ONTARIO GEOLOGICAL SURVEY

Geophysical Data Set 1077

Ontario Airborne Geophysical Surveys
Magnetic and Gamma-Ray Spectrometric Data
Mahon Lake and Flatrock Lake Areas

by

Ontario Geological Survey

2015

Ontario Geological Survey
Ministry of Northern Development and Mines
Willet Green Miller Centre, 933 Ramsey Lake Road,
Sudbury, Ontario P3E 6B5 Canada

Contents

FIGURES

CREDITS

List of accountabilities and responsibilities.

- Jack Parker, Senior Manager, Earth Resources and Geoscience Mapping Section, Ontario Geological Survey (OGS), Ministry of Northern Development and Mines (MNDM) – accountable for the geophysical survey projects, including contract management
- Edna Mueller-Markham, Senior Consulting Geophysicist, Paterson, Grant & Watson Limited (PGW), Toronto, Ontario, Geophysicist under contract to MNDM – responsible for the airborne geophysical survey project management, quality assurance (QA) and quality control (QC)
- Tom Watkins, Manager, Publication Services Unit, GeoServices Section, Ontario Geological Survey, MNDM – managed the project-related hard-copy products
- Desmond Rainsford, Geophysicist, Earth Resources and Geoscience Mapping Section, Ontario Geological Survey – responsible for final quality assurance (QA), quality control (QC) of published digital products
- CGG, Ottawa, Ontario – data acquisition and data compilation

DISCLAIMER

To enable the rapid dissemination of information, this digital data has not received a technical edit. However, every possible effort has been made to ensure the accuracy of the information presented in this report and the accompanying data; however, the Ontario Ministry of Northern Development and Mines does not assume liability for errors that may occur. Users should verify critical information.

CITATION

Parts of this publication may be quoted if credit is given. It is recommended that reference to this publication be made in the following form:

Ontario Geological Survey 2015. Ontario airborne geophysical surveys, magnetic and gamma-ray spectrometric data, grid and profile data (ASCII and Geosoft® formats) and vector data, Mahon Lake and Flatrock Lake areas, Ontario Geological Survey, Geophysical Data Set 1077.

NOTE

Users of OGS products are encouraged to contact those Aboriginal communities whose traditional territories may be located in the mineral exploration area to discuss their project.

1. Introduction

The airborne survey contract was awarded through a Request for Proposal and Contractor Selection process. The system and contractor selected for the survey area were judged on many criteria, including the following:

- applicability of the proposed system to the local geology and potential deposit types
- aircraft capabilities and safety plan
- experience with similar surveys
- QA/QC plan
- capacity to acquire the data and prepare final products in the allotted time
- price-performance

2. Survey Location and Specifications

2.1. SURVEY LOCATION

The Mahon Lake and Flatrock Lake survey areas are located within Quetico and Wawa sub-provinces, respectively; both of which form part of the Archean Superior province. The simplified geology is shown in Figure 1.

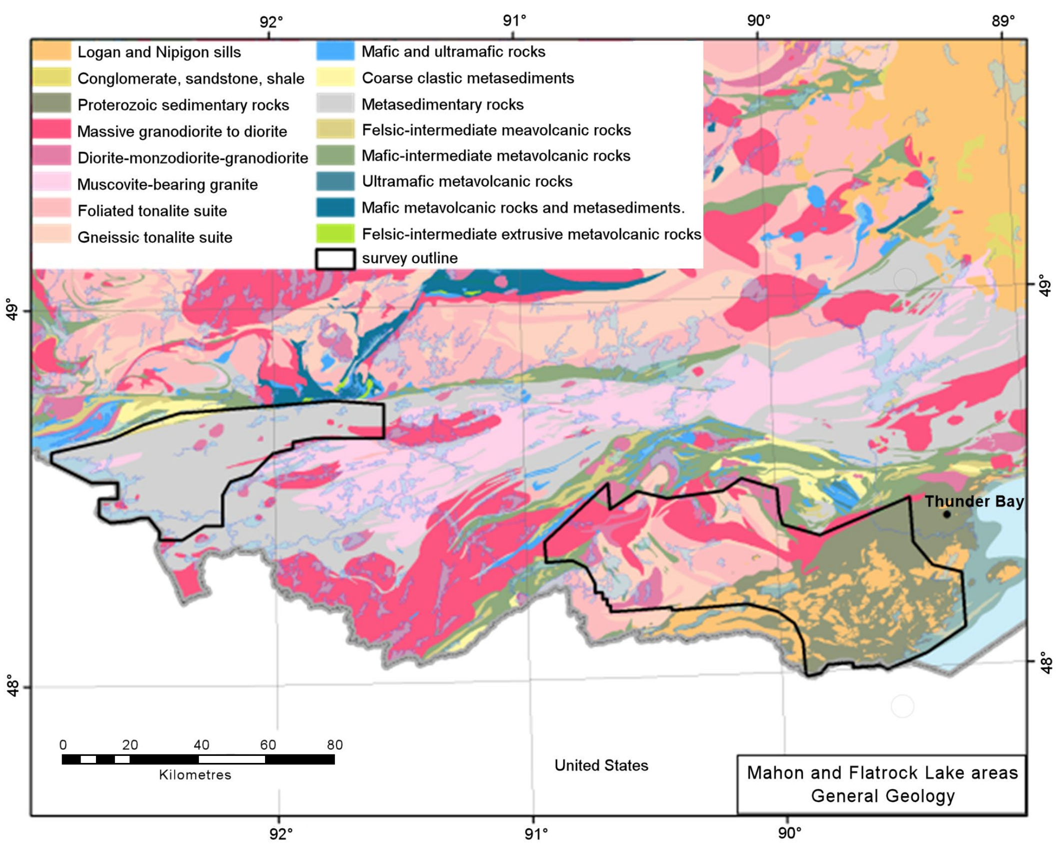


Figure 1. The bedrock geology of the Mahon Lake and Flatrock Lake survey areas (*from* Ontario Geological Survey 2011); survey boundaries shown in black.

The Mahon Lake area is underlain primarily by metasedimentary rocks. These metasedimentary rocks have a mixed clastic composition and are wacke dominated with lesser amounts of conglomerates, mudstones and carbonates. Local intrusions of granitic and gabbroic composition have been recognized. Regional geological strike is approximately east-west.

The Flatrock Lake area can be described in 2 parts. The south and east portions of the survey area is a rugged, upland area of diabase-capped mesas and ridges that occupies a 70 km by 30 km, northeast-trending topographic feature between Thunder Bay and the Minnesota border, termed the Logan Basin. Logan Sills underlie mesas that commonly rise 150 m above valleys underlain by deeply eroded, flat-lying, Rove Formation sedimentary rocks. The topography present in the southeast portion of the Logan Basin is dominated by northeast-trending, linear ridges underlain by Pigeon River dikes.

The northwest portion of the Flatrock Lake area lies north of the Logan Basin and spans from the Quetico Provincial Park boundary to the west and the village of Nolalu to the east. The geology is dominated by Archean granitoid rocks of the Superior Province forming low, rolling hills with slivers of the Shebandowan greenstone also present albeit in less abundance. This area displays less relief compared to the Logan Basin and can been described as peneplain.

2.2. SURVEY SPECIFICATIONS

The Mahon Lake and Flatrock Lake survey areas specifications and tolerances are as follows:

a) Traverse-line spacing and direction
- flight-line spacing is 200 m
- flight-line direction 0°
- maximum deviation from the nominal traverse line location could not exceed 50 m over a distance greater than 2000 m
- minimum separation between 2 adjacent lines could be no smaller than 250 m or larger than 350 m.

b) Control-line spacing and direction
- control-line direction 90°
- at regular 2000 m intervals, perpendicular to the flight-line direction
- along each survey boundary (if not parallel with the flight-line direction)
- maximum deviation from the nominal control line location could not exceed 50 m over a distance greater than 2000 m.

c) Terrain clearance of the magnetometers
- nominal terrain clearance is 100 m and will be consistent with safety of aircraft and crew
- altitude tolerance limited to ±15 m, except in areas of severe topography
- altitude tolerance limited to ±10 m at flight-line–control-line intersections except in areas of severe topography

d) Aircraft speed
- nominal aircraft speed is 65 to 85 m/sec
- aircraft speed tolerance limited to ±10.0 m/sec, except in areas of severe topography.

e) Magnetic diurnal variation
- could not exceed a maximum deviation of 3.0 nT peak-to-peak over a long chord equivalent to 1 minute

f) Magnetometer noise envelope
- in-flight noise envelope could not exceed 0.1 nT, for straight and level flight

  - base station noise envelope could not exceed 0.1 nT

g) Reflights and turns
  - all reflights of flight-line segments intersected at least 2 control lines
  - all turns at the end of flight lines or control lines took place beyond the survey or block boundaries

3. Aircraft, Equipment and Personnel

Aircraft:

Operator:	CGG
Registration:	C-FZLK
Type:	Cessna 208B
Mean Survey Speed:	65 to 85 m/s
Magnetometer:	Scintrex CS-3 single cell cesium vapour, sensitivity = 0.005 nT, sampling rate = 0.1 s, ambient range 20 000 to 100 000 nT. The general noise envelope was kept below 0.1 nT. The nominal sensor height was approximately100 m above ground.
Spectrometer:	Exploranium GR-820 with 33.6 L (2048 cubic inches) of main (downward) NaI crystal detectors and 8.4 L (512 cubic inches) of upward looking detectors. The entire 256 channel spectra were recorded with a sample rate of 1 second.
Digital Acquisition:	FASDAS showing the total magnetic field at 2 vertical scales, the radar and barometric altimeters, the 4th difference of the magnetics, and fiducials; data were recorded on a hard drive.
Barometric Altimeter:	Vaisala PMB100, sensitivity 1 foot, 0.1 sec recording interval.
Radar Altimeter:	King KRA-10A, accuracy 5%, sensitivity 1 foot, range 20 to 2500 feet, 0.1 sec recording interval.
Camera:	Sanyo VCC-3972 digital video camera, Bullet digital video recorder
Electronic Navigation:	NovAtel OEMV-3G 14 channel dual frequency, 1 sec recording interval, with a resolution of 0.00001 degree and an accuracy of ±5 m.

Base Station Equipment:

Magnetometer:	Scintrex CS-3 single cell caesium vapour, located in a magnetically quiet area, measuring the total intensity of the earth's magnetic field in units of 0.01 nT at intervals of 0.1 sec, within a noise envelope of 0.1 nT.
GPS Receiver:	NovAtel dual frequency NovAtel OEM4 , measuring all GPS channels, for up to 12 satellites.

Personnel:

Pilots:	Steve Parks
	David Maertens
	George Sakgaev
	Phil Viotto
	Fred Goebau

Electronics Technician/Operator:	Christopher Walker
Aircraft Maintenance Engineer:	Derek Rowney
Project Manager:	General project management was the responsibility of Jason Joseph, CGG, in Ottawa, Ontario.

4. Data Acquisition

4.1. ACQUISTION SUMMARY

CGG was selected by the MNDM to perform the Mahon Lake and Flatrock Lake areas horizontal magnetic gradient and gamma-ray survey near Thunder Bay, Ontario.

The principal geophysical sensors were 3 high-sensitivity cesium vapour magnetometers and a gamma-ray spectrometer linked to 42 L (33.6 L downward-looking and 8.4 L upward-looking) of sodium iodide detectors. Ancillary equipment included a GPS navigation system with GPS base station, a colour video tracking camera, temperature and pressure sensors, radar altimeters and 2 base station magnetometers.

CGG utilized 1 of its aircraft—registration C-FZLK—for this survey and based its operations out of Thunder Bay, Ontario.

The survey area, which consisted of 2 blocks (Mahon Lake and Flatrock Lake), was flown with traverse lines oriented N0°S, and perpendicular control lines. The traverse-line spacing was 200 m, whereas the control-line spacing was 2000 m. Additional tie lines were flown along the off-angle survey borders. Total survey coverage was 33 085 line-kilometres.

The aircraft (C-FZLK) and airborne crew first mobilized to Thunder Bay, Ontario (the base of operations) on July 12, 2014. This was followed by several days of setup, safety briefings, calibrations and permit signings. Data acquisition started on July 16, 2014 and continued well, averaging 1 flight per day, with few weather days.

Base station A (combined high sensitivity magnetometer and GPS) was set up at a private location, well away from cultural interference, in the field. The exact location was 48º 22′ 15.6623″ N and 89º 22′ 27.6997″ W at an elevation of 214.412 m above the geoid. Base station B was located at 48º 22′ 15.6566″ N and 89º 22′ 27.3858″ W at an elevation of 214.261 m above the geoid.

General Statistics:

Survey dates:	July 16, 2014 to August 27, 2014
Total km flown:	33 085 km of horizontal magnetic gradient
Total flying hours:	245:00 (hours:minutes)
Production hours:	225:54 (hours:minutes)
Number of production days:	28 days
Number of production flights:	48 flights
Bad weather days:	8.5 days
Magnetic diurnal days:	0 days
Testing and calibration:	2.5 days
Equipment breakdown:	0.25 days

Aircraft maintenance:	3.75 days
Average production per flight:	689.3 km
Average production per hour:	146.5 km
Average per production day:	1181.6 km

4.2. PRESURVEY TESTS AND CALIBRATIONS

The following tests and calibrations were performed prior to the commencement of the survey:

- Magnetometer Figure of Merit (FOM) check
- Magnetometer Heading (cloverleaf) check
- Magnetometer Lag
- Altimeter Calibration
- GPS Electronic Navigation
- Stationary Magnetometer Sensors' Comparison Test
- Stationary Aircraft GPS Position Test
- Gamma-Ray Spectrometer Pad Calibration
- Gamma-Ray Spectrometer Cosmic Calibration
- Gamma-Ray Spectrometer Dynamic Test Range (Breckenridge)

The altitude attenuation and sensitivity calibration was flown over the Geological Survey of Canada (GSC)–approved Breckenridge calibration range. The heading test was flown over the Bourget magnetic observatory site near Ottawa before commencement of data collection. The presurvey calibrations, test flights were flown in the field, as part of the start-up procedures. Details of these tests and their results are given in Appendix A.

All digital data were verified for validity and continuity. The data from the aircraft and base station were transferred to the personal computer's hard disk. Two additional data copies were written to external hard disks. Basic statistics were generated for each parameter recorded. These included the minimum, maximum and mean values, the standard deviation and any null values located. Editing of all recorded parameters for spikes or datum shifts was done, followed by final data verification via an interactive graphics screen with on-screen editing and interpolation routines.

The satellite navigation system with real time correction by CDGPS was used to ferry to the survey site and to survey along each line. Co-ordinates for the survey blocks were supplied by MNDM and were used to establish the survey boundaries and the flight lines. Any other aircraft operating in the area were notified about the location of the survey blocks and flying height for safety reasons.

The accuracy of the flight path guidance system is variable; depending on the number and condition of satellites employed. The raw GPS accuracy was for the most part better than 10 m. Real-time correction using the CDGPS (broadcast services) improves the accuracy to about 3 m or less.

A video camera recorded the ground image in *avi* format along the flight path. The field operator reviewed the flight path after each survey flight for continuity.

Checking all data for adherence to specifications was carried out in the office by an experienced CGG data processor.

5. Data Compilation and Processing

5.1. PERSONNEL

The following personnel were involved in the compilation of data and creation of the final products:

Project Manager:	Jason Joseph
Processing Manager:	Michael Pearson
Processing Supervisor:	David Murray
Processor:	Katarzyna Zawadzka

5.2. BASE MAPS

Base maps of the survey area were supplied by the Ontario Ministry of Northern Development and Mines.

5.2.1. PROJECT DESCRIPTION

Datum:	North American Datum 1983 (NAD83)
Local Datum:	(4 m) Canada
Ellipsoid:	Geodetic Reference System 1980 (GRS 80)
Projection:	UTM (Zone 15N) – Mahon Lake
Projection:	UTM (Zone 16N) – Flatrock Lake
Central Meridian:	93°W – Mahon Lake
Central Meridian:	87°W – Flatrock Lake
False Northing:	0 m
False Easting:	500 000 m
Scale Factor:	0.9996

5.3. PROCESSING OF THE POSITIONAL AND ALTITUDE DATA

5.3.1. PREPROCESSING OF THE POSITIONAL DATA (GPS)

The raw GPS data from both the aircraft and base station were recovered as binary files. The latitudes, longitudes and altitudes were converted from the WGS84 spheroid to the local map projection and datum (NAD83) in both geographic (decimal degree) and UTM (metre) co-ordinates. A point to point speed calculation was then done from the final X, Y co-ordinates and reviewed as part of the quality control. The flight data were then cut back to the proper survey line limits and a preliminary plot of the actual flight path was done and compared to the planned flight path to verify the navigation.

5.3.2. PROCESSING OF THE POSITIONAL DATA

The positional data, which includes the radar altimeter and the real-time corrected GPS elevation values were checked and corrected for spikes. The raw radar altimeter data were converted to metres using the calibrations determined from the altimeter flight test. There were no periods of poor satellite visibility which may affect the resolution of the GPS elevation values. The filtered radar altimeter data were also lagged to account for system parallax. Following this, a digital elevation model (DEM) was computed by subtracting the radar altimeter values from the differentially corrected GPS elevation values. Following a QC inspection, the DEM channel was gridded and microlevelled via a 2-D procedure. The microlevel corrections were than brought back into the database to create the final levelled DEM channel.

5.4. PROCESSING OF THE MAGNETIC DATA

5.4.1. PROCESSING OF BASE STATION DATA

The recorded magnetic diurnal base station data were converted from raw binary to ASCII and loaded into a database. After initial verification of the integrity of the data by statistical analysis, the appropriate portion of the data was selected to correspond to the exact start and end time of the flight. The data were then checked and corrected for spikes using a Median and Hanning noise filter of 2.5 seconds width. The filtered base station data were imported into the master airborne database registered using common GPS time stamps. The long wavelength component of the diurnal signal was then extracted through an averaging filter of 71 seconds width. Finally, the mean diurnal value for the entire airborne survey, calculated to be 56 320 nT, was subtracted from the continuous diurnal variations and then subtracted from the airborne magnetic data as a prelevelling step.

5.4.2. PROCESSING OF MAGNETIC DATA

The binary raw data were reformatted and loaded into the database. After initial verification of the data by statistical analysis, the values were adjusted for system lag. The data were then checked and corrected for any spikes and gaps on the screen using a graphic profile display. Interactive editing, if necessary, was done at this stage. A preliminary grid of the values was then created and verified for obvious problems, such as errors in positioning or bad diurnal. Appropriate corrections were then applied to the data, as required. These steps were applied to the data from all 3 magnetic sensors (tail and wingtips). Following this, the long wavelength component of the diurnal was subtracted from the data as a prelevelling step on the tail sensor.

The final levelling process was applied to the data from the tail sensor. This consists of calculating the positions of the control points (intersections of lines and tie lines), calculating the magnetic differences at the control points and applying a series of levelling corrections (combination of movements and compensations) to reduce the misclosures to zero. A new grid of the values was then created and checked for residual errors. Any gross errors detected were corrected in the profile database and the levelling process repeated. Residual errors were extracted from the gridded values using a microlevelling technique and stored in the profile database as a second compensation field, along with the initial compensation values calculated by the line–tie-line analysis. The microlevel correction was limited in amplitude and wavelength to preserve geological signal.

The International Geomagnetic Reference Field (IGRF) was then calculated from the 2010 model year extrapolated to 2014.58 (August 1, 2014) at the mean survey elevation of 462 m (Mahon Lake) and 514 m (Flatrock Lake) ASL and removed from the corrected values.

The GSC levelling process was then applied to the microlevelled and IGRF-corrected residual magnetic field (*see* "Geological Survey of Canada Data Levelling"). This channel was then gridded using the minimum curvature algorithm and a cell size of 40 m, to prepare the grid of residual magnetic field.

