GEO INSTRUMENTS
A.C.N. 000 978 174 Pty. Limited

Operations and Processing Report

HELICOPTER ELECTROMAGNETIC SURVEY

MOINA AREA, TASMANIA

November 2001

for

Jervois Mining N.L.
Level 4, 114 William Street
MELBOURNE, VIC 3000

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1. INTRODUCTION

This report describes the field operations and subsequent data processing for a series of helicopter geophysical survey conducted for Jervois Mining N.L. during November 2001. The survey area is located at Moina, within one of the regional survey blocks selected for helicopter electromagnetic coverage by Mineral Resources Tasmania, on behalf of the Tasmanian Department of Infrastructure, Energy and Resources (DIER).

The Department of Infrastructure, Energy and Resources is conducting these airborne frequency domain electromagnetic and magnetic surveys in western and northwestern Tasmania as part of the Western Tasmanian Regional Minerals Program. The DIER program entails approximately 1 870 square kilometres over areas where prospective rocks fall within granite aureoles and over the Mt Read Volcanic Belt. These surveys will be integrated with other data to form a high quality database for exploration. The rugged terrain in the DIER survey areas requires the use of helicopter acquisition platforms.

The data are being acquired by DIER to provide the basic infrastructure to encourage mineral exploration and discovery. The surveys will have 200 m line spacing and 30 m nominal bird ground clearance. The electromagnetic and magnetic data are being collected in such a manner as to allow comprehensive reprocessing in the future as new technology is developed.

DIER considers it desirable that the private sector be encouraged to extend the 200 m surveys under Western Tasmanian Regional Minerals Program. DIER has advised that it will permit the private sector to concurrently and contemporaneously undertake "infill" or "extension" lines with and during the regional surveys.

The data acquisition for Jervois Mining comprised short lines at the same line spacing as the DIER program, viz. 200 metres. The Jervois flying was offset by 100 metres to effectively infill the DIER data to 100 metre line spacing over a specific area of interest to Jervois Mining. The program was undertaken by Geo Instruments Pty Ltd for Jervois Mining commenced on 14 November 2001 and concluded the same day. The corner coordinates of the survey areas in AMG84 zone 55 are provided in Appendix 1. A flight path map of the area is also provided in Appendix 1.

The survey collected a total of 98 line kilometres of electromagnetic, magnetic and elevation data during 1 day of survey operations. The results of the geophysical survey are presented as digital grids of the resistivity parameters and of the magnetics and digital terrain model, plus fully corrected located data files containing all survey data.

2. SURVEY SPECIFICATIONS

The survey comprises airborne geophysical mapping of an elongate block at the Moina, Tasmania, which is located within Block A of the Department of Infrastructure, Energy and Resources survey program.

Data acquisition totalled 98 line kilometres (refer to the catalog of flight lines contained in Appendix 2) of airborne electromagnetic, magnetic and elevation data.

2.1 LINE SPECIFICATIONS

Traverse Line Direction	090°- 180°
Traverse Line Spacing	200 metres
Tie Line Direction	00°- 360°
Tie Line Spacing	1,200 metres

2.2 INSTRUMENTAL SPECIFICATIONS

Electromagnetic	
Sampling Interval	0.1 second
Sensitivity	1 ppm
Coaxial Coil Frequencies	980 and 7001 Hz
Coplanar Coil Frequencies	875, 6606 and 34133 Hz

Magnetics	
Sampling Interval	0.1 second
Total Noise	< 0.05 nT

Base Station Magnetometer	
Sampling Interval	1 second
Noise Level	< 0.2 nT
Resolution	Better than or equal to 0.1 nT

Radar Altimeter	Output 13.1mV/m

2.3 FLYING SPECIFICATIONS

Electromagnetic and Magnetometer Sensor Nominal Terrain Clearance	30 metres (30 metre bird cable)
Flying Speed	40 m/second

3. SURVEY OPERATIONS

3.1 SURVEY BASE

The survey entailed 98 line kilometres at 200 metre line spacing flown at an off-set of 100 metres to the regional government coverage within Block A

The Geo Instruments survey equipment and the crew travelled to Sheffield on 6 November. The Hummingbird system was assembled and tested on 7 November and surveying of DIER Block A commenced on 11 November.

