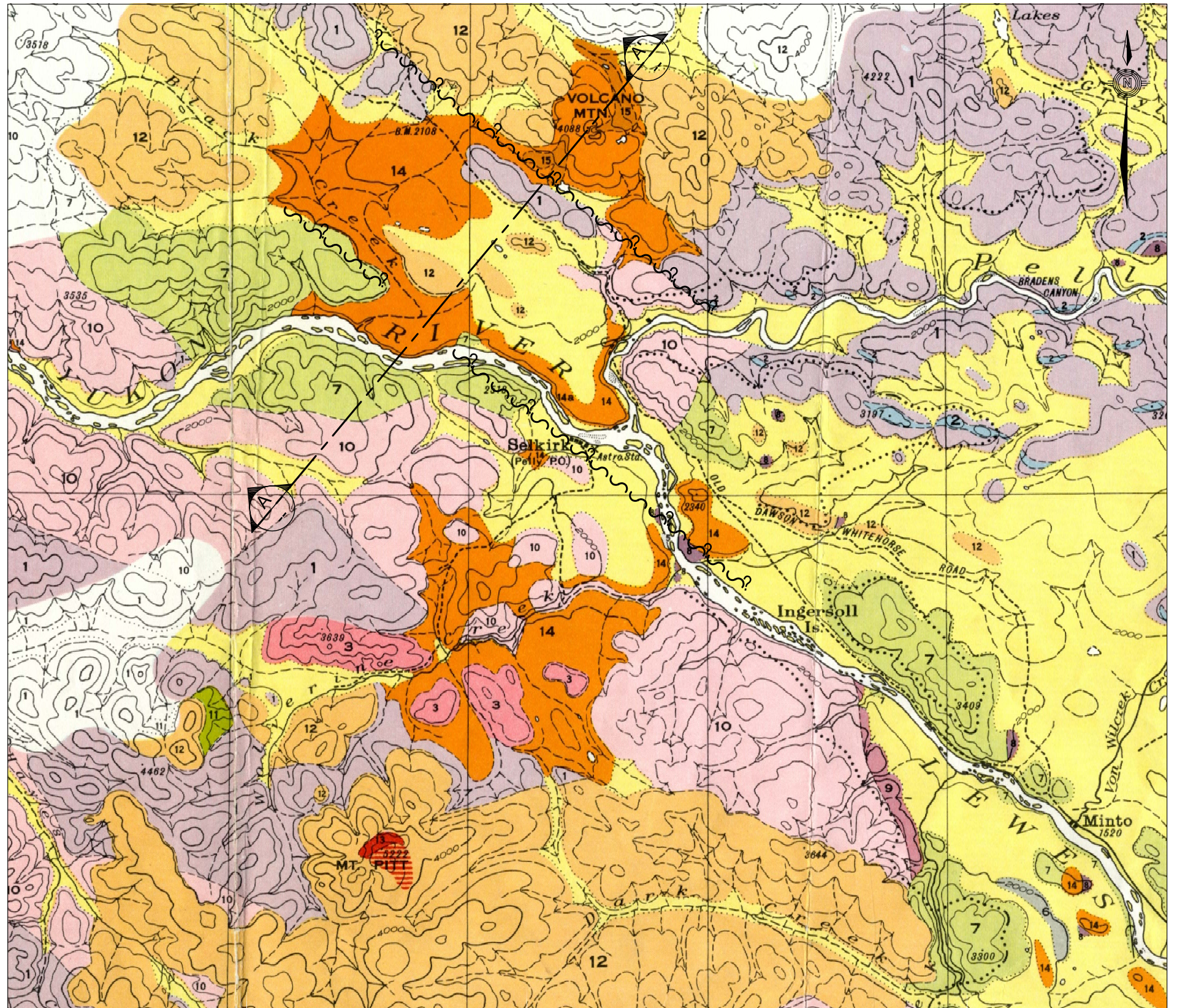
**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON**

**McARTHUR HOT SPRINGS AREA
CROSS SECTION A - A'
SHOWING CONCEPTUAL GEOLOGY MODEL**

PROJECT NO. W23101159.008	DWN JSB	CKD JTD	REV 0
OFFICE WHSE	DATE December 1, 2008		

Figure 10

C:\Whitehorse\Drawings\Whitehorse\W231159.008\VEG_Geothermal\Project\W231159.008_Fig-1.dwg [FIGURE 11] December 04, 2008 - 11:25:33 am (BY: JAMES BUTCH)



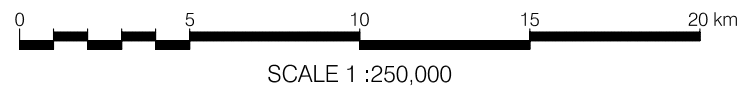
LEGEND

- 15** Selkirk Series (Modern and Tertiary): basalt and andesite flows.
 - 14** Selkirk Series (Modern and Tertiary): basalt and andesite flows, breccias and tuffs.
 - 12** Carmacks Volcanics (Tertiary): basalt, andesite, dacite and trachyte flows, breccias and tuffs.
 - 10** Pluton (Jurassic or Later): granite, granodiorite.
 - 7** Mount Nansen Group (Mesozoic): basalt, andesite and dacite flows, breccias and tuffs.
 - 1** Yukon Group (PreCambrian and Later): mica-quartz schist; some chlorite schist, graphite schist, quartzite, serpentine, gneiss, limestone.
- Fault (assumed)

NOTES

1. GEOLOGY FROM BOSTOCK, H.S. CARMACKS SHEET GEOLOGY. GEOLOGICAL SURVEY OF CANADA. 1934.
2. DRAWING HAS BEEN PRODUCED IN COLOR, ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

ISSUED FOR USE



CLIENT



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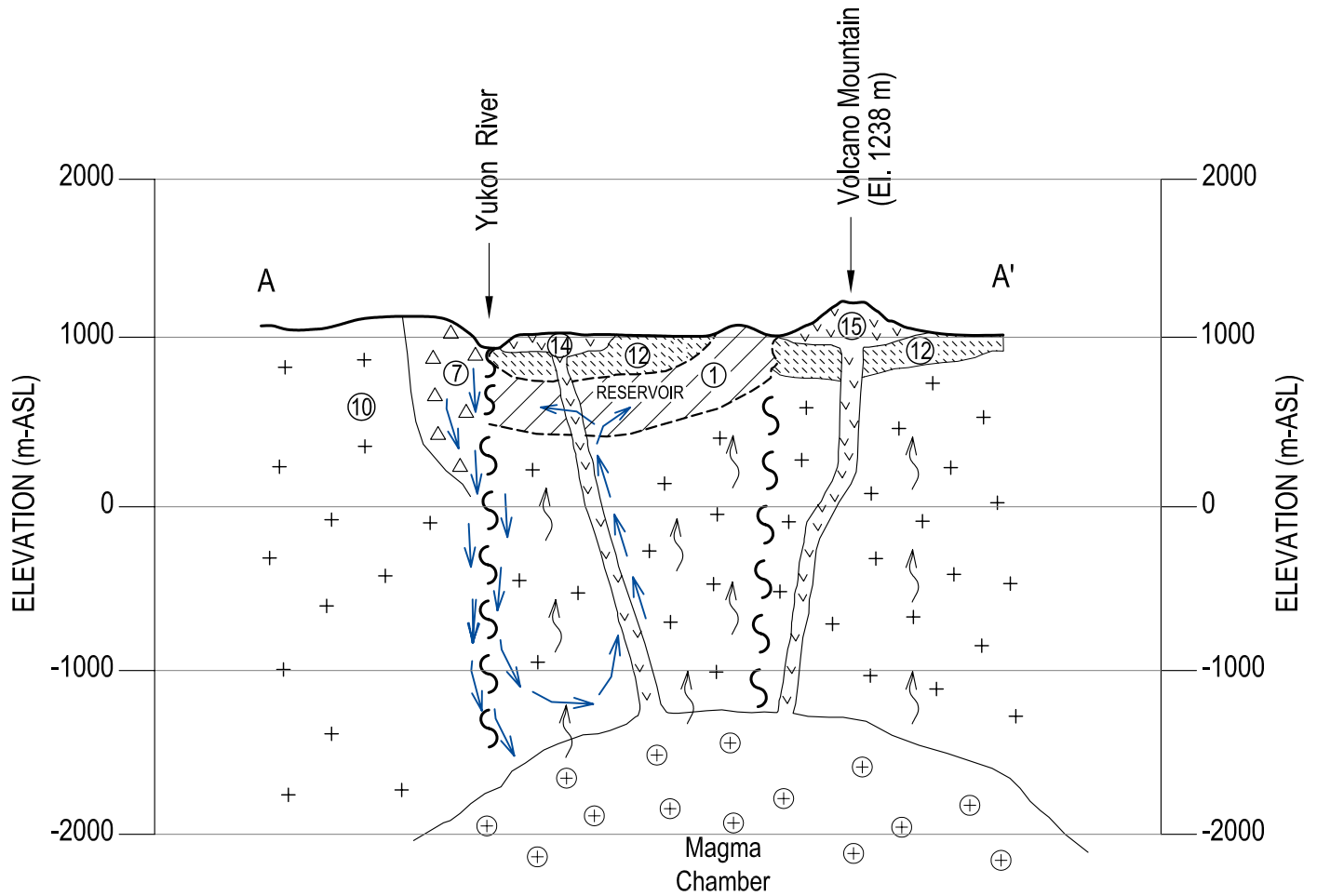
GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON

**Volcano Mountain
Site Plan Showing
Geology and Section A - A'**

PROJECT NO. W23101159.008	DWN JSB	CKD JTD	REV 0
OFFICE WHSE	DATE December 2, 2008		

Figure 11

C:\Whitehorse\Drawings\Whitehorse\W23101159_008 YEC Geothermal Project\W23101159_008 Fig-12.dwg [Figure 12] December 04, 2008 - 11:23am jbuyck



CROSS SECTION A - A'
N.T.S.

ISSUED FOR USE

LEGEND

- Meteoric Recharge Path
- Fault
- Geological Contact
- Heat from High Thermal Gradient
- Kg

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GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON

VOLCANO MOUNTAIN
CROSS SECTION A - A' SHOWING
CONCEPTUAL GEOLOGY MODEL

PROJECT NO.
W23101159.008

DWN
JSB

CKD
JTD

REV
0

OFFICE
EBA-WHSE

DATE
December 1, 2008

Figure 12

C:\Whitehorse\Drawings\Whitehorse\W2311W23101159.008 YEC Geothermal Project\W23101159.008 Fig-13.dwg [FIGURE 13] December 04, 2008 - 2:02:15 pm (BY: JAMES BUYCK)