5.4.3. PROCESSING OF MEASURED MAGNETIC GRADIENTS

The lateral gradient for C-FZLK was calculated for a 15.75 m wing span, while the longitudinal gradients were calculated over 12.42 m. Lateral gradients were calculated by subtracting the measured total magnetic field of the right wingtip sensor from that of the left wingtip sensor. The longitudinal gradients were calculated by averaging the wingtip values and subtracting that value from the total magnetic field measured at the tail sensor. Lateral gradients were flipped (multiplied by -1) for lines flown from north to south. Both gradients were then mean levelled. Following this, the lateral and longitudinal gradients were gridded and carefully microlevelled with limited magnitude corrections. Grids of the final lateral gradient (oriented across the traverse lines at N90°E) and the longitudinal gradient (oriented along the traverse lines at N0°E) were prepared using the minimum curvature algorithm and a cell size of 40 m.

The measured lateral and longitudinal gradients provide an improved rendition of the shorter wavelengths in magnetic field than the total magnetic field measured by the tail sensor alone. This is because the direction and amplitude of the field's total horizontal gradient can be determined using the 2 measured gradients, providing information regarding the behaviour of the magnetic field in between traverse lines. Thus, it is useful to incorporate the gradient data in the preparation of the total magnetic field grid. The resulting product is the gradient-enhanced total magnetic field grid. The tie line levelled magnetic field data were used as the input to the gradient-enhanced gridding process.

5.4.4. GEOLOGICAL SURVEY OF CANADA DATA LEVELLING

In 1989, as part of the requirements for the contract with the Ontario Geological Survey to compile and level all existing Geological Survey of Canada aeromagnetic data (flown prior to 1989) in Ontario, Paterson, Grant and Watson Limited developed a robust method to level the magnetic data of various base levels to a common datum provided by the GSC as 812.8 m grids. The essential theoretical aspects of the levelling methodology were fully discussed in Gupta et al. (1989) and Reford et al. (1990). The method was later applied to the remainder of the GSC data across Canada and the high-resolution airborne magnetic and electromagnetic surveys flown by the OGS (Ontario Geological Survey 1996). It has since been applied to all newly acquired OGS aeromagnetic surveys.

a) Terminology

Master grid: refers to the 200 m Ontario magnetic grid compiled and levelled to the 812.8 m magnetic datum from the GSC

GSC levelling: the process of levelling profile data to a master grid, first applied to GSC data

Intrasurvey levelling or microlevelling:
refers to the removal of residual line noise described earlier in this chapter; the wavelengths of the noise removed are usually shorter than tie-line spacing

Intersurvey levelling or GSC levelling:
refers to the level adjustments applied to a block of data; the adjustments are the long wavelength (in the order of tens of kilometres) differences with respect to a common datum, in this case, the 200 m Ontario master grid, which was derived from all pre-1989 GSC magnetic data and adjusted, in turn, by the 812.8 m GSC Canada-wide grid

b) The GSC Levelling Methodology

The GSC levelling methodology is described below, using, as an example, the Vickers survey flown for the OGS.

Several data processing procedures are assumed to be applied to the survey data prior to levelling, such as microlevelling, IGRF calculation and removal. The final levelled data are gridded at 1/5 of the line spacing. If a survey was flown as several distinct blocks with different flight directions, then each block is treated as an independent survey.

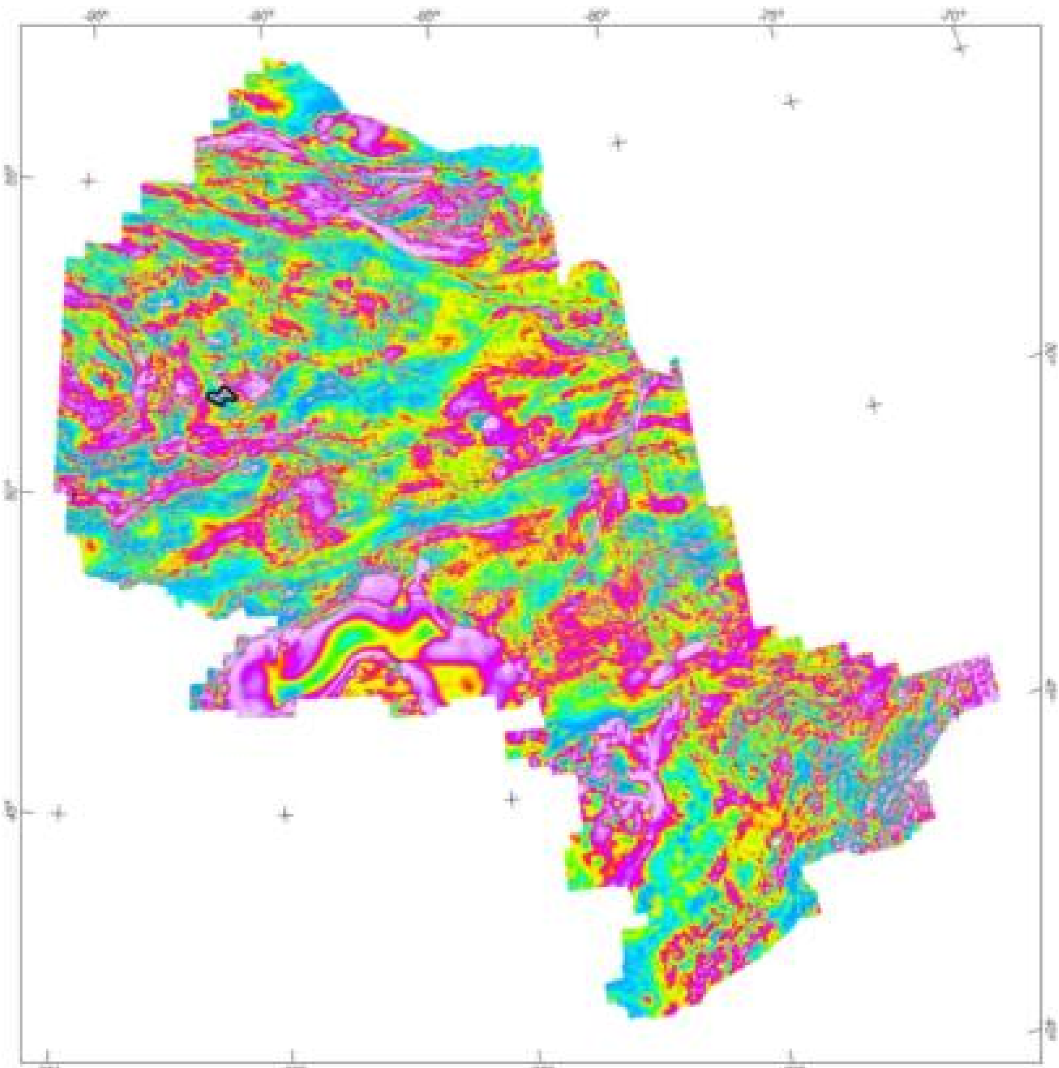


Figure 2. Ontario master aeromagnetic grid (Ontario Geological Survey 1999). The outline for the sample data set to be levelled, using the Vickers survey area as the example, is shown.

The steps in the GSC levelling process are as follows:

1. Create an upward continuation of the survey grid to 305 m.

   Almost all recent surveys (1990 and later) to be compiled were flown at a nominal terrain clearance of 100 m or less. The first step in the levelling method is to upward continue the survey grid to 305 m, the nominal terrain clearance of the Ontario master grid (Figure 2).

   The grid cell size for the survey grids is set at 100 m. Since the wavelengths of level corrections will be greater than 10 to 15 km, working with 100 m or even 200 m grids at this stage will not affect the integrity of the levelling method. Only at the very end, when the level corrections are imported into the databases, will the level correction grids be regridded to 1/5 of line spacing.

The unlevelled 100 m grid is extended by at least 2 grid cells beyond the actual survey boundary, so that in the subsequent processing, all data points are covered.

2. Create a difference grid between the survey grid and the Ontario master grid.

The difference between the upward-continued survey grid and the Ontario master grid, regridded at 100 m, is computed (Figure 3). The short wavelengths represent the higher resolution of the survey grid. The long wavelengths represent the level difference between the 2 grids.

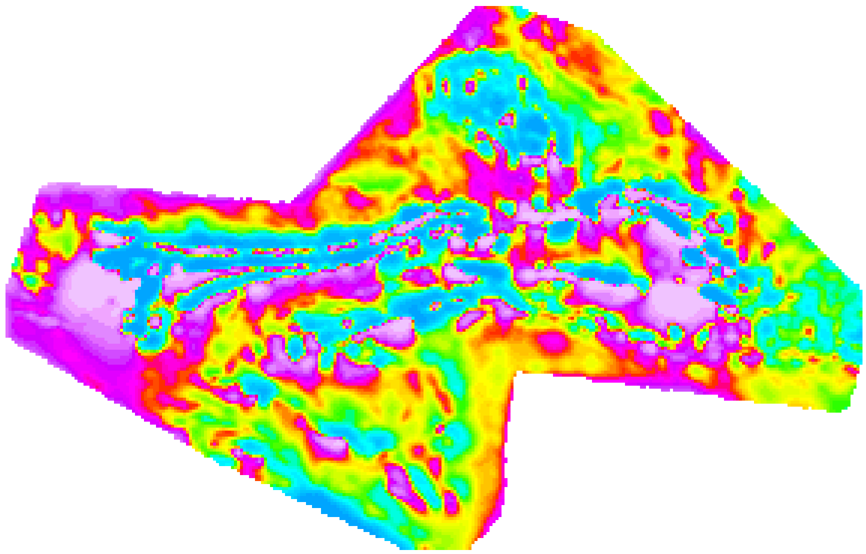


Figure 3. Difference grid (difference between survey grid and master grid), using the Vickers survey as the example.

3. Rotate difference grid so that flight-line direction is parallel with grid column or row, if necessary.
4. Apply the first pass of a nonlinear filter (Naudy and Dreyer 1968) of wavelength on the order of 15 to 20 km along the flight-line direction. Reapply the same nonlinear filter across the flight-line direction.
5. Apply the second pass of a nonlinear filter of wavelength on the order of 2000 to 5000 m along the flight-line direction. Reapply the same nonlinear filter across the flight-line direction.
6. Rotate the filtered grid back to its original (true) orientation (Figure 4).
7. Apply a low-pass filter to the nonlinear filtered grid.
   Streaks may remain in the nonlinear filtered grid, mostly caused by edge effects. They must be removed by a frequency-domain, low-pass filter with the wavelengths in the order of 12 km (Figure 5).
8. Regrid to 1/5 line spacing and import level corrections into database.
9. Subtract the level correction channel from the unlevelled channel to obtain the level corrected channel.
10. Make final grid using the gridding algorithm of choice with grid cell size at 1/5 of line spacing.

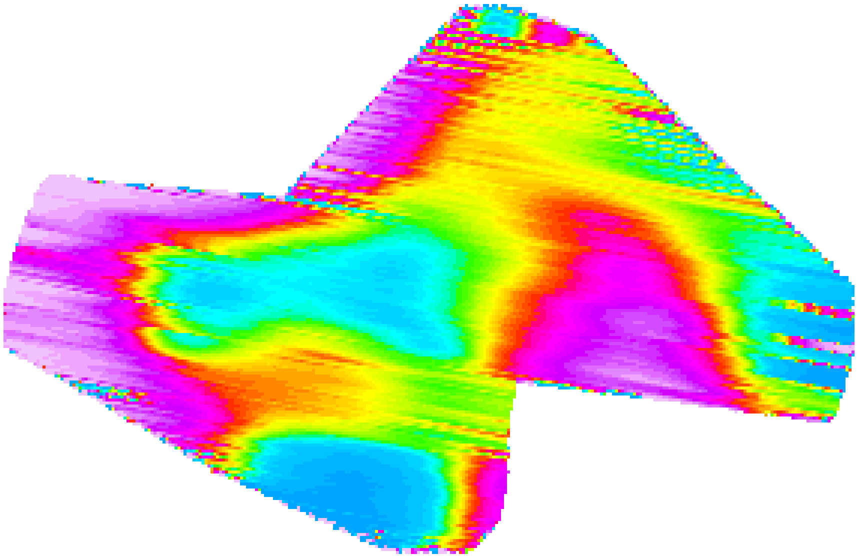


Figure 4. Difference grid after application of nonlinear filtering and rotation, using the Vickers survey as the example.

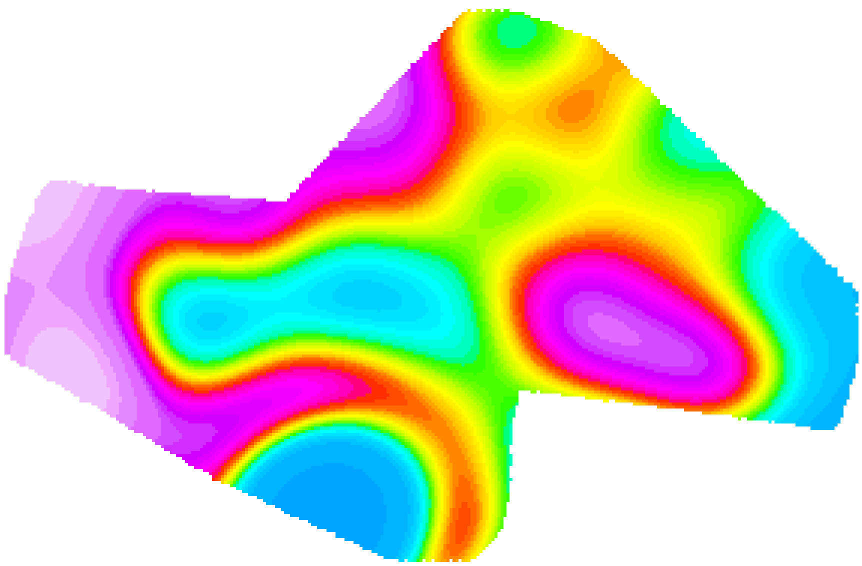


Figure 5. Level correction grid, using the Vickers survey as the example.

c) Survey Specific Parameters

The following GSC levelling parameters were used in the Thunder Bay survey:

- Upward continuation distance: 205 m
- First pass nonlinear filter length: 10 000 m
- Second pass nonlinear filter length: 2 500 m
- Low-pass filter cut-off wavelength: 12 500 m

5.4.5. Final Magnetic Field and Second Vertical Derivative Grids

After GSC levelling was applied to the total magnetic field channel, both the total magnetic field and the GSC levelled grids were gradient-enhanced. The corresponding magnetic grids were calculated from the final reprocessed profiles using a bidirectional minimum curvature algorithm (Briggs 1974). The accuracy standard for gridding is that the grid values fit the profile data to within 0.001 nT for 99.99% of the profile data points, for 100 iterations (or 0.00001 nT/m for the horizontal gradient data). The average gridding error is well below 0.1 nT.

Minimum curvature gridding provides the smoothest possible grid surface that also honours the profile line data. However, sometimes this can cause narrow linear anomalies cutting across flight lines to appear as a series of isolated spots. This effect is minimized in the gradient-enhanced GSC levelled magnetic grid, and as a result it was used for the map products.

Both the final levelled gradient-enhanced grids of the total magnetic field values and the GSC levelled magnetic field values were then used as input to create the second vertical derivative grids. The latter grid was presented on the second vertical derivative maps due to its superior rendition of the magnetic anomalies. The calculation was done in the frequency domain by combining the transfer function of the second vertical derivative and a three-point Hanning filter. The Hanning filter was used to attenuate unwanted high frequencies enhanced by the second derivative operator, without aliasing the geological signal.

5.4.6. Calculation of the Keating Coefficients

Possible kimberlite targets were identified from analytic signal of the residual magnetic intensity data, based on the identification of roughly circular anomalies. This procedure was automated by using a known pattern recognition technique (Keating 1995), which consists of computing, over a moving window, a first-order regression between a vertical cylinder model anomaly and the gridded magnetic data. Only the results where the absolute value of the correlation coefficient is above a threshold of 75% were retained. On the magnetic maps, the results are depicted as circular symbols, scaled to reflect the correlation value. The most favourable targets are those that exhibit a cluster of high-amplitude solutions. Correlation coefficients with a negative value correspond to reversely magnetized sources.

The cylinder model parameters are as follows:

Cylinder diameter:	200 m
Cylinder length:	infinite
Overburden thickness:	5.5 m Mahon Lake (average) and 6.5 m Flatrock Lake (average)
Magnetic inclination:	74.0° N Mahon Lake and 74.1° N Flatrock Lake
Magnetic declination:	1.1° W Mahon Lake and 3.0° W Flatrock Lake
Window size:	17 x 17 cells (680 m x 680 m)
Magnetization scale factor:	100
Model window grid cell size:	40 m

An example of the model's magnetic response is shown in Figure 6.

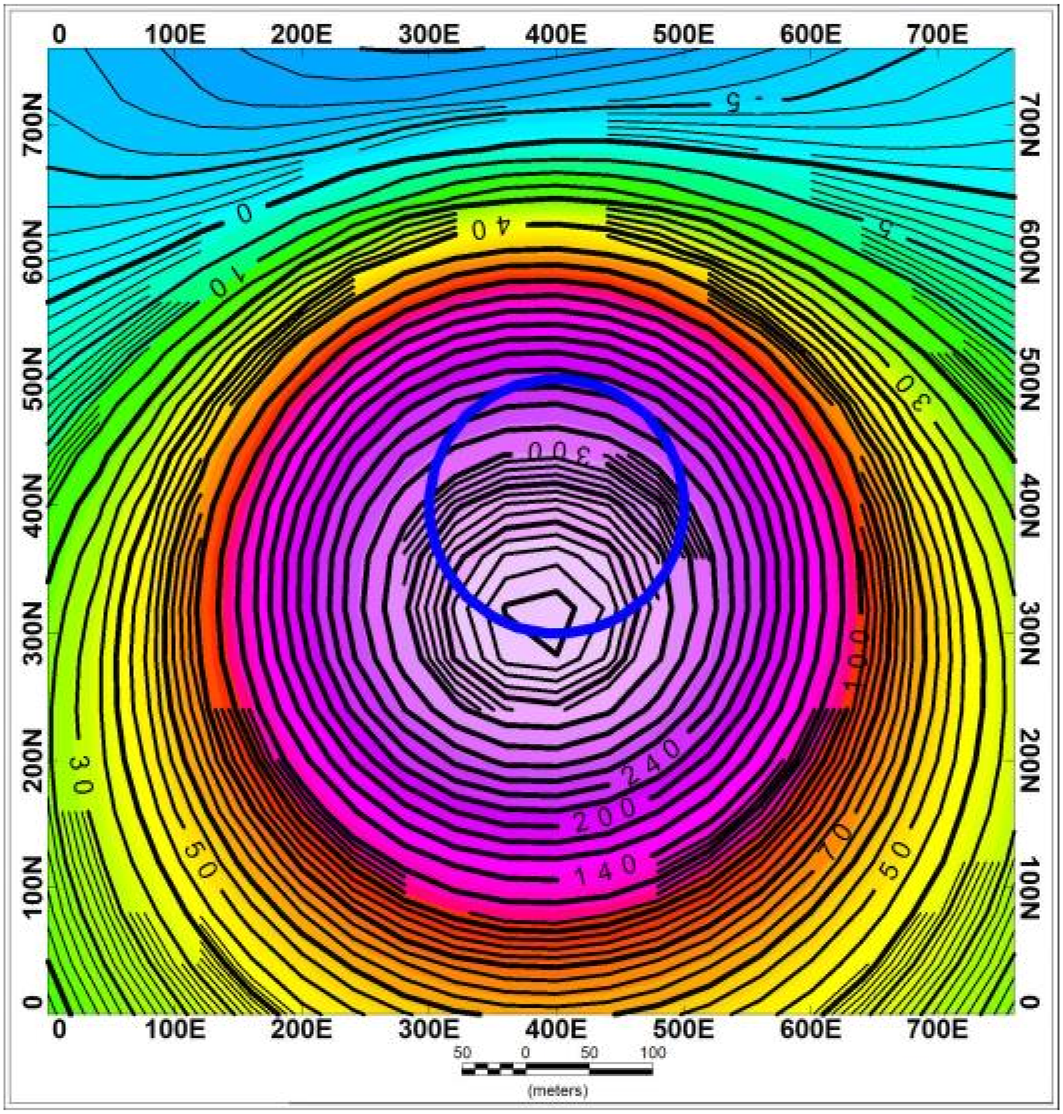


Figure 6. Vertical cylinder anomaly model used for Keating correlation. Top of cylinder outlined in blue. On the Mahon Lake and Flatrock Lake survey areas the grid cell interval is 40 m.