Data acquisition within the Jervois Mining Moina block commenced and concluded on 14 November. A summary report on the survey program is included in Appendix 3.

The quality control (QC) and field data processing were carried out the survey base at the Kentish Hills Retreat in Sheffield. The helicopter was always parked at the same location at the base to ensure consistency in ground calibration checks.

3.2 FLIGHT PLANNING

Flight planning for the flight block was accomplished using proprietary software. A map of the proposed flight lines and tie lines was reviewed with the client's representative prior to commencement of flying. The Moina survey area is located in UTM Zone 55.

3.3 FLIGHT PATH CONTROL

An Ashtech G12 receiver integrated with an Omnistar Model LR3000 virtual base station was used for navigation. This unit is capable of tracking and receiving up to 12 GPS satellites simultaneously and deriving positions from the satellites in view. The accuracy is better than 5m rms using differential GPS post processing. Positions are generated at 0.2 second intervals for the pilot indicator and are recorded at 0.5 second intervals. The GPS antenna was mounted approximately one metre behind the cesium vapour magnetometer sensor on the boom.

A real time differential solution was obtained through the use of the Fugro "Omnistar" virtual base station differential GPS service. Corrections are transmitted via a geo-stationary satellite to the helicopter navigation and position displays. The positional data are used to calculate the flight path guidance information which is presented to the pilot on both digital and analogue displays mounted in direct view. The radar altimeter display is mounted in close proximity to the guidance displays for easy cross reference.

The actual flight path for this survey is presented in Appendix 1.

3.4 SURVEY PLATFORM

Helicopter: Aerospatiale AS350BA “Squirrel” Helicopter
Registration: VH-RTV
Contracted From: Heli-Aust Pty Ltd of Bankstown
Endurance: 3.5 hours fully loaded
Survey Speed: 40 m/sec

3.5 WEATHER DETAILS

The weather throughout the survey period was generally cold, windy and foggy.

3.6 SAFETY MANAGEMENT

Prior to the commencement of all of the survey operations, a safety meeting involving Heli-Aust staff and Geo Instruments staff was conducted and a search and rescue plan was prepared.

There were no aviation incidents during the implementation of the airborne survey for the aircraft utilised on the project. Safety issues were discussed every morning during pre-flight preparation.

Safety procedures included pilot duty time monitoring and adherence to daily and scheduled maintenance of the helicopter. Daily flight planning meetings and mobile telephone communication with the survey base on completion of each flight line served to predict the position of the helicopter at all times.

3.7 ENVIRONMENTAL MANAGEMENT

The aircraft operations are non-polluting except for noise associated with take-off and landing. All operations were conducted during normal day time and no complaints were received regarding noise. Extreme care was maintained during all refuelling operations to eliminate the risk of fuel spillage or fire.

Ground operations are minor, usually focused around the survey base. Common sense rules apply to these tasks with particular reference to public facilities, residential areas, stock yards, access paths, etc. Any staff member responsible for damaging property or land is liable for dismissal.

4. PERSONNEL

Survey management and geophysical personnel were provided by Geo Instruments Pty Ltd, Sydney. The helicopter and the pilot were provided by Heli-Aust Pty Ltd. In field quality control was undertaken at the survey bases, and final data processing and map production were undertaken by Geo Instruments Pty Ltd in Sydney.