LEGEND

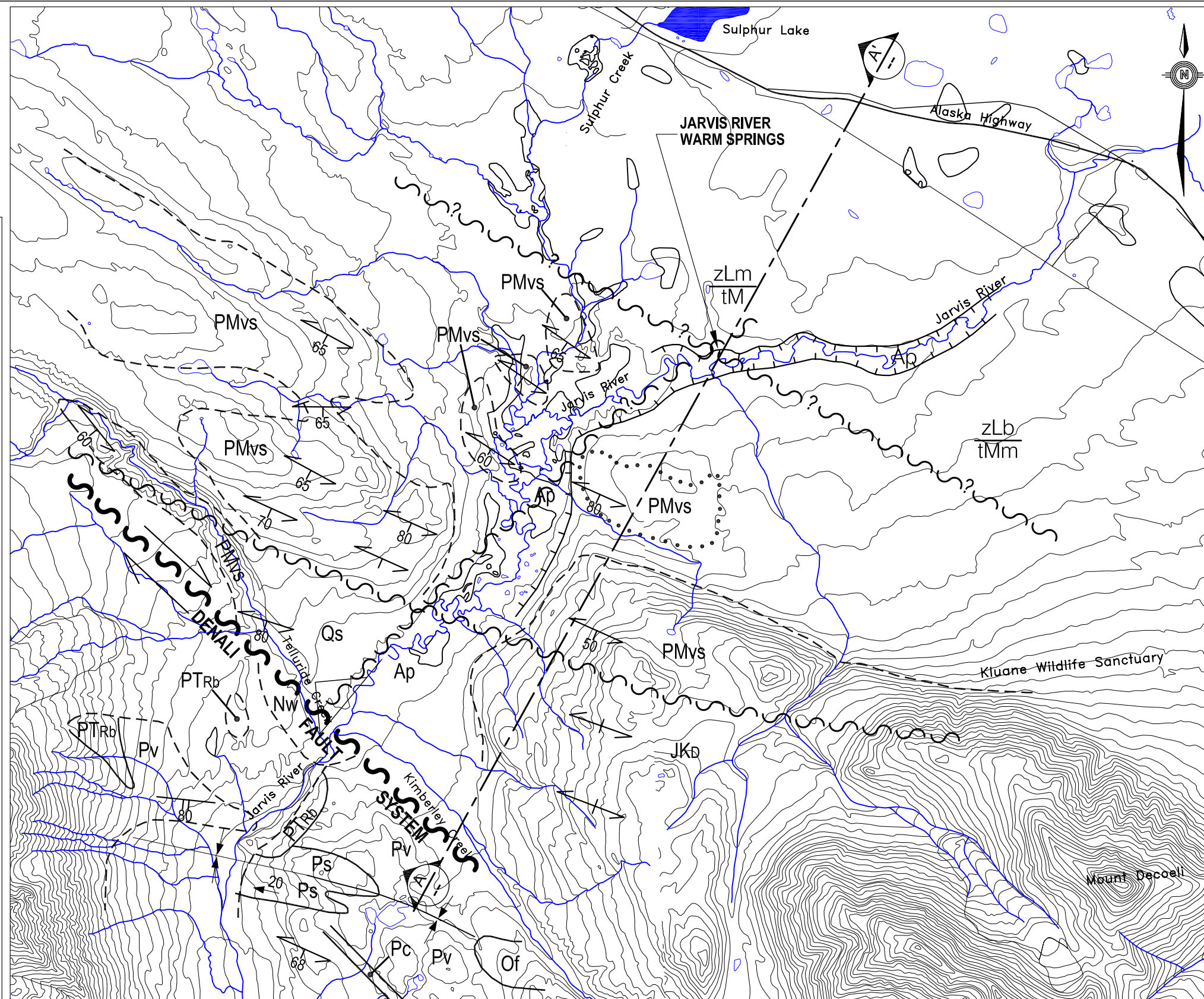
BEDROCK

- KTg** Coast Plutonic Complex (Cretaceous to Tertiary), biotite hornblende quartz diorite.
- JKD** Desadeash Group; (Upper Jurassic to Lower Cretaceous): interbedded light to dark buff grey, lithic greywacke, sandstone, siltstone, thin dark grey shale, argillite and conglomerate) and (?).
- PTRb** (Permian and/or Triassic and/or (?) Cretaceous): medium grey green, massive, med. grained pyx gabbro sills).
- PMvs** (Paleozoic and /or Mesozoic): greenstone, greenschist, minor argillite, and greywacke.
- YGP** Yukon Group (PreCambrian): quartz mica-schists, gneiss, slate, quartzite, crystalline limestone, greenstone; hornblende, chlorite and garnetiferous schists.

SURFICIAL GEOLOGY

- Ap** Alluvial plain (silt; fine sand)
- zLb** glaciolacustrine mostly silt, blanket (> 1 m)
- zLm** glaciolacustrine, mostly silt, rolling
- tMm** till, sandy silt with trace to some gravel, rolling
- Qs** Quaternary sediments, undivided

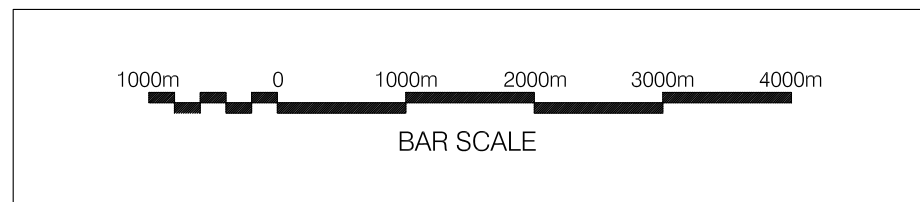
- Outcrop limit, drift boundary
- foliation, vertical
- foliation, with dip angle
- high angle fault
- escarpment



NOTES

1. BASE DATA SOURCE: NTDB 1:50,000 (115B16 - ZONE 7 & 115A/13 - ZONE 8)
2. DRAWING HAS BEEN PRODUCED IN COLOR, ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

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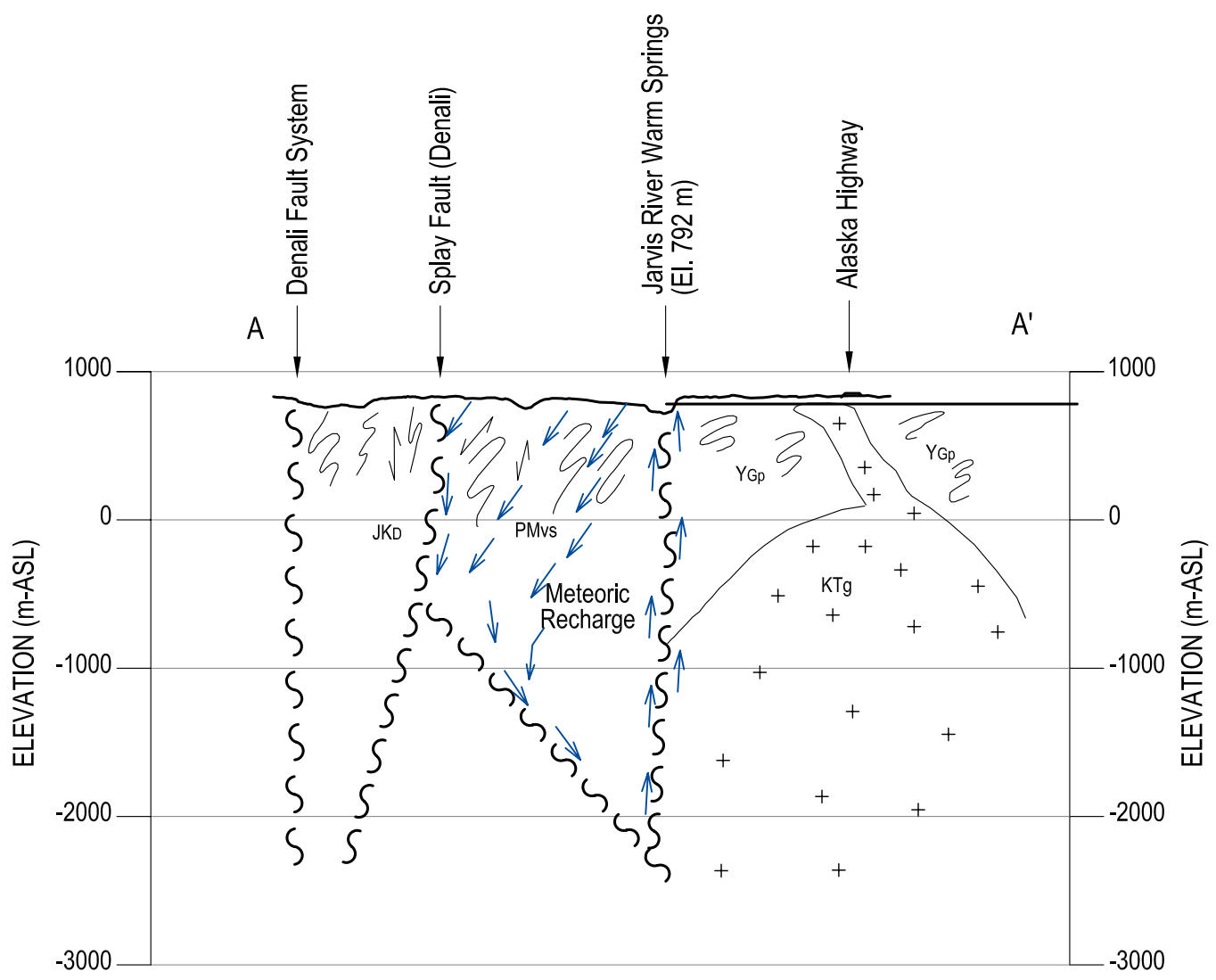
**GROUND-BASED GEOTHERMAL RECONNAISSANCE PROGRAM
MULTIPLE AREAS, YUKON**

**Jarvis River Warm Springs
Site Plan Showing
Geology and Section A - A'**

PROJECT NO. W23101159.008	DWN JSB	CKD JTD	REV 0
OFFICE WHSE	DATE December 2, 2008		

Figure 13

C:\Whitehorse\Data\0201\drawings\Whitehorse\W231159\008 YEC Geothermal Project\W23101159_008 Fig-14.dwg [Figure 14] December 04, 2008 - 1:41pm jbuyc



CROSS SECTION A -A'
N.T.S.

LEGEND
 Meteoric Recharge Path
 Fault

ISSUED FOR USE

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Ground Geothermal Reconnaissance Program
Multiple Areas - Yukon

JARVIS RIVER WARM SPRINGS
CROSS SECTION A - A' SHOWING
CONCEPTUAL GEOLOGY MODEL

PROJECT NO. W23101159.008	DWN JSB	CKD JTD	REV 0
OFFICE EBA-WHSE	DATE December 1, 2008		

Figure 14



PHOTOGRAPHS





Photo M1 - Aerial view of McArthur Hot Springs looking southeast (September 9, 2008)



Photo M2 - Overview to south of McArthur Hot Springs (September 9, 2008)



Photo M3 - Drainage of McArthur Hot Springs runoff into Hot Springs Creek (September 9, 2008)



Photo M4 - Detail of ferns at vent; M08S-2 (September 9, 2008)



Photo M5 - M08S-2; Overview downstream looking west (September 9, 2008)



Photo M6 - M08S-2 source in McArthur Hot Springs (September 9, 2008)



Photo M7 - M08S-3; Detail of seep & white crusted gravel.
Spearmint growing by seep. Minor flow ~1-2 gpm (September 9, 2008)



Photo M8 - M08S-4; minor spring vent, flow ~5-10 gpm.
White encrusted band 5 cm above water level indicates past higher flow (September 9, 2008)



Photo M9 - M08S-5; seep flow ~3-5 gpm. View North (September 9, 2008)



Photo M10 - M08S-5; Water line ~12 cm higher indicates higher flow in past. (September 9, 2008)



Photo M11 - M08S-6; Likely major vent along with M08S-2 vent. Discharge estimated 20 gpm.
White encrusting 10 cm above water level. (September 9, 2008)



Photo M12 - Algae and iron hydroxide precipitate down drainage ~7m from M08S-6 (September 9, 2008)



Photo M13 - M08S-7; Major vent with filamentous white/pink/cream algae, mats of floating green algae & orange iron floc. Overview looking northeast. (September 9, 2008)



Photo M14 - M08S-8; Detail of iron hydroxide floc downstream from M08S-7 source (September 9, 2008).



Photo M15 - M08S-8; Overview northeast to M08S-7;
white crust shows abundant flow 3-4" deep across 8 m wide zone (September 9, 2008).



Photo M16 - M08S-12; Overview to NNE.

Note abundant white crust minerals and high historic crust ~13 cm above current water level (September 9, 2008).

