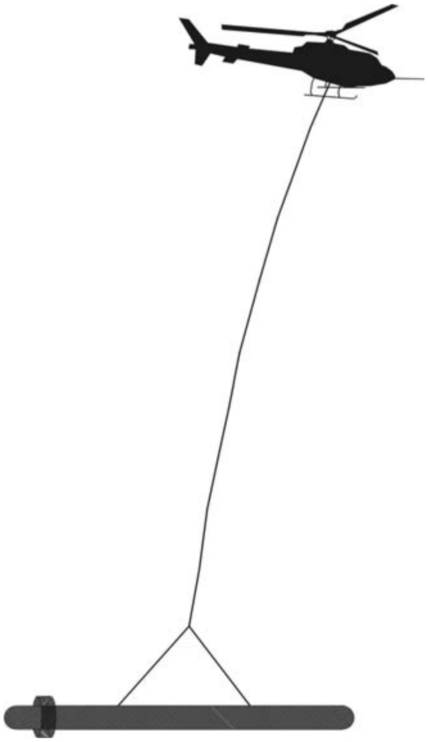
Report # 08035

RESOLVE SURVEY
FOR
NORTH PLATTE RESOURCE DISTRICT

NORTH PLATTE RIVER, LODGEPOLE CREEK AND SIDNEY DRAW AREAS

WESTERN NEBRASKA



Fugro Airborne Surveys Corp.
Mississauga, Ontario

September 19th, 2008

SUMMARY

This report describes the logistics, data acquisition, processing and presentation of results of a RESOLVE airborne geophysical survey carried out for the North Platte Natural Resources District over three areas located in Western Nebraska. Total coverage of the survey blocks amounted to 1375.24 km. The survey was flown from June 15th to June 23rd, 2008.

The purpose of the survey was to define conductivity contrasts within the survey blocks and to provide information that could be used to map the geology and structure of the survey areas, with the objective of mapping the subsurface features that control surface and subsurface ground-water distribution. This was accomplished by using a RESOLVE multi-coil, multi-frequency electromagnetic system, supplemented by a high sensitivity cesium magnetometer. The information from these sensors was processed to produce maps that display the magnetic and conductive properties of the survey areas. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base maps.

The survey data were processed and compiled in the Fugro Airborne Surveys Toronto office. Map products and digital data were provided in accordance with the scales and formats specified in the Survey Agreement.

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APPENDICES

1. INTRODUCTION

A RESOLVE electromagnetic/resistivity/magnetic survey was flown for North Platte Natural Resources District from June 15th to June 23rd, 2008, over three areas located in Western Nebraska. The survey areas are shown in figures 2-1 and 2-2.

Survey coverage consisted of approximately 1375 line-km, including 22.8 line-km of tie lines. The breakdown of kilometres flown per area as well as the line direction and line spacing where applicable is given below in table 1-1.

Table 1-1

Block	Traverse line azimuth	Tie Line azimuth	Traverse line spacing (m)	Tie line spacing (m)	Traverse Line (km)	Tie Line (km)	Total
N. Platte E – W	Varies E-W				187.27		187.27
N Platte N - S	Varies N-S				428.91		428.91
N Platte Block	358°/178°	89°/269°	200		219.75	9.09	228.84
Lodgepole	Varies E-W	0°/180°			272.63	3.55	276.18
Sidney D SW	varies		200		141.89	2.58	144.47
Sidney D NE	varies		200		85.99	7.56	93.55
Additional	varies				16.02		16.02
TOTAL					1352.16	22.78	1375.24

The survey employed the RESOLVE electromagnetic system. Ancillary equipment consisted of a magnetometer, radar and laser altimeters, video camera, digital data recorder, and an electronic navigation system. The instrumentation was installed in an AS350-B3 turbine helicopter (Registration C-FQDA) that was provided by Great Slave Helicopters Ltd. The helicopter flew at an average airspeed of 120 km/h with an EM sensor height of approximately 35 metres.

Figure 1: Fugro Airborne Surveys RESOLVE EM bird with AS350-B3

2. SURVEY OPERATIONS

The base of operations for the survey was established at the Scottsbluff Airport, and the Sydney Airport, Nebraska. The survey areas can be seen in Figure 2-1 and 2-2.

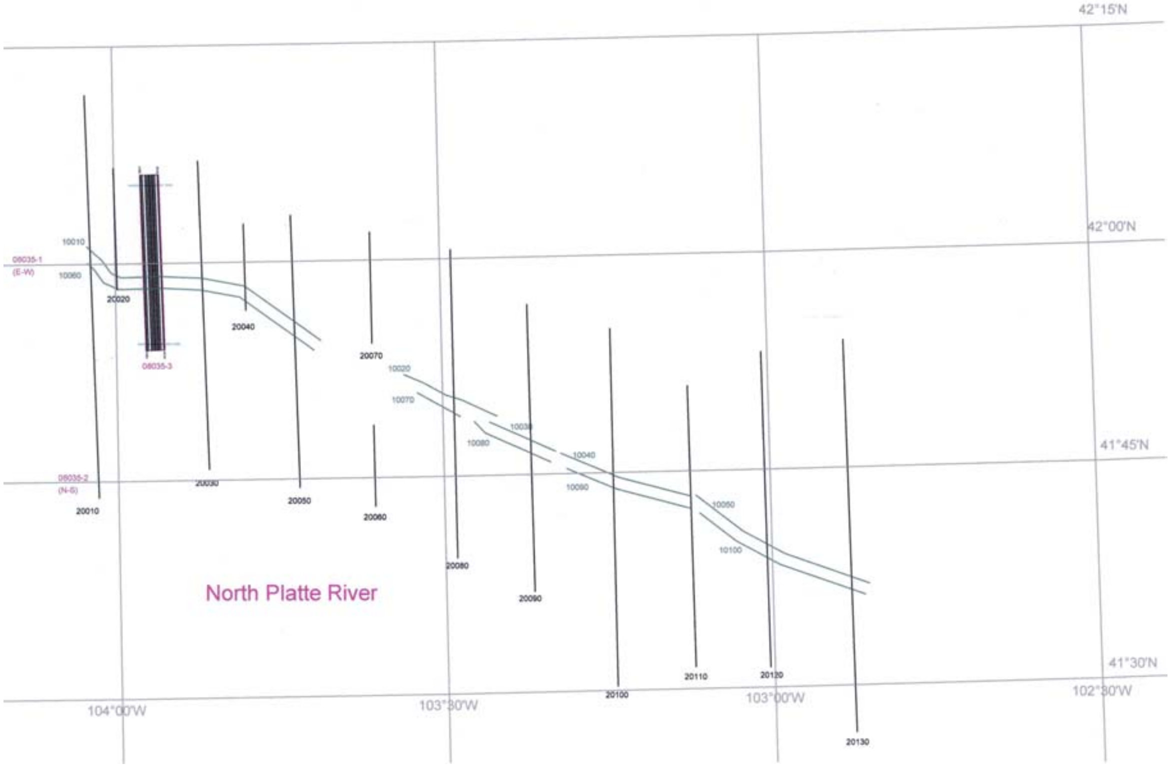

Figure 2-1
Location Map
North Platte Area
Job # 08035

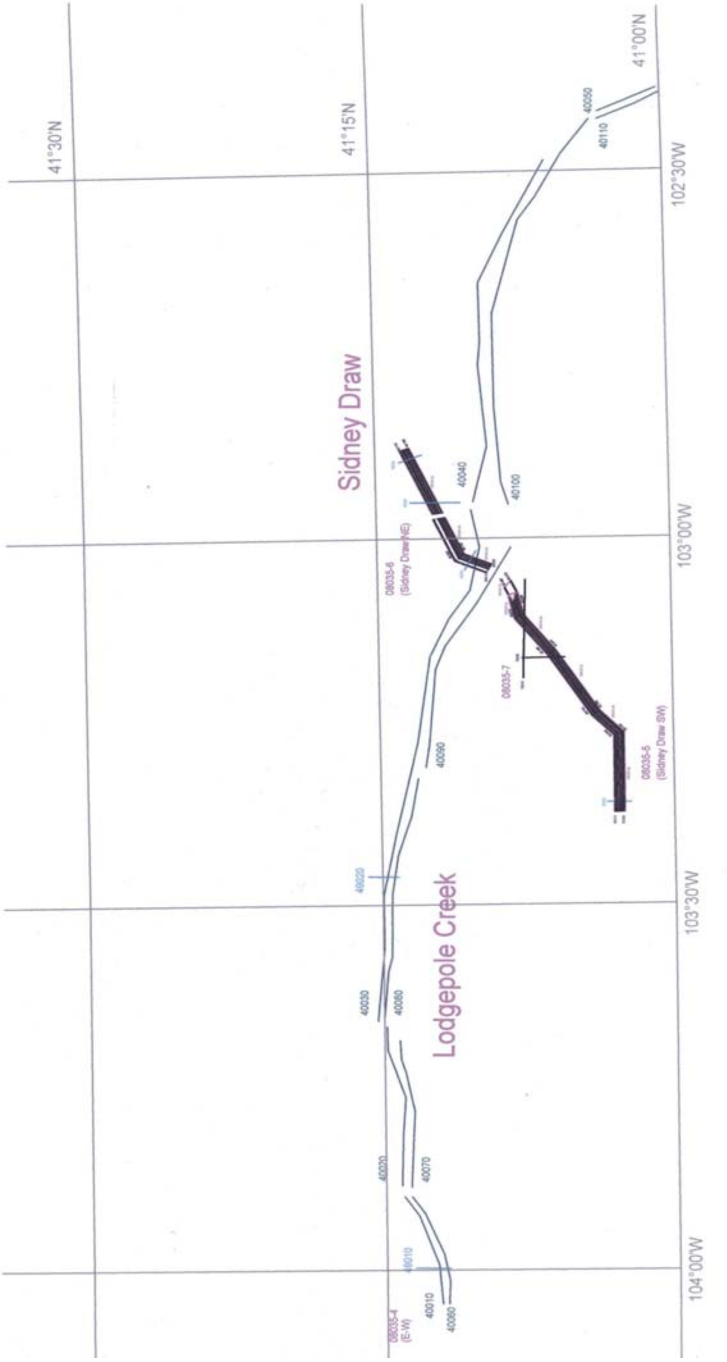

Figure 2-2
Location Map
South Platte Area
Job # 08035

The survey specifications were as follows:

Table 2-1 Survey Specifications

Parameter	Specifications
Traverse line direction:	
N Platte E-W	varies E-W
N Platte N-S	varies N-S
N Platte block	0°/180°
Lodgepole	varies E-W
Sidney Draw SW	varies
Sidney Draw NE	varies
Additional	varies
Traverse line spacing:	
N Platte E-W	na
N Platte N-S	na
N Platte block	200 m
Lodgepole	na
Sidney Draw SW	200 m
Sidney Draw NE	200 m
Additional	na
Tie line direction, all areas:	varies
Tie line spacing all areas:	na
Sample interval	10 Hz, 3.3 m @ 120 km/h
Aircraft mean terrain clearance	63 m
EM sensor mean terrain clearance	35 m
Mag sensor mean terrain clearance	35 m
Average speed	120 km/h
Navigation (guidance)	±5 m, Real-time GPS
Post-survey flight path	±2 m, Differential GPS

3. SURVEY EQUIPMENT

This section provides a brief description of the geophysical instruments used to acquire the survey data and the calibration procedures employed. The geophysical equipment was installed in an AS350-B3 helicopter. This aircraft provides a safe and efficient platform for surveys of this type.

Electromagnetic System

Model: RESOLVE

Type: Towed bird, symmetric dipole configuration operated at a nominal survey altitude of 35 metres. Coil separation is 7.9 metres for 380 Hz, 1793 Hz, 8171 Hz, 41,020 Hz and 129, 550 Hz, and 9.0 metres for the 3345 Hz coil-pair.

Coil orientations, frequencies and dipole moments

	orientation	nominal	actual
	coplanar	400 Hz	380 Hz
1	coplanar	1800 Hz	1776 Hz
	coaxial	3300 Hz	3345 Hz
	coplanar	8200 Hz	8171 Hz
	coplanar	40,000 Hz	41 020 Hz
	coplanar	140,000 Hz	129 550 Hz

Channels recorded:
6 in-phase channels
6 quadrature channels
2 monitor channels

Sensitivity:
0.12 ppm at 380 Hz Cp
0.12 ppm at 1800 Hz Cp
0.12 ppm at 3300 Hz Cx
0.24 ppm at 8200 Hz Cp
0.60 ppm at 40,000 Hz Cp
0.60 ppm at 140,000 Hz Cp

Sample rate: 10 per second, equivalent to 1 sample every 3.3 m, at a survey speed of 120 km/h.

The electromagnetic system utilizes a multi-coil coaxial/coplanar technique to energize conductors in different directions. The coaxial coils are vertical with their axes in the flight direction. The coplanar coils are horizontal. The secondary fields are sensed simultaneously by means of receiver coils that are maximum coupled to their respective transmitter coils. The system yields an in-phase and a quadrature channel from each transmitter-receiver coil-pair.

In-Flight EM System Calibration

Calibration of the system during the survey uses the Fugro AutoCal automatic, internal calibration process. At the beginning and end of each flight, and at intervals during the flight, the system is flown up to high altitude to remove it from any “ground effect” (response from the earth). Any remaining signal from the receiver coils (base level) is measured as the zero level, and is removed from the data collected until the time of the next calibration. Following the zero level setting, internal calibration coils, for which the response phase and amplitude have been determined at the factory, are automatically triggered – one for each frequency. The on-time of the coils is sufficient to determine an accurate response through any ambient noise. The receiver response to each calibration coil “event” is compared to the expected response (from the factory calibration) for both phase angle and amplitude, and any phase and gain corrections are automatically applied to bring the data to the correct value.

In addition, the outputs of the transmitter coils are continuously monitored during the survey, and the gains are adjusted to correct for any change in transmitter output.

Because the internal calibration coils are calibrated at the factory (on a resistive halfspace) ground calibrations using external calibration coils on-site are not necessary for system calibration. A check calibration may be carried out on-site to ensure all systems are working correctly. All system calibrations will be carried out in the air, at sufficient altitude that there will be no measurable response from the ground.

The internal calibration coils are rigidly positioned and mounted in the system relative to the transmitter and receiver coils. In addition, when the internal calibration coils are calibrated at the factory, a rigid jig is employed to ensure accurate response from the external coils.

Using real time Fast Fourier Transforms and the calibration procedures outlined above, the data are processed in real time, from measured total field at a high sampling rate, to in-phase and quadrature values at 10 samples per second.

Airborne Magnetometer

Model: Fugro D1344 processor with Scintrex CS2 sensor

Type: Optically pumped cesium vapour

Sensitivity: 0.01 nT

Sample rate: 10 per second

The magnetometer sensor is housed in the EM bird, 28 m below the helicopter.

Magnetic Base Station

Primary

Model: Fugro CF1 base station with timing provided by integrated GPS

Sensor type: Scintrex CS-3

Counter specifications:
  Accuracy: ±0.1 nT
  Resolution: 0.01 nT
  Sample rate 1 Hz

Secondary

Model: Gem Proton

Sensor type: Geometrics GR822A

Counter specifications:
  Accuracy: ±0.1 nT
  Resolution: 0.01 nT
  Sample rate 1 Hz

GPS specifications:
  Model: Novatel OEM 4
  Type: Code and carrier tracking of L1 band, 12-channel, C/A code at 1575.42 MHz
  Sensitivity: -90 dBm, 1.0 second update
  Accuracy: Manufacturer's stated accuracy for differential corrected GPS is 2 metres

Environmental
Monitor specifications: Temperature:

- Accuracy: ±1.5ºC max
- Resolution: 0.0305ºC
- Sample rate: 1 Hz
- Range: -40ºC to +75ºC

Barometric pressure:

- Model: Motorola MPXA4115A
- Accuracy: ±3.0º kPa max (-20ºC to 105ºC temp. ranges)
- Resolution: 0.013 kPa
- Sample rate: 1 Hz
- Range: 55 kPa to 108 kPa

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronized with that of the airborne system, using GPS time, to permit subsequent removal of diurnal drift. The base station locations are given below in Table 3-1.

Table 3-1 Magnetic Base Station Location

Status	Location Name	WGS84 Latitude (deg-min-sec)	WGS84 Longitude (deg-min-sec)	WGS84 Elevation (m)	Date Setup	Date Torn Down
Primary	Scottsbluff Airport	41 52 20.22433 N	103 35 53.68191 W	1183.54	14-Jun-08	21-Jun-08
Secondary	Scottsbluff Airport	41 52 20.22433 N	103 35 53.68191 W	1183.54	14-Jun-08	21-Jun-08
Primary	Sidney Airport	41 6 16.7473 N	102 59 9.90721 W	1291.39	21-Jun-08	24-Jun-08
Secondary	Sidney Airport	4 6 17.31652 N	102 59 9.98203 W	1286.70	21-Jun-08	24-Jun-08

Navigation (Global Positioning System)

Airborne Receiver for Guidance

Model:	PNAV 2100
Type:	SPS (L1 band), 24-channel, C/A code at 1575.42 MHz, S code at 0.5625 MHz, Real-time differential
Sensitivity:	-132 dBm, 0.5 second update
Accuracy:	Manufacturer's stated accuracy is better than 5 metres real-time
Antenna:	Mounted on tail of aircraft

Airborne Receiver for Flight Path Recovery

Model: Novatel OEM4

Type: Code and carrier tracking of L1-C/A code at 1575.42 MHz and L2-P code at 1227.0 MHz. Dual frequency, 24-channel

Sample rate: 10 Hz update

Accuracy: Better than 1 metre in differential mode

Antenna: Mounted on nose of EM bird

Primary Base Station for Post-Survey Differential Correction

Model: Novatel OEM4

Type: Code and carrier tracking of L1-C/A code at 1575.42 MHz and L2-P code at 1227.0 MHz. Dual frequency, 24-channel

Sample rate: 0.5 second update

Accuracy: Manufacturer's stated accuracy for differential corrected GPS is better than 1 metre

Secondary GPS Base Station

Model: Marconi Allstar OEM, CMT-1200

Type: Code and carrier tracking of L1 band, 12-channel, C/A code at 1575.42 MHz

Sensitivity: -90 dBm, 1.0 second update

Accuracy: Manufacturer's stated accuracy for differential corrected GPS is 2 metres.

The Novatel OEM4 is a line of sight, satellite navigation system that utilizes time-coded signals from at least four of forty-eight available satellites. Both Russian GLONASS and American NAVSTAR satellite constellations are used to calculate the position and to provide real time guidance to the helicopter. For flight path processing an Ashtech Z-surveyor was used as the mobile receiver. A similar system was used as the primary base station receiver. The mobile and base station raw XYZ data were recorded, thereby permitting post-survey differential corrections for theoretical accuracies of better than 2 metres. A Marconi Allstar GPS unit, part of the CF-1, was used as a secondary (back-up) base station.

