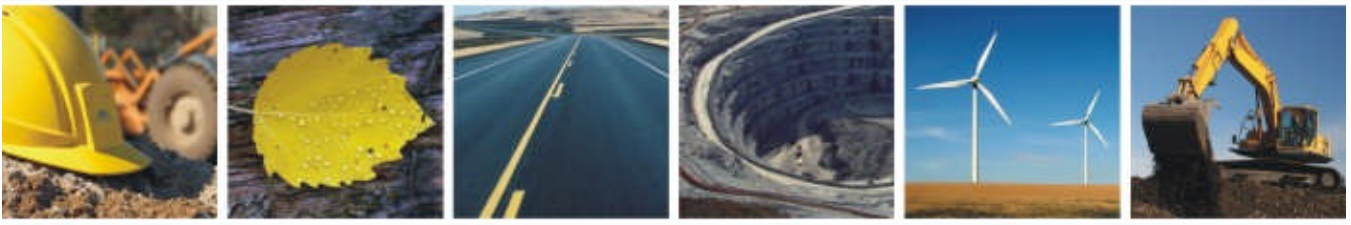


YUKON ENERGY CORPORATION

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## GEOPHYSICAL SURVEY AT STINKY LAKE, WHITEHORSE



### REPORT

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APRIL 2011  
ISSUED FOR USE  
EBA FILE: W23101159.106

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## LIMITATIONS OF REPORT

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## EXECUTIVE SUMMARY

EBA, A Tetra Tech Company (EBA), was commissioned by Yukon Energy Corporation to investigate the geological structure of a site exhibiting potentially favourable geothermal attributes, located in the Porter Creek subdivision, within the City of Whitehorse, Yukon.

This report describes the undertaking and results of a geophysical (magnetic) survey conducted at the site. The project objectives were to acquire, present, and interpret total magnetic field data from the area surrounding Stinky Lake, a waterbody associated with a geothermal spring feature located 1 km east of the Porter Creek drainage.

Under the direction of EBA, Aurora Geosciences, of Whitehorse, undertook a magnetic field survey at this site and supplied the resulting data to EBA for interpretation. In this report, we have presented and interpreted those results with consideration of additional geological and topographic information.

The magnetic data do not support the presence of a previously unidentified igneous body located to the north of the known Whitehorse Plutonic Suite, which outcrops approximately 1 km to the south of Stinky Lake. This suggests that the geothermal heat source is probably located within either the Whitehorse Suite or rocks underlying that unit.

We consider that the Whitehorse-Lewes margin may extend laterally from McIntyre Creek to the northwest. If it does, then the contact between the igneous rocks of the Whitehorse Plutonic Group and a fault that extends towards and apparently terminates close to Stinky Lake could lie considerably closer to Stinky Lake than previously suspected.

The trend of the magnetic data is northwest to southeast; this is similar to the strike of geological contacts that have been mapped to the northwest of Stinky Lake. The nearby Versluce Spring is a warm spring that is thought to be geothermally related to the Stinky Lake spring. This feature lies along the direction of strike indicated by the magnetic data. Although this is not conclusive evidence of a connection between the geothermal sources, it may be useful when interpreting any future drilling data from the area.

The results presented do not presently enable us to pinpoint the geothermal source area for Stinky Lake, but they have allowed us to reduce the area considered likely to contain the geothermal source to within a region located either south or southwest of the Stinky Lake spring. We consider that drilling in the area close to the fault where the greatest amplitude of magnetic anomaly was recorded would be a logical step towards locating the geothermal source of the Stinky Lake spring.

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# TABLE OF CONTENTS

**EXECUTIVE SUMMARY ..... i**

**1.0 INTRODUCTION ..... 1**

    1.1 Background Information ..... 1

    1.2 Geophysical Survey Technique ..... 2

**2.0 RESULTS ..... 2**

    2.1 Data Quality ..... 2

    2.2 Data Presentation ..... 2

**3.0 DISCUSSION ..... 3**

**4.0 CLOSURE ..... 5**

**REFERENCES ..... 6**

## FIGURES

- Figure 1 Site Location and Geology
- Figure 2 Survey Coverage
- Figure 3 Total Magnetic Field Strength
- Figure 4 Total Magnetic Field Strength: 3D View

## APPENDICES

- Appendix A EBA's General Conditions

## 1.0 INTRODUCTION

EBA, A Tetra Tech Company (EBA), was commissioned by Yukon Energy Corporation to investigate the geological structure of a site exhibiting potentially favourable geothermal attributes located in the Porter Creek subdivision, within the City of Whitehorse, Yukon. This report describes the undertaking and results of a geophysical survey conducted at the site. The project objectives were to acquire, present, and interpret total magnetic field data from the area surrounding Stinky Lake, a waterbody associated with a geothermal spring feature 1 km east of the Porter Creek drainage.