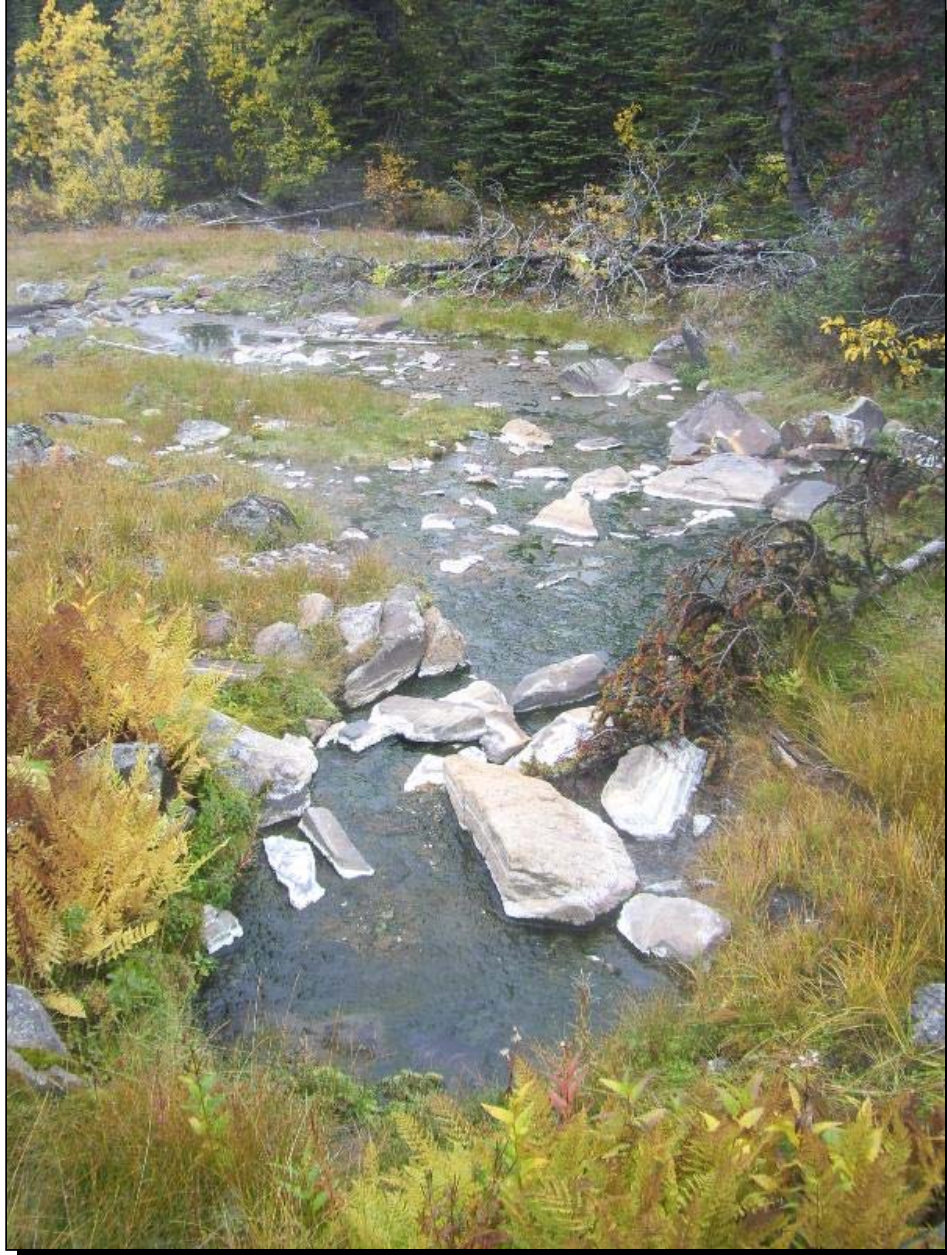


Photo M17 - M08S-12; View south from M08S-12 to Hot Spring Creek in distance (September 9, 2008).



Photo M18 - M08S-12; Detail of historic higher crust. ~7m down from M08S-12 vent.
Note faint higher band ~9 cm above current water level (September 9, 2008).



Photo M19 - M08S-12; Dark green and hot pink algae,
plus iron hydroxide flow ~10 m downstream from M08S-12 (September 9, 2008).



Photo M20 - M08S-16; Cool spring with green moss; flow ~5-10 gpm.
Overview looking southwest (September 9, 2008)



Photo M21 - M08S-18; Detail of white crust opal sinter (collected from M08S-6) (September 9, 2008)

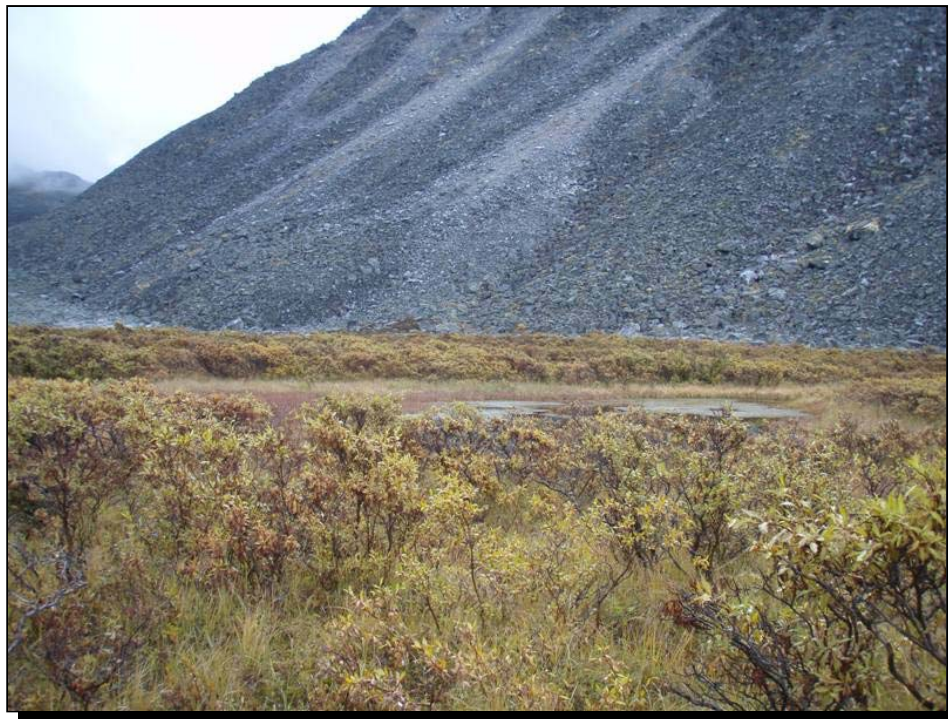


Photo M22 - Headwaters of Hot Spring Creek; near M08D-3 (September 9, 2008)



Photo M23 - M08D-3 water sampling point (September 9, 2008)



Photo M24 - M08D-4 near headwaters of Hot Spring Creek (September 9, 2008)



Photo M25 - M08D-7 view upstream (September 9, 2008)



Photo V1 - Overview of Volcano Mountain looking southwest (September 10, 2008)



Photo V2 - Lava dome in Volcano Mountain crater, looking north (September 10, 2008)



Photo V3 - Inside view of Volcano Mountain crater, west side (September 10, 2008)



Photo V4 - Lava pillars in lava dome inside Volcano Mountain crater; pillars are >3 m tall (September 10, 2008)



Photo V5 - V08J-19 "Jack's Pond"; drained pond east of Volcano Mountain (September 10, 2008)



Photo V6 - Detail of Jack's Pond (drained); V08J-19 (September 10, 2008)



Photo V7 - V08S-14; aerial view of mud slide on stream bank (September 10, 2008)

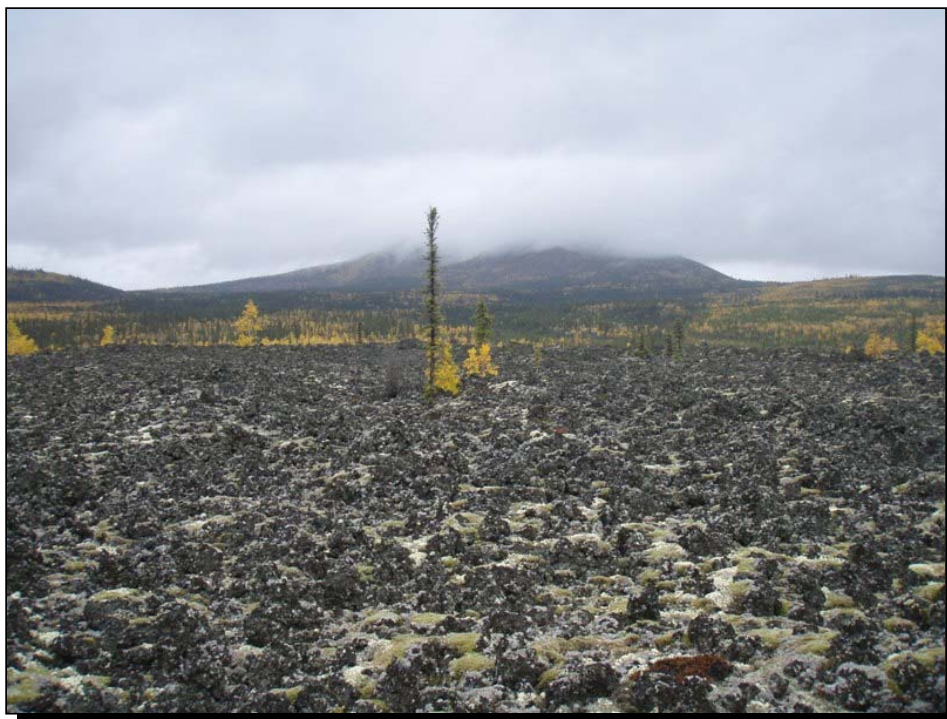


Photo V8 - Blocky lava flow; view from "Lava Lake" north-northeast toward Volcano Mountain (in cloud) (September 8, 2008)



Photo V9 - Helicopter used for survey - Bell Jet Ranger III (September 11, 2008)

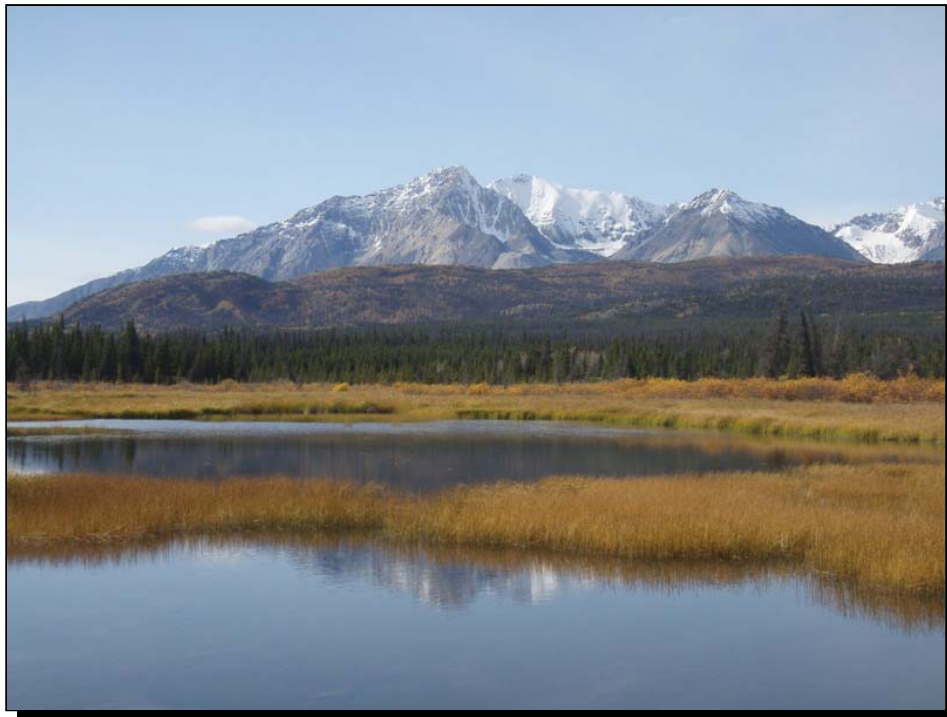


Photo H1 - Station H08D-9 with Kluane Range in background (September 15, 2008)