Table 3-1 GPS Base Station Location

Status	Make	Location Name	WGS84 Latitude	WGS84 Longitude	Elevation	Date Setup
Primary	Novatel OEM4	Scottsbluff Airport	41 52 19.90279 N	103 35 53.7236 W	1187.79	14-Jun-08
Secondary	CF1 Marconi	Scottsbluff Airport	41 52 20.22433 N	103 35 53.68191 W	1183.54	14-Jun-08
Primary	Novatel OEM4	Sidney Airport	41 6 16.7473 N	102 59 9.90721 W	1291.39	21-Jun-08
Secondary	CF1 Marconi	Sidney Airport	4 6 17.31652 N	102 59 9.98203 W	1286.70	21-Jun-08

The GPS records data relative to the WGS84 ellipsoid, which is the basis of the revised North American Datum (NAD83). Conversion software is used to transform the WGS84 coordinates to the UTM system displayed on the maps.

Radar Altimeter

Manufacturer:	Honeywell/Sperry
Model:	RT330 or AT220
Type:	Short pulse modulation, 4.3 GHz
Sensitivity:	0.3 m
Sample rate:	2 per second

The radar altimeter measures the vertical distance between the helicopter and the ground.

Barometric Pressure and Temperature Sensors

Model:	DIGHEM D 1300	
Type:	Motorola MPX4115AP analog pressure sensor AD592AN high-impedance remote temperature sensors	
Sensitivity:	Pressure:	150 mV/kPa
	Temperature:	100 mV/°C or 10 mV/°C (selectable)
Sample rate:	10 per second	

The D1300 circuit is used in conjunction with one barometric sensor and up to three temperature sensors. Two sensors (baro and temp) are installed in the EM console in the aircraft, to monitor pressure (1KPA) and internal operating temperatures (2TDC).

Laser Altimeter

Manufacturer: Optech

Model: G150

Type: Fixed pulse repetition rate of 2 kHz

Sensitivity: ±5 cm from 10ºC to 30ºC
±10 cm from -20ºC to +50ºC

Sample rate: 2 per second

The laser altimeter is housed in the EM bird, and measures the distance from the EM bird to ground, except in areas of dense tree cover. This information is used in the processing algorithm that determines conductor depth.

Digital Data Acquisition System

Manufacturer: Fugro

Model: HELIDAS

Recorder: Compact Flash Card

The stored data are downloaded to the field workstation PC at the survey base, for verification, backup and preparation of in-field products.

Video Flight Path Recording System

Type: Sony DXC-101 Digital Network Camera

Recorder: Axis 241S Video Server + Tablet computer

Fiducial numbers are recorded continuously and are displayed on the margin of each image. This procedure ensures accurate correlation of data with respect to visible features on the ground.

4. QUALITY CONTROL AND IN-FIELD PROCESSING

Digital data for each flight were transferred to the field workstation, in order to verify data quality and completeness. A database was created and updated using Geosoft Oasis Montaj and proprietary Fugro Atlas software. This allowed the field personnel to calculate, display and verify both the positional (flight path) and geophysical data on a screen or printer. Records were examined as a preliminary assessment of the data acquired for each flight.

In field processing of Fugro survey data consists of differential corrections to the airborne GPS data, verification of EM calibrations, drift correction of the raw airborne EM data, spike rejection and filtering of all geophysical and ancillary data, verification of flight videos, calculation of preliminary resistivity data, diurnal correction, and preliminary levelling of magnetic data.

All data, including base station records, were checked on a daily basis, to ensure compliance with the survey contract specifications. Reflights were required if any of the following specifications were not met.

Navigation - Positional (x,y) accuracy of better than 10 m, with a CEP (circular error of probability) of 95%.

Flight Path - Deviations from the planned (pre-flight) paths could not exceed 10 percent of the designated flight line spacing. Gaps between adjacent flight lines greater than 1.5 times the designated flight line spacing for more than 2 linear miles (3.2 km) required fill-in intermediate flight lines. However, if the flight-line spacing deviation was caused by a safety requirement, FAA regulation, or military requirement, a fill-in line was not required. Aircraft air speed maintained at a constant during surveying operations.

Clearance - Mean terrain sensor clearance of 30 m, ±10 m, except where precluded by safety considerations, e.g., restricted or populated areas, severe topography, obstructions, tree canopy, aerodynamic limitations, etc.

Airborne Mag - Airborne survey data were not acceptable when gathered during magnetic storms or short term disturbances of magnetic activity at the ground station used that exceeded the following:

- Monotonic changes in the magnetic field of 5 nT in any five-minute period.
- Pulsations having periods of 5 minutes or less did not exceed 2 nT.
- Pulsations having periods between 5 and 10 minutes did not exceed 4 nT.

- Pulsations having periods between 10 and 20 minutes did not exceed 8 nT.

The period of a pulsation is defined as the time between adjacent peaks or troughs. The amplitude of a pulsation is one-half the sum of the positive and negative excursions from trough to trough or peak to peak.

Total intensity magnetometer used to perform the surveys had a sensitivity of 0.1 nT or better. Values were obtained along flight lines at intervals no greater than 10 feet (3 m). The error envelope due to turbulence and the internal magnetometer noise did not exceed ±0.1 nT for more than 10% of any flight line.

Base Mag - Diurnal variations not to exceed 10 nT over a straight line time chord of 1 minute.

EM - Spheric pulses may occur having strong peaks but narrow widths. The EM data area considered acceptable when their occurrence is less than 10 spheric events exceeding the stated noise specification for a given frequency per 100 samples continuously over a distance of 2,000 metres.

Frequency	Coil Orientation	Peak to Peak Noise Envelope (ppm)
385 Hz	horizontal coplanar	5.0
1793 Hz	horizontal coplanar	10.0
3345 Hz	vertical coaxial	10.0
8171 Hz	horizontal coplanar	10.0
41,020 Hz	horizontal coplanar	20.0
129,550 Hz	horizontal coplanar	40.0

5. DATA PROCESSING

Flight Path Recovery

The raw range data from at least four satellites are simultaneously recorded by both the base and mobile GPS units. The geographic positions of both units, relative to the model ellipsoid, are calculated from this information. Differential corrections, which are obtained from the base station, are applied to the mobile unit data to provide a post-flight track of the aircraft, accurate to within 2 m. Speed checks of the flight path are also carried out to determine if there are any spikes or gaps in the data.

The corrected WGS84 latitude/longitude coordinates are transformed to the coordinate system used on the final maps. Images or plots are then created to provide a visual check of the flight path.

Electromagnetic Data

EM data are processed at the recorded sample rate of 10 samples/second. Spheric rejection median and Hanning filters are then applied to reduce noise to acceptable levels.

Apparent Resistivity

The apparent resistivities in ohm-m are generated from the in-phase and quadrature EM components for all of the coplanar frequencies, using a pseudo-layer half-space model. The inputs to the resistivity algorithm are the in-phase and quadrature amplitudes of the secondary field. The algorithm calculates the apparent resistivity in ohm-m, and the apparent height of the bird above the conductive source. Any difference between the apparent height and the true height, as measured by the laser altimeter, is called the pseudo-layer and reflects the difference between the real geology and a homogeneous halfspace. This difference is often attributed to the presence of a highly resistive upper layer. Any errors in the altimeter reading, caused by heavy tree cover, are included in the pseudo-layer and do not affect the resistivity calculation. The apparent depth estimates, however, will reflect the altimeter errors. Apparent resistivities calculated in this manner may differ from those calculated using other models.

In areas where the effects of magnetic permeability or dielectric permittivity have suppressed the in-phase responses, the calculated resistivities will be erroneously high. Various algorithms and inversion techniques can be used to partially correct for the effects of permeability and permittivity.

Apparent resistivity maps portray all of the information for a given frequency over the entire survey area. The preliminary apparent resistivity maps and images are carefully inspected to identify any lines or line segments that might require base level adjustments. Because this survey uses wide line spacings and in some areas few lines comparing line to line variations in search of resistivity levelling problems does not work. Only blocks 3, 5, 6 and 7 have sufficient density of lines to allow this comparison. In the case of widespread lines differential resistivity sections were calculated and the response of the various frequencies were compared to each other in an attempt to detect and correct any levelling problems. If required, manual level adjustments are carried out to eliminate or minimize resistivity differences that can be attributed, in part, to changes in operating temperatures. These levelling adjustments are usually very subtle, and do not result in the degradation of discrete anomalies.

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Resistivity-Depth Sections

The apparent resistivities for all frequencies are displayed simultaneously as coloured resistivity-depth sections. Only the coplanar data are displayed as the close frequency separation between the coplanar and adjacent coaxial data tends to distort the section. The sections are plotted using the topographic elevation profile as the surface. The digital terrain values, in metres above the WGS84 ellipsoid have been calculated from the GPS Z-value, minus the laser altimeter.

Differential resistivity sections are derived from the pseudo-layer half-space model. They yield a coloured resistivity-depth section that attempts to portray a smoothed approximation of the true resistivity distribution with depth. Resistivity-depth sections are most useful in conductive layered situations, but may be unreliable in areas of moderate to high resistivity where signal amplitudes are weak. In areas where in-phase responses have been suppressed by the effects of magnetite, or adversely affected by cultural features, the computed resistivities shown on the sections may be unreliable.

Residual Magnetic Intensity

The residual magnetic intensity (RMI) is derived from the total magnetic field (TMF), the diurnal, and the regional magnetic field. The total magnetic intensity is measured in the aircraft, the diurnal is measured from the ground station, and the regional magnetic field is calculated from the international geo-referenced magnetic field (IGRF). First a fourth difference editing routine was applied to the magnetic data to remove any spikes. The low frequency component of the diurnal was then extracted from the filtered ground station data and removed from the TMF. The average of the diurnal is then added back in to obtain the resultant total magnetic intensity. The regional magnetic field, calculated for the specific survey location and the time of the survey, is then removed from the resultant total magnetic intensity to yield the residual magnetic intensity.

The results were then levelled using tie and traverse line intercepts where applicable. Manual adjustments were applied to any lines that required levelling, as indicated by shadowed images of the gridded magnetic data. The manually levelled data were then subjected to a microlevelling filter if the lines were close enough to allow a useable grid to be generated.

Magnetic Derivatives (optional)

The total magnetic field data can be subjected to a variety of filtering techniques to yield maps or images of the following:

second vertical derivative
reduction to the pole/equator
magnetic susceptibility with reduction to the pole
upward/downward continuations
analytic signal

All of these filtering techniques improve the recognition of near-surface magnetic bodies, with the exception of upward continuation. Any of these parameters can be produced on request.

Digital Elevation

The radar altimeter values (ALTR – aircraft to ground clearance) are subtracted from the differentially corrected and de-spiked GPS-Z values to produce profiles of the height above the ellipsoid along the survey lines. Where there were enough lines close enough together, the data were gridded to produce contour maps showing approximate elevations within the survey areas. The calculated digital terrain data were then tie-line levelled where appropriate. Any remaining subtle line-to-line discrepancies were manually removed.

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, ALTR and GPS-Z. The ALTR value may be erroneous in areas of heavy tree cover, where the altimeter reflects the distance to the tree canopy rather than the ground. The GPS-Z value is primarily dependent on the number of available satellites. Although post-processing of GPS data will yield X and Y accuracies in the order of 1-2 metres, the accuracy of the Z value is usually much less, sometimes in the ±10 metre range. Further inaccuracies may be introduced during the interpolation and gridding process.

Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, <u>THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.</u>

6. PRODUCTS

This section lists the final maps and products that have been provided under the terms of the survey agreement. Other products can be prepared from the existing dataset, if requested.

Final Products

There are no map products required for this survey. Gridded data of apparent resistivity for each coplanar frequency plus pdf files of differential resistivity sections are provided in digital format.

All gridded data has been created using the following coordinate system;

Projection Description:

Datum:	NAD83
Ellipsoid:	GRS 1980
Projection:	UTM (Zone: 13)
Central Meridian:	105°W
False Northing:	0
False Easting:	500000
Scale Factor:	0.9996
WGS84 to Local Conversion:	Molodensky
Datum Shifts:	DX: 0 DY: 0 DZ: 0

Additional Products

Digital Archive (see Archive Description)	2 copies on DVD-ROM
Survey Logistics Report	2 copies

APPENDIX A

LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing and presentation of data, relating to a RESOLVE airborne geophysical survey carried out for the North Platte Natural Resources District, over three areas located in western Nebraska.

David Miles	Manager, Geophysical Projects
Emily Farquhar	Manager, Geophysical Services
Graham Konieczny	Manager, Data Processing and Interpretation
Andy Semple	Supervisor Field Operators
Jorge Naranjo	Geophysical Operator
Darren Hamill	Field Geophysicist/Crew Leader
Chris Tucker	Pilot (Great Slave Helicopters Ltd.)
Jerry Chambers	AME (Great Slave Helicopters Ltd.)
Jacques F.	AME (Great Slave Helicopters Ltd.)
Terry Brazil	Fuel Truck Driver (inten Helicopters.)
Russell Imrie	Interpretation Geophysicist
Richardo White	Geophysical Dataprocessor
Lyn Vanderstarren	Drafting Supervisor
Susan Pothiah	Word Processing Operator
Albina Tonello	Secretary/Expeditor

The survey consisted of 1375.24 km of coverage, flown from June 15th to June 23rd, 2008.

All personnel are employees of Fugro Airborne Surveys, except where indicated.

APPENDIX B

BACKGROUND INFORMATION

- Appendix B.1 -

BACKGROUND INFORMATION

Electromagnetics

Fugro electromagnetic responses fall into two general classes, discrete and broad. The discrete class consists of sharp, well-defined anomalies from discrete conductors such as sulphide lenses and steeply dipping sheets of graphite and sulphides. The broad class consists of wide anomalies from conductors having a large horizontal surface such as flatly dipping graphite or sulphide sheets, saline water-saturated sedimentary formations, conductive overburden and rock, kimberlite pipes and geothermal zones. A vertical conductive slab with a width of 200 m would straddle these two classes.

The vertical sheet (half plane) is the most common model used for the analysis of discrete conductors. All anomalies plotted on the geophysical maps are analyzed according to this model. The following section entitled **Discrete Conductor Analysis** describes this model in detail, including the effect of using it on anomalies caused by broad conductors such as conductive overburden.

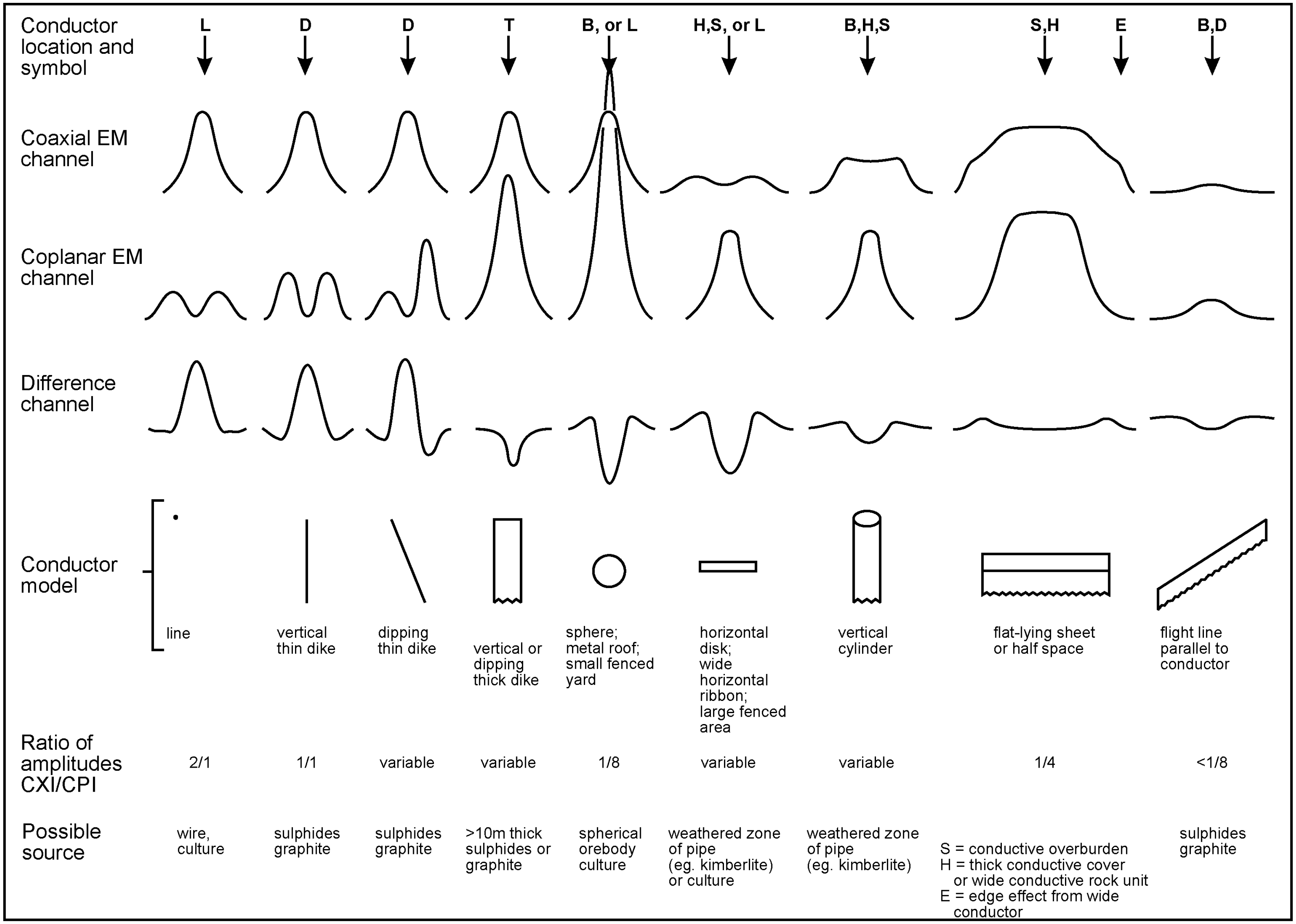
The conductive earth (half-space) model is suitable for broad conductors. Resistivity contour maps result from the use of this model. A later section entitled **Resistivity Mapping** describes the method further, including the effect of using it on anomalies caused by discrete conductors such as sulphide bodies.

Geometric Interpretation

The geophysical interpreter attempts to determine the geometric shape and dip of the conductor. Figure B-1 shows typical HEM anomaly shapes which are used to guide the geometric interpretation.

Discrete Conductor Analysis

The EM anomalies appearing on the electromagnetic map are analyzed by computer to give the conductance (i.e., conductivity-thickness product) in siemens (mhos) of a vertical sheet model. This is done regardless of the interpreted geometric shape of the conductor. This is not an unreasonable procedure, because the computed conductance increases as the electrical quality of the conductor increases, regardless of its true shape. DIGHEM anomalies are divided into seven grades of conductance, as shown in Table B-1. The conductance in siemens (mhos) is the reciprocal of resistance in ohms.