Field Operations

Field Project Manager:	Pat Healy
Pilots:	Tony Feller
Operator	Rob Reid

Data Processing

Data Supervisor:	Anton Rada

Client Representatives

Survey Design:	Anthony Jannink

5. GEOPHYSICAL EQUIPMENT

5.1 ELECTROMAGNETIC SYSTEM

The electromagnetic system is the Geotech Hummingbird 5-frequency system. It consists of two vertical coaxial coil pairs operating at 980 Hz and 7001 Hz and three horizontal coplanar coil pairs operating at 875 Hz, 6606 Hz, and 34133 Hz housed in a 6.5m long bird together with the magnetometer sensor. The transmitter-receiver separation and the dipole moment for each coil pair is given below:

Frequency	Coil Separation	Dipole Moment
875 Hertz	6.01 metres	200 NIA
980 Hertz	6.01 metres	200 NIA
6,606 Hertz	6.26 metres	150 NIA
7,001 Hertz	6.26 metres	150 NIA
34,133 Hertz	4.93 metres	40 NIA

The receiver coil responses are converted into their in-phase and out-of-phase (quadrature) components by processors installed in the bird, and then transmitted as digital data by a serial cable to the Geotech processor console in the aircraft. This console retains the calibration coefficients to convert the digital data representing voltages to parts per million. These data are transmitted to the Geo Instruments data acquisition system at 1 second intervals.

The EM system is mounted in a lightweight Kevlar boom which is towed 30 metres below the helicopter. Measurements of the in-phase and out-of-phase signals for each frequency are recorded at the rate of 10 times per second, with a sensitivity of one millionth of the primary field (1 part per million).

5.2 MAGNETOMETER

The Geometrics G822A Magnetometer is a highly sensitive unit incorporating an optically pumped sensor. The constant harmonic frequency from the sensor is proportional to the surrounding scalar magnetic field. This frequency is resolved by the Counter/ Processor which provides the magnetic field to a nominal accuracy of 0.01nT at 10 times per second both in analogue and digital forms.

The sensor and pre-amplifier are mounted in the EM boom, which is attached by approximately 30 metres of cable to the helicopter. Magnetic data are recorded in duplicate, once in the Geo Instruments files and also in the Hummingbird EM files.

The sensor is positioned well out of the magnetic field of the helicopter, whatever the type of helicopter. Therefore the magnetic data requires no compensation for the varying magnetic field associated with manoeuvres of the aircraft in the Earth's magnetic field, such as required for boom-mounted magnetic sensors.

5.3 ALTIMETER

A Collins Alt-50 radar altimeter system was installed in the helicopter. This controls the pilot's analogue indicator, which provides a terrain clearance display from 0 to 750 metres (0 to 2,500 ft.) above ground level. This is the primary tool used to maintain a consistent terrain clearance. The output of the altimeter is 13.1 mV/m and it can be read to a resolution of 1 mV for 0.076 metres.

The reference height above the geoid used for data purposes, was derived from the differentially corrected height value provided by the GPS receiver.

Both GPS altitude and the radar terrain clearance were recorded every tenth of a second by the digital acquisition system.

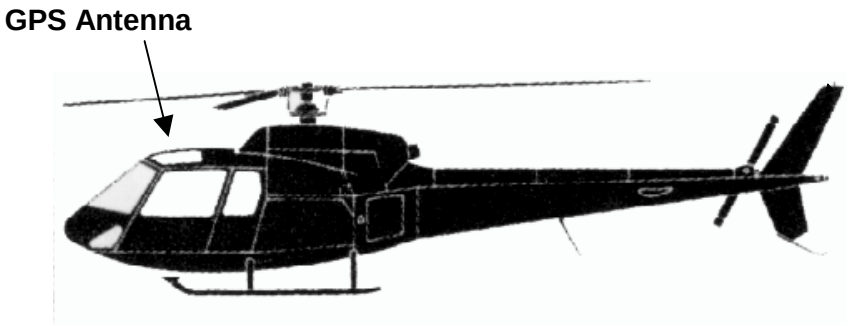
Barometric pressure was recorded every 0.1 second using a Sentra pressure transducer with a range of 600 to 1600 Hpa and a resolution of 0.04 Hpa (equivalent to 0.4 metres).

A Geo Instruments thermometer with a resolution of 0.1ºC was mounted underneath the helicopter cowling. Temperature was recorded every 0.1 second.

5.4 GPS NAVIGATION SYSTEM

The guidance system for the helicopter was based on the U.S. Global Positioning System. GPS co-ordinates were referenced to the WGS84 spheroid.