It is important to be aware that other magnetic sources may correlate well with the vertical cylinder model, whereas some kimberlite pipes of irregular geometry may not. The user should study the magnetic anomaly that corresponds with the Keating symbols, to determine whether it does resemble a kimberlite pipe signature, reflects some other type of source or even noise in the data e.g. boudinage (beading) effect of the minimum curvature gridding. All available geological information should be incorporated in kimberlite pipe target selection.

5.5. PROCESSING OF RADIOMETRIC DATA

All radiometric raw channels were background corrected from overwater background line segments, flown preflight and postflight, in the field for quality control.

The processing methodology was as described in the *IAEA Airborne Gamma Ray Spectrometer Surveying Report* (International Atomic Energy Agency 1991). In this case, no energy calibration or dead-time correction was done as the dead time is typically much less than 0.1% with the Radiation Solutions Inc. system.

5.5.1. Filtering of the Cosmic and Upward Uranium Channels

Variations in the cosmic channel are of long wavelength and usually attributed to changes in altitude or atmospheric conditions. A 35 point Hanning filter was applied to the cosmic channel to allow for a smooth correction, free of statistical noise in the process described in section 5.5.2. Similarly, the upward uranium channel, used in the correction of atmospheric radon, is highly susceptible to statistical noise due to generally low count rates. A 101 point low-pass filter was applied to the upward-looking uranium channel.

5.5.2. Cosmic Background Corrections

Radiation in the 3 to 6 MeV range, the cosmic channel, is attributed to non-Earth sources and can be considered as pure noise, in that it has no relationship with the desired geological signal. As such, it can be measured independently and used to remove the cosmic component in lower energy windows.

Theory suggests that the cosmic measurement should increase linearly as altitude increases, provided there is no contamination from radon. Methodology for the removal of the cosmic background involves a cosmic calibration flight where measurements are taken at a variety of heights from 1500 m to 3500 m altitude. Linear regressions are derived for each of the regions of interest relative to the cosmic channel. The slope yields the “cosmic stripping ratio” and the y intercept is the aircraft background.

The correction applied is then expressed as

$$N_i = (a_i * C) + b_i$$

where,

N_i = cosmic correction in the i’th channel;
a_i = cosmic stripping ratio in the i’th channel;
C = counts in cosmic window (3 to 6 MeV);
b_i = aircraft background in the i’th channel.

The cosmic stripping ratios and aircraft backgrounds for the aircraft determined from the cosmic calibration flight are listed below. A complete summary of the test is listed in Appendix A.

Stripping ratio:

C-FZLK				
a_{TC}	a_K	a_U	a_{TH}	a_{UPU}
0.6394	0.0326	0.0293	0.0344	0.0082

Aircraft background:

C-FZLK				
b_{TC}	b_K	b_U	b_{TH}	b_{UPU}
60.3915	8.6042	1.9456	0.3296	0.4447

5.5.3. RADON BACKGROUND CORRECTIONS

Radon concentrations vary from flight to flight and are affected by weather and topography. A variety of methods can be used to model and remove this signal. The upward detector, which is mostly shielded from geologic signal by being centred above 4 downward detectors, is used to estimate the contribution of atmospheric radon into the downward uranium channel, U_r, and overwater tests are used to determine the ratio between radon in the uranium window and radon contributions to the other windows.

After cosmic and background corrections have been applied, the signal detected over water is solely due to atmospheric radon. Overwater "backgrounds" were flown at the beginning and end of every flight to collect data with a variety of ambient radon concentrations.

These data were averaged and analyzed to solve the following equations by linear regressions:

$$u_r = a_U * U_r + b_U$$
$$K_r = a_K * U_r + b_K$$
$$Th_r = a_{Th} * U_r + b_{Th}$$
$$TC_r = a_{TC} * U_r + b_{TC}$$

where,

u_r = the radon component in the upward U window;
K_r , U_r , Th_r , TC_r= the radon components in the various windows of the downward detectors (where K = potassium; U = uranium; Th = thorium; TC = total count);
a_i = coefficients are the calibration constants determined by linear regression;
b_i = coefficients are now near-zero after removal of aircraft and cosmic backgrounds.

The ai coefficients, determined by linear regression of count rates in the i'th window to downward uranium count rates of the overwater test data for the aircraft, are as follows:

C-FZLK			
a_{TC}	a_K	a_{TH}	a_{UPU}
14.2892	0.7664	0.0647	0.2528

The radon contribution to the downward uranium window, U_r, can be determined from

$$U_r = \frac{(u - a_1 * U - a_2 * Th + a_2 * b_{Th} - b_U)}{(a_U - a_1 - a_2 * a_{Th})}$$

where,

u = count rate in the upward uranium window;
U , Th = count rates in the uranium and thorium windows;
a_U = ratio of upward uranium counts to downward uranium counts in the overwater data;
a_{Th} = ratio of thorium counts to downward uranium counts in the overwater data;
b_U , b_{Th} = the small non-zero background in the uranium and thorium channels after removal of cosmic and aircraft backgrounds;
a_1 , a_2 = coefficients that relate counts in the downward uranium and thorium channels to counts in the upward uranium channels. These are determined in the following process.

The signal measured in the upward uranium window is made up of a contribution from atmospheric radon and a geologic component due to radioactive sources in the ground. This component (ug) has a linear relationship with the downward uranium (Ug) and thorium (Thg) given by

$$u_g = a_1 * U_g + a_2 * Th_g$$

Values of ug, Ug and Thg are found by analyzing the differences in count rates in each window for adjacent sections of survey lines. Differences between count rates are found at some interval, m, in the upward and downward uranium and thorium channels. Where the overall radioactivity was decreasing, as evidenced by the difference in the total count window, the sign of the differences was reversed.

$$U_g = (U_n - U_{n+m})$$
$$Th_g = (Th_n - Th_{n+m})$$
$$u_g = (u_n - u_{n+m})$$

The differences then are accumulated over the entire survey to determine the calibration factors for upward uranium to downward uranium and thorium for sources in the ground by solving the simultaneous linear equations:

$$a_1 * \sum(U_g)^2 + a_2 * \sum(U_g * Th_g) = \sum(u_g * U_g)$$

and

$$a_1 * \sum(U_g * Th_g) + a_2 * \sum(Th_g)^2 = \sum(u_g * Th_g)$$

where the summation is carried out over all (n) points in the database. The following coefficients were determined for the aircraft:

C-FZLK			
Mahon Lake		**Flatrock Lake**	
a_1	0.03115	**a_1**	0.03002
a_2	0.02555	**a_2**	0.02460

5.5.4. SPECTRAL STRIPPING CORRECTIONS

The spectra of the potassium, uranium and thorium series overlap. Because of this, each spectral window contains counts from each of the other windows. This can be corrected by “stripping” the data using coefficients derived by obtaining measurements over concrete pads with known radioelement concentrations. Each crystal pack was tested prior to the survey with the Geological Survey of Canada calibrated test pads (Grasty and Hovgaard 1996). The averaged stripping coefficients determined for the aircraft are as follows:

C-FZLK	
α	0.2304
β	0.3421
γ	0.6656
A	0.0472
B	-0.0023
G	0.0068

These coefficients are then applied to the data as follows to determine stripped count rates:

$$k_{Strip} = \frac{n_{th}(\alpha\gamma - \beta) + n_u(A\beta - \gamma) + n_k(1 - A\alpha)}{1 - G\gamma - A(\gamma - G\beta) - B(\beta - \alpha\gamma)}$$

$$u_{Strip} = \frac{n_{th}(G\beta - \gamma) + n_u(1 - B\beta) + n_k(B\alpha - G)}{1 - G\gamma - A(\gamma - G\beta) - B(\beta - \alpha\gamma)}$$

$$th_{Strip} = \frac{n_{th}(1 - G\gamma) + n_u(B\gamma - A) + n_k(AG - B)}{1 - G\gamma - A(\gamma - G\beta) - B(\beta - \alpha\gamma)}$$

where,

n_{th} , n_k , n_u = radon corrected count rates.

5.5.5. Calculation of Effective Height

The height of the detectors must be corrected to standard temperature and pressure (STP) height to account for the attenuating properties of changes in air density on count rates. This effective height, h_e, is calculated from the formula below:

$$h_e = h * \left(\frac{273.15}{T + 273.15}\right) * \left(\frac{P}{1013.25}\right)$$

where,

h = the observed height above ground level (AGL) in metres;
T = temperature in degrees Celsius;
P = barometric pressure in millibars.

5.5.6. Height Attenuation Correction and Conversion to Radioelement Concentrations

The aircraft was flown over the Geological Survey of Canada–approved Breckenridge Dynamic Calibration range, located near Ottawa, Ontario, to determine the system sensitivities and height attenuation coefficients. These parameters are installation specific and relate to the detector crystal packs used, the aircraft and the location of the equipment within the aircraft. A calibrated meter was used to traverse the test range while the aircraft was flying over at several altitudes. The data were background corrected by immediately flying over nearby water at the same height. They were then stripped and reduced to survey height. The system sensitivities are the ratios of counts to the measured concentrations. The attenuation coefficient was then derived from the exponential relationship between the stripped counts at the various heights.

C-FZLK		
	Attenuation	**Sensitivities**
TC	-0.0066	25.3729
K	-0.0082	74.5758
U	-0.0072	8.8690
Th	-0.0067	4.7969

The survey data in each window were first reduced to the observed count rate at standard temperature and pressure (STP) height and then scaled by the sensitivity to determine the final ground concentration, C, using the following equation

$$C = \frac{n_0 e^{-\mu(H-h)}}{S}$$

where,

n_0	=	stripped count rate;
e	=	Euler's constant
μ	=	window attenuation coefficient;
H	=	nominal survey terrain clearance;
h	=	standard temperature and pressure (STP) height above ground of observation;
S	=	sensitivity.

5.5.7. Calculation of the Elemental Ratios

Ratios of 3 final radioelement concentrations were calculated, in profile form, using a procedure originally designed by the GSC. The selected ratios are: thorium–over-potassium; uranium-over-potassium; and uranium-over-thorium. In order to reduce fluctuations caused by limited statistical certainty in the final radioelement concentrations, minimum standards are set for each ratio calculation. These are somewhat arbitrarily selected to equate to a corrected ROI count rate of about 100 c/second for each element. For this spectrometer system these values are:

K $\geq$ 1.34 %

eU $\geq$ 11.28 ppm

eTh $\geq$ 20.85 ppm

where:

K is the concentration of potassium (%)

eU is the equivalent concentration of uranium (ppm)

eTh is the equivalent concentration of thorium (ppm)

In order to extend ratio values to those data points that fall below these minimum standards, a simple variable length filter is applied prior to ratio calculation. This consists of summing data from adjacent points on each side of the initial data point, for both numerator and denominator, and checking to see if both now meet the required minima. If so the ratio is calculated. If not, this process is continued to the next adjacent pair until a successful check is achieved or until a maximum number of adjacent data pairs have been included. This maximum number of pairs has been set to 10 for this survey. If the minimum check fails after 10 pairs have been added, the ratio is set to null at the subject data point.

In order to eliminate calculation of ratios at those locations most likely to be over water, an initial standard is required at each data point before any ratios are calculated. The potassium concentration must be $\geq$ 0.25 %. Otherwise all 3 ratios are set to null. This "kill" process applies only to the initial data point. Such points may be included in the addition process applied to nearby points that have not been "killed".

5.5.8. Generation of the Ternary Radioelement Image

The ternary map is produced by scaling the distribution of potassium, thorium and uranium against red, green and blue, respectively. In this case, the data were processed using the GSC S-Tergen utility, which normalizes the data and applies an optimum colour distribution. The algorithm used is as described in Broome et al. (1987).

6. Final Products

The following products were delivered to the MNDM.

a) Profile Databases

Databases, in both Geosoft® *gdb* and ASCII format, of the following, were provided:

- Magnetic line data archive
- Radiometric line data archive
- Radiometric line data array archive
- Keating coefficient archive

b) Gridded Data

Grids, in both Geosoft® *grd* and *gxf* formats, gridded from co-ordinates in UTM Zone 15N Mahon Lake and UTM Zone 16N Flatrock Lake, NAD83, of the following data:

- digital elevation model
- total magnetic field from the tail sensor
- second vertical derivative of the total magnetic field from the tail sensor
- GSC-levelled, gradient-enhanced residual magnetic field
- calculated second vertical derivative of the GSC-levelled gradient-enhanced residual magnetic field
- measured lateral horizontal gradient
- measured longitudinal horizontal gradient
- total air-absorbed dose rate
- percent potassium
- equivalent uranium
- equivalent thorium
- percent potassium ratio / equivalent thorium
- equivalent uranium / percent potassium ratio
- equivalent uranium / equivalent thorium ratio

c) Project Report

- Provided in portable document format (*pdf*)

d) Flight Videos

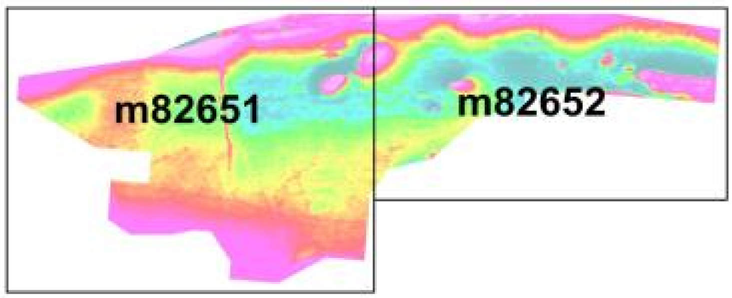
- The digitally recorded video from each survey flight are provided in a compressed binary format on a hard drive.

e) Maps

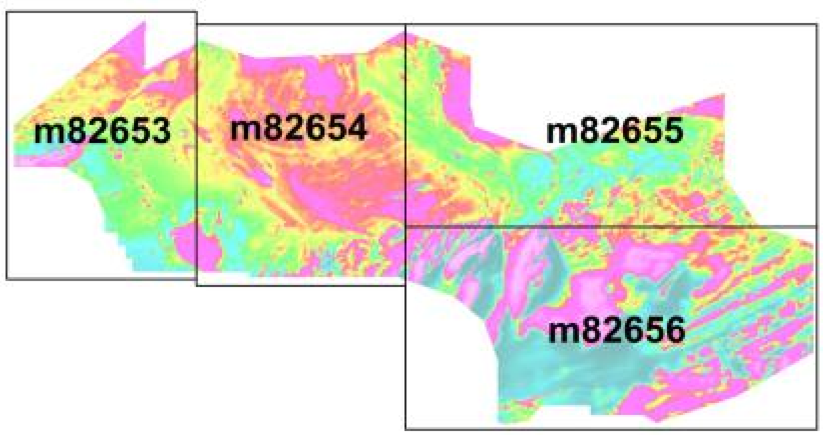
Digital 1:50 000 scale maps (NAD83 UTM Zone 15N Mahon Lake and 16N Flatrock Lake) in Geosoft® MAP format, with a topographic layer, of the following:

- colour-filled contours of gradient-enhanced residual magnetic field and flight lines (with the following tile names and layout, where "m826xx" indicates OGS Map 826xx):

Mahon Lake

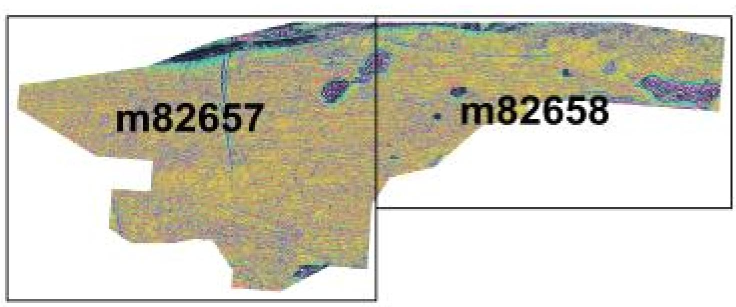


Flatrock Lake

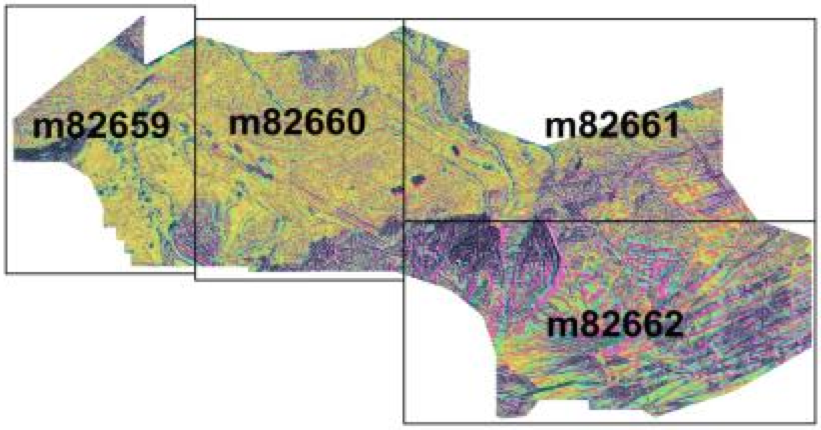


- shaded colour of the second vertical derivative of the gradient-enhanced total magnetic intensity with Keating coefficients (with the following tile names and layout, where "m826xx" indicates OGS Map 826xx):

Mahon Lake

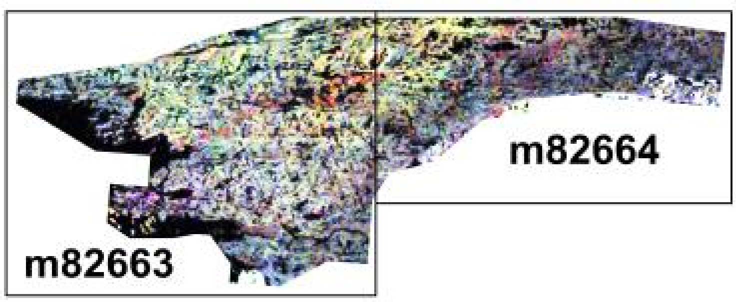


Flatrock Lake

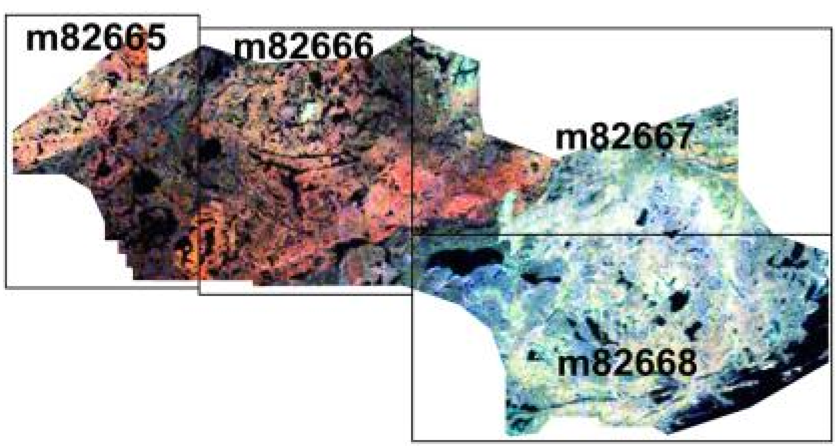


- histogram-equalized ternary red, green and blue radioelement image with inset images of percent potassium, equivalent uranium, equivalent thorium and dose rate (with the following tile names and layout, where “m826xx” indicates OGS Map 826xx):

Mahon Lake



Flatrock Lake



7. Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) were undertaken by the survey contractor CGG and PGW, as well as MNDM. Stringent QA/QC is emphasized throughout the project so that the optimal geological signal is measured, archived and presented.