Photo H2 - Shakwak Valley with Kluane Range behind (September 16, 2008)



Photo H3 - Helicopter view of silt bluffs in Jarvis River Warm Springs area (September 15, 2008)



Photo H4 - Aerial overview of Jarvis River Warm Springs area (September 16, 2008)



Photo H5 - H08J-33; Jarvis River Warm Springs Pond #1 (September 16, 2008)



Photo H6 - H08J-33; Jarvis River Warm Springs Pond#2 (September 16, 2008)



Photo H7 - H08J-44; spring outlet with white crusted cobbles (September 16, 2008)



Photo H8 - H08J-39; round pool in grassy wetland (September 16, 2008)



Photo H9 - Overview of H08K-15 (September 15, 2008)



Photo H10 - Overview of H08K-3 (September 15, 2008)



Photo H11 - Overview of H08K-35 (September 16, 2008)



Photo H12 - Overview of landform at H08K-41 (September 16, 2008)



Photo H13 - H08D-3; detail of spring discharge and algae (September 15, 2008)



Photo H14 - Overview of H08D-3 (September 15, 2008)



Photo H15 - Water course at H08D-7 (September 15, 2008)



Photo H16 - H08D-21 thermal spring pool (September 16, 2008)



Photo H17 - H08D-22 thermal spring pool (September 16, 2008)



Photo H18 - H08D-24 warm spring outlet (September 16, 2008)



APPENDIX

APPENDIX A SUMMARY OF FIELD DATA

Table A1 - Summary of Field Data

ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
H08D-1	08V	340901	6755087	7.40	7.40	274	274	3.9	3.9	233	<0.5		
H08D-2	08V	340908	6755003	7.23	7.23	207	207	7.5	7.5	281	<0.5		
H08D-3	08V	340874	6755010	8.94	8.94	241	241	8.5	8.5	260	<0.5		
H08D-4	07V	661207	6754774	6.52	6.52	717	717	3.6	3.6	244	<0.5		
H08D-5	07V	661163	6754757	6.87	6.87	692	692	3.5	3.5	243	<0.5		
H08D-6	07V	662030	6756307	7.02	7.02	231	231	4.6	4.6	223	<0.5		
H08D-7	07V	661913	6756544	7.23	7.23	481	481	5.2	5.2	210	<0.5		
H08D-8	07V	661627	6757004	7.44	7.44	567	567	6.3	6.3	268	<0.5		
H08D-9	07V	661627	6757423	6.88	6.88	634	634	7.1	7.1	219	<0.5		UTMs estimated from map
H08D-10	07V	661397	6757967	7.04	7.04	521	521	7.0	7.0	221	<0.5		
H08D-11	07V	661392	6758122	6.99	6.99	545	545	7.3	7.3	286	<0.5		
H08D-12	08V	337414	6754756	7.19	7.19	509	509	10.5	10.5	233	<0.5		
H08D-13	08V	342238	6761490	6.93	6.93	476	476	6.7	6.7	224	<0.5		No water between H08D-13 & 14
H08D-14	08V	342871	6756151	7.22	7.22	433	433	6.0	6.0	284	<0.5		2 sets of UTMs recorded; Dave confirm location
H08D-15	08V	343062	6758944	6.20	6.20	337	337	3.7	3.7	NA	NA		No UTMs supplied
H08D-16	08V	342829	6756161	6.59	6.59	503	503	5.6	5.6	208	<0.5		
H08D-17	08V	342793	6756114	6.72	6.72	432	432	5.5	5.5	211	<0.5		
H08D-18	08V	342824	6756112	6.94	6.94	322	322	3.8	3.8	291	<0.5		
H08D-19	08V	342855	6756120	7.02	7.02	410	410	4.4	4.4	236	<0.5		
H08D-20	08V	338335	6755284	7.72	7.72	699	699	14.2	14.2	196.5	1		
H08D-21	08V	338356	6755283	7.52	7.52	394	394	17.9	17.9	196.1	1		
H08D-22	08V	338358	6755301	7.10	7.10	690	690	16.6	16.6	191.4	1		
H08D-23	08V	338361	6755299	6.97	6.97	1343	1343	8.6	8.6	177.7	2		Water cooler & different chem than H08D-12
H08D-24	08V	338378	6755271	7.62	7.62	679	679	14.8	14.8	198.6	1		
H08D-25	08V	338371	6755190	NA	NA	NA	NA	NA	NA	NA	NA		Waypoint only. End of search area.
H08D-26	08V	338344	6755239	7.49	7.49	664	664	13.7	13.7	NA	NA		Waypoint only. Warm spring Heli-pad.
H08D-27	08V	338335	6755264	7.92	7.92	667	667	13.1	13.1	NA	NA		
H08D-28	08V	338291	6755264	7.94	7.94	662	662	12.9	12.9	NA	NA		
H08D-29	08V	338262	6755295	7.91	7.91	668	668	12.8	12.8	NA	NA		
H08D-30	08V	338310	6755284	7.56	7.56	682	682	10.7	10.7	NA	NA		
H08D-31	08V	338306	6755323	7.57	7.57	595	595	12.9	12.9	NA	NA		
H08D-32	08V	338312	6755347	NA	NA	NA	NA	NA	NA	NA	NA		
H08D-34	08V	338568	6755446	7.03	7.03	2235	2235	9.1	9.1	198.2	1		
H08D-35	08V	661433	6755775	7.89	7.89	2011	2011	10.3	10.3	162.3	3		
H08D-36	07V	661407	6755772	8.01	8.01	1497	1497	11.1	11.1	210	<0.5		
H08D-37	07V	661367	6755792	7.77	7.77	722	722	5.5	5.5	NA	NA		
H08D-38	07V	661378	6755800	7.90	7.90	1196	1196	10.8	10.8	189	1		
H08D-39	08V	340874	6755010	8.08	8.08	234	234	12.8	12.8	199	1	Y	Same as H08-D3
H08D-40	08V	340333	6758347	7.48	7.48	77	77	16.1	16.1	NA	NA		Is this zone correct?
H08K-1	08V	340870	6755003	9.05	9.05	221	221	9.4	9.4	NA	NA		some upwelling. Cross-checked probes
H08K-2	07V	661739	6755285	9.08	9.08	1312	1312	2.7	2.7	NA	NA		
H08K-3	07V	661871	6755318	9.99	9.05	1042	1042	4.8	4.8	NA	NA		
H08K-4	07V	661773	6755216	9.91	8.97	1715	1715	3.6	3.6	NA	NA		
H08K-5	07V	661773	6755216	10.2	9.26	2205	2205	6.6	6.6	NA	NA		
H08K-6	07V	662201	6756204	10.23	8.09	1037	1037	3.7	3.7	NA	NA		
H08K-7	07V	661989	6756430	10.44	8.3	557	557	5.1	5.1	NA	NA		
H08K-8	08V	337929	6756442	10.5	8.36	2574	2574	8.0	8	NA	NA		small pond adjacent to lake
H08K-9	08V	337988	6756322	9.91	7.77	2874	2874	7.3	7.3	NA	NA		Small seep

Table A1 - Summary of Field Data

ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
H08K-10	08V	337843	6756037	10.23	8.09	3301	3301	7.9	7.9	NA	NA		Along line with series of targets
H08K-11	08V	338120	6755196	10.23	8.09	233	233	8.6	8.6	NA	NA		
H08K-12	08V	338349	6755080	9.86	7.72	248	248	8.5	8.5	NA	NA		
H08K-13	08V	338783	6755232	9.85	7.71	1227	1227	4.8	4.8	NA	NA		
H08K-14	08V	338833	6755256	9.72	7.58	1148	1148	3.6	3.6	NA	NA		Ponds near river; H2S odour
H08K-15	08V	338896	6755285	NA	NA	NA	NA	NA	NA	NA	NA		White deposit on ground
H08K-16	08V	339054	6755248	10.10	7.96	213	213	10.8	10.8	NA	NA		Jarvis River at the road
H08K-17	08V	337600	6757530	9.75	7.61	402	402	4.4	4.4	NA	NA		Swampy area
H08K-18	08V	337616	6757685	9.55	7.41	531	531	7.5	7.5	NA	NA		Swampy area; H2S odour
H08K-19	08V	337614	6757745	9.53	7.39	664	664	6.9	6.9	NA	NA		
H08K-20	07V	658732	6761169	9.64	7.5	389	389	6.9	6.9	NA	NA		
H08K-21	07V	659298	6761024	10.18	8.04	380	380	5.0	5	NA	NA		
H08K-22	07V	659446	6760956	10.09	7.95	336	336	4.8	4.8	NA	NA		
H08K-23	07V	658232	6761621	9.96	7.82	549	549	4.4	4.4	NA	NA		
H08K-24	07V	658192	6761647	9.69	7.55	522	522	6.3	6.3	NA	NA		
H08K-25	07V	658231	6761623	10.05	7.91	575	575	0.7	0.7	NA	NA		Right where water bubbling out
H08K-26	08V	342275	6761235	9.65	6.79	1417	1417	11.5	11.5	NA	NA		Bog along road
H08K-27	08V	342324	6761320	9.84	6.98	408	408	11.8	11.8	NA	NA		Bog along road
H08K-28	08V	342632	6759754	10.64	7.78	254	254	11.1	11.1	NA	NA		
H08K-29	08V	342711	6759617	10.41	7.55	289	289	6.2	6.2	NA	NA		
H08K-30	08V	342566	6759322	10.02	7.16	181	181	6.7	6.7	NA	NA		
H08K-31	08V	342662	6759174	10.07	7.21	160	160	5.4	5.4	NA	NA		
H08K-32	08V	342529	6758759	9.89	7.03	278	278	7.7	7.7	NA	NA		
H08K-33	08V	338628	6755424	10.67	7.81	>4000	>4000	7.2	7.2	NA	NA		Swamp above warm springs; Brine taste
H08K-34	08V	338363	6755267	10.68	7.82	731	731	14.9	14.9	NA	NA		Noisy; Lots of bubbling at warm spring
H08K-35	08V	338314	6755320	11.24	7.18	285	285	13.3	13.3	NA	NA		Flowing water among rocks; white deptsits
H08K-36	08V	362322	6738183	12.12	8.06	245	245	15.6	15.6	NA	NA	Y	Haines Junction well; ~130 L/min, artesian
H08K-37	08V	337946	6759610	11.88	7.82	735	735	9.6	9.6	NA	NA		Sulphur Lake drainage & wetlands
H08K-38	08V	338949	6758878	11.72	7.66	140	140	7.8	7.8	NA	NA		Drainage on Hwy across from sulphur lake
H08K-39	08V	338925	6758782	10.76	6.7	149	149	6.8	6.8	NA	NA		
H08K-40	07V	662185	6758869	11.34	7.28	863	863	10.6	10.6	NA	NA		
H08K-41	08V	338040	6759053	11.48	7.42	>4000	>4000	>15	>15	NA	NA		H2S odour; odd thrusted till features
H08K-42	08V	338005	6759075	11.44	7.38	>3999	>3999	13.7	13.7	NA	NA		
H08K-43	08V	337734	6759365	11.30	7.24	760	760	9.7	9.7	NA	NA		
H08K-44	08V	337650	6759421	11.77	7.71	787	787	10.7	10.7	NA	NA		
H08K-45	08V	341194	6757423	12.36	8.3	53	53	11.3	11.3	NA	NA		
H08K-46	08V	340572	6756886	11.86	7.8	76	76	11.7	11.7	NA	NA		
H08J-1	07V	662166	6754969	NA	NA	248	188	8.7	6.8	NA	NA		
H08J-1A	08V	340933	6755131	NA	NA	317	257	5.5	3.6	NA	NA		Katherine took these readings
H08J-2	07V	662342	6756991	NA	NA	NA	NA	NA	NA	NA	NA		
H08J-2A	08V	340901	6755168	NA	NA	616	556	6.4	4.5	NA	NA		Katherine took these readings
H08J-3	08V	337764	6756511	10.64	7.78	3473	3413	9.9	9.9	NA	NA		
H08J-3A	08V	340859	6755010	NA	NA	235	175	10.4	8.5	NA	NA		Katherine took these readings
H08J-4	08V	337623	6756451	NA	NA	1960	1900	7.6	5.7	NA	NA		Small pothole with water in bottom
H08J-5	08V	337544	6756335	NA	NA	298	238	9.1	7.2	NA	NA		Standing water in wetland
H08J-6	08V	337432	6756296	NA	NA	232	172	6.5	4.6	NA	NA		Pond in wetland
H08J-7	08V	337850	6756020	NA	NA	1910	1850	7.1	5.2	NA	NA		Puddle in forest
H08J-8	08V	337703	6756217	NA	NA	1006	946	6.7	4.8	NA	NA		Small spring pool with water plant cover