An Ashtech G12 receiver mounted on the upper window of the helicopter cabin was used for navigation by means of analog and digital displays of the aircraft position located directly in front of the pilot. The corrected position is accurate to 1 metre for X and Y and 5 metres for Z (see Section 3.3).



GPS Co-ordinates were referenced to the WGS84 spheroid and converted to AGD66 coordinates during data processing. The GPS base antenna was mounted on the processing caravan at GDA coordinates: 15:42.952° south, 126:22.818° east and 387.4m elevation.

5.5 DATA ACQUISITION SYSTEM

The Geo Instruments G2002 digital acquisition system is based on the IBM PC AT architecture. The system is fitted with several modules tailored to condition the input data from the various sensing instruments. A custom written software package facilitates the following:

(a) Correct synchronisation of the data streams,
(b) Formatting of all data received,
(c) Extended error checking of all parameters,
(d) Visual data presentation for monitoring purposes,
(e) Generation and distribution of synchronising fiducial numbers,
(f) Recording of data to magnetic media,
(g) Calculation of position and provision of steering display for pilot.

5.6 BASE STATION MAGNETOMETER

A Geometrics Recording Base Station Model G-856 with analog and digital recording was used as a diurnal monitor and run continuously during the survey periods. The sensor of the magnetometer is always placed in a low gradient area beyond the region of expected influence of any man-made interference. The base station records the diurnal variations in the earth's magnetic field every 3 seconds with a resolution of 0.1nT and an accuracy of 0.1nT and is synchronised with the airborne magnetometer.

The base magnetometer was located on the southeast corner of the lake at the Kentish Hills Retreat at Sheffield

All diurnal base station magnetometer data form part of the delivered digital information.

Diurnal activity was classed as quiet to moderate throughout the survey period and there were no reflights due to significant diurnal magnetic variations.

6. CALIBRATIONS

6.1 ELECTROMAGNETIC SYSTEM

The electromagnetic response was calibrated each morning during the DIER program using an external Q coil at the commencement of the survey program. There was no pre-existing geophysical data to indicate ground conditions. A special calibration jig was used for ground calibrations, as suggested by Fitterman (1998) and as presented in the photographs in Appendix 4. Firmly anchored cradles are used to hold the EM bird to ensure any ground response is consistent.

Calibration checks are conducted at the beginning and end of each sortie using internal coils, and at the beginning of each day using a ferrite phasing bar. Any drift is monitored by flying out of ground effect (above 350 metres) at least twice per hour to record electromagnetic zero levels. Prior to the commencement of surveying the EM system is run for at least an hour to stabilise temperatures and the system drift is observed and verified to be less than 5 ppm in 5 minutes.

6.2 MAGNETOMETER

The Geometrics G-822A Caesium vapour magnetometer operates on a split-beam principle with a constant relationship between the earth's magnetic field and the Larmor frequency (the frequency with which gyromagnetic moments precess in a magnetic field). They are therefore not subject to instrumental drift and do not require calibration.

6.3 ALTIMETER

The radar altimeter was calibrated against GPS height by multi-level flights prior to the commencement of the DIER survey.

7. DATA PROCESSING

7.1 IN-FIELD DATA VERIFICATION

In-field quality control (QC) of the survey data entailed two stages of assessment. Firstly the field party leader at the survey base conducted an analysis of the most recently acquired data using both proprietary company software and commercial software (e.g. Geosoft and ERMapper).

At the survey base the post-processed GPS position information was merged with the geophysical data and then subjected to the following checks:

a) Speed correlation,
b) Identification of spikes, dropouts and noise bursts in all data streams,
c) Verification that adequate flight path coverage was achieved,
d) Checking flight line spacing and terrain clearance tolerances,
e) Conformity to Contract specifications.

All QC assessment was implemented on screen, as no large format plotter was available at the various operating bases.

7.2 FINAL PROCESSING

The final data processing was undertaken by Geo Instruments Pty Ltd using the HEM module in Geosoft, together with ERMapper and Intrepid software. All data had previously been checked for any abnormalities by the in-field data verification system described in 7.1 above.