Typical HEM anomaly shapes

Figure B-1

The conductance value is a geological parameter because it is a characteristic of the conductor alone. It generally is independent of frequency, flying height or depth of burial, apart from the averaging over a greater portion of the conductor as height increases. Small anomalies from deeply buried strong conductors are not confused with small anomalies from shallow weak conductors because the former will have larger conductance values.

Table B-1. EM Anomaly Grades

Anomaly Grade	Siemens
7	> 100
6	50 - 100
5	20 - 50
4	10 - 20
3	5 - 10
2	1 - 5
1	< 1

Conductive overburden generally produces broad EM responses which may not be shown as anomalies on the geophysical maps. However, patchy conductive overburden in otherwise resistive areas can yield discrete anomalies with a conductance grade (cf. Table B-1) of 1, 2 or even 3 for conducting clays which have resistivities as low as 50 ohm-m. In areas where ground resistivities are below 10 ohm-m, anomalies caused by weathering variations and similar causes can have any conductance grade. The anomaly shapes from the multiple coils often allow such conductors to be recognized, and these are indicated by the letters S, H, and sometimes E on the geophysical maps (see EM legend on maps).

For bedrock conductors, the higher anomaly grades indicate increasingly higher conductances. Examples: the New Insco copper discovery (Noranda, Canada) yielded a grade 5 anomaly, as did the neighbouring copper-zinc Magusi River ore body; Mattabi (copper-zinc, Sturgeon Lake, Canada) and Whistle (nickel, Sudbury, Canada) gave grade 6; and the Montcalm nickel-copper discovery (Timmins, Canada) yielded a grade 7 anomaly. Graphite and sulphides can span all grades but, in any particular survey area, field work may show that the different grades indicate different types of conductors.

Strong conductors (i.e., grades 6 and 7) are characteristic of massive sulphides or graphite. Moderate conductors (grades 4 and 5) typically reflect graphite or sulphides of a less massive character, while weak bedrock conductors (grades 1 to 3) can signify poorly connected graphite or heavily disseminated sulphides. Grades 1 and 2 conductors may not respond to ground EM equipment using frequencies less than 2000 Hz.

The presence of sphalerite or gangue can result in ore deposits having weak to moderate conductances. As an example, the three million ton lead-zinc deposit of Restigouche Mining Corporation near Bathurst, Canada, yielded a well-defined grade 2 conductor. The 10 percent by volume of sphalerite occurs as a coating around the fine grained massive pyrite, thereby inhibiting electrical conduction. Faults, fractures and shear zones may produce anomalies that typically have low conductances (e.g., grades 1 to 3). Conductive rock formations can yield anomalies of any conductance grade. The conductive materials in such rock formations can be salt water, weathered products such as clays, original depositional clays, and carbonaceous material.

For each interpreted electromagnetic anomaly on the geophysical maps, a letter identifier and an interpretive symbol are plotted beside the EM grade symbol. The horizontal rows of dots, under the interpretive symbol, indicate the anomaly amplitude on the flight record. The vertical column of dots, under the anomaly letter, gives the estimated depth. In areas where anomalies are crowded, the letter identifiers, interpretive symbols and dots may be obliterated. The EM grade symbols, however, will always be discernible, and the obliterated information can be obtained from the anomaly listing appended to this report.

The purpose of indicating the anomaly amplitude by dots is to provide an estimate of the reliability of the conductance calculation. Thus, a conductance value obtained from a large ppm anomaly (3 or 4 dots) will tend to be accurate whereas one obtained from a small ppm anomaly (no dots) could be quite inaccurate. The absence of amplitude dots indicates that the anomaly from the coaxial coil-pair is 5 ppm or less on both the in-phase and quadrature channels. Such small anomalies could reflect a weak conductor at the surface or a stronger conductor at depth. The conductance grade and depth estimate illustrates which of these possibilities fits the recorded data best.

The conductance measurement is considered more reliable than the depth estimate. There are a number of factors that can produce an error in the depth estimate, including the averaging of topographic variations by the altimeter, overlying conductive overburden, and the location and attitude of the conductor relative to the flight line. Conductor location and attitude can provide an erroneous depth estimate because the stronger part of the conductor may be deeper or to one side of the flight line, or because it has a shallow dip. A heavy tree cover can also produce errors in depth estimates. This is because the depth estimate is computed as the distance of bird from conductor, minus the altimeter reading. The altimeter can lock onto the top of a dense forest canopy. This situation yields an erroneously large depth estimate but does not affect the conductance estimate.

Dip symbols are used to indicate the direction of dip of conductors. These symbols are used only when the anomaly shapes are unambiguous, which usually requires a fairly resistive environment.

A further interpretation is presented on the EM map by means of the line-to-line correlation of bedrock anomalies, which is based on a comparison of anomaly shapes on adjacent lines. This provides conductor axes that may define the geological structure over portions of the survey area. The absence of conductor axes in an area implies that anomalies could not be correlated from line to line with reasonable confidence.

The electromagnetic anomalies are designed to provide a correct impression of conductor quality by means of the conductance grade symbols. The symbols can stand alone with geology when planning a follow-up program. The actual conductance values are printed in the attached anomaly list for those who wish quantitative data. The anomaly ppm and depth are indicated by inconspicuous dots which should not distract from the conductor patterns, while being helpful to those who wish this information. The map provides an interpretation of conductors in terms of length, strike and dip, geometric shape, conductance, depth, and thickness. The accuracy is comparable to an interpretation from a high quality ground EM survey having the same line spacing.

The appended EM anomaly list provides a tabulation of anomalies in ppm, conductance, and depth for the vertical sheet model. No conductance or depth estimates are shown for weak anomalous responses that are not of sufficient amplitude to yield reliable calculations.

Since discrete bodies normally are the targets of EM surveys, local base (or zero) levels are used to compute local anomaly amplitudes. This contrasts with the use of true zero levels which are used to compute true EM amplitudes. Local anomaly amplitudes are shown in the EM anomaly list and these are used to compute the vertical sheet parameters of conductance and depth.

Questionable Anomalies

The EM maps may contain anomalous responses that are displayed as asterisks (*). These responses denote weak anomalies of indeterminate conductance, which may reflect one of the following: a weak conductor near the surface, a strong conductor at depth (e.g., 100 to 120 m below surface) or to one side of the flight line, or aerodynamic noise. Those responses that have the appearance of valid bedrock anomalies on the flight profiles are indicated by appropriate interpretive symbols (see EM legend on maps). The others probably do not warrant further investigation unless their locations are of considerable geological interest.

The Thickness Parameter

A comparison of coaxial and coplanar shapes can provide an indication of the thickness of a steeply dipping conductor. The amplitude of the coplanar anomaly (e.g., CPI channel) increases relative to the coaxial anomaly (e.g., CXI) as the apparent thickness increases, i.e., the thickness in the horizontal plane. (The thickness is equal to the conductor width if the conductor dips at 90 degrees and strikes at right angles to the flight line.) This report refers to a conductor as thin when the thickness is likely to be less than 3 m, and thick when in excess of 10 m. Thick conductors are indicated on the EM map by parentheses "( )". For base metal exploration in steeply dipping geology, thick conductors can be high priority targets because many massive sulphide ore bodies are thick. The system cannot sense the thickness when the strike of the conductor is subparallel to the flight line, when the conductor has a shallow dip, when the anomaly amplitudes are small, or when the resistivity of the environment is below 100 ohm-m.

Resistivity Mapping

Resistivity mapping is useful in areas where broad or flat lying conductive units are of interest. One example of this is the clay alteration which is associated with Carlin-type deposits in the south west United States. The resistivity parameter was able to identify the clay alteration zone over the Cove deposit. The alteration zone appeared as a strong resistivity low on the 900 Hz resistivity parameter. The 7,200 Hz and 56,000 Hz resistivities showed more detail in the covering sediments, and delineated a range front fault. This is typical in many areas of the south west United States, where conductive near surface sediments, which may sometimes be alkalic, attenuate the higher frequencies.

Resistivity mapping has proven successful for locating diatremes in diamond exploration. Weathering products from relatively soft kimberlite pipes produce a resistivity contrast with the unaltered host rock. In many cases weathered kimberlite pipes were associated with thick conductive layers that contrasted with overlying or adjacent relatively thin layers of lake bottom sediments or overburden.

Areas of widespread conductivity are commonly encountered during surveys. These conductive zones may reflect alteration zones, shallow-dipping sulphide or graphite-rich units, saline ground water, or conductive overburden. In such areas, EM amplitude changes can be generated by decreases of only 5 m in survey altitude, as well as by increases in conductivity. The typical flight record in conductive areas is characterized by in-phase and quadrature channels that are continuously active. Local EM peaks reflect either increases in conductivity of the earth or decreases in survey altitude. For such conductive areas, apparent resistivity profiles and contour maps are necessary for the correct interpretation of the airborne data. The advantage of the resistivity parameter is that anomalies caused by altitude changes are virtually eliminated, so the resistivity data reflect only those anomalies caused by conductivity changes. The resistivity analysis also helps the interpreter to differentiate between conductive bedrock and conductive overburden. For example, discrete conductors will generally appear as narrow lows on the contour map and broad conductors (e.g., overburden) will appear as wide lows.

The apparent resistivity is calculated using the pseudo-layer (or buried) half-space model defined by Fraser (1978)[1]. This model consists of a resistive layer overlying a conductive half-space. The depth channels give the apparent depth below surface of the conductive material. The apparent depth is simply the apparent thickness of the overlying resistive layer. The apparent depth (or thickness) parameter will be positive when the upper layer is more resistive than the underlying material, in which case the apparent depth may be quite close to the true depth.

The apparent depth will be negative when the upper layer is more conductive than the underlying material, and will be zero when a homogeneous half-space exists. The apparent depth parameter must be interpreted cautiously because it will contain any errors that might exist in the measured altitude of the EM bird (e.g., as caused by a dense tree cover). The inputs to the resistivity algorithm are the in-phase and quadrature components of the coplanar coil-pair. The outputs are the apparent resistivity of the conductive half-space (the

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[1] Resistivity mapping with an airborne multicoil electromagnetic system: Geophysics, v. 43, p.144-172

source) and the sensor-source distance. The flying height is not an input variable, and the output resistivity and sensor-source distance are independent of the flying height when the conductivity of the measured material is sufficient to yield significant in-phase as well as quadrature responses. The apparent depth, discussed above, is simply the sensor-source distance minus the measured altitude or flying height. Consequently, errors in the measured altitude will affect the apparent depth parameter but not the apparent resistivity parameter.

The apparent depth parameter is a useful indicator of simple layering in areas lacking a heavy tree cover. Depth information has been used for permafrost mapping, where positive apparent depths were used as a measure of permafrost thickness. However, little quantitative use has been made of negative apparent depths because the absolute value of the negative depth is not a measure of the thickness of the conductive upper layer and, therefore, is not meaningful physically. Qualitatively, a negative apparent depth estimate usually shows that the EM anomaly is caused by conductive overburden. Consequently, the apparent depth channel can be of significant help in distinguishing between overburden and bedrock conductors.

Interpretation in Conductive Environments

Environments having low background resistivities (e.g., below 30 ohm-m for a 900 Hz system) yield very large responses from the conductive ground. This usually prohibits the recognition of discrete bedrock conductors. However, Fugro data processing techniques produce three parameters that contribute significantly to the recognition of bedrock conductors in conductive environments. These are the in-phase and quadrature difference channels (DIFI and DIFQ, which are available only on systems with “common” frequencies on orthogonal coil pairs), and the resistivity and depth channels (RES and DEP) for each coplanar frequency.

The EM difference channels (DIFI and DIFQ) eliminate most of the responses from conductive ground, leaving responses from bedrock conductors, cultural features (e.g., telephone lines, fences, etc.) and edge effects. Edge effects often occur near the perimeter of broad conductive zones. This can be a source of geologic noise. While edge effects yield anomalies on the EM difference channels, they do not produce resistivity anomalies. Consequently, the resistivity channel aids in eliminating anomalies due to edge effects. On the other hand, resistivity anomalies will coincide with the most highly conductive sections of conductive ground, and this is another source of geologic noise. The recognition of a bedrock conductor in a conductive environment therefore is based on the anomalous responses of the two difference channels (DIFI and DIFQ) and the resistivity channels (RES). The most favourable situation is where anomalies coincide on all channels.

The DEP channels, which give the apparent depth to the conductive material, also help to determine whether a conductive response arises from surficial material or from a conductive zone in the bedrock. When these channels ride above the zero level on the depth profiles (i.e., depth is negative), it implies that the EM and resistivity profiles are responding primarily to a conductive upper layer, i.e., conductive overburden. If the DEP channels are below the zero level, it indicates that a resistive upper layer exists, and this usually implies the existence of a bedrock conductor. If the low frequency DEP channel is below the zero level and the high frequency DEP is above, this suggests that a bedrock conductor occurs beneath conductive cover.

Reduction of Geologic Noise

Geologic noise refers to unwanted geophysical responses. For purposes of airborne EM surveying, geologic noise refers to EM responses caused by conductive overburden and magnetic permeability. It was mentioned previously that the EM difference channels (i.e., channel DIFI for in-phase and DIFQ for quadrature) tend to eliminate the response of conductive overburden.

Magnetite produces a form of geological noise on the in-phase channels. Rocks containing less than 1% magnetite can yield negative in-phase anomalies caused by magnetic permeability. When magnetite is widely distributed throughout a survey area, the in-phase EM channels may continuously rise and fall, reflecting variations in the magnetite percentage, flying height, and overburden thickness. This can lead to difficulties in recognizing deeply buried bedrock conductors, particularly if conductive overburden also exists. However, the response of broadly distributed magnetite generally vanishes on the in-phase difference channel DIFI. This feature can be a significant aid in the recognition of conductors that occur in rocks containing accessory magnetite.

EM Magnetite Mapping

The information content of HEM data consists of a combination of conductive eddy current responses and magnetic permeability responses. The secondary field resulting from conductive eddy current flow is frequency-dependent and consists of both in-phase and quadrature components, which are positive in sign. On the other hand, the secondary field resulting from magnetic permeability is independent of frequency and consists of only an in-phase component which is negative in sign. When magnetic permeability manifests itself by decreasing the measured amount of positive in-phase, its presence may be difficult to recognize. However, when it manifests itself by yielding a negative in-phase anomaly (e.g., in the absence of eddy current flow), its presence is assured. In this latter case, the negative component can be used to estimate the percent magnetite content.

A magnetite mapping technique, based on the low frequency coplanar data, can be complementary to magnetometer mapping in certain cases. Compared to magnetometry, it is far less sensitive but is more able to resolve closely spaced magnetite zones, as well as providing an estimate of the amount of magnetite in the rock. The method is sensitive to 1/4% magnetite by weight when the EM sensor is at a height of 30 m above a magnetitic half-space. It can individually resolve steep dipping narrow magnetite-rich bands which are separated by 60 m. Unlike magnetometry, the EM magnetite method is unaffected by remanent magnetism or magnetic latitude.

The EM magnetite mapping technique provides estimates of magnetite content which are usually correct within a factor of 2 when the magnetite is fairly uniformly distributed. EM magnetite maps can be generated when magnetic permeability is evident as negative in-phase responses on the data profiles.

Like magnetometry, the EM magnetite method maps only bedrock features, provided that the overburden is characterized by a general lack of magnetite. This contrasts with resistivity mapping which portrays the combined effect of bedrock and overburden.

The Susceptibility Effect

When the host rock is conductive, the positive conductivity response will usually dominate the secondary field, and the susceptibility effect[2] will appear as a reduction in the in-phase, rather than as a negative value. The in-phase response will be lower than would be predicted by a model using zero susceptibility. At higher frequencies the in-phase conductivity response also gets larger, so a negative magnetite effect observed on the low frequency might not be observable on the higher frequencies, over the same body. The susceptibility effect is most obvious over discrete magnetite-rich zones, but also occurs over uniform geology such as a homogeneous half-space.

High magnetic susceptibility will affect the calculated apparent resistivity, if only conductivity is considered. Standard apparent resistivity algorithms use a homogeneous half-space model, with zero susceptibility. For these algorithms, the reduced in-phase response will, in most cases, make the apparent resistivity higher than it should be. It is important to note that there is nothing wrong with the data, nor is there anything wrong with the processing algorithms. The apparent difference results from the fact that the simple geological model used in processing does not match the complex geology.

Measuring and Correcting the Magnetite Effect

Theoretically, it is possible to calculate (forward model) the combined effect of electrical conductivity and magnetic susceptibility on an EM response in all environments. The difficulty lies, however, in separating out the susceptibility effect from other geological effects when deriving resistivity and susceptibility from EM data.

Over a homogeneous half-space, there is a precise relationship between in-phase, quadrature, and altitude. These are often resolved as phase angle, amplitude, and altitude. Within a reasonable range, any two of these three parameters can be used to calculate the half space resistivity. If the rock has a positive magnetic susceptibility, the in-phase component will be reduced and this departure can be recognized by comparison to the other parameters.

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[2] Magnetic susceptibility and permeability are two measures of the same physical property. Permeability is generally given as relative permeability, μ_r, which is the permeability of the substance divided by the permeability of free space ($4 \pi \times 10^{-7}$). Magnetic susceptibility k is related to permeability by $k=\mu^r-1$. Susceptibility is a unitless measurement, and is usually reported in units of 10^{-6}. The typical range of susceptibilities is –1 for quartz, 130 for pyrite, and up to 5×10^5 for magnetite, in 10^{-6} units (Telford et al, 1986).

The algorithm used to calculate apparent susceptibility and apparent resistivity from HEM data, uses a homogeneous half-space geological model. Non half-space geology, such as horizontal layers or dipping sources, can also distort the perfect half-space relationship of the three data parameters. While it may be possible to use more complex models to calculate both rock parameters, this procedure becomes very complex and time-consuming. For basic HEM data processing, it is most practical to stick to the simplest geological model.

Magnetite reversals (reversed in-phase anomalies) have been used for many years to calculate an “FeO” or magnetite response from HEM data (Fraser, 1981). However, this technique could only be applied to data where the in-phase was observed to be negative, which happens when susceptibility is high and conductivity is low.

Applying Susceptibility Corrections

Resistivity calculations done with susceptibility correction may change the apparent resistivity. High-susceptibility conductors, that were previously masked by the susceptibility effect in standard resistivity algorithms, may become evident. In this case the susceptibility corrected apparent resistivity is a better measure of the actual resistivity of the earth. However, other geological variations, such as a deep resistive layer, can also reduce the in-phase by the same amount. In this case, susceptibility correction would not be the best method. Different geological models can apply in different areas of the same data set. The effects of susceptibility, and other effects that can create a similar response, must be considered when selecting the resistivity algorithm.