7.1. SURVEY CONTRACTOR

Important checks are required during the data acquisition stage to ensure that the data quality is kept within the survey specifications. The following lists, in detail, the standard data quality checks that were performed by CGG during the course of the survey.

7.1.1. TESTS AND CALIBRATIONS

The full results of the tests and calibrations described below can be found in Appendix A.

a) Compensation Figure of Merit

Aircraft movements induce spurious magnetic fields, which are removed from the magnetic data by the compensator. The efficiency of this removal can be evaluated by conducting a test called a Figure of Merit (FOM). The aircraft flies a series of 3 manoeuvres of ±10° rolls, ±5° pitches and ±5° yaws in each of the traverse- and control-line directions in a magnetically quiet zone (low magnetic gradient). The peak-to-peak amplitudes of the responses obtained on the magnetometer compensated channel are determined for each of the 3 manoeuvre types and for each of the 4 directions. The 12 values are then summed giving the Figure of Merit.

Compensation figure of merit test was performed by the aircraft both prior to commencement and after completion of the survey.

In all calibrations performed by the aircraft, the resultant figures of merit for the tail and wing-tip sensors were below the specified threshold of 1.5 nT.

b) Heading Test

To verify system accuracy and acceptable heading error, a heading test was performed over the GSC magnetic observatory at Bourget, Ontario, prior to commencement of the survey. The aircraft performed 2 passes in each cardinal direction directly over the observatory and the aircraft measured total field was compared against the observatory data.

For the calibration performed the calculated heading errors were minimal and the absolute accuracies were within the contract threshold of 10 nT.

c) Lag Tests

To verify the magnetic system latency, the survey aircraft conducted lag tests. These tests involve flying multiple passes over a known magnetic feature and comparing the position of the observed magnetic peaks with the known position of the target.

Both prior to commencement and after completion of the survey, C-FZLK flew this test over a bridge near Ottawa.

The calculated system latencies from these tests were determined to be consistent between the pre- and postsurvey values and were consistent with previous tests performed by this aircraft.

d) Radar Altimeter Calibration

The radar altimeter calibration and verification were performed by acquiring altitude data from several passes of increasing altitude over the Ottawa River. The radar altimeter of the aircraft was confirmed to have a linear relationship with and within acceptable range of the GPS height.

e) Cosmic Calibration

High-altitude cosmic calibration flight was performed by the aircraft prior to the survey. In this test, the aircraft climbed from 1500 m to 3500 m in increments of 500 m and accumulated approximately 10 minutes of data at each altitude. The resultant data determined the linear relationship between counts in the cosmic window and each region of interest window.

f) Radiometric Test Range

The aircraft performed a calibration flight over Breckenridge radiometric test range near Ottawa, Ontario, to determine the radiometric system sensitivities and altitude attenuation factors. The aircraft repeated a 10 km test line and an adjacent over-water line (for background corrections) at altitudes of 60 to 240 m in 30 m increments.

Simultaneously, actual ground concentrations were measured by a ground crew equipped with a calibrated hand-held Exploranium™ GR-320 spectrometer. At 8 predetermined stations along the survey test line, four 120-second sample accumulations were acquired, each approximately 15 m apart. The processed measurements are then averaged giving the ground concentrations in each window for the test line.

g) Radiometric Pad Test

To determine the stripping ratios of each detector, calibrations were done in the CGG hangar using calibrated Geological Survey of Canada pads. Four concrete pads, 3 embedded with the ROI radioelements and one "bare" pad for background corrections, were placed beneath detector packs installed in the aircraft. Data were then accumulated for approximately 30 minutes. The averaged count rates can then be used to compute the 6 stripping ratios for each spectrometer.

7.1.2. Daily Quality Control

a) Navigation Data

- The differentially corrected GPS flight track was recovered and matched against the theoretical flight path to ensure that any deviations are within the specifications (i.e. deviations not greater than 50 m from the nominal line spacing over a 2 km distance).
- All altimeter data were checked for consistency and deviations in terrain clearance were monitored closely. The survey was flown in a smooth drape fashion maintaining a nominal terrain clearance of 100 metres, whenever possible. A digital elevation trace, calculated from the radar altimeter and the GPS elevation values, was also generated to further control the quality of the altimeter data.
- The synchronicity of the GPS time and the acquired time of the geophysical data was checked by matching the recorded time fields.
- A final check on the navigation data was done by computing the point-to-point speed from the corrected UTM X and Y values. The computed values should be free of erratic behaviour showing a nominal ground speed of between 65 m/s and 85 m/s with point-to-point variations not exceeding ± 10 m/s.

b) Magnetic Data

- The diurnal variation was examined for any deviations that exceed the specified 3 nT peak-to-peak over a 60 second chord. Data were re-acquired when this condition was exceeded, with any re-flown line segment crossing a minimum of two control lines. A further quality control on the diurnal variation was to examine the data for any man-made disturbances. When noted, these artifacts were graphically removed by a polynomial interpolation so that they are not introduced into the final data when the diurnal values are subtracted from the recorded airborne data.
- The integrity of the airborne magnetometer data was checked through statistical analysis and graphically viewed in profile form to ensure that there were no gaps and that the noise specifications were met.
- A fourth difference editing routine was applied to the raw data to locate and correct any small steps and/or spikes in the data.
- Any effects of filtering applied to the data were examined by displaying, in profile form, the final processed results against the original raw data, via a graphic screen. This was done to ensure that any noise filtering applied has not compromised the resolution of the geological signal.
- Ongoing gridding and imaging of the data was also done to control the overall quality of the magnetic data.

c) Radiometric Data

- Ongoing gridding and imaging of the data was also done to control the overall quality of the magnetic data.
- Onsite, weather conditions were continuously monitored to ensure that no radiometric survey took place within 4 hours after measurable precipitation or 12 hours after heavy precipitation.
- Prior to each survey flight, the field crew performed 2 system verification tests. The results of these system verification tests are plotted in Appendix A.
- Source Tests: While the aircraft sat stationary, a ^{232}Th source was placed in a cradle and attached to the aircraft beneath the spectrometer detector pack and data were collected for 2 minutes. The sample was then removed and data were again collected for 2 minutes for background determination. The results analyzed and plotted to ensure consistent sensitivities throughout the survey.
- System Resolution Test: A ^{232}Th source was used determine the full width–half amplitude (FWHM) of the 2615 keV photopeak, expressed as a percentage, as a measure of system performance. In all tests performed, FWHM of the photopeak remained well below the contract specified threshold of 12%.
- Before and after each radiometric survey flight, a repeat line was flown as an additional measure of system consistency throughout the survey as well as consistency between aircraft.
- During a survey flight, the flight crew is presented with a diagnostic display of the radiometric acquisition system showing a combined spectra and status of each detector crystal. In the event of anomalous system state or error, a visual alert is displayed.
- Post flight, the radiometric data were viewed in profile format. The data were checked for any gaps, erroneous detector crystal states or stabilization errors. Any records that show an error in detector state were removed and scheduled for reflight if needed. Rough background correction estimates were removed from the ROI channels and the data were displayed in grid format to check for coherence.

7.1.3. NEAR-FINAL FIELD PRODUCTS

Near-final products of the profile and gridded magnetic and radiometric data were made available to the QA/QC Geophysicist during visits to the survey site, for review and approval, prior to demobilization.

7.1.4. QUALITY CONTROL IN THE OFFICE

a) Review of preliminary processed data

The general results of the preliminary processing were reviewed in the profile database by producing a multichannel stacked display of the data (raw and processed) for every line, using a graphic viewing tool. The magnetic and altimeter data were checked for spikes and residual noise.

b) Review of the final processed data

The results of the field levelling of the magnetics were reviewed, using imaging and shadowing techniques. Any residual errors noted were corrected and the final microlevelling re-applied to the profile data.

c) Creation of first and second vertical derivative

The first and second vertical derivatives were created from the final gridded values of the total field magnetic data and checked for any residual errors using imaging and shadowing techniques.

7.1.5. INTERIM PRODUCTS

Archive files containing the raw and interim processed profile data and the gridded data were provided to the QA/QC Geophysicist for review and approval.

Creation of 1:50 000 maps

After approval of the interim data, the 1:50,000 maps were created and verified for registration, labelling, dropping weights, general surround information, etc. The corresponding digital files were provided to the QA/QC Data Manager for review and approval.

7.2. QA/QC GEOPHYSICIST

The QA/QC Geophysicist received data on a regular basis throughout the data acquisition, focusing initially on the data acquisition procedures, base station monitoring and instrument calibration. As data were collected, they were reviewed for adherence to the survey specifications and completeness. Any problems encountered during data acquisition were discussed and resolved.

The QA/QC checks included the following:

a) Navigation Data

- appropriate location of the GPS base station
- flight line and control line separations are maintained, and deviations along lines are minimized
- verify synchronicity of GPS navigation and flight video
- all boundary control lines are properly located
- terrain clearance specifications are maintained
- aircraft speed remained within the satisfactory range
- area flown covers the entire specified survey area
- real-time corrected GPS data does not suffer from satellite induced shifts or dropouts

- GPS height and radar/laser altimeter data are able to produce an image quality DEM
- GPS and geophysical data acquisition systems are properly synchronized
- GPS data are adequately sampled.

b) Magnetic Data

- appropriate location of the magnetic base station, and adequate sampling of the diurnal variations
- heading error and lag tests are satisfactory
- magnetometer noise levels are within specifications
- magnetic diurnal variations remain within specifications
- magnetometer drift is minimal once diurnal and IGRF corrections are applied
- spikes and/or drop-outs are minimal to non-existent in the raw data
- filtering of the profile data is minimal to non-existent
- preliminary levelling produces image-quality grids of total magnetic field and higher order products (e.g., second vertical derivative)

c) Radiometric data

- consistency between daily test lines
- consistency between daily fixed source and static background measurements
- shifts in radioelement concentrations between flights
- precipitation limitations are observed
- the energy resolution is confirmed daily with ^{232}Th and, using the 2615 keV photopeak of ^{232}Th, a total system resolution better than 12% is maintained

The QA/QC Geophysicist reviewed interim and final digital and map products throughout the data compilation phase, to ensure that noise was minimized and that the products adhered to the QA/QC specifications. This typically resulted in several iterations before all digital products were considered satisfactory. Considerable effort was devoted to specifying the data formats and verifying that the data adhered to these formats.

7.3. MINISTRY OF NORTHERN DEVELOPMENT AND MINES

MNDM prepared all of the base map and map surround information required for the hard copy maps. This ensured consistency and completeness for all of the geophysical map products. The base map was constructed from digital files of the 1:50 00 NTS map sheet series.

MNDM worked with the QA/QC Geophysicist to ensure that the digital files adhered to the specified ASCII and binary file formats, that the file names and channel names were consistent, and that all required data were delivered on schedule. The map products were carefully reviewed in digital and hard copy form to ensure legibility and completeness.

MNDM and the QA/QC geophysicist provided the magnetic profile and gridded data guidelines for CGG as part of the GSC levelling process.

References

Briggs, I.C. 1974. Machine contouring using minimum curvature; Geophysics v.39, p.39-48.

Broome, J., Carson, J.M., Grant, J.A. and Ford, K. 1987. A modified ternary radioelement mapping technique and its application to the south coast of Newfoundland; Geological Survey of Canada, Paper 87-14, scale 1:500 000.

Grasty, R.L. and Hovgaard, J. 1996. The calibration of upward looking detectors in gamma ray surveys; *in* Expanded Abstracts, Society of Exploration Geophysicists, 66th Annual International Meeting, San Francisco, v.15, p.1422-1425, DOI:10.1190/1.1826379.

Gupta, V., Paterson, N., Reford, S., Kwan, K., Hatch, D. and Macleod, I. 1989. Single master aeromagnetic grid and magnetic colour maps for the province of Ontario; *in* Summary of Field Work and Other Activities 1989, Ontario Geological Survey, Miscellaneous Paper 146, p.244-250.

International Atomic Energy Agency 1991. Airborne gamma ray spectrometer surveying; International Atomic Energy Agency, Vienna, Austria, Technical Reports Series 323, 97p.

Keating, P.B. 1995. A simple technique to identify magnetic anomalies due to kimberlite pipes; Exploration and Mining Geology, v.4, no.2, p.121-125.

Naudy, H. and Dreyer, H. 1968. Essai de filtrage nonlinéaire appliqué aux profiles aeromagnétiques; Geophysical Prospecting, v.16, p.171-178.

Ontario Geological Survey 1996. Ontario airborne magnetic and electromagnetic surveys, processed data and derived products: Archean and Proterozoic “greenstone” belts—Matachewan area; Ontario Geological Survey, Geophysical Data Set 1014.

——— 1999. Single master gravity and aeromagnetic data for Ontario—Geosoft® format; Ontario Geological Survey, Geophysical Data Set 1036.

——— 2011. 1:250 000-scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release—Data 126–Revision 1.

Reford, S.W., Gupta, V.K., Paterson, N.R., Kwan, K.C.H. and Macleod, I.N. 1990. Ontario master aeromagnetic grid: A blueprint for detailed compilation of magnetic data on a regional scale; *in* Expanded Abstracts, Society of Exploration Geophysicists, 60th Annual International Meeting, San Francisco, p.617-619, DOI:10.1190/1.1890282.

Appendix A. Test and Calibration Results

1. TIME OFFSET (LAG)

Time offset (lag) is determined by flying perpendicular to a magnetic feature in opposing directions. A total of four passes was flown. Lag is then calculated based on distance between magnetic anomaly peaks (opposing directions) and speed. Data are then lagged by this amount of time to confirm that the magnetic anomaly peaks are lined up.

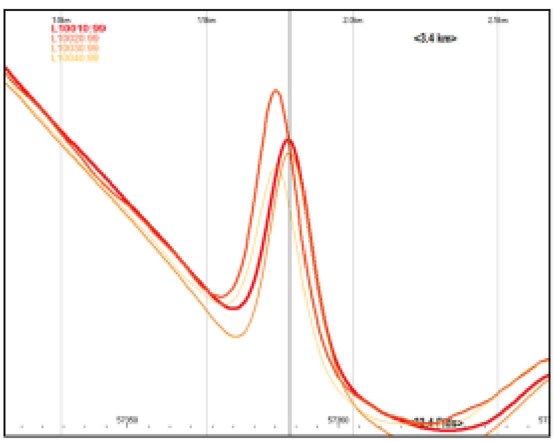
Tail Stinger Lag Test

Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

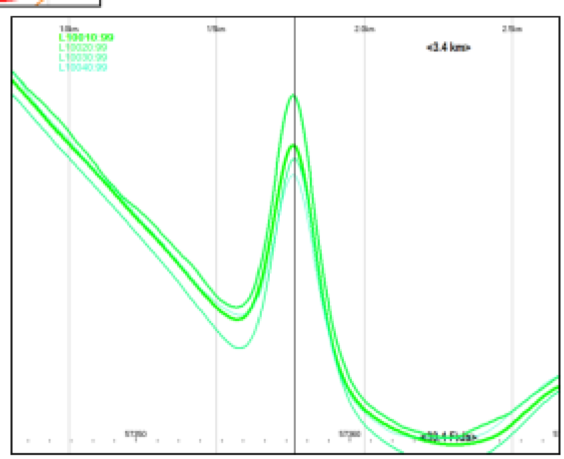
Aircraft Registration: C-FZLK
General Location: Ottawa
Sensor Installation: Tail Stinger
Calculated Avg Lag/-Lead: 0.30

	LINE	Direction	PEAK FID (s)	X (m)	Y (m)	SPEED (m/s)
1st Pass	10010	E	57357.60	399472.00	5035572.20	72.06
2nd Pass	10020	W	57514.40	399434.90	5035556.50	69.30
3rd Pass	10030	E	57673.80	399476.80	5035574.60	71.80
4th Pass	10040	W	57842.20	399432.10	5035578.30	68.85

Lag Correction Applied: 0.30 seconds



No lag correction applied (left)



Lag correction applied (right)

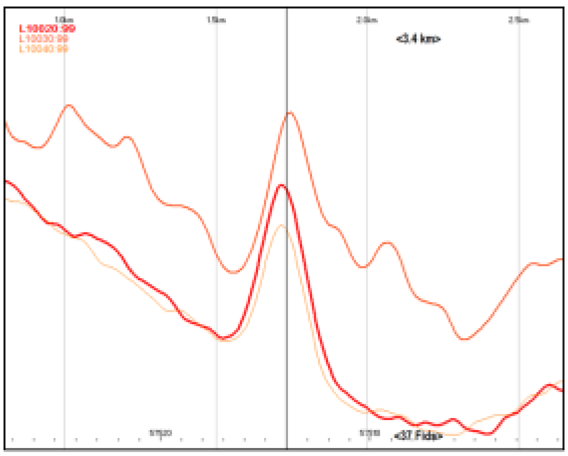
Port Pod Lag Test

Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

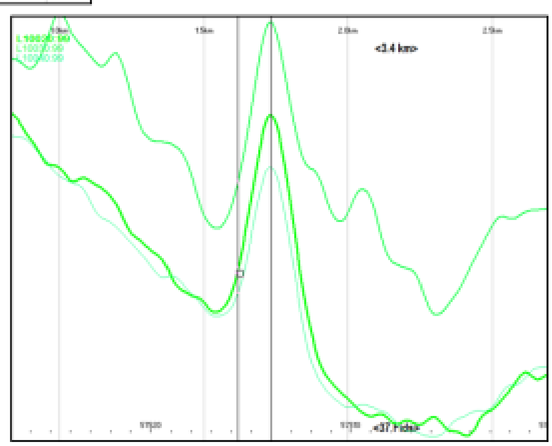
Aircraft Registration: C-FZLK
General Location: Ottawa
Sensor Installation: Port Pod
Calculated Avg Lag/-Lead: 0.20

	LINE	Direction	PEAK FID (s)	X (m)	Y (m)	SPEED (m/s)
1st Pass		E				
2nd Pass	10020	W	57514.20	399448.60	5035558.70	69.30
3rd Pass	10030	E	57673.70	399469.70	5035573.80	71.80
4th Pass	10040	W	57842.10	399438.90	5035579.40	68.85

Lag Correction Applied: 0.20 seconds



No lag correction applied (left)



Lag correction applied (right)

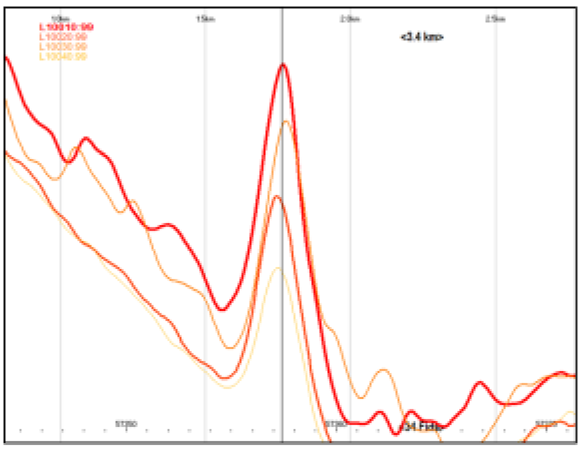
Starboard Pod Lag Test

Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Ottawa
Sensor Installation: Starboard Pod
Calculated Avg Lag/-Lead: 0.21

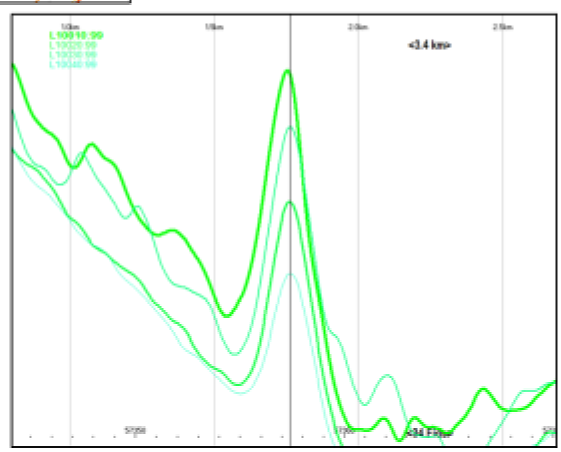
	LINE	Direction	PEAK FID (s)	X (m)	Y (m)	SPEED (m/s)
1st Pass	10010	E	57357.50	399464.90	5035570.80	72.24
2nd Pass	10020	W	57514.30	399441.80	5035557.60	69.30
3rd Pass	10030	E	57673.70	399469.70	5035573.80	71.80
4th Pass	10040	W	57842.10	399438.90	5035579.40	68.85