The 200m line spacing data acquired for Jervois Mining N.L. was merged with the excised segments of the Government 200m line spacing data which occurs within the Moina flight block. The specific processing parameters for each survey block are described in the “Readme File” which accompanies set of processed data. An example of this file is included in Appendix 5.

7.2.1 Flight Path Recovery

Processing of the differential GPS location data entailed the following steps:

a) Post-flight differential GPS corrections using the “Grafnav” differential position processing software where the real time differential GPS data was affected by limited correction satellite visibility (in valleys) or by microwave interference,
b) No fiducial synchronisation is required as both range data and fiducials are synchronised to GPS time,
c) Merging of positional data with geophysical data.

7.2.2 Electromagnetic Data Processing

Processing of the in phase and quadrature EM channels follows Cheesman (1998) and Valleau (2000), and entailed:

a) Filtering to remove major sferic events and reduce system noise,
   (i) First pass – non linear filter, 6 points wide, 0.5ppm threshold
   (ii) Second pass – low pass filter, 6 points wide.
b) Base level correction using high altitude EM zero levels;
c) System parallax removal
d) Calculation of apparent resistivity for the coplanar coils;
e) Gridding at 10m x 10m and micro-levelling.

The resistivity formulae are taken from "Geo-Electromagnetism" by Wait (1982). They are standard integrals involving Bessel functions and reflection coefficients for a layered halfspace. For the nomogram look-up, a large number of models over a range of resistivities and depths are calculated, giving in-phase and quadrature results, to produce the nomogram grids (with in-phase and quadrature values on the axes, and the grid variables being resistivity, and depth.) The resistivity for a given value of in-phase and quadrature is then found by interpolating the grid. A 20m x 20m cell size and a 3 x 3 grid filter was employed with the minimum curvature algorithm.

The calculation of resistivities from HEM data is discussed by Fraser (1978). The need for levelling of resistivity values derived from HEM surveys is discussed by Huang and Fraser (1999).

7.2.3 Magnetic Processing

Having verified all data in the field, the final processing sequence is reduced to the following steps:

a) Five point low pass filter,
b) Diurnal variation removal,
c) System parallax removal,
d) IGRF removal,
e) Tie line levelling and micro levelling,
f) Addition of the mean diurnal value and the IGRF base value,
g) Gridding at 20m x 20m.

The helicopter magnetic data have been corrected for regional gradient by subtraction of the IGRF Model for 2001.9 derived from the 2000-2005 secular variation model. The IGRF was calculated at each sample point at the GPS height of the aircraft, adjusted for the geoid-spheroid separation. Diurnal variations and system parallax have been removed. The mean diurnal value and IGRF base value have been added to the data. No filters were applied to the data prior to gridding. The minimum curvature algorithm was used for gridding of the data.

7.2.4 Digital Terrain Model (DTM) Processing

The digital terrain model is computed from the difference in GPS height and radar altitude. The raw GPS range data are recorded internally every one second and corrected using real time factors provided by the Fugro Omnistar satellite system. This yields the position of the aircraft GPS antenna, including longitude, latitude and height relative to the AGD84 reference ellipsoid for each set of range data (every one second).

The radar altimeter provided the aircraft's ground clearance, the altimeter data being sampled every tenth of a second. The radar altimeter results were lightly smoothed to remove any spikes, spurious reflections or instrument noise.

The raw ground elevation data were then calculated as the difference between the height of the aircraft above the ellipsoid and the height of the aircraft above the ground. These raw elevation data calculated every one second are relative to the AGD84 reference geoid.

The GPS antenna was mounted on the upper rear fuselage of the aircraft. The radar altimeter sensor was located under the belly at the front of the aircraft.

The digital terrain model information was gridded at 20m x 20m using the minimum curvature gridding algorithm and a 3 x 3 grid filter. Decorrugation and microlevelling tools were then applied as appropriate.