Table A1 - Summary of Field Data

ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
H08J-9	08V	337741	6756252	NA	NA	8400	8340	10.4	8.5	NA	NA		Small pool in wetland; H2S odour
H08J-10	08V	337796	6756277	NA	NA	2560	2500	11.8	9.9	NA	NA		Ivory/white coating around 30 m pool
H08J-11	08V	337940	6756301	NA	NA	2690	2630	12.4	10.5	NA	NA		5x3m pool in wetland
H08J-12	08V	338396	6756154	NA	NA	1310	1250	13.8	11.9	NA	NA		Small Lake in wetland
H08J-13	08V	338029	6756332	NA	NA	2380	2320	6.55	4.65	NA	NA		Small pool in wetland
H08J-14	08V	339037	6755323	NA	NA	1771	1711	3.8	1.9	NA	NA		Pool in ephemeral stream
H08J-14A	08V	339037	6755323	NA	NA	NA	NA	2.7	2.7	NA	NA		Katherine took this reading
H08J-15	07V	660179	6760415	NA	NA	388	328	7.4	5.5	NA	NA		Small pond in wetland
H08J-16	07V	660084	6160533	NA	NA	383	323	8.1	6.2	NA	NA		Pool in wetland
H08J-17	07V	660056	6760621	NA	NA	383	323	7.9	6	NA	NA		Open water in wetland
H08J-18	07V	660061	6760715	NA	NA	601	541	9.6	7.7	NA	NA		Small pond in wetland
H08J-19	07V	659932	6760838	NA	NA	388	328	8.4	6.5	NA	NA		Large pond in wetland
H08J-20	07V	659780	6760934	NA	NA	517	457	6.9	5	NA	NA		Pond with milfoil in wetland
H08J-21	07V	659697	6761027	NA	NA	550	490	9.6	7.7	NA	NA		Pond with milfoil in wetland
H08J-22	07V	659547	6761007	NA	NA	386	326	9.5	7.6	NA	NA		wetland
H08J-23	07V	656790	6762264	NA	NA	424	364	10.4	8.5	NA	NA		large pond in wetland
H08J-24	07V	656594	6462272	NA	NA	421	361	12.3	10.4	NA	NA		pond in wetland;warmed by sun?
H08J-25	08V	342795	6760137	NA	NA	2020	1960	10.4	8.5	NA	NA		puddle in large wetland
H08J-26	08V	342886	6760247	NA	NA	1844	1784	10.4	8.5	NA	NA		Small pond in wetland
H08J-27	08V	343084	6760547	NA	NA	1225	1165	11.9	10	NA	NA		Small puddle in willow stand
H08J-28	08V	342981	6760318	NA	NA	811	751	11.5	9.6	NA	NA		
H08J-29	07V	662589	6755447	NA	NA	297	237	8.0	6.1	NA	NA		Ponded water by river
H08J-30	07V	662525	6755502	NA	NA	339	279	7.3	5.4	NA	NA		Puddle in grassy clearing
H08J-31	07V	662521	6755449	NA	NA	2810	2750	6.9	5	NA	NA		Puddle in grassy clearing
H08J-32	07V	662539	6755388	NA	NA	1050	990	7.2	5.3	NA	NA		Puddle in dead spruce
H08J-33	08V	338364	6755256	NA	NA	NA	NA	16.1	16.1	190.2	1		Jarvis R. warm spgs.;water turbid from belching gas
H08J-33A	08V	338364	6755256	7.82	7.82	660	660	14.4	14.4	190.2	1	Y	Readings & sample by Dave
H08J-33B	08V	338364	6755256	NA	NA	NA	NA	17.7	17.7	NA	NA		Hottest in silty mud at warm spg; Katherine readings
H08J-34	07V	655868	6762322	NA	NA	423	363	8.3	6.4	NA	NA		Abandoned beaver pond
H08J-35	07V	655881	6761974	NA	NA	188.8	128.8	9.7	7.8	NA	NA		Small lake in wetland
H08J-36	07V	656969	6761532	NA	NA	506	446	12.2	10.3	NA	NA		Large pond in depression; fringed by grasses
H08J-37	07V	657143	6761363	NA	NA	489	429	9.3	7.4	NA	NA		Small stream 1m deep? 0.5m wide
H08J-38	07V	657318	6761318	NA	NA	604	544	8.4	6.5	NA	NA		Large pond
H08J-39	07V	657179	6760800	NA	NA	167	107	11.2	9.3	NA	NA		Muddy puddle in circular grass wetland
H08J-40	07V	658059	6760004	NA	NA	243	183	9.4	7.5	NA	NA		
H08J-41	07V	658835	6758617	NA	NA	1156	1096	8.4	6.5	NA	NA		Puddle in wetland
H08J-42	07V	660185	6757990	NA	NA	452	392	11.2	9.3	NA	NA		Pond in wetland 25m from stream
H08J-43	07V	660272	6757940	NA	NA	1144	1084	10.0	8.1	NA	NA		Pond in wetland
H08J-44	07V	661288	6755435	NA	NA	794	734	6.4	4.5	NA	NA		Small spring; no visible flow
H08J-45	07V	661283	6755930	NA	NA	798	738	7.3	5.4	NA	NA		Series of small pools; boulders with white precipitate.
H08J-46	07V	661263	6755892	NA	NA	770	710	4.5	2.6	NA	NA		Stream from H08J-45
H08J-47	07V	661384	6755803	NA	NA	1308	1248	11.3	9.4	NA	NA		Small pond in grassy clearing
H08J-48	07V	661537	6755803	NA	NA	951	891	10.4	8.5	NA	NA		Small pond in depression
H08J-49	07V	661469	6755707	NA	NA	1840	1780	11.0	9.1	NA	NA		Pond by till mound; rusty water
H08J-50	07V	661370	6755436	NA	NA	1520	1460	11.4	9.5	NA	NA		Pond with milfoil in wetland
H08J-51	08V	341891	6756965	NA	NA	72.5	72.5	7.7	5.8	NA	NA		Small lake in wetland
H08J-52	08V	341361	6957217	NA	NA	45.0	45	12.8	10.9	NA	NA		Wetland near small lake
H08J-53	08V	343125	6757673	NA	NA	661	601	11.4	9.5	NA	NA		Pond in wetland; E. side of Hwy.

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ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
M08J-1	08V	463071	6991264	6.7	6.7	38	38	0.3	0.3	NA	NA		Cold spring with low flow
M08J-2	08V	463023	6991394	5.57	5.57	2	2	3.7	3.7	NA	NA		
M08J-3	08V	462995	6991542	5.35	5.35	2	2	4.6	4.6	NA	NA		Puddle in depression
M08J-4	08V	462971	6991639	5.52	5.52	0	0	6.3	6.3	NA	NA		Small, deep pond
M08J-5	08V	462971	6991705	5.09	5.09	2	2	4.4	4.4	NA	NA		Shallow pool
M08J-6	08V	462996	6992015	5.81	5.81	2	2	4.2	4.2	NA	NA		
M08J-7	08V	464055	6993154	8.2	8.2	47	47	6.6	6.6	NA	NA		Small stream draining wetland
M08J-8	08V	464041	6993214	8.07	8.07	56	56	4.8	4.8	NA	NA		
M08J-9	08V	464071	6993141	10.29	7.59	159	159	29.1	29.1	NA	NA		Small seep
M08J-10	08V	464079	6993163	10.6	7.9	226	226	41.4	41.4	NA	NA		Side channel; small white precipitate
M08J-11	08V	464079	6993178	10.44	7.74	218	218	36.8	36.8	NA	NA		
M08J-12	08V	464067	6993193	7.95	7.95	114	114	10.8	10.8	NA	NA		Puddle in wetland with watercress
M08J-13	08V	464119	6993203	10.74	8.04	224	224	45.2	45.2	NA	NA		Hot spring 3m from hot spr. Creek; good flow
M08J-14	08V	464119	6993205	10.45	7.75	206	206	41	41	NA	NA		2 m north of M08J-13
M08J-15	08V	464122	6993224	10.46	7.76	224	224	43.7	43.7	NA	NA		Flowing hot spring with floating bog mat
M08J-16	08V	467730	6995673	7.8	6.3	38	38	6.2	6.2	NA	NA		Circular pool in granitic rocks
M08J-17	08V	464171	6993223	8.45	6.45	59	59	5.0	5	NA	NA		Small spring on stream bank
M08J-18	08V	464171	6693298	NA	NA	NA	NA	NA	NA	NA	NA		Granitic boulder train
M08J-19	08V	464102	6993166	9.3	7.2	33	33	3.3	3.3	NA	NA		Main channel Hot spg. Cr.
M08J-20	08V	460193	6990997	NA	NA	NA	NA	4	4	NA	NA		Tributary to hot spg. Cr.; temp estimated
M08J-21	08V	460243	6990497	NA	NA	NA	NA	1	1	NA	NA		Cold spring; high flow; temp. estimated
M08J-22	08V	466548	6993150	NA	NA	NA	NA	NA	NA	NA	NA		Granodiorite outcrop in tributary
M08J-23	08V	466111	6993367	NA	NA	NA	NA	NA	NA	NA	NA		Quartzite/granodiorite talus
M08J-24	08V	465505	6993244	NA	NA	NA	NA	NA	NA	NA	NA		Granodiorite/Diabase contact 50 m to NE
M08J-25	08V	465365	6993206	NA	NA	NA	NA	NA	NA	NA	NA		Talus; siliceous hornblende intrusive rocks
M08J-26	08V	464807	6992920	NA	NA	NA	NA	NA	NA	NA	NA		Foliated, jointed metased rocks 75m to NE
M08S-1	08V	464111	6993123	NA	NA	NA	NA	NA	NA	NA	NA		Confluence hot spg drainage & South Bk
M08S-2	08V	464169	6993120	10.02	7.79	238	268	54.5	54.5	NA	NA		Major spg. at MHS; ferns surround
M08S-2A	08V	464169	6993120	7.13	7.13	298	298	51.9	51.9	291	<0.5	Y	Dave took these readings
M08S-3	08V	464163	6993131	10.14	7.91	205	235	31.3	31.3	NA	NA		Small seep at MHS; white stained gravel
M08S-4	08V	464171	6993132	9.97	7.74	176	206	29.9	29.9	NA	NA		Minor spg. at MHS; white crust
M08S-4A	08V	464171	6993132	7.34	7.34	222	222	26.2	26.2	293	<0.5	Y	Dave took these readings
M08S-5	08V	464166	6993135	10.28	8.05	237	267	40.4	40.4	NA	NA		Oozy seep at MHS
M08S-6	08V	464145	6993130	10.24	8.01	244	274	52.8	52.8	NA	NA		Major srg. at MHS; flow 20 gpm; white crust
M08S-6A	08V	464145	6993130	9.18	9.18	265	265	47.5	47.5	290	<0.5	Y	Dave took these readings
M08S-7	08V	464143	6993142	10.28	8.05	244	274	51.6	51.6	NA	NA		Major spg. at MHS; flow 40-50gpm
M08S-8	08V	464168	6993152	9.13	6.9	160	190	13.3	13.3	NA	NA		Broad seep at MHS; no visible flow; blue sheen
M08S-9	08V	464129	6993156	8.47	6.24	139	169	13.8	13.8	NA	NA		Stagnant seep at MHS
M08S-10	08V	464125	6993171	8.81	6.58	189	219	15.5	15.5	NA	NA		Stagnant seep at MHS
M08S-11	08V	464129	6993189	8.34	6.11	100	130	12.2	12.2	NA	NA		Seep at MHS; v. low flow
M08S-11A	08V	464129	6993189	7.14	7.14	149	149	12.5	12.5	271	<0.5	Y	Dave took these readings
M08S-12	08V	464123	6993180	10.28	8.05	243	273	50.9	50.9	NA	NA		Major spg. at MHS; flow 20-30 gpm; higher in past
M08S-12A	08V	464123	6993180	7.13	7.13	267	267	47.0	47.0	321	<0.5	Y	Dave took these readings
M08S-13	08V	464113	6993176	10.25	8.02	243	273	51.9	51.9	NA	NA		Mod. Spg. at MHS; flow 20 gpm; Fe floc
M08S-14	08V	464812	6992052	9.24	7.01	174	204	3.0	3	NA	NA		Spring on hillslope; another 150 m upslope
M08S-15	08V	466376	6995257	9.51	7.28	16	46	7.9	7.9	NA	NA		Tarn lake/wetland
M08S-16	08V	464242	6993524	8.46	7.41	116	116	7.8	7.8	NA	NA		Spring; flow 5-10 gpm
M08S-17	08V	464252	6993524	8.48	7.43	115	115	5.5	5.5	NA	NA		Edge of spring at M08S-16