Susceptibility from EM vs Magnetic Field Data

The response of the EM system to magnetite may not match that from a magnetometer survey. First, HEM-derived susceptibility is a rock property measurement, like resistivity. Magnetic data show the total magnetic field, a measure of the potential field, not the rock property. Secondly, the shape of an anomaly depends on the shape and direction of the source magnetic field. The electromagnetic field of HEM is much different in shape from the earth’s magnetic field. Total field magnetic anomalies are different at different magnetic latitudes; HEM susceptibility anomalies have the same shape regardless of their location on the earth.

In far northern latitudes, where the magnetic field is nearly vertical, the total magnetic field measurement over a thin vertical dike is very similar in shape to the anomaly from the HEM-derived susceptibility (a sharp peak over the body). The same vertical dike at the magnetic equator would yield a negative magnetic anomaly, but the HEM susceptibility anomaly would show a positive susceptibility peak.

Effects of Permeability and Dielectric Permittivity

Resistivity algorithms that assume free-space magnetic permeability and dielectric permittivity, do not yield reliable values in highly magnetic or highly resistive areas. Both magnetic polarization and displacement currents cause a decrease in the in-phase component, often resulting in negative values that yield erroneously high apparent resistivities. The effects of magnetite occur at all frequencies, but are most evident at the lowest frequency. Conversely, the negative effects of dielectric permittivity are most evident at the higher frequencies, in resistive areas.

The table below shows the effects of varying permittivity over a resistive (10,000 ohm-m) half space, at frequencies of 56,000 Hz (DIGHEM^V) and 102,000 Hz (RESOLVE).

Apparent Resistivity Calculations
Effects of Permittivity on In-phase/Quadrature/Resistivity

Freq (Hz)	Coil	Sep (m)	Thres (ppm)	Alt (m)	In Phase	Quad Phase	App Res	App Depth (m)	Permittivity
56,000	CP	6.3	0.1	30	7.3	35.3	10118	-1.0	1 Air
56,000	CP	6.3	0.1	30	3.6	36.6	19838	-13.2	5 Quartz
56,000	CP	6.3	0.1	30	-1.1	38.3	81832	-25.7	10 Epidote
56,000	CP	6.3	0.1	30	-10.4	42.3	76620	-25.8	20 Granite
56,000	CP	6.3	0.1	30	-19.7	46.9	71550	-26.0	30 Diabase
56,000	CP	6.3	0.1	30	-28.7	52.0	66787	-26.1	40 Gabbro
102,000	CP	7.86	0.1	30	32.5	117.2	9409	-0.3	1 Air
102,000	CP	7.86	0.1	30	11.7	127.2	25956	-16.8	5 Quartz
102,000	CP	7.86	0.1	30	-14.0	141.6	97064	-26.5	10 Epidote
102,000	CP	7.86	0.1	30	-62.9	176.0	83995	-26.8	20 Granite
102,000	CP	7.86	0.1	30	-107.5	215.8	73320	-27.0	30 Diabase
102,000	CP	7.86	0.1	30	-147.1	259.2	64875	-27.2	40 Gabbro

Methods have been developed (Huang and Fraser, 2000, 2001) to correct apparent resistivities for the effects of permittivity and permeability. The corrected resistivities yield more credible values than if the effects of permittivity and permeability are disregarded.

Recognition of Culture

Cultural responses include all EM anomalies caused by man-made metallic objects. Such anomalies may be caused by inductive coupling or current gathering. The concern of the interpreter is to recognize when an EM response is due to culture. Points of consideration used by the interpreter, when coaxial and coplanar coil-pairs are operated at a common frequency, are as follows:

1. Channels CXPL and CPPL monitor 60 Hz radiation. An anomaly on these channels shows that the conductor is radiating power. Such an indication is normally a guarantee that the conductor is cultural. However, care must be taken to ensure that the conductor is not a geologic body that strikes across a power line, carrying leakage currents.

2. A flight that crosses a "line" (e.g., fence, telephone line, etc.) yields a centre-peaked coaxial anomaly and an m-shaped coplanar anomaly.[3] When the flight crosses the cultural line at a high angle of intersection, the amplitude ratio of coaxial/coplanar response is 2. Such an EM anomaly can only be caused by a line. The geologic body that yields anomalies most closely resembling a line is the vertically dipping thin dike. Such a body, however, yields an amplitude ratio of 1 rather than 2. Consequently, an m-shaped coplanar anomaly with a CXI/CPI amplitude ratio of 2 is virtually a guarantee that the source is a cultural line.

3. A flight that crosses a sphere or horizontal disk yields centre-peaked coaxial and coplanar anomalies with a CXI/CPI amplitude ratio (i.e., coaxial/coplanar) of 1/8. In the absence of geologic bodies of this geometry, the most likely conductor is a metal roof or small fenced yard.[4] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

4. A flight that crosses a horizontal rectangular body or wide ribbon yields an m-shaped coaxial anomaly and a centre-peaked coplanar anomaly. In the absence of geologic bodies of this geometry, the most likely conductor is a large fenced area.[5] Anomalies of this type are virtually certain to be cultural if they occur in an area of culture.

5. EM anomalies that coincide with culture, as seen on the camera film or video display, are usually caused by culture. However, care is taken with such coincidences because a geologic conductor could occur beneath a fence, for example. In this example, the fence would be expected to yield an m-shaped coplanar anomaly as in case #2 above. If, instead, a centre-peaked coplanar anomaly occurred, there would be concern that a thick geologic conductor coincided with the cultural line.

6. The above description of anomaly shapes is valid when the culture is not conductively coupled to the environment. In this case, the anomalies arise from inductive coupling to the EM transmitter. However, when the environment is quite conductive (e.g., less than 100 ohm-m at 900 Hz), the cultural conductor may be conductively coupled to the environment. In this latter case, the anomaly shapes tend to be governed by current gathering. Current gathering can completely distort

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[3] See Figure B-1 presented earlier.

[4] It is a characteristic of EM that geometrically similar anomalies are obtained from: (1) a planar conductor, and (2) a wire which forms a loop having dimensions identical to the perimeter of the equivalent planar conductor.

the anomaly shapes, thereby complicating the identification of cultural anomalies. In such circumstances, the interpreter can only rely on the radiation channels and on the camera film or video records.

Magnetic Responses

The measured total magnetic field provides information on the magnetic properties of the earth materials in the survey area. The information can be used to locate magnetic bodies of direct interest for exploration, and for structural and lithological mapping.

The total magnetic field response reflects the abundance of magnetic material in the source. Magnetite is the most common magnetic mineral. Other minerals such as ilmenite, pyrrhotite, franklinite, chromite, hematite, arsenopyrite, limonite and pyrite are also magnetic, but to a lesser extent than magnetite on average.

In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulphides than one which is non-magnetic. However, sulphide ore bodies may be non-magnetic (e.g., the Kidd Creek deposit near Timmins, Canada) as well as magnetic (e.g., the Mattabi deposit near Sturgeon Lake, Canada).

Iron ore deposits will be anomalously magnetic in comparison to surrounding rock due to the concentration of iron minerals such as magnetite, ilmenite and hematite.

Changes in magnetic susceptibility often allow rock units to be differentiated based on the total field magnetic response. Geophysical classifications may differ from geological classifications if various magnetite levels exist within one general geological classification. Geometric considerations of the source such as shape, dip and depth, inclination of the earth's field and remanent magnetization will complicate such an analysis.

In general, mafic lithologies contain more magnetite and are therefore more magnetic than many sediments which tend to be weakly magnetic. Metamorphism and alteration can also increase or decrease the magnetization of a rock unit.

Textural differences on a total field magnetic contour, colour or shadow map due to the frequency of activity of the magnetic parameter resulting from inhomogeneities in the distribution of magnetite within the rock, may define certain lithologies. For example, near surface volcanics may display highly complex contour patterns with little line-to-line correlation.

Rock units may be differentiated based on the plan shapes of their total field magnetic responses. Mafic intrusive plugs can appear as isolated "bulls-eye" anomalies. Granitic intrusives appear as sub-circular zones, and may have contrasting rings due to contact metamorphism. Generally, granitic terrain will lack a pronounced strike direction, although granite gneiss may display strike.

Linear north-south units are theoretically not well-defined on total field magnetic maps in equatorial regions due to the low inclination of the earth's magnetic field. However, most stratigraphic units will have variations in composition along strike that will cause the units to appear as a series of alternating magnetic highs and lows.

Faults and shear zones may be characterized by alteration that causes destruction of magnetite (e.g., weathering) that produces a contrast with surrounding rock. Structural breaks may be filled by magnetite-rich, fracture filling material as is the case with diabase dikes, or by non-magnetic felsic material.

Faulting can also be identified by patterns in the magnetic total field contours or colours. Faults and dikes tend to appear as lineaments and often have strike lengths of several kilometres. Offsets in narrow, magnetic, stratigraphic trends also delineate structure. Sharp contrasts in magnetic lithologies may arise due to large displacements along strike-slip or dip-slip faults.

APPENDIX C

DATA ARCHIVE DESCRIPTION

APPENDIX C

ARCHIVE DESCRIPTION

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Reference #    : CDVD00314
Number of DVD's: 1
Archive Date   : 2008-Sept-12

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This archive contains final data archives, grids and map files of an airborne
geophysical survey conducted by FUGRO AIRBORNE SURVEYS CORP. on behalf of
North Platte Natural Resources over North Platte River, Lodgepole Creek and Sydney Draw
areas, Nebraska.

Job # 08035

--------------------------------------------------------------------------------

******* Disc 1 of 1 *******

This archive comprises 142 files in four directories and 2 files in the root directory:


\README.txt - This file


\FASSurveyReplay.exe  - Fugro Airborne Surveys flight video viewer installation program.
                  To install the viewer run the executeable file and accept the default
settings
                  To view the digital video copy the *.bin and *.bdx files to same
directory.
                  Press the play tab to start video or stop to end video.
                        If you have any difficulty with this program contact the
processing manager.

Grids\

        ADDITIONAL_ALTRADAR.GRD          - Radar Altimeter m
        ADDITIONAL_DTM.GRD               - Digital Terrain Model m
        ADDITIONAL_LASER.GRD             - Laser Altimeter m
        ADDITIONAL_MAG.GRD               - Residual Magnetic Field nT
        ADDITIONAL_RES140K.GRD           - Apparent Resistivity 129550 Hz coplanar ohm.m
        ADDITIONAL_RES1800.GRD           - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        ADDITIONAL_RES400.GRD            - Apparent Resistivity 380 Hz coplanar ohm.m
        ADDITIONAL_RES40K.GRD            - Apparent Resistivity 41020 Hz coplanar ohm.m
        ADDITIONAL_RES8200.GRD           - Apparent Resistivity 8171 Hz coplanar ohm.m
        LODGEPOLE_ALTRADAR.GRD           - Radar Altimeter m
        LODGEPOLE_DTM.GRD                - Digital Terrain Model m
        LODGEPOLE_LASER.GRD              - Laser Altimeter m
        LODGEPOLE_MAG.GRD                - Residual Magnetic Field nT
        LODGEPOLE_RES140K.GRD            - Apparent Resistivity 129550 Hz coplanar ohm.m
        LODGEPOLE_RES1800.GRD            - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        LODGEPOLE_RES400.GRD             - Apparent Resistivity 380 Hz coplanar ohm.m
        LODGEPOLE_RES40K.GRD             - Apparent Resistivity 41020 Hz coplanar ohm.m
        LODGEPOLE_RES8200.GRD            - Apparent Resistivity 8171 Hz coplanar ohm.m
        NPlatteBLOCK_ALTRADAR.GRD        - Radar Altimeter m
        NPlatteBLOCK_DTM.GRD             - Digital Terrain Model m
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        NPlatteBLOCK_LASER.GRD            - Laser Altimeter m
        NPlatteBLOCK_MAG.GRD              - Residual Magnetic Field nT
        NPlatteBLOCK_RES140K.GRD          - Apparent Resistivity 129550 Hz coplanar ohm.m
        NPlatteBLOCK_RES1800.GRD          - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        NPlatteBLOCK_RES400.GRD           - Apparent Resistivity 380 Hz coplanar ohm.m
        NPlatteBLOCK_RES40K.GRD           - Apparent Resistivity 41020 Hz coplanar ohm.m
        NPlatteBLOCK_RES8200.GRD          - Apparent Resistivity 8171 Hz coplanar ohm.m
        NPlatte-EW_ALTRADAR.GRD           - Radar Altimeter m
        NPlatte-EW_DTM.GRD                - Digital Terrain Model m
        NPlatte-EW_LASER.GRD              - Laser Altimeter m
        NPlatte-EW_MAG.GRD                - Residual Magnetic Field nT
        NPlatte-EW_RES140K.GRD            - Apparent Resistivity 129550 Hz coplanar ohm.m
        NPlatte-EW_RES1800.GRD            - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        NPlatte-EW_RES400.GRD             - Apparent Resistivity 380 Hz coplanar ohm.m
        NPlatte-EW_RES40K.GRD             - Apparent Resistivity 41020 Hz coplanar ohm.m
        NPlatte-EW_RES8200.GRD            - Apparent Resistivity 8171 Hz coplanar ohm.m
        NPlatte-NS_ALTRADAR.GRD           - Radar Altimeter m
        NPlatte-NS_DTM.GRD                - Digital Terrain Model m
        NPlatte-NS_LASER.GRD              - Laser Altimeter m
        NPlatte-NS_MAG.GRD                - Residual Magnetic Field nT
        NPlatte-NS_RES140K.GRD            - Apparent Resistivity 129550 Hz coplanar ohm.m
        NPlatte-NS_RES1800.GRD            - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        NPlatte-NS_RES400.GRD             - Apparent Resistivity 380 Hz coplanar ohm.m
        NPlatte-NS_RES40K.GRD             - Apparent Resistivity 41020 Hz coplanar ohm.m
        NPlatte-NS_RES8200.GRD            - Apparent Resistivity 8171 Hz coplanar ohm.m
        SYDNEYD-NS_ALTRADAR.GRD           - Radar Altimeter m
        SYDNEYD-NS_DTM.GRD                - Digital Terrain Model m
        SYDNEYD-NS_LASER.GRD              - Laser Altimeter m
        SYDNEYD-NS_MAG.GRD                - Residual Magnetic Field nT
        SYDNEYD-NS_RES140K.GRD            - Apparent Resistivity 129550 Hz coplanar ohm.m
        SYDNEYD-NS_RES1800.GRD            - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        SYDNEYD-NS_RES400.GRD             - Apparent Resistivity 380 Hz coplanar ohm.m
        SYDNEYD-NS_RES40K.GRD             - Apparent Resistivity 41020 Hz coplanar ohm.m
        SYDNEYD-NS_RES8200.GRD            - Apparent Resistivity 8171 Hz coplanar ohm.m
        SYDNEYD-SW_ALTRADAR.GRD           - Radar Altimeter m
        SYDNEYD-SW_DTM.GRD                - Digital Terrain Model m
        SYDNEYD-SW_LASER.GRD              - Laser Altimeter m
        SYDNEYD-SW_MAG.GRD                - Residual Magnetic Field nT
        SYDNEYD-SW_RES140K.GRD            - Apparent Resistivity 129550 Hz coplanar ohm.m
        SYDNEYD-SW_RES1800.GRD            - Apparent Resistivity 1792.6 Hz coplanar ohm.m
        SYDNEYD-SW_RES400.GRD             - Apparent Resistivity 380 Hz coplanar ohm.m
        SYDNEYD-SW_RES40K.GRD             - Apparent Resistivity 41020 Hz coplanar ohm.m
        SYDNEYD-SW_RES8200.GRD            - Apparent Resistivity 8171 Hz coplanar ohm.m


Linedata\

        Additional.gdb                    - linedata archive in Geosoft binary format
        Additional.xyz                    - linedata archive in Geosoft ASCII format
        Lodgepole.gdb                     - linedata archive in Geosoft binary format
        Lodgepole.xyz                     - linedata archive in Geosoft ASCII format
        NPlatteBlock.gdb                  - linedata archive in Geosoft binary format
        NPlatteBlock.xyz                  - linedata archive in Geosoft ASCII format
        NPlatte-EW.gdb                    - linedata archive in Geosoft binary format
```

- Appendix C.3 -

```
        NPlatte-EW.xyz                    - linedata archive in Geosoft ASCII format
        NPlatte-NS.gdb                    - linedata archive in Geosoft binary format
        NPlatte-NS.xyz                    - linedata archive in Geosoft ASCII format
        SydneyD-NE.gdb                    - linedata archive in Geosoft binary format
        SydneyD-NE.xyz                    - linedata archive in Geosoft ASCII format
        SydneyD-SW.gdb                    - linedata archive in Geosoft binary format
        SydneyD-SW.xyz                    - linedata archive in Geosoft ASCII format
        NPlatteArchive.txt                - linedata archive in Geosoft binary format

The GDB and XYZ files contain the following channels;