### 1.1 Background Information

The Stinky Lake site (Figure 1) is located at approximate UTM zone 8N grid reference [492500, 6735250], and lies within an area of which the topographic map coverage is bisected by the margins of adjoining NTS sheets 105/D11 and 105/D14. The dimensions of the area investigated for this report are approximately 1.8 km east-west by 1.7 km south-north. The relief ranges from 700 m above mean sea level (amsl) to 800 m amsl, and comprises an area of land elevated above two adjacent drainage features: McIntyre Creek to the south and Porter Creek to the west. The site is characterized further by:

- Overall slope gradients of 5°;
- Steeper slopes of approximately 15° to the southwest, south, and southeast adjacent to McIntyre Creek;
- Forested land cover; and
- A lake, 'Stinky Lake', the diameter of which is less than 200 m. Stinky Lake remains partly unfrozen during winter. The name originates from reports by local residents that describe a slightly sulphurous odour (attributed to the presence of H<sub>2</sub>S) associated with the lake.

Previous work conducted by EBA (2009), included an investigation of the hydrogeochemistry and isotope signatures of three natural warm springs in the Porter Creek area, including Versluce Spring and Stinky Lake Spring (Figure 2). The reported water temperatures in these springs were between 12°C and 19°C; this is greater than the typical background surface water temperature in the Whitehorse area, which is around 5°C. Three water samples were taken from the Stinky Lake area: one from Stinky Lake, one from Stinky Lake Spring (which feeds Stinky Lake), and the third from a second smaller spring located in the same wetland as Stinky Lake. Chemical analysis of the samples indicated they shared a local, meteoric origin, and a likely groundwater residence time of less than fifty years. It is suspected (EBA 2009) that the shallow, meteoric water had been mixed with older groundwater during circulation, and that the minimum groundwater temperature attained by the Stinky Lake source waters is approximately 90°C. The geothermometer methods utilized in the temperature estimation do not provide information concerning the potential depth or location of the causative thermal body.

A detailed review of the geology of the Stinky Lake area has been presented by EBA (2011). In this report, we will consider only those aspects of that report that are considered relevant to interpretation of the geophysical data presented.

Stinky Lake and Verslucce Springs are located in close proximity and within a similar geological setting; therefore, it is considered likely that both are related to a single geothermal anomaly. Both springs emerge from sedimentary rocks of the Triassic Lewes River Group (Figure 1), close to its contact with a mid-Cretaceous granodiorite intrusion (the Whitehorse Plutonic Suite). This is the nearest of several intrusive igneous units that outcrop in the area; it outcrops less than 1 km to the south and west of Stinky Lake. Rocks within this suite have been described as 'strongly magnetic' (EBA 2011). Other intrusions identified nearby include the Late Pliocene Nisling Range Plutonic Suite, granitic constituents of which have been identified within approximately 4 km of Stinky Lake. A northeast-southwest trending fault has been identified near Stinky Lake (Figure 1); this fault appears to terminate approximately 200 m to the south of the lake. At lower elevations, the bedrock in this area is usually covered by Quaternary glacial deposits.

## 1.2 Geophysical Survey Technique

Under instruction from EBA, a geophysical survey of the site was planned and executed by Aurora Geosciences, of Whitehorse. The survey comprised 14 parallel lines of total magnetic field measurements, oriented southwest/northeast, with a total length of 18 km, and an inter-line interval of 50 m (Figure 2). The survey work was conducted between November 25, 2010, and November 28, 2010, using two GEM 19T proton precession magnetometers (serial numbers 4111460 and 4121471), which were synchronized daily. One unit was deployed as a base station, located at UTM 8N, 497234, 6721903, recording automatically at intervals of three seconds; the other unit was deployed as a roving field instrument.

The data acquired were positioned using a non-differential global positioning system (GPS) unit with a nominal horizontal accuracy of  $\pm 7$  m. Survey stations were 12.5 m apart along each line, and positions were reported in UTM coordinates (zone 8N, NAD 83). Data values were recorded in units of nanoTesla (nT).

## 2.0 RESULTS

### 2.1 Data Quality

Quality assurance (QA)/quality control (QC) routines applied to the data set included the correction of diurnal effects that were recorded in the base station data, relative to a base value of 59,000 nT. This process included the removal of data that had been acquired during periods when the rate of diurnal field variability was demonstrated to have exceeded 10 nT in 10 s. Levelling of values acquired on different days was achieved through comparison of two parallel levelling lines, along which repeated data points were acquired each morning, prior to the commencement of surveying. Data were provided to EBA in two formats: Geosoft database (.gdb) and ASCII (.xyz), and have been presented using Golden Software's Surfer V.10 software.