DISCLAIMER NOT TO BE USED FOR NAVIGATION

This digital terrain model (DTM) has been computed from data generated during the course of an airborne geophysical survey flown at a nominal line spacings and data have been interpolated/gridded between such lines. Every effort has been made to make the model a useful general reference. No guarantee can be made that this model is a true representation of height above sea level and it does contain radar altimeter responses from buildings and dense timber. Users of this product should be aware of the topographic limitations mapped here within. **Do not use this DTM for navigation purposes.**

8. DELIVERED ITEMS

Following implementation of all corrections and levelling of the EM, magnetic and DTM fields, Geosoft GRD grid files were generated and subject to further micro-levelling. Preliminary grid files were delivered for review and approval, then final digital data files were delivered.

Final Map Products

No hard copy maps were required.

Digital Data

CD-ROM containing raw GPS, magnetic and electromagnetic data.

CD-ROM containing final located data, gridded apparent resistivity for each coplanar and coaxial coil set, gridded total magnetic intensity and gridded digital terrain model.

Operations and Processing Report

Data delivery included this Operations and Processing Report on the helicopter electromagnetic survey program and data processing.

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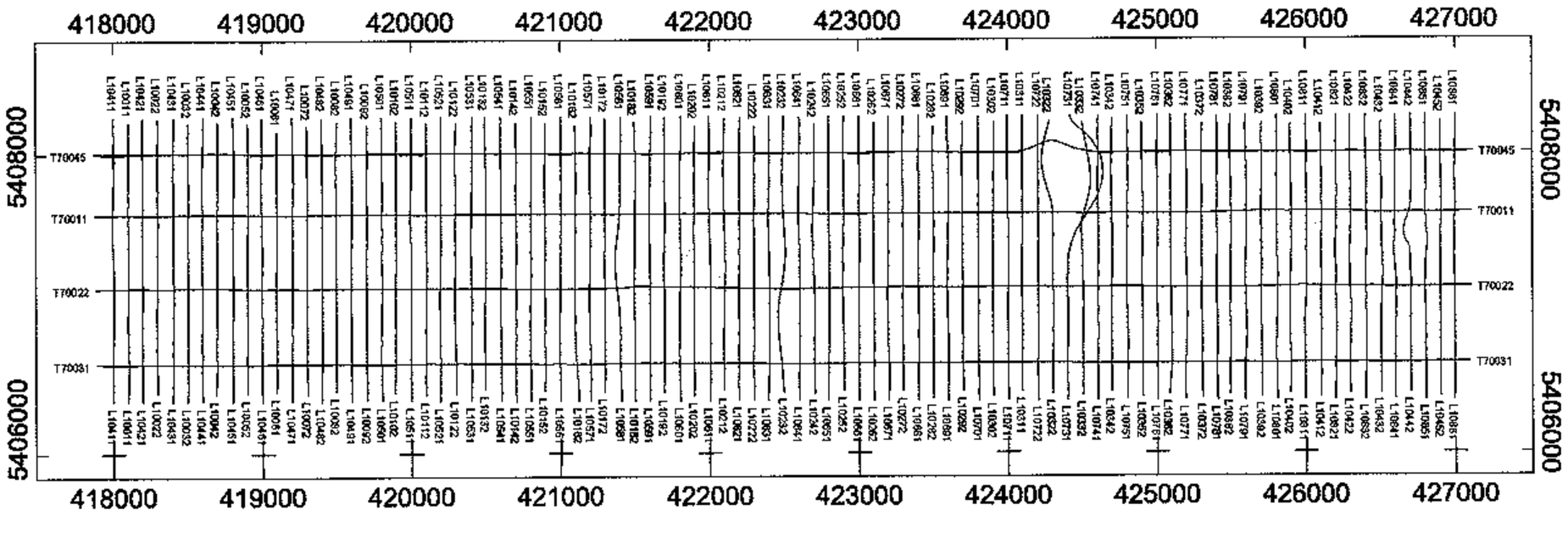
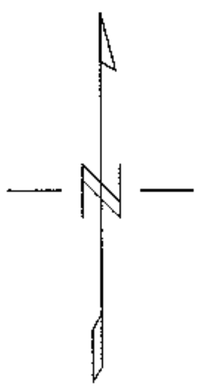
Wait, J.R., 1982, Geoelectromagnetism: Academic Press Inc.