*****************************************************************************************
Survey Data Format
-------------------
#      Channel      Time   Units         Description
 1 Line        0.1         Line numbers
 2 X           0.1   m     Final bird easting (NAD83) UTM Z13N
 3 Y           0.1   m     Final Bird Northing (NAD83) UTM Z13N
 4 FID         0.1         Fiducial counter
 5 Z           0.1   m     Leveled height of EM bird above WGS84 ellipsoid
 6 BALT        0.1   m     Leveled barometric altitude of helicopter
 7 LASER       0.1   m     Em Bird to Earth-Surface, Laser Altimeter
 8 ALTRADAR    0.1   m     Helicopter to Earth-Surface, Radar Altimeter
 9 DTM         0.1   m     Digital Terrain Model
10 MAGSP       0.1   nT    Despiked total magnetic field
11 DIURNAL     0.1   nT    Base level removed diurnal magnetic correction
12 MAGLD       0.1   nT    Lagged diurnal corrected total magnetic field
13 IGRF        0.1   nT    International Geomagnetic Reference Field 2005 based on date
14 MAG         0.1   nT    Leveled residual magnetic field
15 CPPL        0.1         Coplanar powerline monitor
16 CXSP        0.1         Coaxial powerline monitor
17 CPSP        0.1         Coplanar atmospheric monitor
18 CPI400_CAL  0.1   ppm   Raw Inphase-Coplanar 380 Hz
19 CPQ400_CAL  0.1   ppm   Raw Quadrature-Coplanar 380 Hz
20 CPI1800_CAL 0.1   ppm   Raw Inphase-Coplanar 1792.6 Hz
21 CPQ1800_CAL 0.1   ppm   Raw Quadrature-Coplanar 1792.6 Hz
22 CXI3300_CAL 0.1   ppm   Raw Inphase-Coaxial 3345 Hz
23 CXQ3300_CAL 0.1   ppm   Raw Quadrature-Coaxial 3345 Hz
24 CPI8200_CAL 0.1   ppm   Raw Inphase-Coplanar 8171 Hz
25 CPQ8200_CAL 0.1   ppm   Raw Quadrature-Coplanar 8171 Hz
26 CPI40K_CAL  0.1   ppm   Raw Inphase-Coplanar 41020 Hz
27 CPQ40K_CAL  0.1   ppm   Raw Quadrature-Coplanar 41020 Hz
28 CPI140K_CAL 0.1   ppm   Raw Inphase-Coplanar 129550 Hz
29 CPQ140K_CAL 0.1   ppm   Raw Quadrature-Coplanar 129550 Hz
30 CPI400_R    0.1   ppm   Background leveled, lagged Inphase-Coplanar 380 Hz
31 CPQ400_R    0.1   ppm   Background leveled, lagged Quadrature-Coplanar 380 Hz
32 CPI1800_R   0.1   ppm   Background leveled, lagged Inphase-Coplanar 1792.6 Hz
33 CPQ1800_R   0.1   ppm   Background leveled, lagged Quadrature-Coplanar 1792.6 Hz
34 CXI3300_R   0.1   ppm   Background leveled, lagged Inphase-Coaxial 3345 Hz
35 CXQ3300_R   0.1   ppm   Background leveled, lagged Quadrature-Coaxial 3345 Hz
36 CPI8200_R   0.1   ppm   Background leveled, lagged Inphase-Coplanar 8171 Hz
37 CPQ8200_R   0.1   ppm   Background leveled, lagged Quadrature-Coplanar 8171 Hz
38 CPI40K_R    0.1   ppm   Background leveled, lagged Inphase-Coplanar 41020 Hz
39 CPQ40K_R    0.1   ppm   Background leveled, lagged Quadrature-Coplanar 41020 Hz
```

40	CPI140K_R	0.1	ppm	Background leveled, lagged Inphase-Coplanar 129550 Hz
41	CPQ140K_R	0.1	ppm	Background leveled, lagged Quadrature-Coplanar 129550 Hz
42	CPI400	0.1	ppm	Final leveled Inphase-Coplanar 380 Hz
43	CPQ400	0.1	ppm	Final leveled Quadrature-Coplanar 380 Hz
44	CPI1800	0.1	ppm	Final leveled Inphase-Coplanar 1792.6 Hz
45	CPQ1800	0.1	ppm	Final leveled Quadrature-Coplanar 1792.6 Hz
46	CXI3300	0.1	ppm	Final leveled Inphase-Coaxial 3345 Hz
47	CXQ3300	0.1	ppm	Final leveled Quadrature-Coaxial 3345 Hz
48	CPI8200	0.1	ppm	Final leveled Inphase-Coplanar 8171 Hz
49	CPQ8200	0.1	ppm	Final leveled Quadrature-Coplanar 8171 Hz
50	CPI40K	0.1	ppm	Final leveled Inphase-Coplanar 41020 Hz
51	CPQ40K	0.1	ppm	Final leveled Quadrature-Coplanar 41020 Hz
52	CPI140K	0.1	ppm	Final leveled Inphase-Coplanar 129550 Hz
53	CPQ140K	0.1	ppm	Final leveled Quadrature-Coplanar 129550 Hz
54	RES400	0.1	ohm.m	Preliminary Apparent Resistivity 380 Hz
55	RES1800	0.1	ohm.m	Preliminary Apparent Resistivity 1792.6 Hz
56	RES3300	0.1	ohm.m	Preliminary Apparent Resistivity 3345 Hz Coaxial
57	RES8200	0.1	ohm.m	Preliminary Apparent Resistivity 8171 Hz
58	RES40K	0.1	ohm.m	Preliminary Apparent Resistivity 41020 Hz
59	RES140K	0.1	ohm.m	Preliminary Apparent Resistivity 129550 Hz
60	DEP400	0.1	m	Preliminary Apparent Depth 380 Hz
61	DEP1800	0.1	m	Preliminary Apparent Depth 1792.6 Hz
62	DEP3300	0.1	m	Preliminary Apparent Depth 3345 Hz Coaxial
63	DEP8200	0.1	m	Preliminary Apparent Depth 8171 Hz
64	DEP40K	0.1	m	Preliminary Apparent Depth 41020 Hz
65	DEP140K	0.1	m	Preliminary Apparent Depth 129550 Hz
66	DRES400	0.1	ohm.m	Differential Apparent Resistivity 380 Hz
67	DRES1800	0.1	ohm.m	Differential Apparent Resistivity 1792.6 Hz
68	DRES8200	0.1	ohm.m	Differential Apparent Resistivity 8171 Hz
69	DRES40K	0.1	ohm.m	Differential Apparent Resistivity 41020 Hz
70	DRES140K	0.1	ohm.m	Differential Apparent Resistivity 129550 Hz
71	DDEP400	0.1	m	Differential Depth 380 Hz
72	DDEP1800	0.1	m	Differential Depth 1792.6 Hz
73	DDEP8200	0.1	m	Differential Depth 8171 Hz
74	DDEP40K	0.1	m	Differential Depth 41020 Hz
75	DDEP140K	0.1	m	Differential Depth 129550 Hz
76	CEN400	0.1	m	Centroid Depth 380 Hz
77	CEN1800	0.1	m	Centroid Depth 1792.6 Hz
78	CEN8200	0.1	m	Centroid Depth 8171 Hz
79	CEN40K	0.1	m	Centroid Depth 41020 Hz
80	CEN140K	0.1	m	Centroid Depth 129550 Hz
81	UTC	0.1	sec	Time
82	FLIGHT	0.1		Flight number
83	DATE	0.1	yyyy/mm/dd	Date

Profiles\ Stacked profiles (2 per sheet in most instances) with differential resistivity color sections in Adobe Acrobat (.pdf) format.

Each PDF file name is based on the name of the first line in the stack.

PROF10010 - contains line 10010 and 10060
PROF10014 - contains line 10014 and 10015
PROF10016 - contains line 10016 and 10060
PROF10020 - contains line 10020 and 10070
PROF10030 - contains line 10030 and 10080

- Appendix C.5 -

PROF10040 - contains line 10040 and 10090
PROF10050 - contains line 10050 and 100100
PROF20010(1) - contains line 20010 and 20020
PROF20010(2) - contains line second half of line 20010
PROF20030 - contains line 20030 and 20040
PROF20050 - contains line 20050 and 20060
PROF20070 - contains line 20070 and 20080
PROF20090 - contains line 20090 and 20100
PROF20110 - contains line 20110 and 20120
PROF20130(1) - contains the first half of line 20130
PROF20130(1) - contains the second half of line 20130
PROF30010 - contains line 30010 and 30020
PROF30030 - contains line 30030 and 30040
PROF30050 - contains line 30050 and 30060
PROF30070 - contains line 30070 and 30080
PROF30090 - contains line 30090
PROF39010 - contains line 39010
PROF40010 - contains line 40010 and 40060
PROF40020 - contains line 40020 and 40070
PROF40030(1) - contains first half of lines 40030 and 40080
PROF40030(2) - contains second half of lines 40030 and 40080
PROF40041 - contains line 40041 and 40090
PROF40042 - contains line 40042 and 40090
PROF40043 - contains line 40043 and 40090
PROF40044 - contains line 40044 and 40090
PROF40051 - contains line 40051 and 40090
PROF40056 - contains line 40056 and 40090
PROF49010 - contains line 49010
PROF50010 - contains line 50010 and 50020
PROF50030 - contains line 50030 and 50040
PROF50050 - contains line 50050
PROF50060 - contains line 50060 and 50070
PROF50080 - contains line 50080 and 50090
PROF50100 - contains line 50100
PROF50110 - contains line 50110 and 50120
PROF50130 - contains line 50130 and 50140
PROF50150 - contains line 50150
PROF50160 - contains line 50160 and 50170
PROF50180 - contains line 50180 and 50190
PROF50200 - contains line 50200
PROF50210 - contains line 50210 and 50220
PROF50230 - contains line 50230 and 50240
PROF50250 - contains line 50250
PROF50260 - contains line 50260 and 50270
PROF59010 - contains line 59010
PROF60010 - contains line 60010 and 60020
PROF60030 - contains line 60030 and 60040
PROF60050 - contains line 60050
PROF60060 - contains line 60060 and 60070
PROF60080 - contains line 60080 and 60090
PROF60100 - contains line 60100
PROF60110 - contains line 60110 and 60120
PROF60130 - contains line 60130 and 60140
PROF60150 - contains line 60150

```
      PROF69011   - contains line 69011
      PROF69020   - contains line 69020
      PROF70010   - contains line 50180 and 70010
      PROF70020   - contains line 50180 and 70020




Report\ report in Adobe Acrobat (.pdf) format v1.3

      r08035_sept.pdf - final report

--------------------------------------------------------------------------------
The coordinate system for all grids and the data archive is projected as follows

Datum                               NAD83
Spheroid                            WGS84
Projection                          UTM
Central meridian                    105 West (Z13N)
False easting                       500000
False northing                      0
Scale factor                        0.9996
Northern parallel                   N/A
Base parallel                       N/A
WGS84 to local conversion method    Molodensky
Delta X shift                       0
Delta Y shift                       0
Delta Z shift                       0
--------------------------------------------------------------------------------
If you have any problems with this archive please contact