### 2.2 Data Presentation

The results from the geophysical survey are presented on Figure 3. This figure shows the survey coverage superimposed on interpolated (kriged) magnetic and topographic data. Digital topographic data were obtained from Natural Resources Canada and interpolated for use in this report. Because the site is located

close to a map sheet boundary, the topographic data are not in close agreement in some areas; this has caused distortion of the topographic contours but does not affect our interpretation.

### 3.0 DISCUSSION

The results indicate magnetic field strength values ranging between approximately 58,850 nT and 59,550 nT. There is an apparent trend in the data set: the magnetic field strength is least in the northeast and greatest in the southwest of the area surveyed. The greatest values were recorded on the edge of the magnetic survey coverage area, on the northern slope of a valley feature occupied by McIntyre Creek, and approximately 1 km southwest of Stinky Lake.

Cross-referencing the local geology (after EBA 2011), the topography, and the interpolated results from the geophysical survey has provided an integrated data set that can be viewed and interpreted in 3D (Figure 4). This figure indicates that:

- The location of the Stinky Lake spring does not coincide with the area of the greatest magnetic field strength values.
- Southeast of the fault, the mapped line of the contact between the igneous Whitehorse Plutonic Suite and the sedimentary Lewes River Group is approximately parallel to McIntyre Creek, which lies in the lowest part of the valley. This orientation is not, however, parallel to the apparent strike of the magnetic data trend; instead, the two are incident at approximately 45°.
- The apparent trend of the magnetic anomaly is similar to that of contacts between units mapped to the northwest of the fault; these include members of the Whitehorse Plutonic Suite and Lewes River Group.
- Within the area investigated, there is no indication of increased magnetic field strength values beneath Stinky Lake, or to the east, north, or west of the lake.
- The magnetic anomaly identified in the southwest corner of the survey area has not been fully delineated.
- There is no clear association between the mapped fault line and the trend of the magnetic data.

Interpretation of the data presented in Figure 4 suggests that:

- Within the area surveyed, the magnetic data do not support the presence of a separate igneous body located to the north of the known Whitehorse Plutonic Suite, i.e., closer to Stinky Lake. This is an important result, as it suggests that if the geothermal heat source lies beneath the area surveyed, it is probably located within either the Whitehorse Suite or rocks underlying that unit.
- The trend of variation in the magnetic data (increasing to the southwest) is orthogonal to that which would be expected if the fault separated magnetic from non-magnetic rocks beneath Stinky Lake. Furthermore, this trend is approximately 45° offset from the orientation of the igneous-sedimentary (Whitehorse-Lewes) contact close to McIntyre Creek. We consider that a simple explanation for this result would be that the Whitehorse-Lewes margin extends laterally from McIntyre Creek to the northwest, rather than being a steeply-inclined west-east oriented feature (as might be inferred from

Figure 1). If this is the case, then igneous rocks on the southeastern side of the fault could lie considerably closer to Stinky Lake than might be expected from the interpretation of the geological map.

- Increased magnetic field strength to the southeast of the fault has been attributed to the Whitehorse Plutonic Suite. Because the main area of this anomaly is located on the edge of the survey coverage, it is not possible to determine whether the anomaly continues across the fault. We can, however, state that there is no similar anomaly located immediately northwest of the fault and closer to Stinky Lake than the anomaly identified to the southeast. This restricts the considered most probable shallow geothermal source area to the locations to the southwest of Stinky Lake where the Whitehorse Plutonic Suite and the fault are in contact.
- A line extrapolated to the northwest across the fault, from the area of greatest magnetic field strength, would intersect with the location of Verslucce Spring at ~1.5 km distance. Furthermore, this line would be parallel to several local geological contacts that have been mapped at the surface (Figure 1). This similarity might be expected if the Verslucce and Stinky Lake springs are geothermally related, as previously suggested (EBA 2009). This information should be reconsidered during interpretation of any future drilling results from the Stinky Lake area.
- The results presented do not presently enable us to pinpoint the geothermal source area for Stinky Lake, but they have allowed us to reduce the area considered likely to contain the geothermal source to within a region located either south or southwest of the Stinky Lake spring. The mapped fault is considered to represent a possible pathway for circulation of groundwater, and therefore, the area where the fault and igneous rocks are in contact is thought to represent a suitable location for further investigation.

Recommendations arising from this interpretation:

- The fault located to the southwest of Stinky Lake is considered to be a potential pathway for geothermal circulation of groundwater between a heat source in or beneath the Whitehorse Plutonic Suite and the Stinky Lake spring. Further understanding of this fault could be gained by conducting a horizontal loop electromagnetic (HLEM) survey in the area between Stinky Lake and the southern edge of the magnetic survey. This action was considered during planning of the magnetic survey, but by delaying a decision until this point, we have been able to substantially reduce the area that would require surveying with the HLEM. The HLEM should detect mineralization associated with the fault, if present. It would be valuable to determine whether the mapped extent of the fault is supported by geophysical data, or whether the fault continues beyond Stinky Lake to the northeast. If it does terminate at Stinky Lake, then this would further support the concept that the source of heat is located to the south or southwest of the lake and that the fault is likely hydraulic conduit.
- Confirmatory drilling of the likely source area will be required. The geophysical survey has provided valuable information on locations unsuited to further investigation and has indicated a general area of interest that will be appropriate for drilling. This area is located to the south and southwest of Stinky Lake.
- The data provided indicate that there is one area of interest within the completed survey coverage. If subsequent investigations fail to locate a likely geothermal source in that area, then the magnetic

survey coverage should be reconsidered, and possibly extended, to include additional areas of potential interest.