Lag Correction Applied: 0.20 seconds



No lag correction applied (left)

Lag correction applied (right)



2. RADAR ALTIMETER CALIBRATION

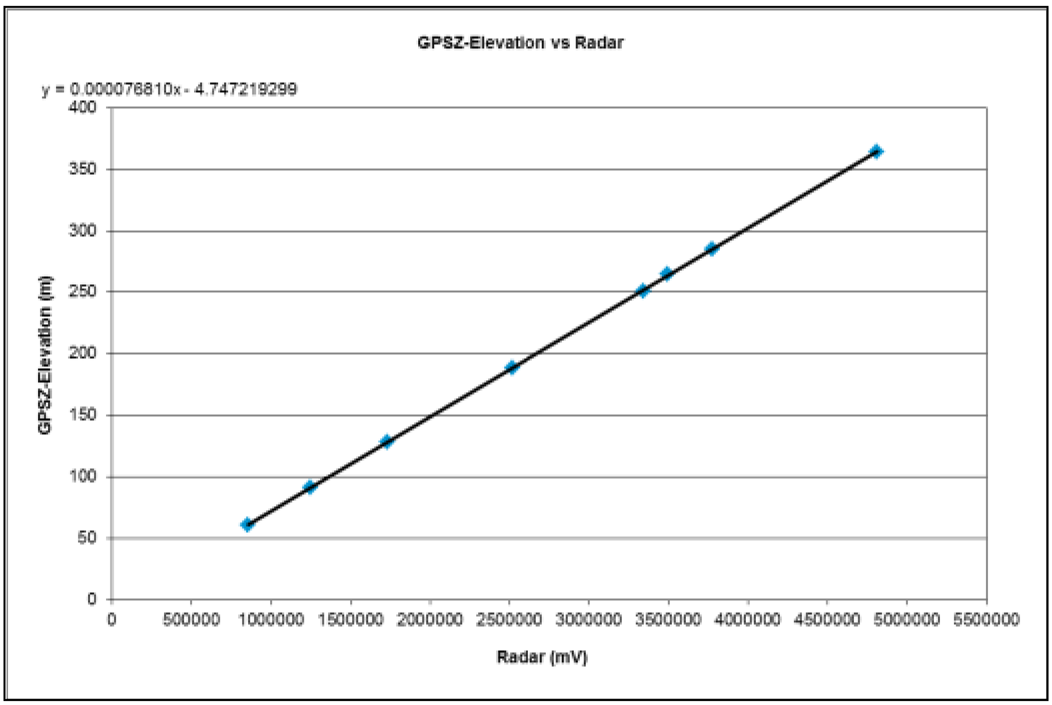
The radar altimeter was calibrated by acquiring altitude data from several passes over a flat surface (e.g. tarmac, lake). The radar data should show a linear relationship with the GPS height. A regression was used to determine the linear equation that converts the radar data from its measured form in millivolts to meters above terrain.

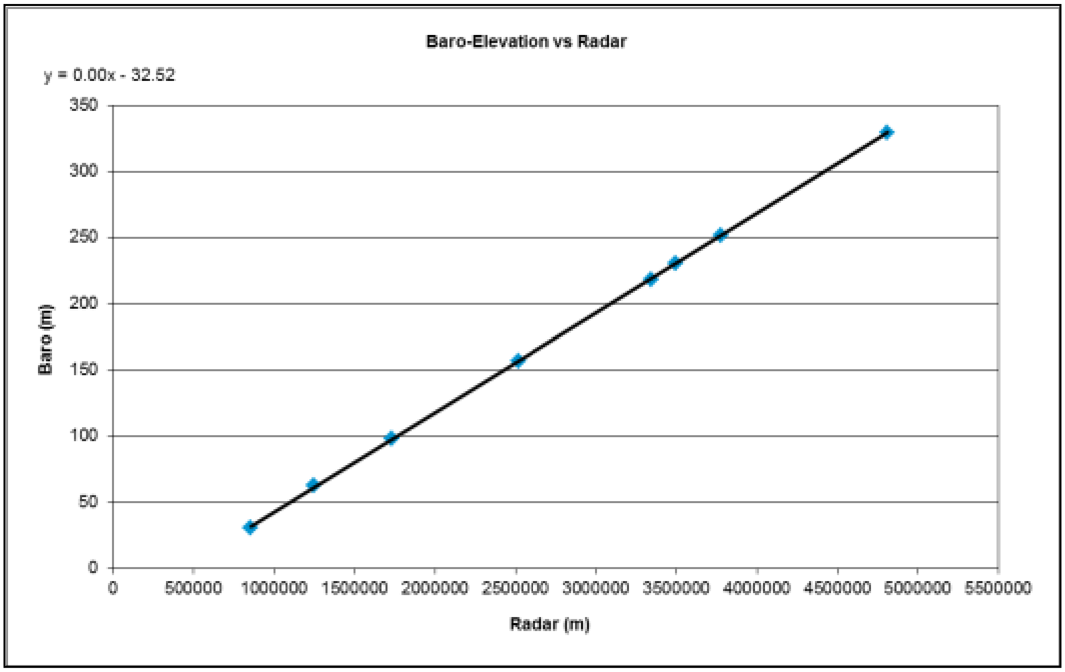
Altimeter Correction Coefficients

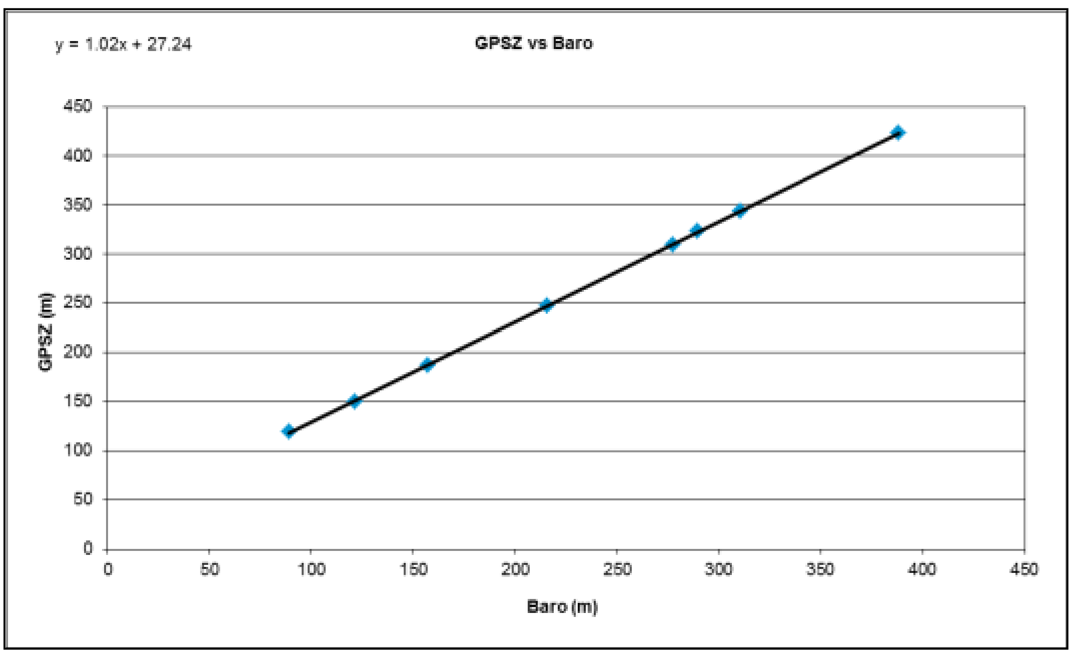
Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Ottawa River
Sensor Installation: Tail Stinger & Port/Starboard Pods
Ground Elevation (m): 58.55

Bench (ft)	Avg Fids (s)	Radar (uV)	GPSZ (m)	GPSZ-ELEV (m)	Baro (m)	Baro-ELEV (m)
400	53817.5	855649.34	119.46	60.91	89.10	30.55
500	54293	1250374.43	149.93	91.38	121.20	62.65
600	54775	1730438.11	186.68	128.13	157.00	98.45
800	55231	2517352.38	247.14	188.59	215.50	156.95
1000	55726	3341898.36	309.85	251.30	277.20	218.65
1080	56168	3497586.16	323.20	264.65	289.10	230.55
1100	56616	3774348.10	343.78	285.23	310.10	251.55
1400	56836	4811063.55	423.20	364.65	388.20	329.65




Baro-Elevation vs Radar
y = 0.00x - 32.52
350
300
250
200
150
100
50
0
Baro (m)
0
500000
1000000
1500000
2000000
2500000
3000000
3500000
4000000
4500000
5000000
5500000
Radar (m)

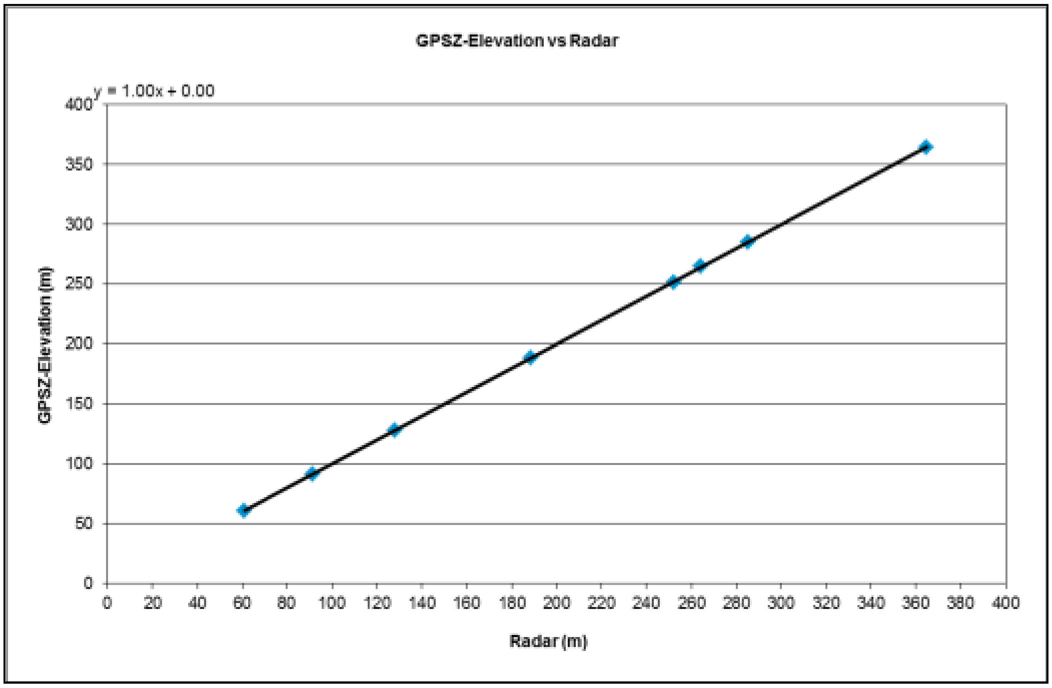

y = 1.02x + 27.24
GPSZ vs Baro
450
400
350
300
250
200
150
100
50
0
GPSZ (m)
0
50
100
150
200
250
300
350
400
450
Baro (m)

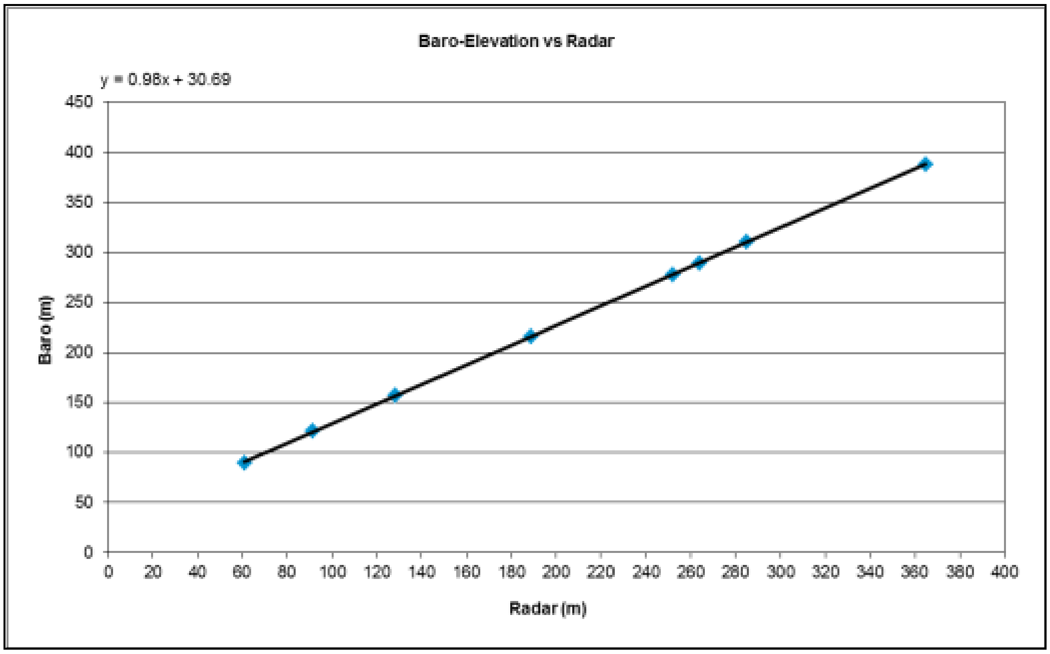
Altimeter Calibration Check

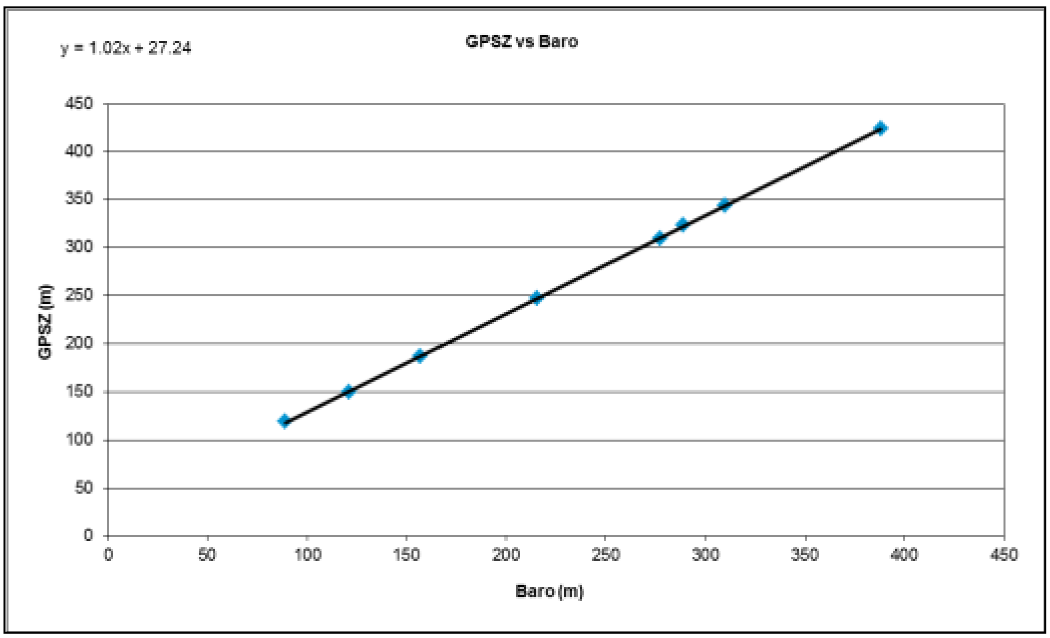
Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Ottawa River
Sensor Installation: Tail Stinger & Port/Starboard Pods
Ground Elevation (m): 58.55

Bench (ft)	Avg Fids (s)	Radar (m)	GPSZ (m)	GPSZ-ELEV (m)	Baro (m)	Baro-ELEV (m)
400	53817.5	60.98	119.46	60.91	89.10	30.55
500	54293	91.29	149.93	91.38	121.20	62.65
600	54775	128.17	186.68	128.13	157.00	98.45
800	55231	188.61	247.14	188.59	215.50	156.95
1000	55726	251.94	309.85	251.30	277.20	218.65
1070	56168	263.90	323.20	264.65	289.10	230.55
1100	56616	285.16	343.78	285.23	310.10	251.55
1400	56836	364.79	423.20	364.65	388.20	329.65




Baro-Elevation vs Radar
y = 0.98x + 30.69
Baro (m)
Radar (m)
0
50
100
150
200
250
300
350
400
450
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400


GPSZ vs Baro
y = 1.02x + 27.24
GPSZ (m)
Baro (m)
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
250
300
350
400
450

3. MAGNETOMETER FIGURE OF MERIT TEST

Aircraft movements induce spurious magnetic fields, which are removed from the magnetic data by the compensator. The efficiency of this removal can be evaluated by conducting a test called a Figure of Merit (F.O.M.). The aircraft flies a series of three manoeuvres of ± 10° rolls, ± 5° pitches and ± 5° yaws in each of the traverse and control line directions in a magnetically quiet zone (low magnetic gradient). The peak-to-peak amplitudes of the responses obtained on the magnetometer compensated channel are determined for each of the three manoeuvre types and for each of the four directions. The twelve values are then summed giving the Figure of Merit. This F.O.M. must be less than 1.5 nT for all sensors (wingtips and tail) or corrective action must be taken to minimize these spurious magnetic fields on the survey aircraft. The F.O.M. is determined at the beginning of the survey and repeated monthly or if a major change in aircraft or magnetometer equipment has occurred. The F.O.M. tests performed during the survey are presented hereafter.