Table A1 - Summary of Field Data

ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
M08S-18	08V	464301	6993237	8.58	7.53	103	103	5.4	5.4	NA	NA		Spring edge of hot spg. Ck.; flow 50 gpm
M08S-19	08V	464172	6993198	7.52	6.47	107	107	2.9	2.9	NA	NA		North bk. Above 2 spgs by hot spg. Ck.
M08S-20	08V	464152	6993201	7.92	6.87	155	155	1.7	1.7	NA	NA		Confluence N bk. & hot spg. Ck.
M08S-21	08V	462929	6992124	7.35	6.3	2	2	5.3	5.3	NA	NA		Pools in wetland
M08S-22	08V	462902	6992530	7.07	6.02	2	2	0.6	0.6	NA	NA		Small brook, rising & disappearing in dead fall
M08S-23	08V	462831	6992671	7.02	5.97	2	2	1.4	1.4	NA	NA		Small brook, rising & disappearing in dead fall
M08S-24	08V	462807	6993052	7.12	6.07	5	5	1.6	1.6	NA	NA		50m above confluence with hot spg. Ck.
M08S-25	08V	462901	6993058	7.58	6.53	32	32	3.7	3.7	NA	NA		Main channel hot spg. Ck.
M08S-26	08V	463022	6993064	6.39	5.34	5	5	1.2	1.2	NA	NA		Small tributary to hot spg. Ck.
M08S-26A	08V	463022	6993067	7.05	6	35	35	3.8	3.8	NA	NA		In hot spg. Ck, UTM's estimated from M08S-26
M08S-27	08V	463317	6993110	6.10	5.05	7	7	1.5	1.5	NA	NA		Tributary S. side hot spg. Ck.
M08S-28	08V	463396	6993082	6.75	5.7	12	12	1.5	1.5	NA	NA		Tributary S. side hot spg. Ck.
M08S-29	08V	463743	6993111	7.75	6.7	35	35	3.8	3.8	NA	NA		Main in channel hot spg. Ck.
M08S-30	08V	463790	6993112	6.92	5.87	101	101	1.4	1.4	NA	NA		Tributary S. side hot spg. Ck.
M08S-31	08V	467400	6992384	NA	NA	37	37	3.5	3.5	NA	NA		Green algae covered pool
M08D-1	08V	467847	6993483	7.21	7.21	23	23	0.7	0.7	217	<0.5		
M08D-2	08V	467600	6993666	5.84	5.84	90	90	3.0	3.0	256	<0.5		UTM's estimated from map
M08D-3	08V	467638	6993591	7.14	7.14	16	16	5.7	5.7	258	<0.5	Y	
M08D-4	08V	467031	6993731	6.78	6.78	17	17	3.5	3.5	265	<0.5		
M08D-5	08V	466475	6993440	6.95	6.95	17	17	3.6	3.6	272	<0.5		
M08D-6	08V	466200	693600	6.98	6.98	19	19	3.6	3.6	270	<0.5		UTM's estimated from map
M08D-7	08V	465945	6993444	6.99	6.99	18	18	3.7	3.7	272	<0.5		
M08D-8	08V	464988	6993328	7.10	7.10	22	22	4.1	4.1	248	<0.5		
M08D-9	08V	464333	6993254	7.14	7.14	168	168	17.5	17.5	265	<0.5		
M08D-10	08V	464159	6993090	NA	NA	143	143	4.9	4.9	228	<0.5	Y	
M08D-11	08V	462627	6993100	NA	NA	38	38	6.3	6.3	212	<0.5		
M08D-12	08V	462220	6993220	NA	NA	46	46	6.3	6.3	214	<0.5		UTM's estimated from map
M08D-13	08V	461000	6993350	NA	NA	21	21	6.9	6.9	228	<0.5		UTM's estimated from map
M08D-14	08V	461169	6993422	NA	NA	20.2	20.2	6.8	6.8	244	<0.5		
V08S-1	08V	377965	6975678	7.35	7.35	108	108	5.3	5.3	NA	NA		
V08S-2	08V	378419	6975687	7.34	7.34	88	88	5.0	5	NA	NA		
V08S-3	08V	378705	6975781	7.66	7.66	158	158	4.3	4.3	NA	NA		Braided brook in wetland
V08S-4	08V	378935	6975677	7.76	7.76	158	158	4.6	4.6	NA	NA		Creek channel; slow-moving
V08S-5	08V	379697	6975644	7.89	7.89	290	290	2.3	2.3	NA	NA		Flowing brook in deadfall
V08S-6	08V	380042	6975678	8.48	7.38	205	215	4.1	4.1	NA	NA		Brook channel 0.75m wide, 0.3m deep
V08S-7	08V	380345	6975833	8.48	7.38	203	213	4.1	4.1	NA	NA		Creek channel in willows
V08S-8	08V	379799	6979816	7.96	6.86	110	120	0.9	0.9	NA	NA		Small pool in leaf litter; No visible flow
V08S-9	08V	379917	6980290	8.21	7.11	179	189	2.1	2.1	NA	NA		Small brook; flow ~50 gpm
V08S-10	08V	380218	6980534	8.24	7.14	90	100	1.7	1.7	NA	NA		Pool in wetland
V08S-11	08V	380435	6981070	8.61	7.51	270	280	2.7	2.7	NA	NA		Brook channel 1-2 m wide, 0.5m deep
V08S-12	08V	380172	6981218	8.71	7.61	257	267	1.2	1.2	NA	NA		Tributary brook 5 m up from confluence
V08S-13	08V	376891	6986114	8.64	7.54	212	222	5.2	5.2	NA	NA		Stream by lava flow
V08S-14	08V	382038	6977608	NA	NA	NA	N	NA	N	NA	NA		Mudslide on ck bank; N 62° 54' 39.8" W137° 19' 19.4"
V08D-1	08V	376968	6975656	7.15	7.15	1496	1496	3.8	3.8	252	<0.5		
V08D-2	08V	376708	6975801	5.87	5.87	165	165	5.3	5.3	259	<0.5		
V08D-3	08V	376609	6975851	NA	NA	NA	N	NA	N	NA	NA		Waypoint only
V08D-4	08V	376434	6975730	NA	NA	NA	N	NA	N	NA	NA		Waypoint only; top of ridge

Table A1 - Summary of Field Data

ID	UTM Zone NAD27	UTM Easting NAD27	UTM Northing NAD27	pH Raw	pH Corrected	EC Raw uS	EC Corrected uS	T Raw deg C	T Corrected deg C	CI Raw mV	CI Calculated mg/L	Water Sample? Y = yes	Comments
V08D-5	08V	376408	6975978	7.14	7.14	126	126	6.0	6.0	245	<0.5		
V08D-6	08V	376244	6976073	7.15	7.15	93	93	5.0	5.0	238	<0.5		
V08D-7	08V	375965	6976187	7.1	7.1	79	79	8.1	8.1	246	<0.5		
V08D-8	08V	375736	6976221	7.13	7.13	88	88	5.4	5.4	241	<0.5		
V08D-9	08V	375419	6976264	7.12	7.12	78	78	5.5	5.5	240	<0.5		
V08D-10	08V	377431	6975739	7.06	7.06	158	158	11.3	11.3	223	<0.5	Y	
V08D-11	08V	383461	6982337	7.04	7.04	76	76	0	0	224	<0.5		Water at freezing point
V08D-12	08V	382981	6982346	7.12	7.12	456	456	2.0	2.0	219	<0.5	Y	
V08D-13	08V	382174	6982234	7.11	7.11	224	224	2.4	2.4	213	<0.5		
V08D-14	08V	381905	6982299	7.29	7.29	206	206	3.1	3.1	254	<0.5		
V08D-15	08V	381365	6982206	7.30	7.30	241	241	3.2	3.2	262	<0.5		
V08D-16	08V	380834	6981997	7.54	7.54	263	263	3.2	3.2	244	<0.5		
V08D-17	08V	380044	6981805	7.21	7.21	234	234	3	3	217	<0.5	Y	
V08D-18	08V	380022	6981823	NA	NA	159	159	3.6	3.6	210	<0.5		
V08D-19	08V	378867	6982120	NA	NA	112	112	2.4	2.4	228	<0.5		UTMs estimated from map
V08J-1	08V	377970	6975675	7.24	7.24	1.14	1.14	5.1	5.1	NA	NA		
V08J-2	08V	378164	6975672	7.05	7.05	97	97	4.5	4.5	NA	NA		Running water on game trail in wetland
V08J-3	08V	378790	6975751	7.39	7.39	185	185	5.7	5.7	NA	NA		Standing water in wetland
V08J-4	08V	379004	6975653	6.90	6.9	145	145	4.2	4.2	NA	NA		Standing water in wetland
V08J-5	08V	378407	6976008	7.90	7.9	112	112	5.4	5.4	NA	NA		Surface flow up from wetland
V08J-6	08V	378435	6976161	7.63	7.63	113	113	4.4	4.4	NA	NA		
V08J-7	08V	378580	6976270	7.70	7.7	113	113	2.9	2.9	NA	NA		Brook channel; visible good flow
V08J-8	08V	378703	6976405	7.28	7.28	72	72	2.3	2.3	NA	NA		Tributary channel from East
V08J-9	08V	378688	6976396	7.57	7.57	118	118	2.5	2.5	NA	NA		Spring with strong discharge; 3m2 area
V08J-10	08V	378816	6976522	7.70	7.7	97	97	3.5	3.5	NA	NA		Brook channel; less flow than V08J-9
V08J-11	08V	378973	6976620	7.31	7.31	95	95	3.3	3.3	NA	NA		Lava Lake (Heli-pad UTM) 377500 - 697600
V08J-12	08V	378198	6978967	NA	NA	NA	NA	NA	NA	NA	NA		Dry grassy clearing in dense forest
V08J-13	08V	378287	6978454	7.46	7.46	87	87	4.7	4.7	NA	NA		Stagnant elongate ponds; readings from S. pond
V08J-14	08V	378719	6978529	NA	NA	NA	N	NA	N	NA	NA		Waypoint in lava/forest terrain
V08J-15	08V	378095	6978485	7.82	7.82	193	193	6.1	6.1	NA	NA		Water in hole dug in muddy depression
V08J-16	08V	379205	6978996	NA	NA	NA	N	NA	N	NA	NA		Saddle at S. side volcano crater
V08J-17	08V	379973	6979115	7.99	7.99	37	37	5.5	5.5	NA	NA		Stagnant pond in lava depression
V08J-18	08V	380435	6979159	7.90	7.9	107	107	4.2	4.2	NA	NA		Stagnant surface runoff in willows & grass
V08J-19	08V	380761	6978807	NA	NA	NA	N	NA	N	NA	NA		Waypoint at "disappearing lake"; no water
V08J-20	08V	377829	6979403	NA	NA	NA	N	NA	N	NA	NA		Circular grassy clearing; wet soil; 5-6 m depression
V08J-21	08V	381603	6979336	7.93	7.93	150	150	6.9	6.9	NA	NA		