APPENDIX 1

Flight Path Map of Area Flown
and
List of Coordinates of Survey Area





Scale 1:50000

500 0 500 1000 1500

metre

Jervois Mining Pty Ltd

Infill Area Moina Tasmania
November 2001

GeoInstruments Pty Ltd

Corners for Moina HEM Survey 2001

AGD84 Coordinates AMG Zone 55

418,000E 5,407000N
427,000E 5,407000N
427,000E 5,405600N
418,000E 5,405600N

APPENDIX 2

Catalog of Survey Lines
(including Government coverage within area)

CATALOG OF LINES FOR MOINA HEM SURVEY, NOVEMBER 2001

Flight	Line	Distance	Number of Gaps	Length of Gaps	StartFID	EndFID	StartX	EndX	StartY	EndY
12	10011	1.87	0	0	5,984	6,079	418,103	418,100	5,408,215	5,406,350
12	10022	1.84	0	0	6,139	6,211	418,299	418,299	5,406,404	5,408,237
12	10032	1.86	0	0	6,263	6,353	418,501	418,497	5,408,207	5,406,350
12	10042	1.81	0	0	6,403	6,458	418,685	418,698	5,406,402	5,408,214
12	10052	1.80	0	0	6,510	6,576	418,900	418,898	5,408,206	5,406,405
12	10061	1.74	0	0	6,619	6,665	419,095	419,098	5,406,414	5,408,149
12	10072	1.79	0	0	6,713	6,782	419,298	419,304	5,408,189	5,406,400
12	10082	1.80	0	0	6,834	6,893	419,495	419,500	5,406,417	5,408,213
12	10092	1.84	0	0	6,952	7,021	419,702	419,704	5,408,193	5,406,359
12	10102	1.81	0	0	7,066	7,123	419,887	419,898	5,406,406	5,408,217
12	10112	1.82	0	0	7,180	7,244	420,103	420,101	5,408,206	5,406,388
12	10122	1.81	0	0	7,296	7,355	420,299	420,299	5,406,397	5,408,205
12	10132	1.82	0	0	7,830	7,882	420,495	420,495	5,406,428	5,408,247
12	10142	1.86	0	0	7,940	8,002	420,696	420,700	5,408,213	5,406,352
12	10152	1.79	0	0	8,053	8,102	420,892	420,896	5,406,416	5,408,206
12	10162	1.84	0	0	8,158	8,211	421,097	421,121	5,408,192	5,406,352
12	10172	1.82	0	0	8,267	8,316	421,294	421,298	5,406,414	5,408,234
12	10182	1.86	0	0	8,372	8,439	421,493	421,498	5,408,210	5,406,350
12	10192	1.84	0	0	8,506	8,555	421,694	421,697	5,406,402	5,408,240
12	10202	1.80	0	0	8,624	8,676	421,899	421,897	5,408,183	5,406,384
12	10212	1.82	0	0	8,729	8,771	422,097	422,099	5,406,414	5,408,236
12	10222	1.83	0	0	8,823	8,875	422,299	422,297	5,408,180	5,406,351
12	10232	1.85	0	0	8,931	8,982	422,498	422,498	5,406,407	5,408,246
12	10242	1.80	0	0	9,051	9,105	422,700	422,703	5,408,193	5,406,399
12	10252	1.83	0	0	9,172	9,224	422,898	422,898	5,406,416	5,408,248
13	10262	1.86	0	0	499	563	423,100	423,101	5,408,207	5,406,352
13	10272	1.83	0	0	609	665	423,299	423,295	5,406,413	5,408,245
13	10282	1.81	0	0	708	760	423,500	423,499	5,408,179	5,406,367
13	10292	1.79	0	0	794	844	423,700	423,696	5,406,412	5,408,204
13	10302	1.84	0	0	879	931	423,905	423,901	5,408,210	5,406,374
13	10311	1.84	0	0	966	1,013	424,096	424,096	5,406,407	5,408,247
13	10322	1.84	0	0	1,063	1,123	424,280	424,299	5,408,212	5,406,391
13	10332	1.84	0	0	1,291	1,356	424,498	424,501	5,408,204	5,406,385
13	10342	1.83	0	0	1,395	1,450	424,692	424,697	5,406,402	5,408,229
13	10352	1.82	0	0	1,501	1,566	424,898	424,904	5,408,197	5,406,377
13	10362	1.86	0	0	1,597	1,666	425,084	425,093	5,406,387	5,408,247
13	10372	1.84	0	0	1,724	1,821	425,302	425,309	5,408,194	5,406,362
13	10382	1.86	0	0	2,038	2,137	425,492	425,494	5,406,388	5,408,245
13	10392	1.83	0	0	2,185	2,279	425,700	425,702	5,408,196	5,406,372
13	10402	1.80	0	0	2,325	2,436	425,893	425,895	5,406,395	5,408,187
10	10411	1.90	0	0	2,821	2,889	418,002	418,002	5,408,248	5,406,353
13	10412	1.82	0	0	2,481	2,590	426,096	426,100	5,408,188	5,406,372
10	10421	1.90	0	0	3,618	3,694	418,198	418,198	5,406,351	5,408,247
13	10422	1.86	0	0	2,642	2,756	426,298	426,295	5,406,391	5,408,242
10	10431	1.90	0	0	3,838	3,918	418,406	418,400	5,408,247	5,406,352
13	10432	1.82	0	0	2,801	2,960	426,500	426,501	5,408,204	5,406,394
10	10441	1.90	0	0	4,858	4,930	418,596	418,601	5,406,351	5,408,248
13	10442	1.89	0	0	3,013	3,190	426,700	426,699	5,406,397	5,408,247
10	10451	1.90	0	0	5,081	5,138	418,802	418,801	5,408,246	5,406,352
13	10452	1.84	0	0	3,231	3,345	426,898	426,902	5,408,208	5,406,371
10	10461	1.90	0	0	5,874	5,942	419,001	418,998	5,406,350	5,408,247
10	10471	1.90	0	0	6,221	6,280	419,201	419,200	5,408,247	5,406,353
10	10482	1.90	0	0	1,774	1,833	419,399	419,398	5,408,246	5,406,350