Tail Stinger Figure of Merit

Project Number: MNDM
Date Acquired: 2014-07-15
Compiled By: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Thunder Bay, Ontario
Sensor Installation: Tail Stinger

Max Specification (nT):
1.5

Direction - 0°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	66859-66881	0.407	0.091	4
Roll	66890-66904	0.583	0.059	10
Yaw	66911-66924	0.152	0.067	2
Total		1.141	0.216	5

Direction - 90°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67006-67028	0.248	0.081	3
Roll	67038-67052	0.220	0.050	4
Yaw	67075-67078	0.043	0.035	1
Total		0.511	0.166	3

Direction - 180°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67134-67157	0.991	0.102	10
Roll	67168-67182	0.616	0.048	13
Yaw	67190-67194	0.112	0.021	5
Total		1.719	0.171	10

Direction - 270°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67248-67269	0.316	0.122	3
Roll	67278-67293	1.088	0.045	24
Yaw	67299-67303	0.117	0.095	1
Total		1.522	0.263	6

Uncompensated Mag (nT)	Compensated mag (nT)	Improv. Ratio
4.893	**0.816**	6

Port Pod Figure of Merit

Project Number: MNDM
Date Acquired: 2014-07-15
Compiled By: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Thunder Bay, Ontario
Sensor Installation: Port Pod

Max Specification (nT):
1.5

Direction - 0°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	66859-66881	1.421	0.079	18
Roll	66890-66904	7.897	0.071	112
Yaw	66911-66924	1.303	0.121	11
Total		10.621	0.271	39

Direction - 90°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67006-67028	1.007	0.069	15
Roll	67038-67052	10.488	0.116	90
Yaw	67075-67078	1.426	0.024	60
Total		12.920	0.209	62

Direction - 180°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67134-67157	0.519	0.101	5
Roll	67168-67182	5.915	0.091	65
Yaw	67190-67194	1.023	0.158	6
Total		7.457	0.350	21

Direction - 270°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67248-67269	0.615	0.153	4
Roll	67278-67293	4.290	0.057	76
Yaw	67299-67303	0.587	0.270	2
Total		5.491	0.481	11

Uncompensated Mag (nT)	Compensated mag (nT)	Improv. Ratio
36.489	**1.310**	28

Starboard Pod Figure of Merit

Project Number: MNDM
Date Acquired: 2014-07-15
Compiled By: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Thunder Bay, Ontario
Sensor Installation: Starboard Pod

Max Specification (nT):
1.5

Direction - 0°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	66859-66881	0.862	0.112	8
Roll	66890-66904	4.130	0.056	74
Yaw	66911-66924	0.741	0.079	9
Total		5.733	0.246	23

Direction - 90°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67006-67028	1.074	0.109	10
Roll	67038-67052	6.814	0.109	63
Yaw	67075-67078	0.915	0.112	8
Total		8.803	0.330	27

Direction - 180°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67134-67157	1.558	0.144	11
Roll	67168-67182	2.927	0.100	29
Yaw	67190-67194	0.761	0.235	3
Total		5.246	0.479	11

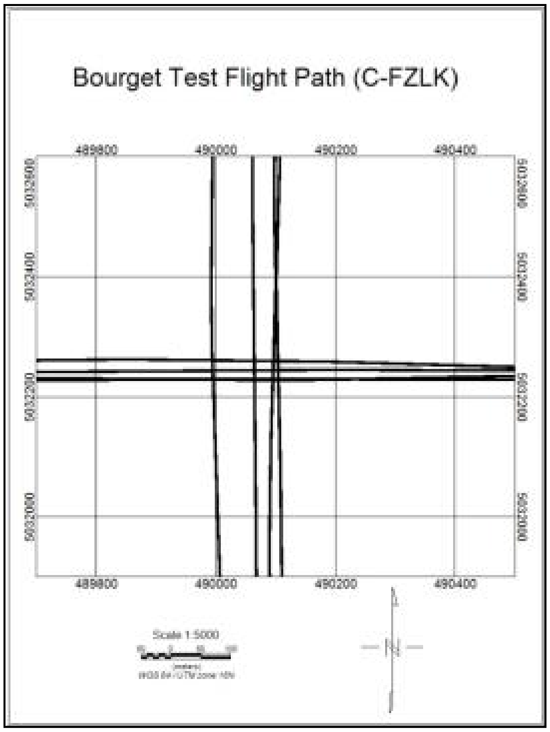
Direction - 270°	Fiducial Range (s)	Uncompensated Mag (nT)	Compensated Mag (nT)	Improv. Ratio
Pitch	67248-67269	0.968	0.124	8
Roll	67278-67293	2.061	0.082	25
Yaw	67299-67303	0.447	0.212	2
Total		3.476	0.418	8

Uncompensated Mag (nT)	Compensated mag (nT)	Improv. Ratio
23.258	**1.472**	16

4. MAGNETOMETER CALIBRATION

The calibration of the magnetometer was carried out at the Bourget test site established by the Geological Survey of Canada near Ottawa. Aeromagnetic survey system calibration is flown in a “cloverleaf” pattern. This pattern allows the airplane to fly two passes in all four directions (N, S, E, W) while crossing over a single intersection point. For each pass (at the intersection point), magnetic data are recorded for both the airplane and on the ground (Bourget, Ontario). These data are then used to determine error values on each magnetometer for each direction as well as heading error effects.

One map showing the accuracy of all flight passes over the target intersection point for the aircraft are shown below.



Tail Stinger Magnetometer Calibration

AEROMAGNETIC SURVEY SYSTEM CALIBRATION TEST RANGES
AT BOURGET, ONTARIO AND MEANOOK, ALBERTA AND BAKER LAKE, NUNAVUT

Aircraft Registration: C-FZLK
Organization (Company): CGG
Magnetometer Type: CS-3
Sensor Installation: **Tail Stinger**
Compiled by: K. Zawadzka

Date Acquired: 2014-06-27
General Location: Ottawa
Sampling Rate: 10 Hz
Data Acquisition System: FASDAS

Direction of flight across the Crossroads	Time that Survey Aircraft was over the Crossroads (SSM) Greenwich Mean Time	Time that Survey Aircraft was over the Crossroads (HH:MM:SS) Greenwich Mean Time	Total Field Value (nT) Recorded in Survey Aircraft over Crossroads **T1**	Observatory Diurnal Reading at Previous Minute i.e. Hours + Minutes **T2**	Observatory Diurnal Reading at Subsequent Minute i.e. H hours + (M + 1) mins. **T3**	Interpolated Observatory Diurnal Reading at Time H hours + M mins + S sec **T4**	Calculated Observatory Value **T5=T4-C***	Error Value **T6=T1-T5**
North	51937.4	14:25:37	54009.5	54559.9	54559.2	54559.5	54009.5	0.0
South	51716.3	14:21:56	54009.8	54560.1	54560.5	54560.5	54010.5	-0.7
East	50822.3	14:07:02	54012.6	54563.2	54562.5	54563.2	54013.2	-0.6
West	51034.0	14:10:34	54010.9	54561.8	54561.7	54561.8	54011.8	-0.9
North	52366.9	14:32:47	54006.6	54557.0	54556.6	54556.7	54006.7	-0.1
South	52142.9	14:29:03	54007.5	54558.9	54557.7	54558.8	54008.8	-1.3
East	51252.4	14:14:12	54011.4	54562.1	54561.6	54562.0	54012.0	-0.6
West	51452.4	14:17:32	54010.9	54561.4	54560.2	54560.8	54010.8	0.1

*C is the difference in the total field between the Blackburn or Meanook Observatory value (O) and the value (B) at the point above the crossroads at a given height.
Blackburn Observatory: **1000 Feet, C = (O-B) = 550 nT**; 500 Feet, C = 556 nT
Meanook Observatory: 1000 Feet, C = (O-B) = 0 nT; **500 Feet, C = 0 nT**
Baker Lake Observatory: 1000 Feet, C = (O-B) = 75 nT;

Total: **-4.0425 nT**

Average North-South Heading Error (T6 North - T6 South): **0.9359 nT**
Average East-West Heading Error (T6 East - T6 West): **-0.247 nT**
Number of Passes for Average 8
Ave: **-0.5053 nT**

Port Pod Magnetometer Calibration

AEROMAGNETIC SURVEY SYSTEM CALIBRATION TEST RANGES
AT BOURGET, ONTARIO AND MEANOOK, ALBERTA AND BAKER LAKE, NUNAVUT

Aircraft Registration: C-FZLK
Organization (Company): CGG
Magnetometer Type: CS-3
Sensor Installation: Port Pod
Compiled by: K. Zawadzka

Date Acquired: 2014-06-27
General Location: Ottawa
Sampling Rate: 10 Hz
Data Acquisition System: FASDAS

Direction of flight across the Crossroads	Time that Survey Aircraft was over the Crossroads (SSM) Greenwich Mean Time	Time that Survey Aircraft was over the Crossroads (HH:MM:SS) Greenwich Mean Time	Total Field Value (nT) Recorded in Survey Aircraft over Crossroads **T1**	Observatory Diurnal Reading at Previous Minute i.e. Hours + Minutes **T2**	Observatory Diurnal Reading at Subsequent Minute i.e. H hours + (M + 1) mins. **T3**	Interpolated Observatory Diurnal Reading at Time H hours + M mins + S sec **T4**	Calculated Observatory Value **T5=T4-C***	Error Value **T6=T1-T5**
North	51937.4	14:25:37	54010.6	54559.9	54559.2	54559.5	54009.5	1.1
South	51716.3	14:21:56	54010.8	54560.1	54560.5	54560.5	54010.5	0.3
East	50822.3	14:07:02	54013.5	54563.2	54562.5	54563.2	54013.2	0.3
West	51034.0	14:10:34	54012.5	54561.8	54561.7	54561.8	54011.8	0.7
North	52366.9	14:32:47	54007.7	54557.0	54556.6	54556.7	54006.7	1.0
South	52142.9	14:29:03	54008.7	54558.9	54557.7	54558.8	54008.8	-0.1
East	51252.4	14:14:12	54012.3	54562.1	54561.6	54562.0	54012.0	0.3
West	51452.4	14:17:32	54012.5	54561.4	54560.2	54560.8	54010.8	1.7

*C is the difference in the total field between the Blackburn or Meanook Observatory value (O) and the value (B) at the point above the crossroads at a given height.

Blackburn Observatory: **1000 Feet, C = (O-B) = 550 nT**; 500 Feet, C = 556 nT
Meanook Observatory: 1000 Feet, C = (O-B) = 0 nT; **500 Feet, C = 0 nT**
Baker Lake Observatory: 1000 Feet, C = (O-B) = 75 nT;

Total: **5.3575 nT**

Average North-South Heading Error (T6 North - T6 South): **0.9359 nT**

Average East-West Heading Error (T6 East - T6 West): **-0.947 nT**

Number of Passes for Average 8

Ave: **0.6697 nT**

Starboard Pod Magnetometer Calibration

AEROMAGNETIC SURVEY SYSTEM CALIBRATION TEST RANGES
AT BOURGET, ONTARIO AND MEANOOK, ALBERTA AND BAKER LAKE, NUNAVUT

Aircraft Registration: C-FZLK
Organization (Company): CGG
Magnetometer Type: CS-3
Sensor Installation: Starboard Pod
Compiled by: K. Zawadzka

Date Acquired: 2014-06-27
General Location: Ottawa
Sampling Rate: 10 Hz
Data Acquisition System: FASDAS

Direction of flight across the Crossroads	Time that Survey Aircraft was over the Crossroads (SSM) Greenwich Mean Time	Time that Survey Aircraft was over the Crossroads (HH:MM:SS) Greenwich Mean Time	Total Field Value (nT) Recorded in Survey Aircraft over Crossroads **T1**	Observatory Diurnal Reading at Previous Minute i.e. Hours + Minutes **T2**	Observatory Diurnal Reading at Subsequent Minute i.e. H hours + (M + 1) mins. **T3**	Interpolated Observatory Diurnal Reading at Time H hours + M mins + S sec **T4**	Calculated Observatory Value **T5=T4-C***	Error Value **T6=T1-T5**
North	51937.4	14:25:37	54018.3	54559.9	54559.2	54559.5	54009.5	8.8
South	51716.3	14:21:56	54018.8	54560.1	54560.5	54560.5	54010.5	8.3
East	50822.3	14:07:02	54021.6	54563.2	54562.5	54563.2	54013.2	8.4
West	51034.0	14:10:34	54019.6	54561.8	54561.7	54561.8	54011.8	7.8
North	52366.9	14:32:47	54015.5	54557.0	54556.6	54556.7	54006.7	8.8
South	52142.9	14:29:03	54016.3	54558.9	54557.7	54558.8	54008.8	7.5
East	51252.4	14:14:12	54020.5	54562.1	54561.6	54562.0	54012.0	8.5
West	51452.4	14:17:32	54019.6	54561.4	54560.2	54560.8	54010.8	8.8

*C is the difference in the total field between the Blackburn or Meanook Observatory value (O) and the value (B) at the point above the crossroads at a given height.

Blackburn Observatory: **1000 Feet, C = (O-B) = 550 nT**; 500 Feet, C = 556 nT
Meanook Observatory: 1000 Feet, C = (O-B) = 0 nT; **500 Feet, C = 0 nT**
Baker Lake Observatory: 1000 Feet, C = (O-B) = 75 nT;

Total: **66.9575 nT**

Average North-South Heading Error (T6 North - T6 South): **0.8859 nT**

Average East-West Heading Error (T6 East - T6 West): **0.103 nT**

Number of Passes for Average 8

Ave: **8.3697 nT**

5. DYNAMIC CALIBRATION RANGE (DCR)

Breckenridge Test is flown with 7 passes over land and water. Ground Concentrations are determined from calculating ground values at known locations. Stripping ratios are determined from a “Pad Test”. These data are then used to determine the attenuation and sensitivities for each of the components.

Dynamic Calibration Range

Project Number: MNDM
Date Acquired: 2014-06-27
Compiled by: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Ottawa
Installation Type, # of Packs: 2 pack
Pack ID(s): 2535, 2516

Land Counts - live time corrected				
Hstp	ltc_TC	ltc_K	ltc_U	ltc_TH
51.398	1828.072	223.8	36.506	51.026
85.407	1508.151	180.735	31.218	42.77
112.329	1282.895	146.155	27.577	36.882
170.638	921.71	94.502	21.715	26.199
207.592	766.974	76.841	19.678	21.765
247.406	633.007	59.908	17.569	18.149
272.977	562.14	52.277	15.405	16.11

Water Counts - live time corrected				
Hstp	ltc_TC	ltc_K	ltc_U	ltc_TH
52.614	179.548	14.247	8.696	4.731
81.124	188.434	14.625	8.982	5.429
115.542	192.729	14.387	9.641	5.058
171.382	194.343	14.468	9.596	5.163
220.049	190.162	14.336	9.146	5.082
236.285	184.034	14.46	9.071	5.52
258.932	181.227	14.505	8.658	5.238
329.903	169.675	13.465	7.55	5.628

Survey Height
100

Ground Concentrations	
TC	46.78202
K	1.72
U	1.12
TH	7.19

If TC is not provided:
TC = 13.078*K + 5.675*U + 2.494*TH

Stripping Ratios	
alpha	0.2304
beta	0.3421
gamma	0.6656
a	0.0472
b	-0.0023
g	0.0068

	Attenuation	Intercept	Sensitivities
TC	-0.006635211	7.742702649	25.37292314
K	-0.008160922	5.670232393	74.57579088
U	-0.007223797	3.018275998	8.869049194
TH	-0.006689232	4.209587112	4.796913856

6. COSMIC / AIRCRAFT CALIBRATION

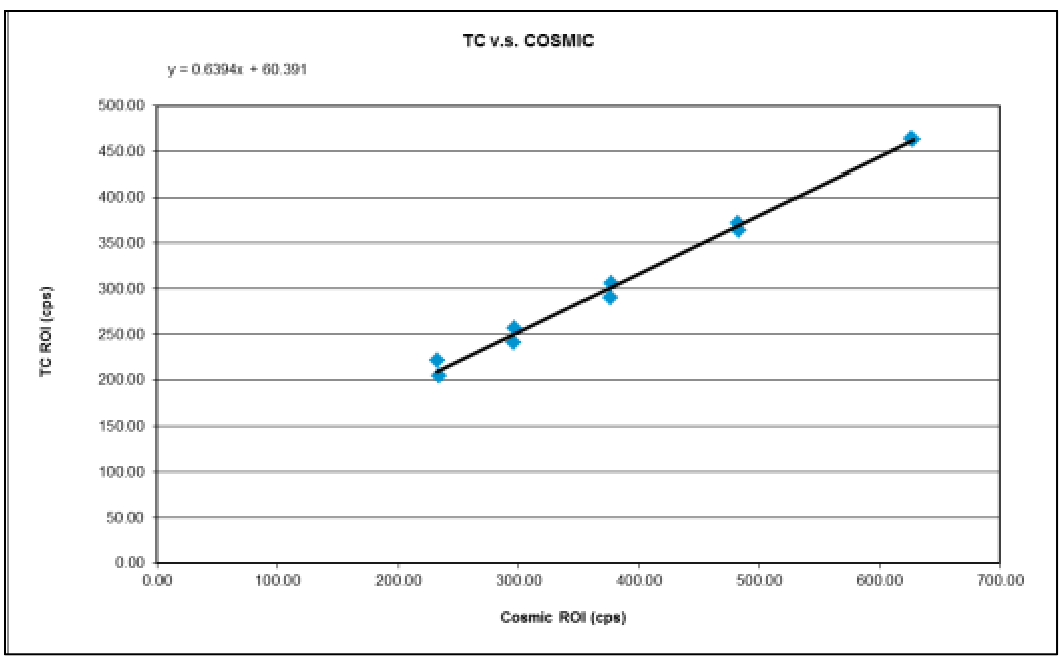
Cosmic / Aircraft calibration is performed by flying a stack at high altitude. Cosmic Coefficients are determined from the slope while aircraft background values are determined from the y-intercept of the resulting graphs.

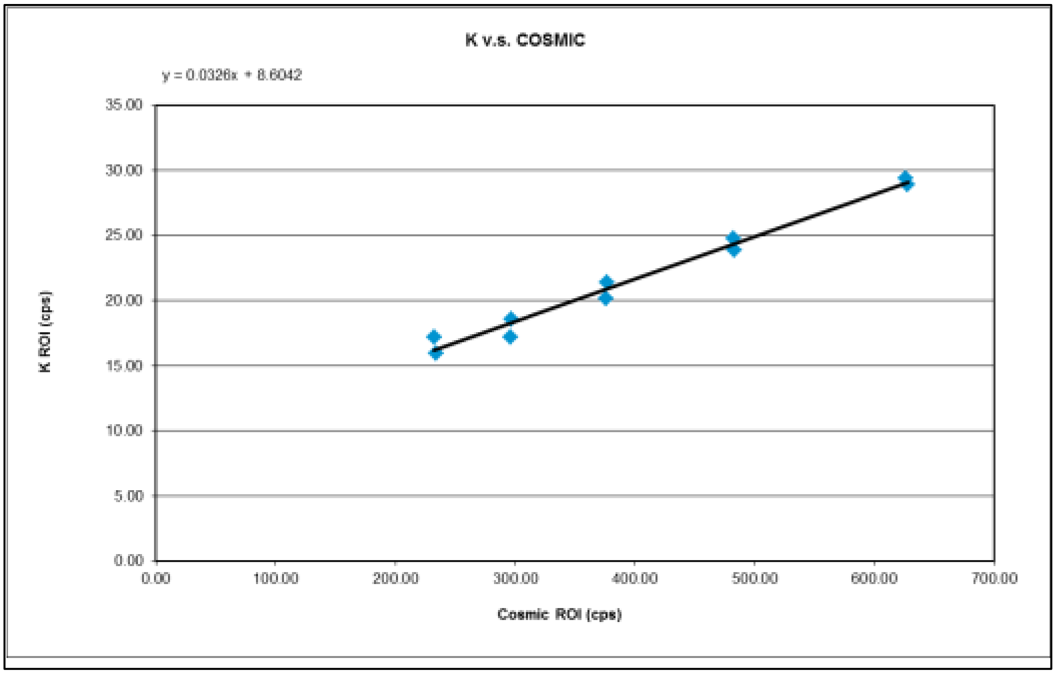
Cosmic Correction Coefficients

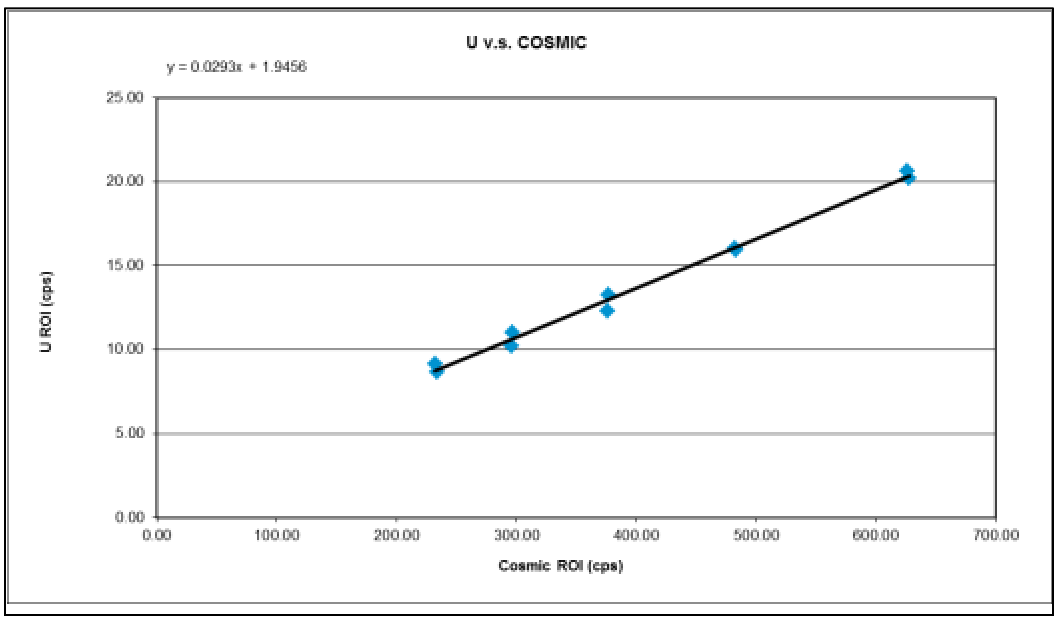
Project Number: MNDM
Date Acquired: 2014-07-15
Compiled by: K. Zawadzka