Notes

NA = not available

Bold = most reliable field readings; taken with higher precision portable instruments by water sampling technician



APPENDIX

APPENDIX B WATER CHEMISTRY AND ISOTOPE LABORATORY ANALYTICAL RESULTS

AUTO FAX

COVER SHEET

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Att'n: Katherine Johnston
From: LINKS Automatic Fax
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MESSAGE:

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Project Name:
Project Number: W23101159.005
Submission Date: September 23, 2008
Matrix: Water

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REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S4	MHS08-S6	MHS08-S11	MHS08-S12	
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08	DETECTION LIMIT
CANTEST ID:		809250443	809250449	809250451	809250454	
Hardness	CaCO3	3	4	14	4	1
Dissolved Fluoride	F	7.30	7.41	3.51	7.70	0.05
Dissolved Chloride	Cl	0.88	0.80	0.61	1.12	0.2
Nitrate and Nitrite	N	<	<	<	0.10	0.05
Dissolved Nitrate	N	<	<	<	0.10	0.05
Nitrite	N	0.002	<	<	<	0.002
Dissolved Sulphate	SO4	15.7	14.9	18.7	15.8	0.5

Results expressed as milligrams per liter (mg/L)

< = Less than detection limit

REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S2	MHS08-D3	MHS08-D10	HJ08-K36	
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 11/08	Sep 16/08	DETECTION LIMIT
CANTEST ID:		809250460	809250463	809250467	809250471	
Hardness	CaCO3	4	6	44	9	1
Dissolved Fluoride	F	7.61	<	0.10	0.28	0.05
Dissolved Chloride	Cl	0.86	<	<	0.43	0.2
Nitrate and Nitrite	N	<	<	0.16	<	0.05
Dissolved Nitrate	N	<	<	0.16	<	0.05
Nitrite	N	<	<	<	<	0.002
Dissolved Sulphate	SO4	14.9	<	46.4	14.6	0.5

Results expressed as milligrams per liter (mg/L)

< = Less than detection limit

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REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		H08-D39	H08-J33	VM08-D12	VM08-D17	DETECTION LIMIT
DATE SAMPLED:		Sep 16/08	Sep 16/08	Sep 10/08	Sep 10/08	
CANTEST ID:		809250476	809250482	809250484	809250490	
Hardness	CaCO3	95	66	51	57	1
Dissolved Fluoride	F	<	0.31	<	<	0.05
Dissolved Chloride	Cl	0.20	26.6	<	4.33	0.2
Nitrate and Nitrite	N	<	0.09	<	0.31	0.05
Dissolved Nitrate	N	<	0.07	<	0.31	0.05
Nitrite	N	<	0.022	<	<	0.002
Dissolved Sulphate	SO4	14.3	32.7	6.19	34.1	0.5

Results expressed as milligrams per liter (mg/L)

< = Less than detection limit

REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		VM08-D10	
DATE SAMPLED:		Sep 10/08	
CANTEST ID:		809250500	
			DETECTION LIMIT
Hardness	CaCO3	51	1
Dissolved Fluoride	F	0.13	0.05
Dissolved Chloride	Cl	0.26	0.2
Nitrate and Nitrite	N	<	0.05
Dissolved Nitrate	N	<	0.05
Nitrite	N	<	0.002
Dissolved Sulphate	SO4	2.60	0.5

Results expressed as milligrams per liter (mg/L)

< = Less than detection limit

REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S4	MHS08-S4 diluted	MHS08-S6	MHS08-S6 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250443	809250446	809250449	809250450	DETECTION LIMIT	UNITS
Aluminum	Al	0.079	-	0.046	-	0.005	mg/L
Antimony	Sb	0.002	-	0.001	-	0.001	mg/L
Arsenic	As	0.19	-	0.19	-	0.001	mg/L
Barium	Ba	0.008	-	0.007	-	0.001	mg/L
Beryllium	Be	<	-	<	-	0.001	mg/L
Bismuth	Bi	<	-	<	-	0.001	mg/L
Boron	B	0.15	-	0.15	-	0.05	mg/L
Cadmium	Cd	<	-	<	-	0.0002	mg/L
Calcium	Ca	1.25	-	1.46	-	0.05	mg/L
Chromium	Cr	<	-	<	-	0.001	mg/L
Cobalt	Co	<	-	<	-	0.001	mg/L
Copper	Cu	<	-	<	-	0.001	mg/L
Iron	Fe	0.47	-	<	-	0.05	mg/L
Lead	Pb	<	-	<	-	0.001	mg/L
Lithium	Li	0.15	-	0.16	-	0.001	mg/L
Magnesium	Mg	0.06	-	<	-	0.05	mg/L
Manganese	Mn	0.007	-	<	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	0.016	-	0.017	-	0.0005	mg/L
Nickel	Ni	<	-	<	-	0.001	mg/L
Phosphorus	P	<	-	<	-	0.15	mg/L
Potassium	K	1.4	-	1.1	-	0.1	mg/L
Selenium	Se	<	-	<	-	0.001	mg/L
Silicon	Si	25.5	6.31	27.3	6.85	0.05	mg/L
Silver	Ag	<	-	<	-	0.00025	mg/L
Sodium	Na	39.8	-	40.9	-	0.05	mg/L
Strontium	Sr	0.009	-	0.012	-	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

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REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S4	MHS08-S4 diluted	MHS08-S6	MHS08-S6 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250443	809250446	809250449	809250450	DETECTION LIMIT	UNITS
Titanium	Ti	0.002	-	<	-	0.001	mg/L
Uranium	U	<	-	<	-	0.0005	mg/L
Vanadium	V	<	-	<	-	0.001	mg/L
Zinc	Zn	<	-	<	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S11	MHS08-S11 diluted	MHS08-S12	MHS08-S12 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250451	809250452	809250454	809250459	DETECTION LIMIT	UNITS
Aluminum	Al	0.61	-	0.042	-	0.005	mg/L
Antimony	Sb	<	-	0.001	-	0.001	mg/L
Arsenic	As	0.087	-	0.18	-	0.001	mg/L
Barium	Ba	0.068	-	0.005	-	0.001	mg/L
Beryllium	Be	<	-	<	-	0.001	mg/L
Bismuth	Bi	<	-	<	-	0.001	mg/L
Boron	B	0.16	-	0.16	-	0.05	mg/L
Cadmium	Cd	0.0003	-	<	-	0.0002	mg/L
Calcium	Ca	3.82	-	1.39	-	0.05	mg/L
Chromium	Cr	<	-	<	-	0.001	mg/L
Cobalt	Co	<	-	<	-	0.001	mg/L
Copper	Cu	0.007	-	<	-	0.001	mg/L
Iron	Fe	0.59	-	<	-	0.05	mg/L
Lead	Pb	0.003	-	<	-	0.001	mg/L
Lithium	Li	0.068	-	0.16	-	0.001	mg/L
Magnesium	Mg	1.12	-	<	-	0.05	mg/L
Manganese	Mn	0.016	-	<	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	0.0097	-	0.017	-	0.0005	mg/L
Nickel	Ni	0.002	-	<	-	0.001	mg/L
Phosphorus	P	<	-	<	-	0.15	mg/L
Potassium	K	1.2	-	1.1	-	0.1	mg/L
Selenium	Se	0.001	-	<	-	0.001	mg/L
Silicon	Si	13.3	2.63	25.5	5.80	0.05	mg/L
Silver	Ag	0.031	-	<	-	0.00025	mg/L
Sodium	Na	26.5	-	39.5	-	0.05	mg/L
Strontium	Sr	0.039	-	0.012	-	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

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REPORTED TO: EBA Engineering Consultants



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Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S11	MHS08-S11 diluted	MHS08-S12	MHS08-S12 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250451	809250452	809250454	809250459	DETECTION LIMIT	UNITS
Titanium	Ti	0.021	-	0.001	-	0.001	mg/L
Uranium	U	0.0014	-	<	-	0.0005	mg/L
Vanadium	V	0.002	-	<	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S2	MHS08-S2 diluted	MHS08-D3	MHS08-D3 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250460	809250462	809250463	809250465	DETECTION LIMIT	UNITS
Aluminum	Al	0.048	-	0.028	-	0.005	mg/L
Antimony	Sb	0.001	-	<	-	0.001	mg/L
Arsenic	As	0.19	-	<	-	0.001	mg/L
Barium	Ba	0.004	-	0.003	-	0.001	mg/L
Beryllium	Be	<	-	<	-	0.001	mg/L
Bismuth	Bi	<	-	<	-	0.001	mg/L
Boron	B	0.16	-	<	-	0.05	mg/L
Cadmium	Cd	<	-	<	-	0.0002	mg/L
Calcium	Ca	1.43	-	2.35	-	0.05	mg/L
Chromium	Cr	<	-	<	-	0.001	mg/L
Cobalt	Co	<	-	<	-	0.001	mg/L
Copper	Cu	<	-	0.001	-	0.001	mg/L
Iron	Fe	<	-	<	-	0.05	mg/L
Lead	Pb	<	-	<	-	0.001	mg/L
Lithium	Li	0.16	-	<	-	0.001	mg/L
Magnesium	Mg	<	-	0.12	-	0.05	mg/L
Manganese	Mn	<	-	0.001	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	0.017	-	<	-	0.0005	mg/L
Nickel	Ni	<	-	<	-	0.001	mg/L
Phosphorus	P	<	-	<	-	0.15	mg/L
Potassium	K	1.1	-	0.2	-	0.1	mg/L
Selenium	Se	<	-	<	-	0.001	mg/L
Silicon	Si	27.1	7.28	0.9	0.27	0.05	mg/L
Silver	Ag	<	-	<	-	0.00025	mg/L
Sodium	Na	40.9	-	0.35	-	0.05	mg/L
Strontium	Sr	0.012	-	0.009	-	0.001	mg/L
Tellurium	Te	<	-	<	-	0.001	mg/L
Thallium	Tl	<	-	<	-	0.0001	mg/L
Thorium	Th	<	-	<	-	0.0005	mg/L
Tin	Sn	0.004	-	<	-	0.001	mg/L