## 4.0 CLOSURE

We trust this report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Respectfully submitted,  
EBA, A Tetra Tech Company

Joe Lenham, Ph.D., C.Geol.  
Senior Geophysical Scientist  
Environment Practice  
Direct Line: 403.203.3305 x355  
jlenham@eba.ca

Neil Parry, MBA, P.Geoph.  
Project Director  
Engineering & Environmental Geophysics  
Direct Line: 780.451.2130 x274  
nparry@eba.ca

/jbn

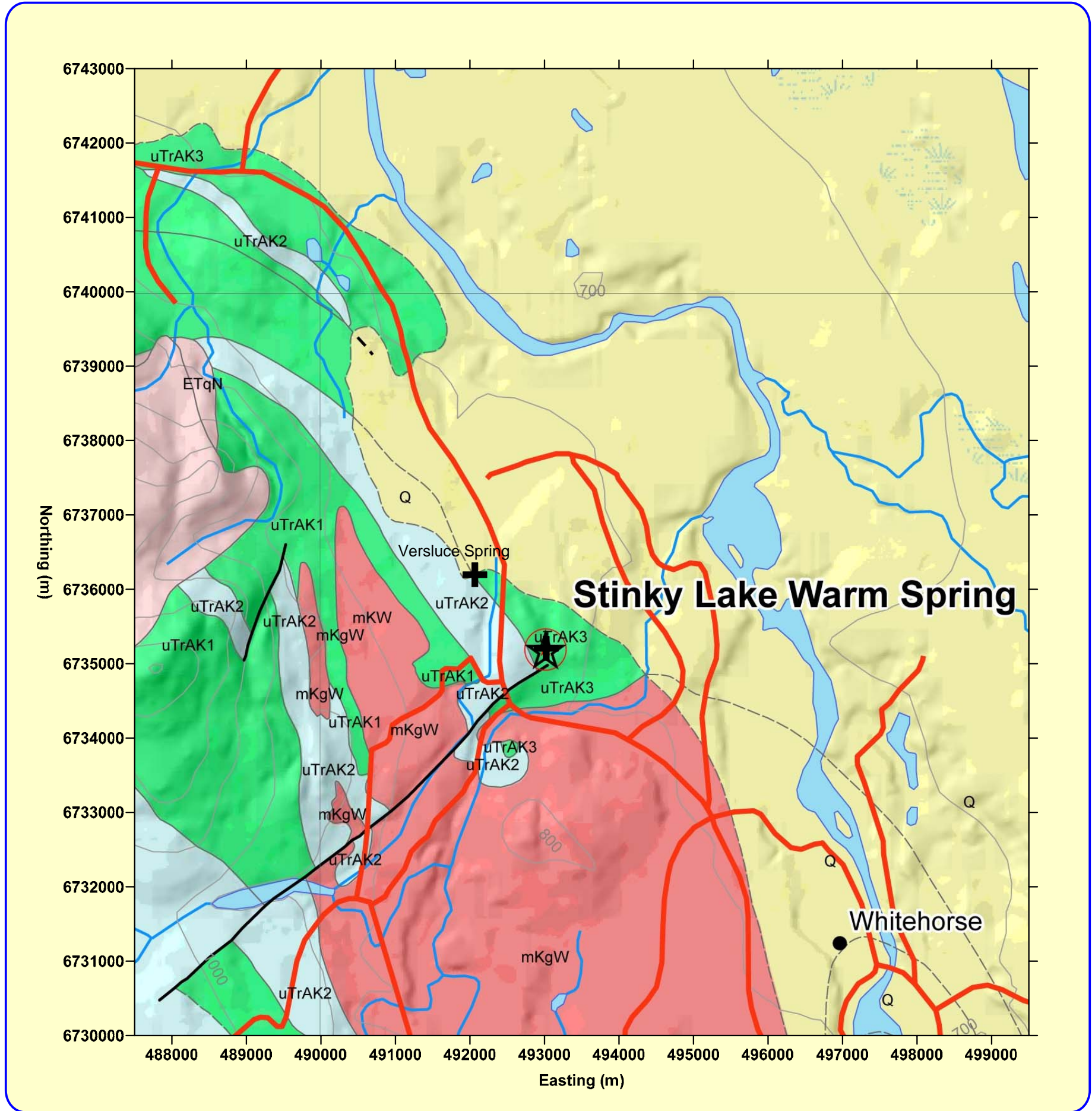
## REFERENCES

- EBA, A Tetra Tech Company. 2011. Geology and Hydrogeochemistry of the Stinky Lake Warm Spring, Whitehorse, Yukon. Report to Yukon Energy Corporation. Report No. W23101159.105.
- EBA Engineering Consultants Ltd. 2009. Hydrogeochemistry and Isotope Signature of Stinky Lake and Versluce Warm Springs in Whitehorse, Yukon. Report No. W23101159.014.
- Wheeler, J.O. 1961. Whitehorse Map-Area, Yukon Territory, 105D. Memoir 312, Geological Survey of Canada, Department of Mines and Technical Surveys Canada.

# FIGURES

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Figure 1	Site Location and Geology
Figure 2	Survey Coverage
Figure 3	Total Magnetic Field Strength
Figure 4	Total Magnetic Field Strength: 3D View



**LEGEND**

UNIT DESCRIPTION

QUATERNARY

Q

Q: QUATERNARY

MID CRETACEOUS

mKw

**mKw: WHITEHORSE SUITE**

grey, medium to coarse grained, generally equigranular granitic rocks of felsic (q), intermediate (g), locally mafic (d) and rarely syenitic (y) composition  
 d. hornblende diorite, biotite-hornblende quartz diorite and mesocratic, often strongly magnetic, hypersthene-hornblende diorite, quartz diorite and gabbro (**Whitehorse Suite, Coast Intrusions**)  
 g. biotite-hornblende granodiorite, hornblende quartz diorite and hornblende diorite; leucocratic, biotite hornblende granodiorite locally with sparse grey and pink potassium feldspar phenocrysts (**Whitehorse Suite, Casino granodiorite, McClintock granodiorite, Nisling Range granodiorite**)  