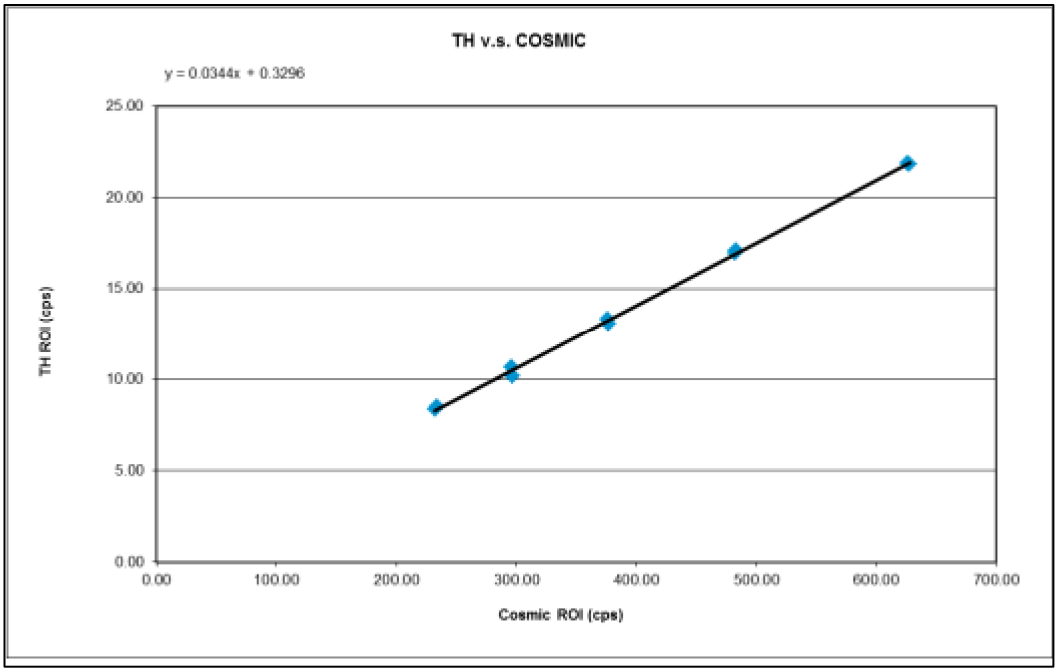
Aircraft Registration: C-FZLK
General Location: Thunder Bay, Ontario
Installation Type, # of Packs: 2 pack
Pack ID(s): 2535, 2516

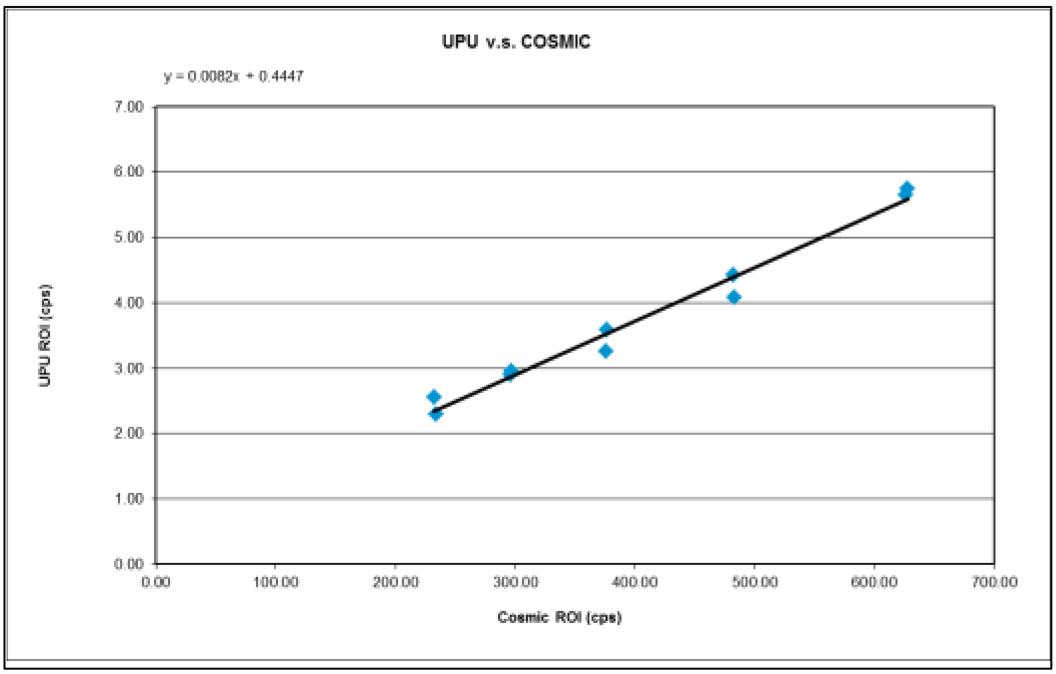
	Mean Counts - live time corrected					Mean Counts
	TC	K	U	TH	UPU	COSMIC
	204.097	15.969	8.688	8.494	2.295	234.000
	241.243	17.170	10.210	10.654	2.901	296.000
	289.784	20.183	12.288	13.339	3.261	376.000
	363.882	23.899	15.935	17.078	4.077	483.000
	462.647	28.916	20.182	21.835	5.743	628.000
	463.852	29.364	20.630	21.867	5.656	626.000
	371.919	24.768	16.064	16.945	4.422	482.000
	306.329	21.372	13.252	13.068	3.585	377.000
	256.585	18.592	10.995	10.150	2.949	297.000
	221.067	17.201	9.161	8.375	2.559	232.000
Cosmic Coeff.	0.639417059	0.032595488	0.029260481	0.03436106	0.008186872	
Aircraft Back.	60.39148338	8.604158809	1.945599974	0.32955664	0.4446717	




K v.s. COSMIC
y = 0.0326x + 8.6042
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
K ROI (cps)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Cosmic ROI (cps)

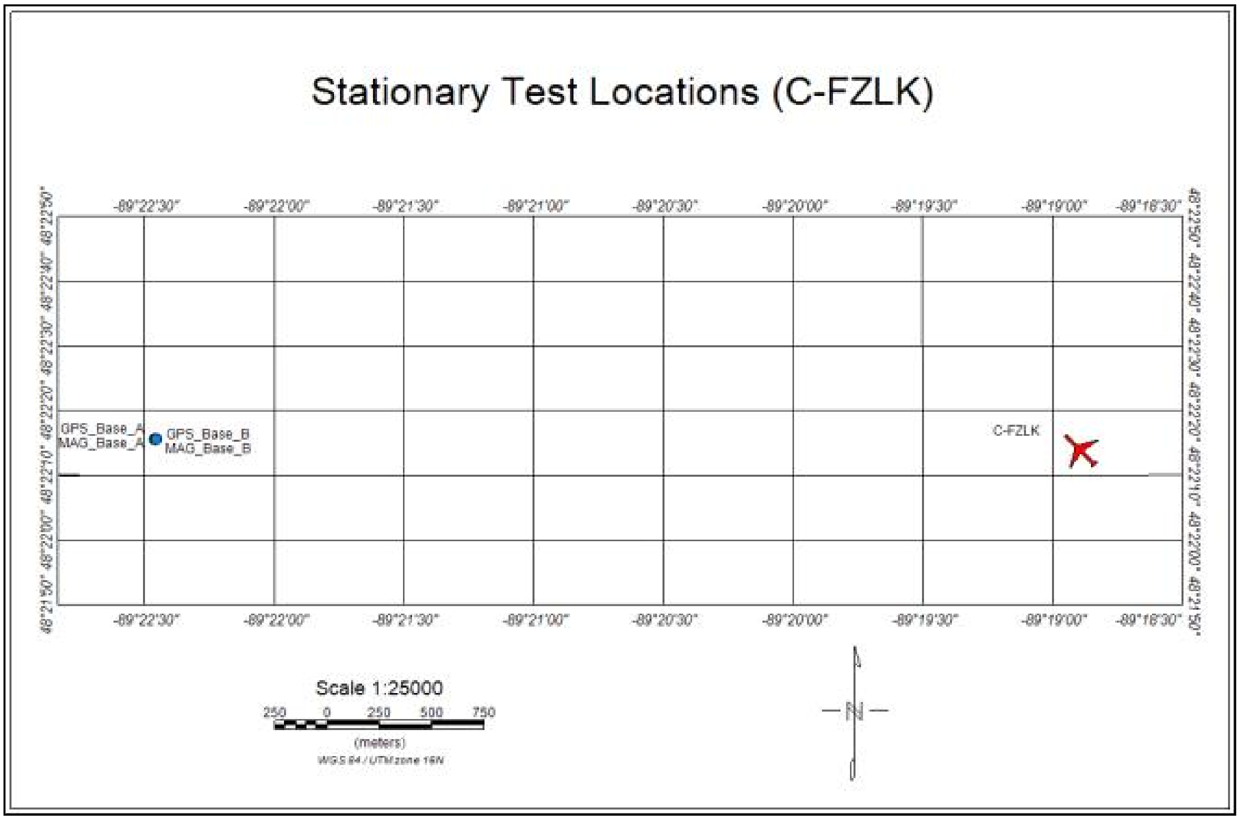

U v.s. COSMIC
y = 0.0293x + 1.9456
25.00
20.00
15.00
10.00
5.00
0.00
U ROI (cps)
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Cosmic ROI (cps)


TH v.s. COSMIC
y = 0.0344x + 0.3296
TH ROI (cps)
25.00
20.00
15.00
10.00
5.00
0.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Cosmic ROI (cps)


UPU v.s. COSMIC
y = 0.0082x + 0.4447
UPU ROI (cps)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Cosmic ROI (cps)

7. STATIONARY AIRCRAFT GPS POSITION AND MAGNETOMETER SENSOR COMPARISON

During a stationary GPS position test, the aircraft GPS system and ground GPS base stations are operating and recording with the stationary aircraft on the airport tarmac. During the magnetometer sensors comparison test, performed in conjunction with the aircraft GPS position test, two base stations (less than 10 km away) and the aircraft magnetometer operate simultaneously while the aircraft is stationary on the airport tarmac.



8. RADON CALIBRATION

Radon calibration is performed by flying a test line at survey altitude at the beginning and end of each production day over a large body of water.

Project Number: MNDM
Date Acquired: 2014-07-16 to 08-10
Compiled by: K. Zawadzka

Aircraft Registration: C-FZLK
General Location: Thunder Bay, Ontario
Installation Type, # of Packs: 2 pack
Pack ID(s): 2535, 2516

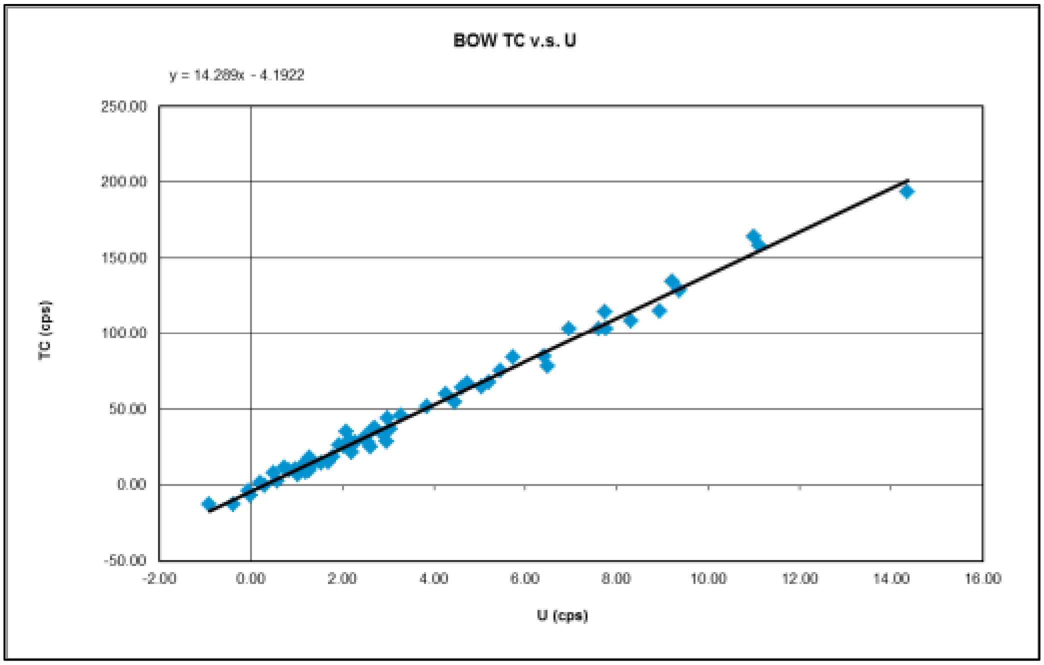
	Mean Counts - live time & background corrected				
	TC	K	TH	UPU	U
	9.885531	0.337988	0.127928	0.278549	1.273206
	14.909456	-0.094158	-0.058659	0.110312	1.682743
	36.805520	1.511308	0.495732	0.386758	3.036294
	35.237233	1.287914	0.252229	0.637237	2.084974
	103.272551	5.398928	0.391791	1.891395	7.599329
	103.270117	5.154118	0.772397	2.003746	6.955394
	128.810510	6.792079	0.531959	2.624869	9.360941
	164.346132	7.267337	1.052381	2.853988	10.992676
	157.933327	7.645497	0.809895	2.556998	11.104049
	134.488877	5.460301	0.519224	2.505289	9.207761
	193.622091	8.391650	0.844267	3.527268	14.350020
	37.096380	0.467149	0.270122	1.010253	2.671542
	-0.309062	-0.873596	0.023314	0.092387	0.291298
	1.720399	-1.669214	0.201695	0.382229	0.208682
	2.610032	-0.913872	-0.002102	0.175178	0.580307
	54.944377	1.940415	0.043935	0.903331	4.449653
	84.856408	3.312354	0.169254	1.767445	6.409302
	114.424179	5.249313	0.619648	2.152554	7.742430
	84.433902	3.291827	0.268982	1.538185	5.731738
	-12.616483	-1.740422	-0.043097	-0.327835	-0.909327
	-6.924115	-1.355570	-0.080412	-0.202165	-0.022382
	18.175992	0.119928	0.115033	0.375596	1.287732
	25.867804	0.098543	0.015393	0.666056	2.020029
	9.879531	-0.233631	-0.055816	0.154328	0.831975
	25.612386	0.831586	0.606767	0.400413	2.194888
	7.096499	-0.674699	-0.119992	0.609513	1.022891
	10.269692	-0.555336	-0.517264	0.480166	0.964133
	-3.766082	-1.218307	0.001289	-0.102931	-0.051989
	14.108624	-0.156148	-0.478667	0.315063	1.350192
	33.462890	0.707035	-0.111961	0.748245	2.881505
	27.987041	0.398394	0.516761	0.540425	2.276811
	-12.518872	-2.005295	0.283325	0.088110	-0.378982
	24.939825	0.678284	-0.099162	0.638036	2.616786
	67.985606	3.559337	-0.142419	0.800281	5.196340
	11.793413	-0.091660	0.088993	0.387345	0.735430
	103.174513	4.509608	0.930759	1.966835	7.771659
	43.890989	1.264569	0.369637	1.126336	2.975439
	75.313728	2.933355	-0.110174	1.314521	5.447802
	26.453561	0.325805	0.501676	0.220811	1.933281
	8.035843	-0.240597	-0.005401	0.183514	0.499743
	28.787214	0.998256	0.109954	0.956523	2.956636
	21.830187	0.498678	0.189380	0.500238	2.205875
	15.359126	-0.118502	0.509643	0.401816	1.317068
	29.523564	0.733870	0.020698	0.439218	2.155314
	51.658491	2.170471	0.060050	1.231182	3.854305
	108.404189	4.761291	0.545472	1.948595	8.319250
	37.734010	1.429062	-0.099804	1.087332	2.714761
	28.295145	0.261953	0.065158	0.571226	2.551066
	8.786168	-0.294597	-0.004198	0.183567	1.206297
	12.564263	-0.531624	-0.076566	0.108808	1.125098
	45.687053	1.652326	0.059542	0.798177	3.285500
	64.297920	3.007901	0.414683	0.981015	4.607537
	67.093829	2.692616	0.390034	0.986162	4.729790
	78.243129	3.347378	0.237721	1.518584	6.492372
	65.030329	2.668701	0.580335	1.519173	5.049679
	59.912148	3.260698	0.073686	0.908717	4.251252
	115.000868	6.647415	0.185087	2.426943	8.936905
	18.877115	0.526041	0.250702	0.484948	1.792829
	31.342789	1.179254	-0.117872	0.703125	2.488444
	25.281729	-0.060797	0.202199	0.315749	2.117285
	14.566911	-0.383282	0.150915	0.086361	1.532764
Radon Ratios	14.2892	0.7664	0.0647	0.2528	
"b"	-4.1922	-1.1001	-0.0246	0.0052	