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Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-S2	MHS08-S2 diluted	MHS08-D3	MHS08-D3 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 9/08	Sep 9/08	Sep 9/08	Sep 9/08		
CANTEST ID:		809250460	809250462	809250463	809250465	DETECTION LIMIT	UNITS
Titanium	Ti	0.001	-	<	-	0.001	mg/L
Uranium	U	<	-	<	-	0.0005	mg/L
Vanadium	V	<	-	<	-	0.001	mg/L
Zinc	Zn	<	-	<	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-D10	MHS08-D10 diluted	HJ08-K36	HJ08-K36 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 11/08	Sep 9/08	Sep 16/08	Sep 16/08		
CANTEST ID:		809250467	809250470	809250471	809250475	DETECTION LIMIT	UNITS
Aluminum	Al	0.051	-	<	-	0.005	mg/L
Antimony	Sb	<	-	<	-	0.001	mg/L
Arsenic	As	<	-	0.016	-	0.001	mg/L
Barium	Ba	0.11	-	0.014	-	0.001	mg/L
Beryllium	Be	<	-	<	-	0.001	mg/L
Bismuth	Bi	<	-	<	-	0.001	mg/L
Boron	B	<	-	0.11	-	0.05	mg/L
Cadmium	Cd	0.0013	-	<	-	0.0002	mg/L
Calcium	Ca	10.7	-	2.96	-	0.05	mg/L
Chromium	Cr	<	-	<	-	0.001	mg/L
Cobalt	Co	<	-	<	-	0.001	mg/L
Copper	Cu	<	-	<	-	0.001	mg/L
Iron	Fe	<	-	<	-	0.05	mg/L
Lead	Pb	<	-	<	-	0.001	mg/L
Lithium	Li	0.002	-	<	-	0.001	mg/L
Magnesium	Mg	4.28	-	0.35	-	0.05	mg/L
Manganese	Mn	0.003	-	0.001	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	<	-	0.0053	-	0.0005	mg/L
Nickel	Ni	0.004	-	<	-	0.001	mg/L
Phosphorus	P	<	-	<	-	0.15	mg/L
Potassium	K	0.4	-	0.3	-	0.1	mg/L
Selenium	Se	0.002	-	<	-	0.001	mg/L
Silicon	Si	3.1	0.80	9.1	2.77	0.05	mg/L
Silver	Ag	<	-	<	-	0.00025	mg/L
Sodium	Na	1.15	-	45.6	-	0.05	mg/L
Strontium	Sr	0.065	-	0.041	-	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

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REPORTED TO: EBA Engineering Consultants



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Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		MHS08-D10	MHS08-D10 diluted	HJ08-K36	HJ08-K36 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 11/08	Sep 9/08	Sep 16/08	Sep 16/08		
CANTEST ID:		809250467	809250470	809250471	809250475	DETECTION LIMIT	UNITS
Titanium	Ti	<	-	<	-	0.001	mg/L
Uranium	U	<	-	<	-	0.0005	mg/L
Vanadium	V	<	-	<	-	0.001	mg/L
Zinc	Zn	0.018	-	0.023	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		H08-D39	H08-D39 diluted	H08-J33	H08-J33 diluted	DETECTION LIMIT	UNITS
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 16/08	Sep 16/08	Sep 16/08	Sep 16/08		
CANTEST ID:		809250476	809250479	809250482	809250483		
Aluminum	Al	0.006	-	0.017	-	0.005	mg/L
Antimony	Sb	<	-	<	-	0.001	mg/L
Arsenic	As	0.001	-	0.002	-	0.001	mg/L
Barium	Ba	0.028	-	0.053	-	0.001	mg/L
Beryllium	Be	<	-	<	-	0.001	mg/L
Bismuth	Bi	<	-	<	-	0.001	mg/L
Boron	B	<	-	0.38	-	0.05	mg/L
Cadmium	Cd	<	-	<	-	0.0002	mg/L
Calcium	Ca	28.6	-	10.5	-	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	<	-	<	-	0.05	mg/L
Lead	Pb	<	-	<	-	0.001	mg/L
Lithium	Li	0.002	-	0.007	-	0.001	mg/L
Magnesium	Mg	5.76	-	9.59	-	0.05	mg/L
Manganese	Mn	<	-	0.011	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	0.0006	-	0.017	-	0.0005	mg/L
Nickel	Ni	<	-	<	-	0.001	mg/L
Phosphorus	P	<	-	<	-	0.15	mg/L
Potassium	K	1.6	-	1.9	-	0.1	mg/L
Selenium	Se	<	-	<	-	0.001	mg/L
Silicon	Si	3.4	0.73	10.7	2.78	0.05	mg/L
Silver	Ag	<	-	<	-	0.00025	mg/L
Sodium	Na	2.98	-	111	-	0.05	mg/L
Strontium	Sr	0.092	-	0.24	-	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

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REPORTED TO: EBA Engineering Consultants



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Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		H08-D39	H08-D39 diluted	H08-J33	H08-J33 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 16/08	Sep 16/08	Sep 16/08	Sep 16/08		
CANTEST ID:		809250476	809250479	809250482	809250483	DETECTION LIMIT	UNITS
Titanium	Ti	<	-	0.002	-	0.001	mg/L
Uranium	U	<	-	<	-	0.0005	mg/L
Vanadium	V	<	-	<	-	0.001	mg/L
Zinc	Zn	<	-	<	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		VM08-D12	VM08-D12 diluted	VM08-D17	VM08-D17 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 10/08	Sep 10/08	Sep 10/08	Sep 10/08		
CANTEST ID:		809250484	809250489	809250490	809250493	DETECTION LIMIT	UNITS
Aluminum	Al	0.15	-	0.031	-	0.005	mg/L
Antimony	Sb	<	-	<	-	0.001	mg/L
Arsenic	As	<	-	0.002	-	0.001	mg/L
Barium	Ba	0.029	-	0.013	-	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	12.3	-	14.2	-	0.05	mg/L
Chromium	Cr	<	-	<	-	0.001	mg/L
Cobalt	Co	<	-	<	-	0.001	mg/L
Copper	Cu	0.002	-	0.003	-	0.001	mg/L
Iron	Fe	0.49	-	0.1	-	0.05	mg/L
Lead	Pb	<	-	<	-	0.001	mg/L
Lithium	Li	0.001	-	0.003	-	0.001	mg/L
Magnesium	Mg	4.91	-	5.23	-	0.05	mg/L
Manganese	Mn	0.084	-	0.012	-	0.001	mg/L
Mercury	Hg	<	-	<	-	0.02	µg/L
Molybdenum	Mo	0.0006	-	0.088	-	0.0005	mg/L
Nickel	Ni	0.003	-	0.001	-	0.001	mg/L
Phosphorus	P	<	-	0.2	-	0.15	mg/L
Potassium	K	0.5	-	9.3	-	0.1	mg/L
Selenium	Se	<	-	<	-	0.001	mg/L
Silicon	Si	3.9	0.92	7.8	1.87	0.05	mg/L
Silver	Ag	<	-	<	-	0.00025	mg/L
Sodium	Na	3.56	-	20.1	-	0.05	mg/L
Strontium	Sr	0.12	-	0.36	-	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

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Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		VM08-D12	VM08-D12 diluted	VM08-D17	VM08-D17 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 10/08	Sep 10/08	Sep 10/08	Sep 10/08		
CANTEST ID:		809250484	809250489	809250490	809250493	DETECTION LIMIT	UNITS
Titanium	Ti	0.005	-	0.002	-	0.001	mg/L
Uranium	U	<	-	<	-	0.0005	mg/L
Vanadium	V	<	-	0.004	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		VM08-D10	VM08-D10 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 10/08	Sep 4/08		
CANTEST ID:		809250500	809250501	DETECTION LIMIT	UNITS
Aluminum	Al	0.067	-	0.005	mg/L
Antimony	Sb	<	-	0.001	mg/L
Arsenic	As	<	-	0.001	mg/L
Barium	Ba	0.011	-	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	13.5	-	0.05	mg/L
Chromium	Cr	<	-	0.001	mg/L
Cobalt	Co	<	-	0.001	mg/L
Copper	Cu	0.003	-	0.001	mg/L
Iron	Fe	0.08	-	0.05	mg/L
Lead	Pb	<	-	0.001	mg/L
Lithium	Li	0.002	-	0.001	mg/L
Magnesium	Mg	4.1	-	0.05	mg/L
Manganese	Mn	0.002	-	0.001	mg/L
Mercury	Hg	<	-	0.02	µg/L
Molybdenum	Mo	0.0027	-	0.0005	mg/L
Nickel	Ni	0.002	-	0.001	mg/L
Phosphorus	P	<	-	0.15	mg/L
Potassium	K	1.8	-	0.1	mg/L
Selenium	Se	<	-	0.001	mg/L
Silicon	Si	2.1	0.63	0.05	mg/L
Silver	Ag	<	-	0.00025	mg/L
Sodium	Na	6.69	-	0.05	mg/L
Strontium	Sr	0.17	-	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 Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

Metals Analysis in Water

CLIENT SAMPLE IDENTIFICATION:		VM08-D10	VM08-D10 diluted		
SAMPLE PREPARATION:		DISSOLVED	DISSOLVED		
DATE SAMPLED:		Sep 10/08	Sep 4/08		
CANTEST ID:		809250500	809250501	DETECTION LIMIT	UNITS
Titanium	Ti	0.005	-	0.001	mg/L
Uranium	U	<	-	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
 < = Less than detection limit

µg/L = micrograms per liter

Analysis Report



CANTEST LTD.

Professional Analytical Services

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

FAX: 604 731 2386

TEL: 604 734 7276

1 800 665 8566

REPORT ON: Analysis of Water Samples
REPORTED TO: EBA Engineering Consultants
Calcite Business Centre
Unit 6
151 Industrial Road
Whitehorse, YT
Y1A 2V3

Att'n: Katherine Johnston

CHAIN OF CUSTODY: 2133663, 2133664
PROJECT NUMBER: W23101159.005

NUMBER OF SAMPLES: 26

REPORT DATE: October 10, 2008

DATE SUBMITTED: September 23, 2008

GROUP NUMBER: 90925103

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).

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

Nitrite in Water - was determined based on Method 4500-NO3 B in Standard Methods for the examination of Water and Wastewater (21st Edition) and from the BC Laboratory Methods Manual (2005).

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.

REPORTED TO: EBA Engineering Consultants



REPORT DATE: October 10, 2008

GROUP NUMBER: 90925103

COMMENTS:

Amended Report - Data from Trace Metals is reported as dissolved.

TEST RESULTS:

(See following pages)

Client: Johnston
 EBA Consulting Engineers and Scientists
 W23101159.005

ISO# 2008705
 Location:
 13 for 18O, 2H

Environmental Isotope Lab
 12/2/2008
 1 of 1

#	Sample	Lab#	$\delta^{18}\text{O}$		$\delta^2\text{H}$			
			H ₂ O	VSMOW	H ₂ O	VSMOW		
1	HJ08K-36 September-16-2008	193064	X	-23.07		X	-176.53	-176.49
2	VM08-D10 September-04-2008	193065	X	-16.63		X	-147.59	-147.81
3	MHS08-D10 September-11-2008	193066	X	-21.10	-21.16	X	-162.89	-163.02
4	VM08-D12 September-10-2008	193067	X	-20.02		X	-161.37	-161.27
5	VM08-D17 September-10-2008	193068	X	-21.98		X	-171.26	-171.85
6	MHS08-D3 September-09-2008	193069	X	-21.87		X	-168.50	-168.61
7	MHS08-S11 September-09-2008	193070	X	-21.29		X	-164.93	-164.54
8	MHS08-S2 September-09-2008	193071	X	-21.91	-21.59	X	-169.34	-169.46
9	MHS08-S6 September-09-2008	193072	X	-21.97		X	-169.82	-170.53
10	MHS08-S12 September-09-2008	193073	X	-21.86		X	-170.21	-170.14
11	MHS08-S4 September-09-2008	193074	X	-21.54	-21.79	X	-168.80	-168.55
12	H08-D39 September-16-2008	193075	X	-19.70		X	-158.79	-159.70
13	H08-J33 September-16-2008	193076	X	-25.61		X	-197.97	-197.88

To Contact uwEILAB:
 519 888 4732

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



APPENDIX

APPENDIX C GENERAL CONDITIONS



GEO-ENVIRONMENTAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

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3.0 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by EBA in its reasonably exercised discretion.