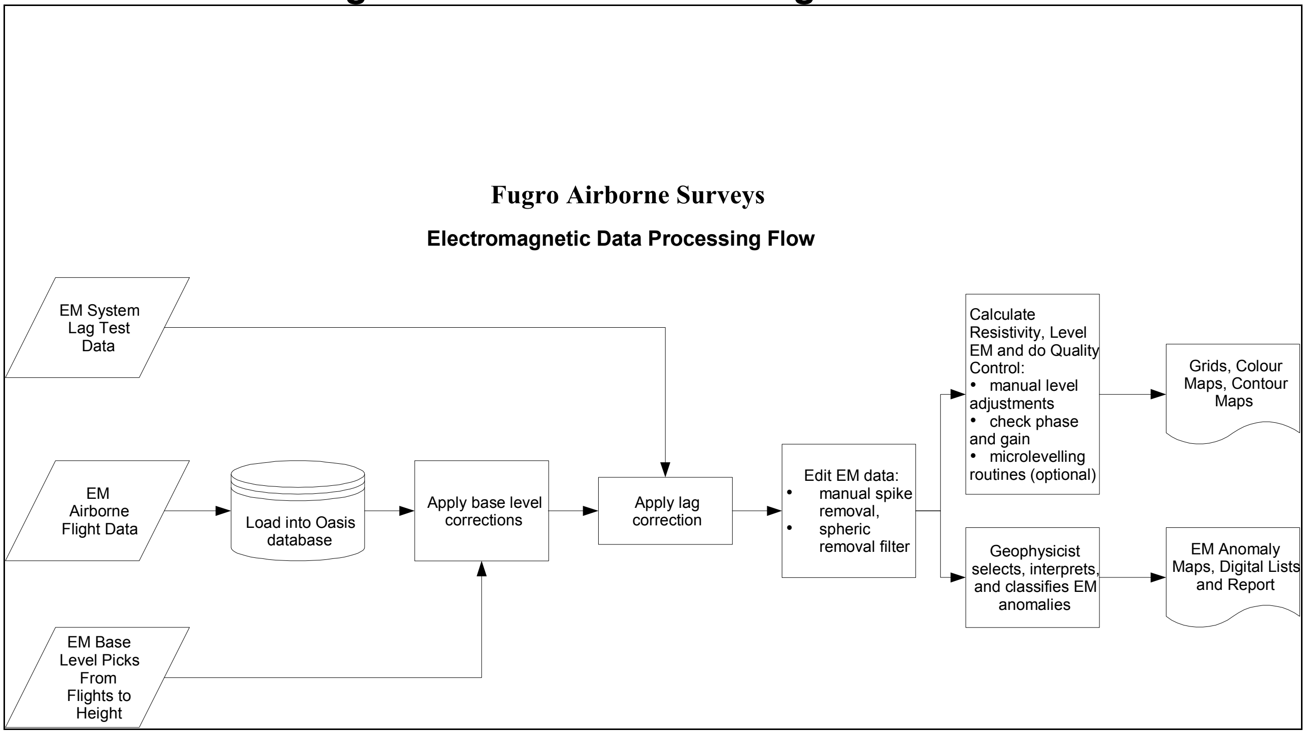
      Processing Manager
      FUGRO AIRBORNE SURVEYS CORP.
      2270 Argentia Road, Unit 2
      Mississauga, Ontario
      Canada    L5N 6A6
      Tel (905) 812-0212
      Fax (905) 812-1504
      E-mail toronto@fugroairborne.com
```

APPENDIX D

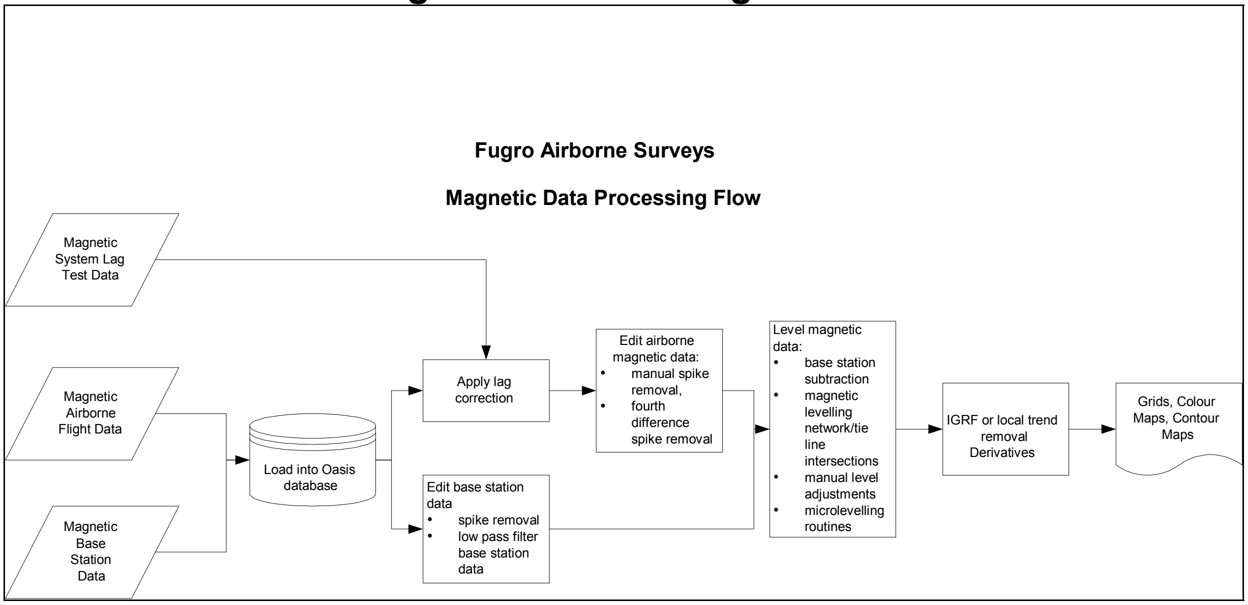
DATA PROCESSING FLOWCHARTS

APPENDIX D

Processing Flow Chart - Electromagnetic Data



Processing Flow Chart - Magnetic Data



APPENDIX E

FLIGHT LOGS

FUGRO

FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0001

DATE June 15, 2008 | OPERATOR Andy S. Jorge | PILOT Chris Tucker
FLIGHT TIME | START: | END: | TOTAL (hrs): 2.6 h. | WEATHER: calm, 13 °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No) | System Changes (Yes / [✓ No]) – If YES, note details below
Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 9] 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8300	380	129K	1793	3347
TX	21.9	19.9	16.5	24.7	19.4	22.1
RX	7	1	22	14	13	24

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status) Scottsbluff, North Platte Nebraska

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal	358	~~1340~~		450	~~138~~
Q				710	
30010	358	1340	2019	Q2108	1389 P.L., 1432 P.L., 1516 building, 1566 P.L.
					1665 P.L. 1752 P.L., 1809 P.L., 1861, 1924 P.L.
30020	178	2303	2970		2387 P.L., 2456 P.L., 2542 P.L. 2590 P.L.
					2637 P.L., 2703 P.L. 2740 P.L., 2868 train
					2913 P.L.
30030	358	3053	3720	Q3882	3053 Farm → offline, 3094 P.L., 3139 Railway
					3250 railway, 3257 P.L. 3370 P.L.
					3512 PL. 3521 P.L. 3551 PL, 3614 Farm (offline)
30040	178	4088	4830		4167 P.L. 4283 P.L, 4330, 4378 P.L. 4542 P.L.
					4558 P.L., 4583 P.L., 4676 P.L., 4735 P.L.
					4795 P.L.
30050	358	4867	5582	Q5731	4964 railway, 5053 P.L. 5078 P.L./house
					5157 P.L., 5320 P.L., 5371 P.L.
30060	178	5912	6653	~~[illegible]~~	6226 P.L, 6300 P.L, 6357 trees.
					6404 P.L., 6418 P.L., 6441 P.L.,
					6535 train, 6585 PL, 6632 PL
30070	358	6735		Q7608	6779 PL, 6827 train, 6894 P.L.
					6922 PL, 6946 P.L. 6960 PL, 7025 PL,
					7038 Building, 7067 PL, 7083 trees.
					7112 PL, 7137 PL, 7238 PL.
30080					
~~7770~~	178	7770			7976 house, 8094 trees, 8124 PL,
					8154 tree, 8176 PL, 8195 house,
					8209 house. 8230 animals "farm"
					8282 P.L 8292 stown, 8322 PL,
					trees, 8353 PL. 8390 house,
					8420, rail train, 8473 PL, 8527 PL,
				Q8660	

358
178

(SAFETY FIRST, be aware of your surroundings)

FUGRO FLIGHT LOG

SYSTEM BKS 60 **JOB#** 08035 **FLT#** 0004

358

DATE	Jun 15/2008	OPERATOR	Jorge, Andy	PILOT	Chris T.
FLIGHT TIME	START:	END:	TOTAL (Hrs): 0,8 H	WEATHER:	, °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	M / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	S / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41 K	8323	380	124 K	1795	3352
TX	23.6	21.4	17.7	26.7	20.7	23.8
RX	7	1	25	12	13	25

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
AutoCAL				15	
Q190					
30090	358	~~339~~ 331	760	Q840	382 pl, 433 rail, 489 pl, 516 pl, trees,
					533 aroma town, 550 pl, 586
					farms, houses, 651 pl, 694 pl,
					721, house, pl, trees, 745 truck,
					CH3 off

Jorge Naranjo

FUGRO FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0006

DATE	June 15, 2008	OPERATOR	Andy S, Jorge N	PILOT	Chris Tucker
START:		END:	TOTAL (hrs): 1.9 H (1.9H)	WEATHER:	,30 °C

1) PRE-FLIGHT CHECK

Tow cable inspection ([✓ Yes] / No) System Changes ([✓ Yes] / No) – If YES, note details below

Details: PFL2 fixed, all Tx driver tuned

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 [✓ 3]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - If Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41k	8320	380	129k	1796	3351
TX	23.0	20.7	17.4	25.5	20.2	23.1
RX	7	1	22	11	11	25

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

358
178

137

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED: ____, CACHE #: ____
[illegible]					
[illegible]		[illegible]	166.	Q 197	
030090	358	572	1277		600 house, 660 Rails, 715 PL, 745 PL.,
					759, around town, 834 farm,
					854, trees, 894, PL, 936 PL,
					960 PL, trees, 1012 house,
39010	269	1455	1589		
30100→ 30100	178	1992		Q 1783	2245, PL, 2298 PL, 2357 PL
					2392 PL, 2417 PL house, 2427 house.
					2460, around town, 2491, PL,
					2510, PL, 2530 MAG off.
		2711 →			Restart section.
	178	2711	2927		2804 PL, train, 2859 PL, 2912 PL
39020	89	3165	3310	Q3474	3259 PL, 3309 PL
Autocal		120		Q170	FLT0009
10010					

(SAFETY FIRST - be aware of your surroundings)

FUGRO

FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0010

DATE June 16, 2008	OPERATOR Andy S Jorge	PILOT Chris Tucker	
FLIGHT TIME START:	END:	TOTAL (hrs): 2.9 H	WEATHER: +15 °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)

System Changes ([✓ Yes] / No) – If YES, note details below

Details: Rx 2 pre-amp changed

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8313	380	129K	1792	3347
TX	23.4	21.3	17.3	26.4	20.1	23.2
RX	7	2	22	15	13	25

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status) Platte North, Nebraska

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				655	
Q				825	
				Q1105	
10011	132	1402			1516 P.L.
10012	143	1582			
10013	114	1645			
10014	088	1687			1720 railway 1802 P.L.
10015	092	1861			1840-1880 mag, 1915 P.L., 1997 P.L.
10016	100	2038			★ mag drop 2050, 2090 P.L. 2170 P.L.
10017	125	2235	2665	Q2740	2258 P.L. 2325 P.L., 2400 P.L.
					2516 P.L., 2560 P.L. 2598
10021	113	2913			2965 P.L. 2985, 3025 P.L. 3042 P.L.
10021	113	3251			3124 airport, 3142 transmit
					3290 P.L.
10022	118	3336			
10023	107	3439			
10024		3508			3520 mag drop, 3577 P.L. 3605 P.L.
10030	113	3680	4005	Q4118	3761 P.L., 3891 P.L. 3942 P.L.
10041	112	4236			4297 P.L. 4397 P.L., 4445 P.L.
10042	104	4563			4585 P.L., 4623 tall trees
10051	127	4903			4925 P.L., 4939 railway, 5012 P.L.
					5049 P.L. 5075 P.L., 5151 P.L.
10052	118	5184			5190 mag drop, 5256 trees
10053	109	5409	5798	Q5886	5568 P.L., 5620 P.L., 5679 P.L.
					5715 P.L.
10103	289	6088			Farm 6011, around farm/town
					6119 P.L., 6181 P.L., 6320 trees/P.L.
10102	298	6460			6390 P.L., 6579 P.L., 6637 P.L.
10101	307	6676			
10092	284	6857			
10091	292	7183	7398	Q7493	7025 mag, 7105 mag, 7398 town → stop
10082	293	7631			▲7621 around town, 7660 mag drop
					7749 P.L.
10081	316	7835			7846 P.L.
10071	298	7920	8137		7955 P.L., 8027 antenna

around town ★ not official

(SAFETY FIRST, be aware of your surroundings)

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FLIGHT LOG

Resolve
SYSTEM BK560 JOB# 08035 FLT# 0011

DATE	Jun 16 / 2008	OPERATOR	Jorge Naranjo	PILOT	Chris Tovar
FLIGHT TIME	START:	END:	TOTAL (hrs): 1.5	WEATHER:	, °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	S / F
Spectrometer (Yes / No) - If Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41[illegible]	8332	380	129	1795	3351
TX	23.3	21.2	17.5	26.0	20.6	23.5.
RX	7	2	23	14	12	25.

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

358
178

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:______, CACHE #:______
20020	358	725	1193	Q413	736 PL, 764 PL, 812 Rail train,
					824 PL, 867 PL, 913 PL, 936 PL,
					996 trees, 1010 PL, 1034 pl,
					1047 over trees 1103 house,
					1071
				Q1400	
20010	178	1707	3479		1767 PL, 1818 PL, 1875 PL, 1934 PL
					1982 pL, 2004 tree, 2030 PL,
					2054 tree, 2079 trees, 2167 trees
					power lines, 2282 PL, 2289 rail
					train, 2339 PL, 2398 pL, 2411 PL,
					2427 rail train, 2507 PL, 2557
					Animals farm 2680 PL, 2709 PL,
					2714 a town, 2803 PL, 2883 PL
					2970 house, PL, trees, 3002 PL, 3030 PL,
					3089 PL, 3151 pl, 3175 pL,
					3211 Big PL, 3269, Pl
20030	358		[illegible]	Q3596	

(SAFETY FIRST, be aware of your surroundings)

FUGRO

FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0012 , 0013

DATE Jun 17/2008 OPERATOR Jorge Naranjo PILOT Christ Toxov

FLIGHT TIME START: 945 END: 12:45 TOTAL (hrs): 2.7 WEATHER: Good. , 17 °C

~~138~~
358
178

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)
System Changes (Yes / [✓ No]) – If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8315	380	129K	1795	3351
TX	22.6	20.12	16.6	25	19.7	22.4
RX						

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Autocal

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Q				Q947	
20040	358	1209	1550		1217, pL, house, 1279 pL, 1334 PL,
					1341 PL, 1386 PL, 1470 house PL,
					1513 elevation, pl
				Q1624	
20030	178	1921			1970 PL, 1988 PL, 2119 BPL, 2215 PL,
					2285 house, 2340 pL, 2373 Big
					farm with animals, 2424 PL, house,
					macanires, 2445 PL, 2519 PL, 2530
					train, 2572 Big PL, 2606 PL, 2693, PL
					2713 house, 2832 BpL, 2952 PL,
Autocal				20	FLT0013
Q				190	
					590 pL, house, 641 PL, 690 pL,
20050	358	538			742 pL, 779 house, pL,
					853 pL, 924 PL 949 around ~~houses~~ houses,
					987 over trucks, 1018 trees,
					1079 pL, 1109 PL, rail train, house,
A		1979			1173 BpL, 1195 PL, 1247 pL,
Q		2168			1341 trees, pL, house, 1409 PL, 1514 PL,
Q	~~178~~	1759			
20070	178	2374	2835		2548 PL, 2557 house, horses, 2647 PL,
					2695 PL, 2784 house, PL, trees
20060	178	3090	3460		3091, PL, 3123 pL, 3168 PL, house,
					3225 PL, 3319 PL,
Q				3625	
20080	358	3927			3965, elevation, 4031 montain, 4077 PL,
					4126 PL, 4149 PL, 4177 BPL,
					4194 montain, 4292 PL, 4315 BPL,

(SAFETY FIRST, be aware of your surroundings)

4368 PL, 4414 PL rail train, 4460 PL,
4477 house, 4510 PL, 4560 PL, 4581 house

#2

FUGRO

FLIGHT LOG

SYSTEM ______ JOB# ______ FLT# ______

DATE | OPERATOR | PILOT

FLIGHT TIME | START: END: TOTAL (hrs): | WEATHER: , °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection (Yes / No) | System Changes (Yes / No) – If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	A / B / C	HELI GPS STATUS	1 / 9	LASER ALTIMETER?	YES / NO
MAG 1 2 3 4	ON / OFF	BIRD GPS STATUS	1 / 9 / NR	DATA STREAMING LIGHT	S / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP						
TX						
RX						

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
					4664 PL, 4734 communication station,
					4763 PL, 4770 PL, 4779 around
					farm, 4809 PL, 4824 over lake
					4913BPL, 5046 PL,
			5104		
Q				5248	

(SAFETY FIRST, be aware of your surroundings)

FUGRO

FLIGHT LOG

Resolve
SYSTEM BKS60 JOB# 03085 FLT# 001[illegible]5

DATE	JULY 17/2008	OPERATOR	Jorge Noronto	PILOT	Christ toker.
FLIGHT TIME	START: 1320 END: 1420 TOTAL (hrs): 1			WEATHER:	hot , °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41 K	8332	381	129k	1796	3353
TX	23.7	21.0	17.26	25.9	20.6	23.4
RX						

R 178
358

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
A				[illegible]31	
Q				213	
					607 PL, 679 PL, 725 PL, 747 PL
20090	178	450	1510.		773 PL, 820 PL, 864 PL, 888 PL,
					911 PL, 958 PL, 1000 PL, 1049 PL,
					1088 PL, 1105 trees, 1138 PL rail train,
					1243 BPL, 1343 montain, elevation,
					1370 B Montain, 1409 montains,
					1443 muntans - VALLES,
Q				1710.	

(SAFETY FIRST, be aware of your surroundings)

FUGRO **FLIGHT LOG** SYSTEM BKS60 Resolve JOB# 08035 FLT# 0017

DATE	June 17 2008	**OPERATOR**		**PILOT**	
FLIGHT TIME	**START:**	**END:**	**TOTAL (hrs):**	**WEATHER:**	+25°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection **(Yes / No)** | System Changes **(Yes / No)** – If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	**A / B / C**	**HELI GPS STATUS**	**1 / 9**	**LASER ALTIMETER?**	**YES / NO**
MAG 1 2 3 4	**ON / OFF**	**BIRD GPS STATUS**	**1 / 9 / NR**	**DATA STREAMING LIGHT**	**S / F**
Spectrometer (Yes / No) - if Yes		**Sample Rate at 1 sec: (Yes / No)**		**Trigger set to External: (Yes / No)**	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41.07K	8319	380.9	129.75	1797.7	3354
TX	20.1	18.4	15.2	22.9	17.8	20.1
RX	256	158	56	523	181	26
ICA	-598	-214	-214	-639	-211	+86

*measured Fop

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

60.5"
93.5"

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				600	
CH1 P		946	1010		-650 I, -140 Q
CH2 P		1055	1120		-650 I, -150 Q
CH3 P		1185	1230		-600 I, 10 Q
CH4 P		1468	1514		-600 I, -950 Q *??
CH5 P		1573	1629		-600 I, T30 Q
CH6 P		1708	1795		
CH1 E		2005	2045		
CH2 E		~~2110~~	~~2180~~	2295	-S 2340
CH3 E		2448	2503		*2380 truck
CH4 E		2110	2180		
CH5 E		2677	2737		
CH6 E		2875	2930		
CH1 I		2970	3005		
CH2 I		3024	3060		
CH3 I		3090	3146		
CH4 I		3150	3198		
CH5 I		3215	3249		
CH6 I		3260	3305		
					note: noisy environment
					at airport site

(SAFETY FIRST, be aware of your surroundings)

Noise cause for electromagnetic discharge.

FUGRO FLIGHT LOG

Resone.

SYSTEM BKS60 JOB# 03085 FLT# 0019.

DATE	Jun 17 / 2008	OPERATOR	Jorge Norarro	PILOT	Chris toker.
FLIGHT TIME	START: 1337	END: 1520	TOTAL (hrs): 1.8	WEATHER:	Windy , °C

0.9H ferry

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	S / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - (*Check the frequencies regularly during the flight to monitor stability*)

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8315	380	129K	1795	3348
TX	22	20.5	17.1	25.1	19.7	22.6
RX	7	2	24	12	17	24

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Cal.				20	* Autocal done manually
Q				250	
Q				1261	
					1629 PL, 1690, house, 1768 PL
50010	089	1528	1807		
50050	269	2209	2432.		2247 PL.
Q				2520	
50040	089	2711	3015.		2710 Channel 6 picks, 2802 PL, 2933 PL. 3003 PL,
50030	269	3097	3361		3156 PL, house, 3187 PL, 3281 PL
50020	089.	3476.	3750		3623 house, 3575 PL, 3636 PL, 3715 PL,
Q			3835		

(SAFETY FIRST - be aware of your surroundings)

Resolve.

FUGRO FLIGHT LOG

SYSTEM BKS60 **JOB#** 08035 **FLT#** 0021

DATE	June 19	**OPERATOR**	Jorge Naranjo	**PILOT**	Chris Tover.
FLIGHT TIME	**START:** 1145pm	**END:** 1230pm	**TOTAL (hrs):** 0.8	**WEATHER:** Spherics ,	°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	**HELI GPS STATUS**	1 / [✓ 9]	**LASER ALTIMETER?**	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	**BIRD GPS STATUS**	[✓ 1] / 9 / NR	**DATA STREAMING LIGHT**	[✓ S] / F
Spectrometer (Yes / No) - if Yes		**Sample Rate at 1 sec: (Yes / No)**		**Trigger set to External: (Yes / No)**	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8317	381	129K.	1797	3335
TX	21.1	19.3	16.1	23.7	19.1	21.3
RX	7	1	24	11	17	23

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:______, CACHE #:______
A				300	
Q				924	
Q				1970.	

(SAFETY FIRST, be aware of your surroundings)

noise limits	CH1	CH2	CH3	CH4	CH5	CH6
	41k	8318	381	130k	1797	3355
	40PPM	20PPM	10PPM	50PPM	10PPM	10PPM

FUGRO

FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0022

DATE	July 20/08	OPERATOR	Jurse Naranjo	PILOT	Chris torker
FLIGHT TIME	START: 1:15 END: 248	TOTAL (hrs): 1.7		WEATHER:	thunder storms, 28°C Cloudy.

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No) System Changes (Yes / [✓ No]) -- If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8320	380	129K.	1775	3348
TX	22.70	205	17.2	25.1	19.7	22.6
RX	5	1	24	11	15	24
	−598	−214	−214	−639	−211	+86.

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
0		30	45		
200		373	440		
250		599	662		
300		816	880		
350		1027	1090		
400		1250	1313		
450		1473	1530.		
500		1705	1765		
A			2116.		
Q		~~[illegible]~~	2372.		
70kts		2500	26120		2-3min
50kts		2669	2779		1min
60kts		2751	2813		1min
80kts		2864	2976		1min
swing		2962	2997		
swoop		3031	3066		
70kn		~~[illegible]~~	~~[illegible]~~		
descent		3184	2249		2500ft → 1000ft
70kts		3107	3167		2min
Q		3350.	3403		
200ft		3510	3630		2min → over powerlines.
2500ft		3836	3956		2min
Q		3956.	4003		
10014	088	4525	4672		
10015	092				4622 house, powerlines,
		4775	4828		4701 PL, 4720 PL, 4769 PL, house,
					4790 BPL, 4816 PL.
Q		5000	5058.		

3268

~~[illegible]~~ 3328

3956
−120
3836

(SAFETY FIRST, be aware of your surroundings)

FLIGHT LOG

Resolve

SYSTEM BKS60 JOB# 08035 FLT# 0027

DATE	JULY 21/08	OPERATOR	Jorge Naranjo	PILOT	Chris to Ken.
FLIGHT TIME	START: 707	END: 945	TOTAL (hrs): 2.8	WEATHER:	Sunny, , °C

08

09

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	[✓ 1] / 9	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	1 / [✓ 3] / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41 K	8333	380	129 K	1722	3346
TX	24.9	23.6	19.7	28.1	21.6	25.0
RX	7	2	27	16	15	27

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
A				37 [illegible]	
Q				182	
					501 house, 545 pL,
10014	88	~~407~~	563		
10015	092	565	696		570 PL, 593 PL, 612 PL, 654 BPL
					682 house animals,
Q			839		
Q [illegible]	[illegible]			1545	
20100	178	1942	3160		2200 trees, 2243 PL, 2288 PL,
					2356PL, 2417 PL, 2439 PL, 2457 PL,
					2507 PL, rail train, 2541 rail train, PL,
					2597 PL, 2633 PL, 2679 BPL,
					2748 PL, 2793 PL, 2921 PL,
Q				3284	
A				3463	
[illegible]	[illegible]			3625	
Q					
20110	358	3783	4800		- 3982 PL, 4212 PL, 4234 PL, 4243 BPL,
					4256 BPL, 4317 rail train, 4332
					rail train, trees, 4347 machines,
					4413 PL, 4436 PL, 4460 PL,
					4473 farm+house, 4489 rail train,
					4550 rail train, 4577 PL, 4766 PL, rail
					train, 4787 PL,
Q				4942	
20120	178	5138	6310		5220 PL, 5294 PL, 5326 BPL,
					5398 PL, 5757 PL, 5798 PL
					5822 PL, 5902 BPL, 5928 PL,
					5956 PL, 5979 BPL, 5996 PL,
					6002 PL, 6099 PL, 6158 PL, 6184 PL,
Q				6444	

(SAFETY FIRST, be aware of your surroundings)

FUGRO

FLIGHT LOG

Resolve

SYSTEM BKS60 JOB# 08035 FLT# 0028 + 0029

DATE	JULY 21	OPERATOR	Jorge Naranjo	PILOT	christopher.
FLIGHT TIME	START: 10:25 END:	TOTAL (hrs):		WEATHER:	nice , 20°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)

System Changes (Yes / [✓ No]) – If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	ON / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8331	380	129K.	1775	3352.
TX	23.9	21.5	17-6.	26.1	20.5	23.6.
RX	8	2.	26.	13	15	25

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
A				345	
Q				515	1580
60110	246	2000	2240		2004P.L. 2197 - 2210 PL
60060	246	2241	2433		2292 tall P.L 2320 P.L., 2376 P.L, 2450 P.L.
60070	066	2532	2668		2511 PL 2590 P.L. 2610 - 2640 PL
60120	066	2668	2895	Q2980	2705 P.L., 2731 P.L. 2825 P.L., 2890 P.L.
60130	246	3147	3416		3191 farm, 3371 PL.
60080	246	3416	3584		3455 PL. 3483 P.L. 3540 P.L, 3590 P.L
60090	066	3680	3810		3710 P.L, 3750 P.L, 3780 PL, 3810 farm (around
60140	246	3813	4039	Q4300	
69020	178	4464	4660		4475 P.L, 4530 PL, 4622 PL
69030	336	4905	4990		4951 P.L.
60150	246	5207	5485		5450 P.L., 5479 P.L.
60100	246	5489	5654	Q5700	5539 P.L. 5566 P.L.
60050	203	5972	6066		Large PL, 5981, 6021 PL.,
60040	023	6133	6230		6172 PL, 6203 PL,
60030	203	6280	6389		6309 tall P.L., 6326 PL, 6351 P.L.
60020	023	6493	6594		6532 tall P.L. 6570 tall P.L.
60010	203	6675	6800		6706 tall PL, 6750 tall P.L
69010	115	7009	7080		*CH4 harmonic *6870 - 6940
					7053 P.L.
					Caused by CH5
					FLT0029
FLT0029 Autocal Q				10	
50260	244	451			
50210	256	496			
50160	232	571			570 P.L, 661 P.L. 695 P.L.
50110	238	736			756 P.L. 876 P.L., CH4 harmonic 820 - 870
50060	227	990	1100		935 P.L.
50070	047	1166			
50120	058	1254			1300 P.L., 1390 P.L.
50170	052	1470			1470 P.L. 1507 PL., 1550 P.L
50220	076	1614	1662	Q1775	end for farm ~1662

246
066

203
023

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FUGRO

FLIGHT LOG

Resolve
SYSTEM BKS60 JOB# 08035 FLT# 0030

DATE	June 21, 2008	OPERATOR	ANOYS, Jorge	PILOT	CHRIS TUCKER
FLIGHT TIME	START:	END:	TOTAL (hrs): 0.4H	WEATHER:	, 30°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41k	8343	381	129k	1777	3353
TX	24.2	22.1	18.6	26.7	20.9	24.2
RX	8	1	26	13	13	26

3) FLIGHT DETAILS *(See reverse for instructions)*
(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				290	
Q				498	
					SPHERICS

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180

FUGRO FLIGHT LOG

SYSTEM Resolve ~~BK~~560 JOB# 08035 FLT# 0031

DATE	June 22, 2008	OPERATOR	ANDY S.	PILOT	Chris Tucker
FLIGHT TIME	START: 745	END: 10:15	TOTAL (hrs): 2.[illegible]5	WEATHER:	22°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - If Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	8321	380	129K	1773	3347
TX	23.1	21.4	17.6	26.2	20.1	23.4
RX	7	2	25	14	14	25

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				305	
Q				480	
50230	256	605	–		restart cow farm
50270	256	915			cow farm, building 920,
50260	266	970			farm (offline) 941
50200	232	1029			1040 P.L., 1066 P.L.