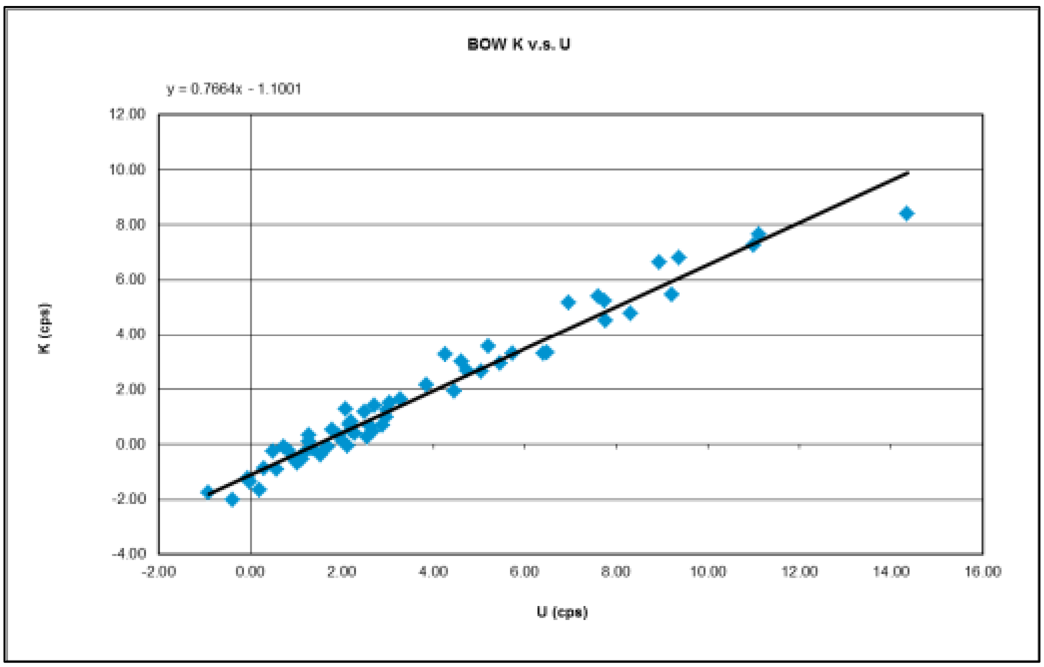
Block A

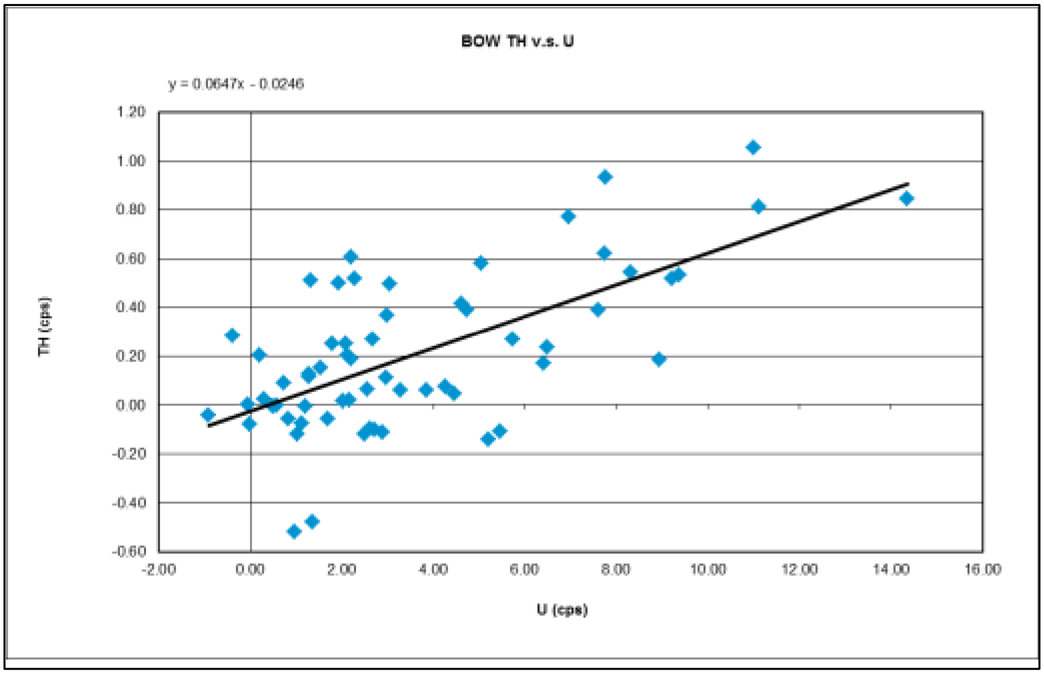
SkyShine Coeff.	
A1	0.03002
A2	0.02460

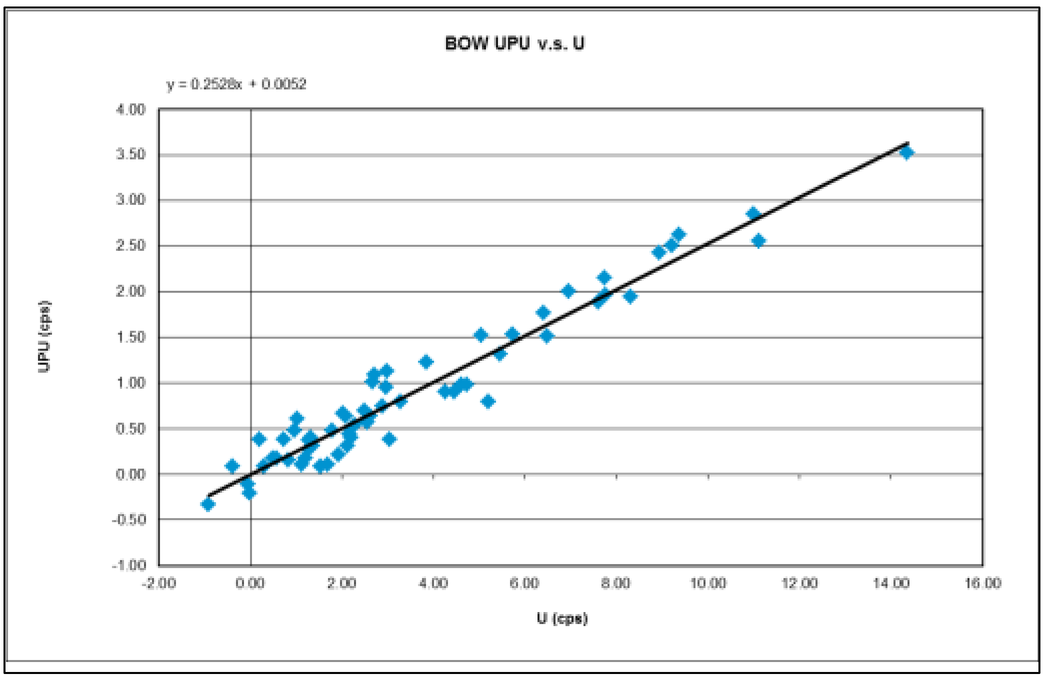
Block B

SkyShine Coeff.	
A1	0.03115
A2	0.02555


BOW TC v.s. U
y = 14.289x - 4.1922
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
TC (cps)
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
U (cps)


BOW K v.s. U
y = 0.7664x - 1.1001
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
K (cps)
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
U (cps)


BOW TH v.s. U
y = 0.0647x - 0.0246
TH (cps)
U (cps)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00


BOW UPU v.s. U
y = 0.2528x + 0.0052
UPU (cps)
U (cps)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00

Appendix B. Archive Definitions

Geophysical Data Set 1077 is derived from surveys using a magnetic gradiometry and gamma-ray spectrometric systems mounted on fixed-wing platforms and carried out by CGG.

1. ARCHIVE LAYOUT

The files for the Mahon Lake (MF1) and Flatrock Lake (MF2) Geophysical Survey are archived on a single hard disk and sold as single product, as outlined below:

Type of Data	Magnetic and Gamma-Ray Spectrometric
Format	Grid and Profile Data (Hard disk)
ASCII and Geosoft® Binary	Geophysical Data Set (GDS) 1077

The content of the ASCII and Geosoft® binary file types are identical. They are provided in both forms to suit the user's available software. The survey data are divided as follows.

Geophysical Data Set 1077 (Hard disk)

a) ASCII (*.gxf*) grids
- digital elevation model
- total magnetic field
- second vertical derivative of the total magnetic field
- "GSC levelled" gradient-enhanced total magnetic field
- second vertical derivative of the "GSC levelled" gradient-enhanced total magnetic field
- measured lateral (across line) horizontal magnetic gradient
- measured longitudinal (along line) horizontal magnetic gradient
- total air absorbed dose rate
- potassium
- equivalent thorium
- equivalent uranium
- percent potassium ratio / equivalent thorium
- equivalent uranium / percent potassium ratio
- equivalent uranium/equivalent thorium ratio

b) Geosoft® binary (*.grd*) grids
- digital elevation model
- total magnetic field
- second vertical derivative of the total magnetic field
- "GSC levelled" gradient-enhanced total magnetic field
- second vertical derivative of the "GSC levelled" gradient-enhanced total magnetic field
- measured lateral (across line) horizontal magnetic gradient
- measured longitudinal (along line) horizontal magnetic gradient
- total air absorbed dose rate
- potassium
- equivalent thorium

- equivalent uranium
- percent potassium ratio / equivalent thorium
- equivalent uranium / percent potassium ratio
- equivalent uranium / equivalent thorium ratio

c) Vector (*.dxf*) files

- flight path
- total field magnetic contours
- Keating coefficients

d) GeoTIFF seamless map images

- "GSC levelled" gradient-enhanced total magnetic field with planimetric base
- shaded second vertical derivative of the "GSC levelled" gradient-enhanced total magnetic field with planimetric base
- potassium, thorium, uranium ternary image with planimetric base

e) Geosoft® (*.gdb*) binary data

- profile database of magnetic data (10 Hz sampling) in Geosoft® GDB format
- profile database of gamma-ray spectrometric data (1 Hz sampling) in Geosoft® GDB format
- profile database of gamma-ray spectrometric data array (1 Hz sampling) in Geosoft® GDB format
- Keating coefficients in Geosoft® GDB format

f) ASCII (*.xyz*) data

- profile database of magnetic data (10 Hz sampling) in ASCII XYZ format
- profile database of gamma-ray spectrometric data (1 Hz sampling) in ASCII XYZ format
- profile database of gamma-ray spectrometric data array (1 Hz sampling) in ASCII XYZ format
- database of Keating coefficients in ASCII CSV (comma-separated values) format

g) Geosoft® (*.map*) map files

- colour-filled contours of gradient-enhanced residual magnetic intensity with flight lines
- shaded colour of the second vertical derivative of the gradient-enhanced total magnetic intensity with Keating coefficients
- histogram-equalized ternary red-green-blue radioelement image with inset images of percent potassium, equivalent uranium, equivalent thorium and dose rate and flight line

h) Survey report in portable document format (*.pdf*)

2. CO-ORDINATE SYSTEMS

The profile data are provided in 3 co-ordinate systems:

- Universal Transverse Mercator (UTM) projection, Zone 15N (Mahon Lake) and 16N (Flatrock Lake), NAD83 datum, Canada local datum
- latitude/longitude co-ordinates, NAD83, Canada local datum

The gridded data are provided in 2 co-ordinate systems:

- Universal Transverse Mercator (UTM) projection, Zone 15N (Mahon Lake) and 16N (Flatrock Lake), NAD83 datum, Canada local datum

3. LINE NUMBERING

The line numbering convention for survey data provided in GDS 1077 is as follows:

- Line numbers are 5 digits with the last digit indicating part or revision number
- i.e. Line 10010 is the first line of the survey followed by line 10020; should line 10010 be in two parts the first is 10010 and the second is 10011. Should line 10020 have been reflown, it will be in the database as line 10021.
- The same convention is used for the labelling of the control lines. In the Geosoft® OASIS montaj binary database, survey lines are designated with a leading character “L” and control lines are designated with a leading character “T”.

4. DATA FILES

The survey data files are provided as follows, with Mahon Lake (MF1) and Flatrock Lake (MF2):

- MF#MAG.gdb — Geosoft® Oasis montaj™ uncompressed binary database file of the magnetic data, sampled at 10 Hz
- MF#MAG.xyz — ASCII file of the magnetic data, sampled at 10 Hz
- MF#SPEC.gdb — Geosoft® Oasis montaj™ uncompressed binary database file of the gamma-ray spectrometric data, sampled at 1 Hz
- MF#SPEC.xyz — ASCII file of the gamma-ray spectrometric data, sampled at 1 Hz
- MF#SPEC256.gdb — Geosoft® Oasis montaj™ uncompressed binary database file of the gamma-ray spectrometric data array, sampled at 1 Hz
- MF#SPEC256.xyz — ASCII file of the gamma-ray spectrometric data array, sampled at 1 Hz
- MF#KC.gdb — Geosoft® Oasis montaj™ uncompressed binary database file of the Keating coefficients
- MF#KC.csv — ASCII file of the Keating coefficients

The contents of MF#MAG.xyz/gdb (both file types contain the same set of data channels) are summarized as follows:

Channel Name	Description	Units
gps_x_raw	raw GPS X	metres
gps_y_raw	raw GPS Y	metres
gps_z_raw	raw GPS Z	metres
gps_x_final	differentially corrected GPS X (NAD83 datum)	metres
gps_y_final	differentially corrected GPS Y (NAD83 datum)	metres
gps_z_final	differentially corrected GPS Z	metres above sea level
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	degrees
lat_nad83	latitude using NAD83 datum	degrees
heading	line heading	degrees
radar_raw	raw radar altimeter	metres above terrain
radar_final	corrected radar altimeter	metres above terrain
dem	digital elevation model	metres above sea level
dem_final	microlevelled digital elevation model	metres above sea level
fiducial	fiducial	seconds
flight	flight number	
line_number	full flight line number (flight line and part numbers)	
line	flight line number	
line_part	flight line part number	
time_utc	UTC time	seconds
time_local	local time	seconds after midnight
date	local date	YYYYMMDD
height_mag	magnetometer height	metres above terrain
mag_baseA_raw	raw magnetic base station A data	nanoteslas
mag_baseA_final	corrected magnetic base station A data	nanoteslas
mag_baseB_raw	raw magnetic base station B data	nanoteslas
mag_baseB_final	corrected magnetic base station B data	nanoteslas
fluxgate_x	X-component field from the compensation fluxgate magnetometer	nanoteslas
fluxgate_y	Y-component field from the compensation fluxgate magnetometer	nanoteslas
fluxgate_z	Z-component field from the compensation fluxgate magnetometer	nanoteslas
drape	drape surface	metres above sea level
mag_raw_left	raw magnetic field from left wingtip sensor	nanoteslas
mag_comp_left	compensated magnetic field from left wingtip sensor	nanoteslas
mag_lag_left	compensated, edited and lag corrected magnetic field from left wingtip sensor	nanoteslas
mag_raw_right	raw magnetic field from right wingtip sensor	nanoteslas
mag_comp_right	compensated magnetic field from right wingtip sensor	nanoteslas
mag_lag_right	compensated, edited and lag corrected magnetic field from right wingtip sensor	nanoteslas
mag_raw_tail	raw magnetic field from tail sensor	nanoteslas
mag_comp_tail	compensated magnetic field from tail sensor	nanoteslas
mag_lag_tail	compensated, edited and lag corrected magnetic field from tail sensor	nanoteslas

Channel Name	Description	Units
mag_diurn_tail	diurnally-corrected magnetic field from tail sensor	nanoteslas
mag_lev_tail	levelled magnetic field from tail sensor	nanoteslas
mag_final_tail	microlevelled magnetic field from tail sensor	nanoteslas
igrf	local IGRF field	nanoteslas
mag_igrf_tail	IGRF-corrected magnetic field from tail sensor	nanoteslas
mag_gsclevel_tail	GSC levelled magnetic field from tail sensor	nanoteslas
mag_grad_lat_raw	raw lateral horizontal magnetic gradient (from wingtip sensors)	nanoteslas/metre
mag_grad_lat_cor	microlevelling correction for lateral horizontal magnetic gradient	nanoteslas/metre
mag_grad_lat_final	levelled lateral horizontal magnetic gradient (from wingtip sensors)	nanoteslas/metre
mag_grad_long_raw	raw longitudinal horizontal magnetic gradient	nanoteslas/metre
mag_grad_long_cor	microlevelling correction for longitudinal horizontal magnetic gradient	nanoteslas/metre
mag_grad_long_final	levelled longitudinal horizontal magnetic gradient	nanoteslas/metre

The contents of MF#SPEC.xyz/.gdb (both file types contain the same set of data channels) are summarized as follows:

Channel Name	Description	Units
gps_x_final	differentially corrected GPS X (NAD83 datum)	metres
gps_y_final	differentially corrected GPS Y (NAD83 datum)	metres
gps_z_final	differentially corrected GPS Z	metres above sea level
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	degrees
lat_nad83	latitude using NAD83 datum	degrees
heading	line heading	degrees
radar_raw	raw radar altimeter	metres above terrain
radar_final	corrected radar altimeter	metres above terrain
dem	digital elevation model	metres above sea level
dem_final	microlevelled digital elevation model	metres above sea level
baro_press	barometric pressure	millibars
air_temp	outside air temperature	degrees Celsius
air_temp_f	low-pass filtered outside air temperature	degrees Celsius
fiducial	fiducial	seconds
flight	flight number	
line_number	full flight line number (flight line and part numbers)	
line	flight line number	
line_part	flight line part number	
time_utc	UTC time	seconds
time_local	local time	seconds after midnight
date	local date	YYYYMMDD
height_rad	gamma-ray spectrometer height at STP	metres above terrain
live_time	gamma-ray spectrometer live time	milliseconds
cosmic_raw	raw cosmic window	counts per second
u_up_raw	raw upward-looking uranium window	counts per second
radon_raw	raw radon calculated with upward-looking uranium window	counts per second

Channel Name	Description	Units
radon_final	radon calculated with upward-looking uranium window	counts per second
total_count_win	windowed total count	counts per second
potassium_win	windowed potassium	counts per second
uranium_win	windowed uranium	counts per second
thorium_win	windowed thorium	counts per second
total_count_corr	corrected total air-absorbed dose rate	nanograys per hour
potassium_corr	corrected potassium	percent
euranium_corr	corrected equivalent uranium	parts per million
ethorium_corr	corrected equivalent thorium	parts per million
dose_rate	natural dose rate	nanograys per hour
total_count_final	microlevelled total air absorbed dose rate	nanograys per hour
potassium_final	microlevelled potassium	percent
euranium_final	microlevelled equivalent uranium	parts per million
ethorium_final	microlevelled equivalent thorium	parts per million
k_over_th	ratio of potassium over equivalent thorium over	percent over parts per million
u_over_k	ratio of equivalent uranium over potassium	parts per million over percent
u_over_th	ratio of equivalent uranium over equivalent thorium	

The contents of MF#SPEC256.xyz/.gdb (both file types contain the same set of data channels) are summarized as follows:

Channel Name	Description	Units
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	degrees
lat_nad83	latitude using NAD83 datum	degrees
fiducial	fiducial	seconds
flight	flight number	
line_number	full flight line number (flight line and part numbers)	
line	flight line number	
line_part	flight line part number	
time_utc	UTC time	seconds
time_local	local time	seconds after midnight
date	local date	YYYYMMDD
spectrum_down_raw	raw 256-channel gamma-ray down spectrum (array channel)	counts per second
spectrum_up_raw	raw 256-channel gamma-ray up spectrum (array channel)	counts per second
spectrum_down_nas	NASVD 256-channel gamma-ray down spectrum (array channel)	counts per second
spectrum_up_nas	NASVD 256-channel gamma-ray up spectrum (array channel)	counts per second

The contents of MF#KC.csv/.gdb (both file types contain the same set of data channels) are summarized as follows:

Channel Name	Description	Units
x_nad83	easting in UTM co-ordinates using NAD83 datum	metres
y_nad83	northing in UTM co-ordinates using NAD83 datum	metres
lon_nad83	longitude using NAD83 datum	degrees
lat_nad83	latitude using NAD83 datum	degrees
corr_coeff	correlation coefficient	percent
pos_coeff	positive correlation coefficient	percent
neg_coeff	negative correlation coefficient	percent
norm_error	standard error normalized to amplitude	percent
amplitude	peak-to-peak anomaly amplitude within window	nanoteslas

5. GRID FILES

The gridded data are provided in 2 formats:

- **.gxf* Geosoft® uncompressed ASCII grid exchange format (revision 3.0)
- **.grd* Geosoft® Oasis montaj™ uncompressed binary grid file

All grids are NAD83 UTM Zone 15N (Mahon Lake) and Zone 16 North (Flatrock Lake), co-ordinates with a grid cell size of 40 m × 40 m and are summarized as follows:

- MF#DEM83.gxf/.grd digital elevation model
- MF#MAG83.gxf/.grd total magnetic field
- MF#2VD83.gxf/.grd second vertical derivative of the total magnetic field
- MF#GMAGGSC83.gxf/.grd "GSC levelled" gradient-enhanced total magnetic field
- MF#G2VDMAGGSC83.gxf/.grd second vertical derivative of the "GSC levelled" gradient-enhanced total magnetic field
- MF#LAG.gxf/.grd measured lateral (across line) horizontal magnetic gradient
- MF#LOG.gxf/.grd measured longitudinal (along line) horizontal magnetic gradient
- MF#TC83.gxf/.grd total air absorbed dose rate
- MF#K83.gxf/.grd percent potassium
- MF#TH83.gxf/.grd equivalent thorium
- MF#U83.gxf/.grd equivalent uranium
- MF#KTHRATIO83.gxf/.grd percent potassium / equivalent thorium ratio
- MF#UKRATIO83.gxf/.grd equivalent uranium / percent potassium ratio
- MF#UTHRATIO83.gxf/.grd equivalent uranium/equivalent thorium ratio

6. GEOREFERENCED IMAGE FILES

Geographically referenced colour images, incorporating a base map, are provided in GeoTIFF format for use in GIS applications:

- MF#GMAGGSC83.TIF — "GSC levelled" gradient-enhanced total magnetic field grid + planimetric base
- MF#G2VDMAGGSC83.TIF — shaded second vertical derivative of the "GSC levelled" gradient-enhanced total magnetic field grid + planimetric base
- MF#TERN83.TIF — potassium, thorium, uranium ternary image + planimetric base

7. VECTOR FILES

Vector line work from the maps is provided in DXF (v.12) ASCII format using the following naming convention:

- MF#PATH83.DXF — flight path
- MF#KC83.DXF — Keating coefficients
- MF#MAG83.DXF — magnetic contours

The layers within the DXF files correspond to the various object types found therein and have intuitive names.