 q. biotite quartz-monzonite, biotite granite and leucogranite, pink granophyric quartz monzonite, porphyritic biotite leucogranite, locally porphyritic (K-feldspar) hornblende monzonite to syenite, and locally porphyritic leucocratic quartz monzonite (**Mt. McIntyre Suite, Whitehorse Suite, Casino Intrusions, Mt. Ward Granite, Coffee Creek Granite**)

UNIT DESCRIPTION

EARLY TERTIARY

ETN

**ETN: NISLING RANGE SUITE**

medium to coarse grained equigranular to porphyritic rocks of intermediate composition (g), fine to coarse grained, equigranular and porphyritic granitic rocks of felsic composition (q) and felsic dyke rocks (f)  
 f. orange and buff weathering light-coloured feldspar porphyry dyke and flow rocks of intermediate to acid composition  
 g. biotite-hornblende granodiorite (locally K-feldspar megacrysts), quartz monzonite, quartz diorite; minor granodiorite-gneiss; hornblende and biotite hornblende diorite; biotite quartz feldspar porphyry and porphyritic biotite quartz monzonite (**Ruby Range Suite**)

UPPER TRIASSIC, CARNIAN TO NORIAN

uTrAK1

**uTrAK: AKSALA**

mixed clastic-carbonate assemblage divisible into three dominant facies including calcareous greywacke (1), locally thick carbonate (2) and red-coloured clastics (3) (**Aksala**)  
 1. brown shale, black and minor red siltstone, greenish, calcareous greywacke and interbedded bioclastic, argillaceous limestone; igneous- or limestone-clast pebble and cobble conglomerate; lahaaric debris flows; rare feldspar-augite porphyry flows (**Casca mb. of Aksala**)  
 2. massive to thick bedded limestone; minor thin bedded argillaceous to sooty limestone; coarsely crystalline, massive dolostone; minor laminated chert; massive to poorly bedded, limestone conglomerate debris flows and fanglomerate (**Hancock mb. of Aksala**)  
 3. red weathering, medium bedded, green and red greywacke and pebble conglomerate; red  
 (Mandanna mb. of Aksala)

uTrAK2

uTrAK3

**LEGEND**

- Community
- ★ Spring location
- Road
- Elevation Contour (m)
- Watercourse
- Waterbody
- Wetland
- Contact
- Defined
- Undefined
- Fault
- Defined
- Undefined