50150	238	1163			1200 P.L., 1220 P.L., pivot 1280, 1306 P.L., 1350 PL
50100	227	1390	1489	Q 1580	1465 P.L.
50080	047	1906			
50130	058	1993			2041 P.L., 2140 P.L. 2190 P.L. 269
50180	052	2210			2220 P.L. 2240 P.L. 2300 P.L. 8c
50230	076	2350	2383		2350 P.L., 2392 break for farm
076 50240	~~256~~	2660	2706		heading 076, stop at farm 2706
50190	232	2767			2780 PL., 2815 P.L., Pivot 2871, 2890 PL
50140	238	2914			2979 P.L., 3035 pivot, 3054 P.L. ⇒ 178
					3067 pivot, 3080 P.L., 3110 P.L.
50090	227	3158	3266	Q	3240 P.L., 3252 P.L.
				Q3400	
			3880		
R 50010	269	3614	[illegible]		3644 pL, 3726 pL, 3789
L 50020	089	3975	4212.		4055 PL, 4066 pL, 4123 PL, 4190 pL
R 50030	269	4277	4547		4341 house ground, 4371 pL
L 50040	089	4625	4870.		4694 PL, 4807 pL 4996 pL, [illegible]
R 50050	269	4927	5197		5114 pL
			Q5325		
59010	359	5480	5558		5516 PL, 8'
49020	000	6048	6133.	Q 6267	6075 PL, 6
10020	178	6957.	7079		0987 PL, 7029 pL
	9.				
NO LOCK line ← 10010	90	7282	7584		7336 pL, 7466 pL, 7529 PL, 7551 PL,
69010	115	7810	7893		

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Q 8015

FUGRO FLIGHT LOG

SYSTEM Resolve RKS60 JOB# 08035 FLT# 0032

DATE June 22, 2008 | OPERATOR ANDY S. Jorge | PILOT Chris T.

FLIGHT TIME | START: END: TOTAL (hrs): 3.0H | WEATHER: SPHERICS ,28 °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No) | System Changes (Yes / [✓ No]) – If YES, note details below

Details:

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY [✓ A] / B / C | HELI GPS STATUS 1 / [✓ 9] | LASER ALTIMETER? [✓ YES] / NO

MAG [✓ 1] 2 3 4 [✓ ON] / OFF | BIRD GPS STATUS [✓ 1] / 9 / NR | DATA STREAMING LIGHT [✓ S] / F

Spectrometer (Yes / [✓ No]) - if Yes | Sample Rate at 1 sec: (Yes / No) | Trigger set to External: (Yes / No)

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41K	83323	3801	130K	1776	3353
TX	22.2	20.2	17.0	23.4	18.4	20.8
RX	4	1	22	10	12	22

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				245	
Q				502	
40039	258	649			674 P.L., 705 P.L., 730 P.L.
40038 – 40038	279	810			800 big P.L.
40037 – 40037	301	950			955 mag drop.
40036 – 40036	291	1073			1055 P.L.
40035	276	1205			1303 around house
40034	280	1503			1525 P.L., 1565 mag drop, 1609 P.L., 1704 house
					1790 P.L., 1811 building
40033	279	1832			1915 P.L., 2037 pivot,
40032	268	2060			
40031	273	2222	2501	Q2590	2296 P.L. 2346 around farm, 2380 trees
					2425 P.L., 2440 P.L, 2474
40024	268	2680			2683 high for town
40023	252	2756			2765 P.L., 2815 Farm, 2870 farm
40022	272	2928			2930 mag, 2965 P.L., 3019 P.L.
40021	270	3057			3089 P.L., 3119 P.L., 3130 mag drop
40013	237	3251			3215 P.L., 3265 P.L
40012	251	3354			
40011	265	3525	3665		3515 P.L., 3607 P.L.
49010	180	3886	3991	Q4085	CH4 noise 3750-3820
					CH4 noise, more inphase ~20ppm
40061	091	4306			
40062	079	4686			
40063	068	4463			4558 P.L.
40064	057	4601			
40071	091	4665			4660 around town, 4680 mag (railway tracks P.L.)
					4802 P.L.
40072	078	4904			4897 around farm, 4910 mag
40073	074	5055			4954 tall trees, 5080 P.L.
40074	086	5105	5163	Q5265	5130 P.L., end for town 5163
					QX2 5330
40081	093	5470			5470 around house, 5470 mag
					5507-30 P.L. CH3 noise
					→ 5575 P.L., 5622 P.L.

69010 69030

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FLIGHT 0032 CONTINUED

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES**
40082	101	5655			
40083	089	5701			5742 P.L., CH2 noisy 5700, 5830 PL
					5870 P.L., 5890 P.L.
40084	096	5898			
40085	105	6021			6010 P.L., 6108 P.L.
40086	098	6150	6249		
40091	096	6249			around town 6249-6300, 6290 P.L.
					6315 P.L., 6426 P.L., 6439 tall tree
40092	093	6377			6536 P.L.
40093	108	6664			
40094	121	6729			6720 tall trees, 6766 P.L. 6794 P.L.
					6850 P.L.
40095	116	6914	7169	Q7319	6934 P.L., 7006 - 7040 over P.L.

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7020 mag, 7040 P.L.
7100 P.L., 7157 P.L.

QX27389

Flight Log Instructions

1) ***Pre-flight Check*** – To be completed to help identify changes to the survey system before every survey flight (**Keep details brief** – ***Examples*** - TX driver changed Ch1, tuned Ch3, mag orientation changes, mag sensor changed.)

2) ***Pre-Survey System Verification*** – To be filled out to verify system operation at the beginning of any survey flight.
   - ***VIDEO QUALITY*** parameters
     - A. Good – clear picture, proper contrast
     - B. Poor – fuzzy picture, bright/dark contrast (**troubleshoot between flights**)
     - C. None or Bad – **DO NOT FLY, Contact office immediately for direction**
   - ***GPS*** (bird/heli) parameters status
     - Status = **1** – GPS lock but not WAAS assisted
     - Status = **9** – GPS lock with WAAS assisted positioning
     - Status = **NR** – GPS Not Recorded (bird gps only)
   - ***DATA STREAMING LIGHT***
     - Solid = Recording normal
     - Flashing = Recording error, go to altitude (1000 ft) then reset console
   - ***MAG*** channels
     - Circle the mag channels being recorded and verify they are on

3) ***Flight Details*** – Details the conditions during the survey flight

   Examples of alerts – gps jumping, EM offset or noise, mag dropouts, etc

   Example of notes – cultural (power line, electric fence), buildings, climbing up a steep vertical wall, extreme turbulence.

   Area name and number – note the area name and area number on every flight log for each flight.

   Weather – describe conditions - calm, windy or turbulent. Also note spherics activity

   Flight Time – record total helicopter hours for every flight

4) ***Technical Problems in Flight*** – Questions to answer when you encounter problems

   Answer while you are airborne:
   - Is it on both inphase and quadrature?
   - Does it happen with all other transmitters turned off?
   - Does it happen when the mag is turned off?
   - Is there any interference from the helicopter generator?
   - Does it happen when you vary speed? (fly between 40 – 80 knots)
   - Does it happen when you vary power setting? (change by 5% torque increments)
   - Is the noise direction dependent?
   - Is it happening on the ground, using the helicopter generator for power with the helicopter at full RPM?

   Ground questions:
   - Does it happen while using the lambda for a power source?
   - What is the helicopter voltage?

FLIGHT LOG

SYSTEM ______ JOB# ______ FLT# 0032 Cont.

DATE		OPERATOR		PILOT	
FLIGHT TIME	START:	END:	TOTAL (hrs):	WEATHER: SPHERICS ,	°C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection (Yes / No)	System Changes (Yes / No) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	A / B / C	HELI GPS STATUS	1 / 9	LASER ALTIMETER?	YES / NO
MAG 1 2 3 4	ON / OFF	BIRD GPS STATUS	1 / 9 / NR	DATA STREAMING LIGHT	S / F
Spectrometer (Yes / No) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP						
TX						
RX						

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
40101	073	7534			around town, start late* around houses*
					7530 mag
40102	085	7599			7638 tall trees, 7660 P.L., 7745 P.L
40103	088	7842			7965 farm, 7994 P.L.
40104	102	8193			8263 P.L, 8312 P.L. 8365 P.L.
40105	121	8534			8619 P.L.
40106	115	8641			8644 P.L., 8727 P.L.
40107	123	8823			8840 airport 8844 P.L
					8922 around Farm
40111	144	8955			9011 Farm, 9080 P.L.
40112	148	9113	9200	Q9280	9184 P.L.

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FLIGHT LOG

SYSTEM Resolve BKS60 JOB# 08035 FLT# 0033

DATE	June 23, 2008	OPERATOR	Andy S. Jarge	PILOT	Chris Tucker
FLIGHT TIME	START: 7:45 END: 8:55	TOTAL (hrs):	1.2H	WEATHER:	20 °C

1) PRE-FLIGHT CHECK *(See reverse for instructions)*

Tow cable inspection ([✓ Yes] / No)	System Changes (Yes / [✓ No]) – If YES, note details below
Details:	

2) PRE-SURVEY SYSTEM VERIFICATION *(See reverse for instructions)*

VIDEO QUALITY	[✓ A] / B / C	HELI GPS STATUS	1 / [✓ 9]	LASER ALTIMETER?	[✓ YES] / NO
MAG [✓ 1] 2 3 4	[✓ ON] / OFF	BIRD GPS STATUS	[✓ 1] / 9 / NR	DATA STREAMING LIGHT	[✓ S] / F
Spectrometer (Yes / [✓ No]) - if Yes		Sample Rate at 1 sec: (Yes / No)		Trigger set to External: (Yes / No)	

Complete table when at altitude (1000 ft) - *(Check the frequencies regularly during the flight to monitor stability)*

EM Chnl	CH1	CH2	CH3	CH4	CH5	CH6
FOP	41k	8318	380	130K	1773	3348
TX	23.0	21.0	16.9	25.8	19.8	22.9
RX	7	2	24	15	15	24

3) FLIGHT DETAILS *(See reverse for instructions)*

(Start data recording ONLY when you have GPS lock - Check HELI GPS Status)

Line	Dir	Start Fid	End Fid	AutoCal/ Q (fid)	**DATA ALERT** **NOTES** **AREA NAME and NUMBER** DRUMS USED:_____, CACHE #:_____
Autocal				175	346 N/C
Q				563	
40041	101	801			858-931 large P.L.
40042	084	992			#north section following large Pwr lines &
40043	093	1255			(parallel), 1259 large pwr lines
40044	088	1331			1323 around house
40055	112	1532			1543 around house 1554-1588 around town
					1594 P.L., 1673-1695 around farm
40056	114	1732	2017	Q2078	1720 P.L., 1818 P.L.
40051	153	2200	2529	Q2670	2230 P.L. 2241 tall trees
					2298 P.L., 2310 P.L., 2330 P.L.
					2390 tall trees, 2408 P.L., 2447 P.L.
					2481 P.L., 2512 P.L.,

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APPENDIX F

GLOSSARY

APPENDIX F

GLOSSARY OF AIRBORNE GEOPHYSICAL TERMS

Note: The definitions given in this glossary refer to the common terminology as used in airborne geophysics.

altitude attenuation: the absorption of gamma rays by the atmosphere between the earth and the detector. The number of gamma rays detected by a system decreases as the altitude increases.

apparent- : the ***physical parameters*** of the earth measured by a geophysical system are normally expressed as apparent, as in "apparent ***resistivity*"**. This means that the measurement is limited by assumptions made about the geology in calculating the response measured by the geophysical system. Apparent resistivity calculated with ***HEM***, for example, generally assumes that the earth is a ***homogeneous half-space*** – not layered.

amplitude: The strength of the total electromagnetic field. In ***frequency domain*** it is most often the sum of the squares of ***in-phase*** and ***quadrature*** components. In multi-component electromagnetic surveys it is generally the sum of the squares of all three directional components.

analytic signal: The total amplitude of all the directions of magnetic ***gradient***. Calculated as the sum of the squares.

anisotropy: Having different ***physical parameters*** in different directions. This can be caused by layering or fabric in the geology. Note that a unit can be anisotropic, but still **homogeneous**.

anomaly: A localized change in the geophysical data characteristic of a discrete source, such as a conductive or magnetic body: something locally different from the **background**.

B-field: In time-domain **electromagnetic** surveys, the magnetic field component of the (electromagnetic) **field**. This can be measured directly, although more commonly it is calculated by integrating the time rate of change of the magnetic field **dB/dt**, as measured with a receiver coil.

background: The "normal" response in the geophysical data – that response observed over most of the survey area. **Anomalies** are usually measured relative to the background. In airborne gamma-ray spectrometric surveys the term defines the **cosmic**, radon, and aircraft responses in the absence of a signal from the ground.

base-level: The measured values in a geophysical system in the absence of any outside signal. All geophysical data are measured relative to the system base level.

base frequency: The frequency of the pulse repetition for a ***time-domain electromagnetic*** system. Measured between subsequent positive pulses.

bird: A common name for the pod towed beneath or behind an aircraft, carrying the geophysical sensor array.

bucking: The process of removing the strong ***signal*** from the ***primary field*** at the ***receiver*** from the data, to measure the ***secondary field***. It can be done electronically or mathematically. This is done in ***frequency-domain EM***, and to measure ***on-time*** in ***time-domain EM***.

calibration coil: A wire coil of known size and dipole moment, which is used to generate a field of known ***amplitude*** and ***phase*** in the receiver, for system calibration. Calibration coils can be external, or internal to the system. Internal coils may be called Q-coils.

coaxial coils: **[CX]** Coaxial coils in an HEM system are in the vertical plane, with their axes horizontal and collinear in the flight direction. These are most sensitive to vertical conductive objects in the ground, such as thin, steeply dipping conductors perpendicular to the flight direction. Coaxial coils generally give the sharpest anomalies over localized conductors. (See also ***coplanar coils***)

coil: A multi-turn wire loop used to transmit or detect electromagnetic fields. Time varying ***electromagnetic*** fields through a coil induce a voltage proportional to the strength of the field and the rate of change over time.

compensation: Correction of airborne geophysical data for the changing effect of the aircraft. This process is generally used to correct data in ***fixed-wing time-domain electromagnetic*** surveys (where the transmitter is on the aircraft and the receiver is moving), and magnetic surveys (where the sensor is on the aircraft, turning in the earth's magnetic field.

component: In ***frequency domain electromagnetic*** surveys this is one of the two **phase** measurements – ***in-phase or quadrature***. In "multi-component" electromagnetic surveys it is also used to define the measurement in one geometric direction (vertical, horizontal in-line and horizontal transverse – the Z, X and Y components).

Compton scattering: gamma ray photons will bounce off electrons as they pass through the earth and atmosphere, reducing their energy and then being detected by ***radiometric*** sensors at lower energy levels. See also ***stripping***.

conductance: See ***conductivity thickness***

conductivity: [σ] The facility with which the earth or a geological formation conducts electricity. Conductivity is usually measured in milli-Siemens per metre (mS/m). It is the reciprocal of ***resistivity***.

conductivity-depth imaging: see ***conductivity-depth transform***.

conductivity-depth transform: A process for converting electromagnetic measurements to an approximation of the conductivity distribution vertically in the earth, assuming a ***layered earth***. (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)

conductivity thickness: [σ**t**] The product of the ***conductivity***, and thickness of a large, tabular body. (It is also called the "conductivity-thickness product") In electromagnetic geophysics, the response of a thin plate-like conductor is proportional to the conductivity multiplied by thickness. For example a 10 metre thickness of 20 Siemens/m mineralization will be equivalent to 5 metres of 40 S/m; both have 200 S conductivity thickness. Sometimes referred to as conductance.

conductor: Used to describe anything in the ground more conductive than the surrounding geology. Conductors are most often clays or graphite, or hopefully some type of mineralization, but may also be man-made objects, such as fences or pipelines.

coplanar coils: **[CP]** In HEM, the coplanar coils lie in the horizontal plane with their axes vertical, and parallel. These coils are most sensitive to massive conductive bodies, horizontal layers, and the ***halfspace***.

cosmic ray: High energy sub-atomic particles from outer space that collide with the earth's atmosphere to produce a shower of gamma rays (and other particles) at high energies.

counts (per second): The number of ***gamma-rays*** detected by a gamma-ray ***spectrometer*.** The rate depends on the geology, but also on the size and sensitivity of the detector.

culture: A term commonly used to denote any man-made object that creates a geophysical anomaly. Includes, but not limited to, power lines, pipelines, fences, and buildings.

current channelling: See current gathering.

current gathering: The tendency of electrical currents in the ground to channel into a conductive formation. This is particularly noticeable at higher frequencies or early time channels when the formation is long and parallel to the direction of current flow. This tends to enhance anomalies relative to inductive currents (see also ***induction***). Also known as current channelling.

daughter products: The radioactive natural sources of gamma-rays decay from the original "parent" element (commonly potassium, uranium, and thorium) to one or more lower-energy "daughter" elements. Some of these lower energy elements are also radioactive and decay further. ***Gamma-ray spectrometry*** surveys may measure the gamma rays given off by the original element or by the decay of the daughter products.

dB/dt: As the ***secondary electromagnetic field*** changes with time, the magnetic field [**B**] component induces a voltage in the receiving ***coil***, which is proportional to the rate of change of the magnetic field over time.

decay: In ***time-domain electromagnetic*** theory, the weakening over time of the ***eddy currents*** in the ground, and hence the ***secondary field*** after the ***primary field*** electromagnetic pulse is turned off. In ***gamma-ray spectrometry***, the radioactive breakdown of an element, generally potassium, uranium, thorium, or one of their ***daughter*** products.

decay constant: see time constant.

decay series: In ***gamma-ray spectrometry***, a series of progressively lower energy ***daughter products*** produced by the radioactive breakdown of uranium or thorium.

depth of exploration: The maximum depth at which the geophysical system can detect the target. The depth of exploration depends very strongly on the type and size of the target, the contrast of the target with the surrounding geology, the homogeneity of the surrounding geology, and the type of geophysical system. One measure of the maximum depth of exploration for an electromagnetic system is the depth at which it can detect the strongest conductive target – generally a highly conductive horizontal layer.

differential resistivity: A process of transforming ***apparent resistivity*** to an approximation of layer resistivity at each depth. The method uses multi-frequency HEM data and approximates the effect of shallow layer ***conductance*** determined from higher frequencies to estimate the deeper conductivities (Huang and Fraser, 1996)

dipole moment: [NIA] For a transmitter, the product of the area of a ***coil***, the number of turns of wire, and the current flowing in the coil. At a distance significantly larger than the size of the coil, the magnetic field from a coil will be the same if the dipole moment product is the same. For a receiver coil, this is the product of the area and the number of turns. The sensitivity to a magnetic field (assuming the source is far away) will be the same if the dipole moment is the same.

diurnal: The daily variation in a natural field, normally used to describe the natural fluctuations (over hours and days) of the earth's magnetic field.

dielectric permittivity: **[ε]** The capacity of a material to store electrical charge, this is most often measured as the relative permittivity [ε_r], or ratio of the material dielectric to that of free space. The effect of high permittivity may be seen in HEM data at high frequencies over highly resistive geology as a reduced or negative ***in-phase***, and higher ***quadrature*** data.

drape: To fly a survey following the terrain contours, maintaining a constant altitude above the local ground surface. Also applied to re-processing data collected at varying altitudes above ground to simulate a survey flown at constant altitude.

drift: Long-time variations in the base-level or calibration of an instrument.

eddy currents: The electrical currents induced in the ground, or other conductors, by a time-varying ***electromagnetic field*** (usually the ***primary field***). Eddy currents are also induced in the aircraft's metal frame and skin; a source of ***noise*** in EM surveys.

electromagnetic: **[EM]** Comprised of a time-varying electrical and magnetic field. Radio waves are common electromagnetic fields. In geophysics, an electromagnetic system is one which transmits a time-varying ***primary field*** to induce ***eddy currents*** in the ground, and then measures the ***secondary field*** emitted by those eddy currents.

energy window: A broad spectrum of ***gamma-ray*** energies measured by a spectrometric survey. The energy of each gamma-ray is measured and divided up into numerous discrete energy levels, called windows.

equivalent (thorium or uranium): The amount of radioelement calculated to be present, based on the gamma-rays measured from a **daughter** element. This assumes that the ***decay series*** is in equilibrium – progressing normally.

exposure rate: in radiometric surveys, a calculation of the total exposure rate due to gamma rays at the ground surface. It is used as a measurement of the concentration of all the **radioelements** at the surface. See also: **natural exposure rate**.

fiducial, or fid: Timing mark on a survey record. Originally these were timing marks on a profile or film; now the term is generally used to describe 1-second interval timing records in digital data, and on maps or profiles.

Figure of Merit: **(FOM)** A sum of the 12 distinct magnetic noise variations measured by each of four flight directions, and executing three aircraft attitude variations (yaw, pitch, and roll) for each direction. The flight directions are generally parallel and perpendicular to planned survey flight directions. The FOM is used as a measure of the **manoeuvre noise** before and after **compensation.**

fixed-wing: Aircraft with wings, as opposed to "rotary wing" helicopters.

footprint: This is a measure of the area of sensitivity under the aircraft of an airborne geophysical system. The footprint of an ***electromagnetic*** system is dependent on the altitude of the system, the orientation of the transmitter and receiver and the separation between the receiver and transmitter, and the conductivity of the ground. The footprint of a ***gamma-ray spectrometer*** depends mostly on the altitude. For all geophysical systems, the footprint also depends on the strength of the contrasting ***anomaly***.

frequency domain: An ***electromagnetic*** system which transmits a ***primary field*** that oscillates smoothly over time (sinusoidal), inducing a similarly varying electrical current in the ground. These systems generally measure the changes in the ***amplitude*** and ***phase*** of the ***secondary field*** from the ground at different frequencies by measuring the **in-phase** and **quadrature** phase components. See also ***time-domain***.

full-stream data: Data collected and recorded continuously at the highest possible sampling rate. Normal data are stacked (see ***stacking***) over some time interval before recording.

gamma-ray: A very high-energy photon, emitted from the nucleus of an atom as it undergoes a change in energy levels.

gamma-ray spectrometry: Measurement of the number and energy of natural (and sometimes man-made) gamma-rays across a range of photon energies.

gradient: In magnetic surveys, the gradient is the change of the magnetic field over a distance, either vertically or horizontally in either of two directions. Gradient data is often measured, or calculated from the total magnetic field data because it changes more quickly over distance than the ***total magnetic field***, and so may provide a more precise measure of the location of a source. See also ***analytic signal***.

ground effect: The response from the earth. A common calibration procedure in many geophysical surveys is to fly to altitude high enough to be beyond any measurable response from the ground, and there establish ***base levels*** or ***backgrounds***.

half-space: A mathematical model used to describe the earth – as infinite in width, length, and depth below the surface. The most common halfspace models are ***homogeneous*** and ***layered earth***.

heading error: A slight change in the magnetic field measured when flying in opposite directions.

HEM: Helicopter ElectroMagnetic, This designation is most commonly used for helicopter-borne, ***frequency-domain*** electromagnetic systems. At present, the transmitter and receivers are normally mounted in a ***bird*** carried on a sling line beneath the helicopter.

herringbone pattern: A pattern created in geophysical data by an asymmetric system, where the **anomaly** may be extended to either side of the source, in the direction of flight. Appears like fish bones, or like the teeth of a comb, extending either side of centre, each tooth an alternate flight line.

homogeneous: This is a geological unit that has the same ***physical parameters*** throughout its volume. This unit will create the same response to an HEM system anywhere, and the HEM system will measure the same apparent ***resistivity*** anywhere. The response may change with system direction (see ***anisotropy***).

HTEM: Helicopter Time-domain ElectroMagnetic, This designation is used for the new generation of helicopter-borne, ***time-domain*** electromagnetic systems.

in-phase: the component of the measured ***secondary field*** that has the same phase as the transmitter and the ***primary field***. The in-phase component is stronger than the ***quadrature*** phase over relatively higher ***conductivity***.

induction: Any time-varying electromagnetic field will induce (cause) electrical currents to flow in any object with non-zero ***conductivity***. (see ***eddy currents***)

induction number: also called the “response parameter”, this number combines many of the most significant parameters affecting the ***EM*** response into one parameter against which to compare responses. For a ***layered earth*** the response parameter is $\mathbf{\mu\omega\sigma h^2}$ and for a large, flat, ***conductor*** it is $\mathbf{\mu\omega\sigma th}$, where μ is the ***magnetic permeability***, ω is the angular ***frequency***, σ is the **conductivity**, t is the thickness (for the flat conductor) and h is the height of the system above the conductor.

inductive limit: When the frequency of an EM system is very high, or the **conductivity** of the target is very high, the response measured will be entirely **in-phase** with no **quadrature** (**phase** angle =0). The in-phase response will remain constant with further increase in conductivity or frequency. The system can no longer detect changes in conductivity of the target.

infinite: In geophysical terms, an “infinite’ dimension is one much greater than the ***footprint*** of the system, so that the system does not detect changes at the edges of the object.

International Geomagnetic Reference Field: **[IGRF]** An approximation of the smooth magnetic field of the earth, in the absence of variations due to local geology. Once the IGRF is subtracted from the measured magnetic total field data, any remaining variations are assumed to be due to local geology. The IGRF also predicts the slow changes of the field up to five years in the future.

inversion, or **inverse modeling**: A process of converting geophysical data to an earth model, which compares theoretical models of the response of the earth to the data measured, and refines the model until the response closely fits the measured data (Huang and Palacky, 1991)

layered earth: A common geophysical model which assumes that the earth is horizontally layered – the ***physical parameters*** are constant to ***infinite*** distance horizontally, but change vertically.

magnetic permeability: **[μ]** This is defined as the ratio of magnetic induction to the inducing magnetic field. The relative magnetic permeability [μ_r] is often quoted, which is the ratio of the rock permeability to the permeability of free space. In geology and geophysics, the ***magnetic susceptibility*** is more commonly used to describe rocks.

magnetic susceptibility: **[k]** A measure of the degree to which a body is magnetized. In SI units this is related to relative ***magnetic permeability*** by $k=\mu_r-1$, and is a dimensionless unit. For most geological material, susceptibility is influenced primarily by the percentage of magnetite. It is most often quoted in units of 10^{-6}. In HEM data this is most often apparent as a negative ***in-phase*** component over high susceptibility, high ***resistivity*** geology such as diabase dikes.

manoeuvre noise: variations in the magnetic field measured caused by changes in the relative positions of the magnetic sensor and magnetic objects or electrical currents in the aircraft. This type of noise is generally corrected by magnetic **compensation**.

model: Geophysical theory and applications generally have to assume that the geology of the earth has a form that can be easily defined mathematically, called the model. For example steeply dipping **conductor**s are generally modeled as being **infinite** in horizontal and depth extent, and very thin. The earth is generally modeled as horizontally layered, each layer infinite in extent and uniform in characteristic. These models make the mathematics to describe the response of the (normally very complex) earth practical. As theory advances, and computers become more powerful, the useful models can become more complex.

natural exposure rate: in radiometric surveys, a calculation of the total exposure rate due to natural-source gamma rays at the ground surface. It is used as a measurement of the concentration of all the natural **radioelements** at the surface. See also: **exposure rate**.

noise: That part of a geophysical measurement that the user does not want. Typically this includes electronic interference from the system, the atmosphere (***sferics***), and man-made sources. This can be a subjective judgment, as it may include the response from geology other than the target of interest. Commonly the term is used to refer to high frequency (short period) interference. See also ***drift***.

Occam's inversion: an ***inversion*** process that matches the measured ***electromagnetic*** data to a theoretical model of many, thin layers with constant thickness and varying resistivity (Constable et al, 1987).

off-time: In a ***time-domain electromagnetic*** survey, the time after the end of the ***primary field pulse***, and before the start of the next pulse.

on-time: In a ***time-domain electromagnetic*** survey, the time during the ***primary field pulse***.

overburden: In engineering and mineral exploration terms, this most often means the soil on top of the unweathered bedrock. It may be sand, glacial till, or weathered rock.

Phase, phase angle: The angular difference in time between a measured sinusoidal electromagnetic field and a reference – normally the primary field. The phase is calculated from $\tan^{-1}$(***in-phase / quadrature***).

physical parameters: These are the characteristics of a geological unit. For electromagnetic surveys, the important parameters are ***conductivity**, **magnetic permeability*** (or ***susceptibility***) and ***dielectric permittivity***; for magnetic surveys the parameter is magnetic susceptibility, and for gamma ray spectrometric surveys it is the concentration of the major radioactive elements: potassium, uranium, and thorium.

permittivity: see ***dielectric permittivity***.

permeability: see ***magnetic permeability***.

primary field: the EM field emitted by a transmitter. This field induces ***eddy currents*** in (energizes) the conductors in the ground, which then create their own ***secondary* fields**.

pulse: In time-domain EM surveys, the short period of intense ***primary*** field transmission. Most measurements (the ***off-time***) are measured after the pulse. **On-time** measurements may be made during the pulse.

quadrature: that component of the measured ***secondary field*** that is phase-shifted 90° from the ***primary field***. The quadrature component tends to be stronger than the ***in-phase*** over relatively weaker ***conductivity***.

Q-coils: see ***calibration coil***.

radioelements: This normally refers to the common, naturally-occurring radioactive elements: potassium (K), uranium (U), and thorium (Th). It can also refer to man-made radioelements, most often cobalt (Co) and cesium (Cs)

radiometric: Commonly used to refer to ***gamma ray*** spectrometry.

radon: A radioactive daughter product of uranium and thorium, radon is a gas which can leak into the atmosphere, adding to the non-geological background of a gamma-ray spectrometric survey.

receiver: the ***signal*** detector of a geophysical system. This term is most often used in active geophysical systems – systems that transmit some kind of signal. In airborne ***electromagnetic*** surveys it is most often a ***coil***. (see also, ***transmitter***)

resistivity: **[ρ]** The strength with which the earth or a geological formation resists the flow of electricity, typically the flow induced by the ***primary field*** of the electromagnetic transmitter. Normally expressed in ohm-metres, it is the reciprocal of ***conductivity***.

resistivity-depth transforms: similar to ***conductivity depth transforms***, but the calculated ***conductivity*** has been converted to ***resistivity***.

resistivity section: an approximate vertical section of the resistivity of the layers in the earth. The resistivities can be derived from the ***apparent resistivity***, the ***differential resistivities***, ***resistivity-depth transforms***, or ***inversions***.

Response parameter: another name for the **induction number**.

secondary field: The field created by conductors in the ground, as a result of electrical currents induced by the ***primary field*** from the ***electromagnetic*** transmitter. Airborne ***electromagnetic*** systems are designed to create and measure a secondary field.

Sengpiel section: a ***resistivity section*** derived using the ***apparent resistivity*** and an approximation of the depth of maximum sensitivity for each frequency.

sferic: Lightning, or the ***electromagnetic*** signal from lightning, it is an abbreviation of "atmospheric discharge". These appear to magnetic and electromagnetic sensors as sharp "spikes" in the data. Under some conditions lightning storms can be detected from hundreds of kilometres away. (see ***noise***)

signal: That component of a measurement that the user wants to see – the response from the targets, from the earth, etc. (See also ***noise***)

skin depth: A measure of the depth of penetration of an electromagnetic field into a material. It is defined as the depth at which the primary field decreases to 1/e of the field at the surface. It is calculated by approximately 503 x √(resistivity/frequency). Note that depth of penetration is greater at higher ***resistivity*** and/or lower ***frequency.***

spectrometry: Measurement across a range of energies, where ***amplitude*** and energy are defined for each measurement. In gamma-ray spectrometry, the number of gamma rays are measured for each energy ***window***, to define the ***spectrum***.

spectrum: In ***gamma ray spectrometry***, the continuous range of energy over which gamma rays are measured. In ***time-domain electromagnetic*** surveys, the spectrum is the energy of the **pulse** distributed across an equivalent, continuous range of frequencies.

spheric: see ***sferic***.

stacking: Summing repeat measurements over time to enhance the repeating ***signal***, and minimize the random ***noise***.

stripping: Estimation and correction for the gamma ray photons of higher and lower energy that are observed in a particular ***energy window***. See also ***Compton scattering***.

susceptibility: See ***magnetic susceptibility***.

tau: [τ] Often used as a name for the ***time constant***.

TDEM: ***time domain electromagnetic***.

thin sheet: A standard model for electromagnetic geophysical theory. It is usually defined as a thin, flat-lying conductive sheet, ***infinite*** in both horizontal directions. (see also ***vertical plate***)

tie-line: A survey line flown across most of the ***traverse lines***, generally perpendicular to them, to assist in measuring ***drift*** and ***diurnal*** variation. In the short time required to fly a tie-line it is assumed that the drift and/or diurnal will be minimal, or at least changing at a constant rate.

time constant: The time required for an ***electromagnetic*** field to decay to a value of 1/e of the original value. In ***time-domain*** electromagnetic data, the time constant is proportional to the size and ***conductance*** of a tabular conductive body. Also called the decay constant.

Time channel: In ***time-domain electromagnetic*** surveys the decaying ***secondary field*** is measured over a period of time, and the divided up into a series of consecutive discrete measurements over that time.

time-domain: ***Electromagnetic*** system which transmits a pulsed, or stepped ***electromagnetic*** field. These systems induce an electrical current (***eddy current***) in the ground that persists after the ***primary field*** is turned off, and measure the change over time of the ***secondary field*** created as the currents ***decay***. See also ***frequency-domain***.

total energy envelope: The sum of the squares of the three ***components*** of the ***time-domain electromagnetic secondary field***. Equivalent to the ***amplitude*** of the secondary field.

transient: Time-varying. Usually used to describe a very short period pulse of ***electromagnetic*** field.

transmitter: The source of the ***signa***l to be measured in a geophysical survey. In airborne ***EM*** it is most often a **coil** carrying a time-varying electrical current, transmitting the ***primary field***. (see also ***receiver***)

traverse line: A normal geophysical survey line. Normally parallel traverse lines are flown across the property in spacing of 50 m to 500 m, and generally perpendicular to the target geology.

vertical plate: A standard model for electromagnetic geophysical theory. It is usually defined as thin conductive sheet, ***infinite*** in horizontal dimension and depth extent. (see also ***thin shee***t)

waveform: The shape of the ***electromagnetic pulse*** from a ***time-domain*** electromagnetic transmitter.

window: A discrete portion of a ***gamma-ray spectrum*** or ***time-domain electromagnetic decay***. The continuous energy spectrum or ***full-stream*** data are grouped into windows to reduce the number of samples, and reduce ***noise***.

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- Appendix F.13 -

Common Symbols and Acronyms

k	Magnetic susceptibility
ε	Dielectric permittivity
μ, μ_r	Magnetic permeability, relative permeability
ρ, ρ_a	Resistivity, apparent resistivity
σ,σ_a	Conductivity, apparent conductivity
σt	Conductivity thickness
τ	Tau, or time constant
Ωm	ohm-metres, units of resistivity
AGS	Airborne gamma ray spectrometry.
CDT	Conductivity-depth transform, conductivity-depth imaging (Macnae and Lamontagne, 1987; Wolfgram and Karlik, 1995)
CPI, CPQ	Coplanar in-phase, quadrature
CPS	Counts per second
CTP	Conductivity thickness product
CXI, CXQ	Coaxial, in-phase, quadrature
FOM	Figure of Merit
fT	femtoteslas, normal unit for measurement of B-Field
EM	Electromagnetic
keV	kilo electron volts – a measure of gamma-ray energy
MeV	mega electron volts – a measure of gamma-ray energy 1MeV = 1000keV
NIA	dipole moment: turns x current x Area
nT	nanotesla, a measure of the strength of a magnetic field
nG/h	nanoGreys/hour – gamma ray dose rate at ground level
ppm	parts per million – a measure of secondary field or noise relative to the primary or radioelement concentration.
pT/s	picoteslas per second: Units of decay of secondary field, dB/dt
S	siemens – a unit of conductance
x:	the horizontal component of an EM field parallel to the direction of flight.
y:	the horizontal component of an EM field perpendicular to the direction of flight.
z:	the vertical component of an EM field.

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