CLIENT

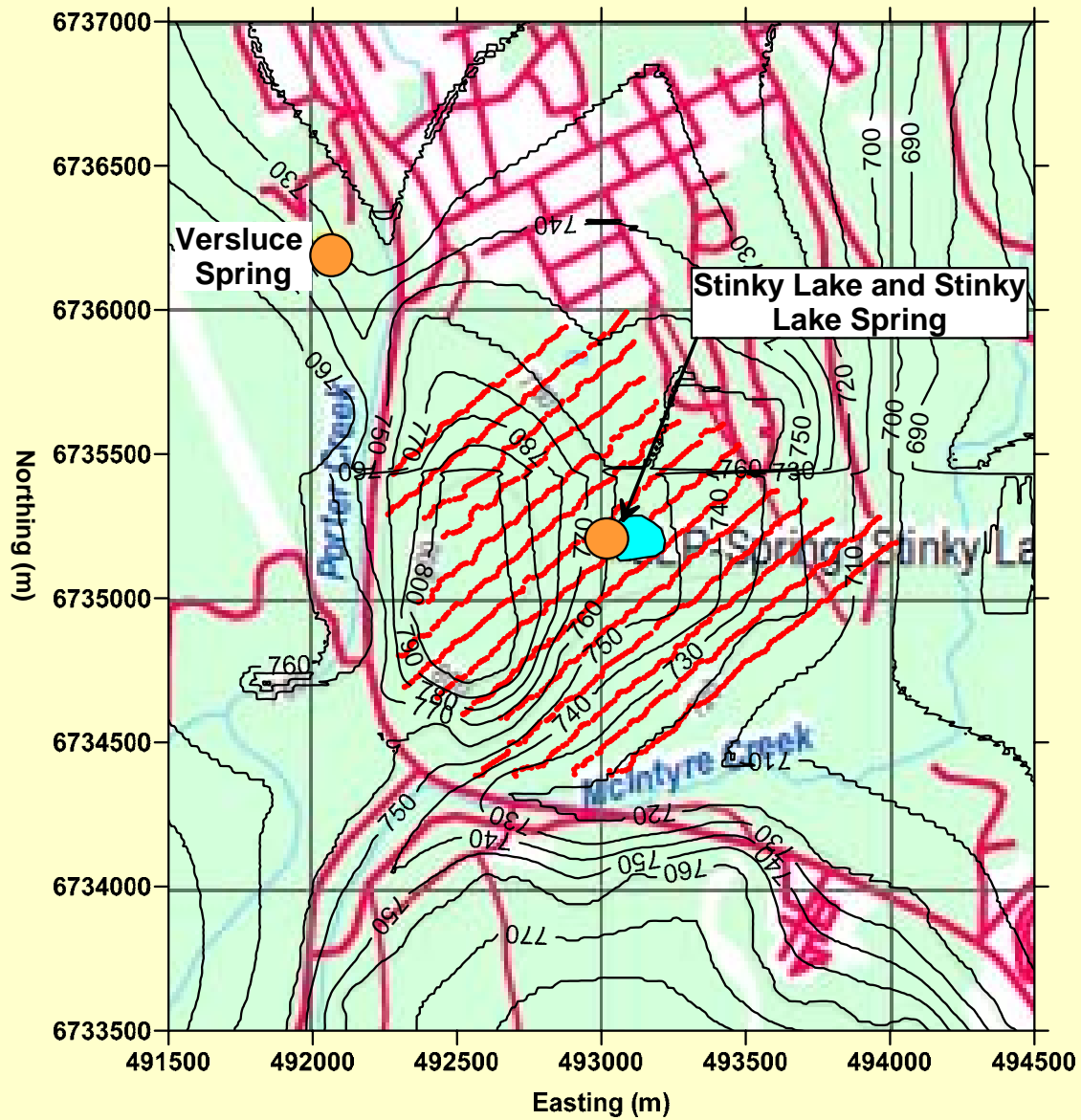


**Geophysical Survey at Stinky Lake**

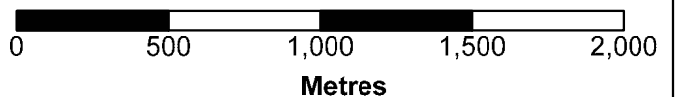
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OFFICE Whitehorse	DATE April 8, 2011			



**Figure 1**



Coordinate system: UTM zone 8N, NAD 83 datum  
 Source of base map: NTS Sheet Whitehorse 105D (1996)  
 Topographic contours are presented at a 10 m amsl interval.  
 Source: Natural Resources Canada



**LEGEND**

-  Location of warm spring feature
-  Geophysical survey coverage

CLIENT

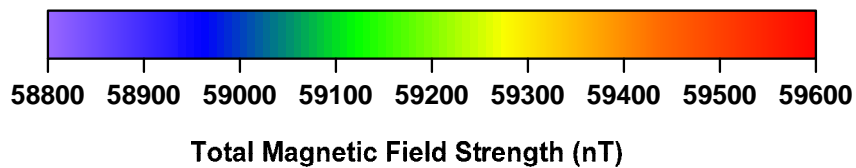
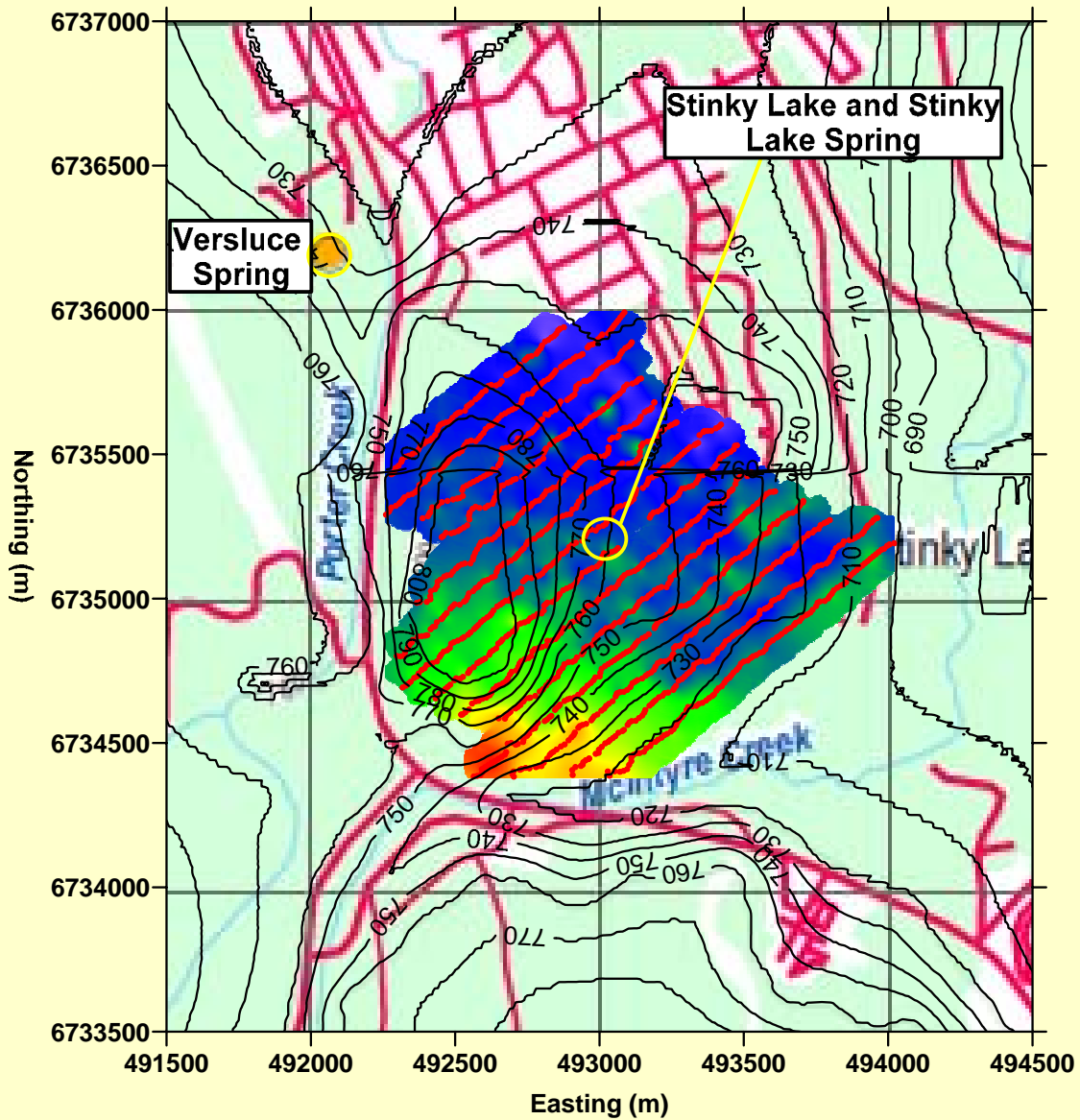


**Geophysical Survey at Stinky Lake  
 Whitehorse**

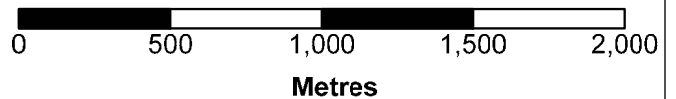
**Survey Coverage**

PROJECT NO. W23101159.106	DWN JWL	CKD SK	APVD SK	REV 000
OFFICE EBA-CGY	DATE March 23, 2011			



**Figure 2**



Coordinate system: UTM zone 8N, NAD 83 datum  
 Source of base map: NTS Sheet Whitehorse 105D (1996)  
 Topographic contours are presented at a 10 m amsl interval.  
 Source: Natural Resources Canada



**LEGEND**

-  Location of warm spring feature
-  Geophysical survey coverage

CLIENT

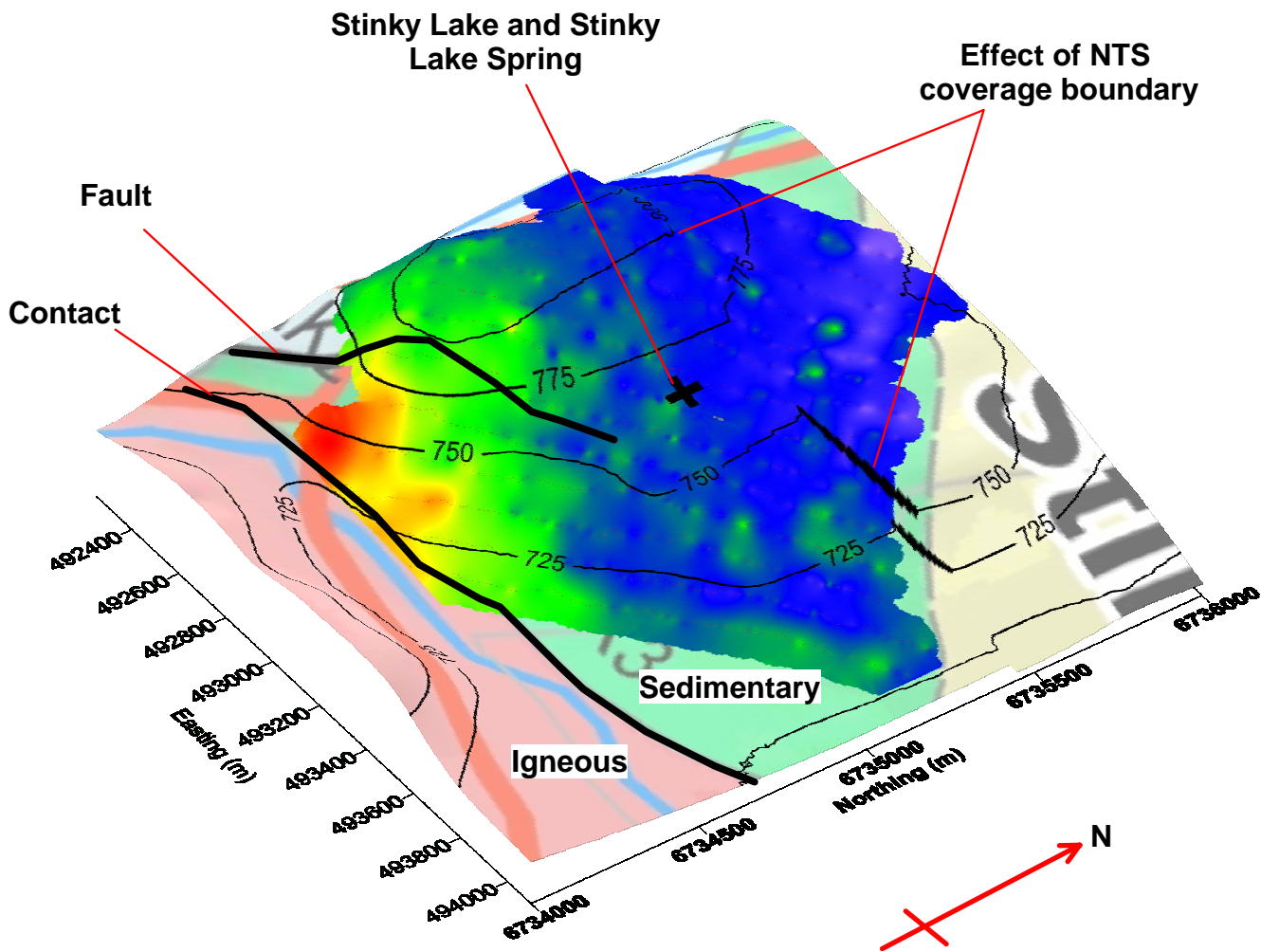


**Geophysical Survey at Stinky Lake Whitehorse**

**Total Magnetic Field Strength**

<b>PROJECT NO.</b> W23101159.106	<b>DWN</b> JWL	<b>CKD</b> SK	<b>APVD</b> SK	<b>REV</b> 000
<b>OFFICE</b> EBA-CGY	<b>DATE</b> March 23, 2011			

**Figure 3**



**LEGEND**

○ Location of warm spring feature

Coordinate system: UTM zone 8N, NAD 83 datum

Topographic contours are presented at a 25 m amsl interval. Source: Natural Resources Canada

**CLIENT**



**Geophysical Survey at Stinky Lake Whitehorse**

**Total Magnetic Field Strength: 3D View**

<b>PROJECT NO.</b> W23101159.106	<b>DWN</b> JWL	<b>CKD</b> SK	<b>APVD</b> SK	<b>REV</b> 000
<b>OFFICE</b> EBA-CGY	<b>DATE</b> March 23, 2011			

**Figure 4**

# APPENDIX A

## APPENDIX A EBA'S GENERAL CONDITIONS

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# GENERAL CONDITIONS

## GEO-ENVIRONMENTAL REPORT

This report incorporates and is subject to these "General Conditions".

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### 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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