10	10491	1.90	0	0	452	516	419,600	419,597	5,406,350	5,408,248
10	10501	1.90	0	0	681	739	419,802	419,804	5,408,248	5,406,353
10	10511	1.90	0	0	1,401	1,462	419,999	420,001	5,406,352	5,408,247
10	10521	1.90	0	0	2,591	2,655	420,195	420,200	5,406,351	5,408,246
11	10531	1.90	0	0	1,064	1,151	420,408	420,402	5,408,248	5,406,353
11	10541	1.90	0	0	1,921	1,983	420,602	420,597	5,406,353	5,408,248
11	10551	1.90	0	0	2,347	2,425	420,802	420,799	5,408,247	5,406,353
8	10561	1.90	0	0	538	633	421,001	421,000	5,408,248	5,406,351
7	10571	1.90	0	0	9,119	9,180	421,203	421,201	5,406,354	5,408,248
7	10581	1.90	0	0	8,270	8,341	421,406	421,411	5,408,248	5,406,352
7	10591	1.90	0	0	7,958	8,014	421,598	421,609	5,406,351	5,408,248
7	10601	1.90	0	0	6,742	6,794	421,808	421,802	5,408,248	5,406,350
7	10611	1.90	0	0	6,493	6,538	422,000	421,995	5,406,350	5,408,247
7	10621	1.89	0	0	5,552	5,598	422,203	422,195	5,408,246	5,406,353
7	10631	1.89	0	0	5,136	5,179	422,391	422,401	5,406,351	5,408,244
7	10641	1.90	0	0	4,242	4,295	422,600	422,599	5,408,247	5,406,350
7	10651	1.90	0	0	3,925	3,970	422,793	422,798	5,406,351	5,408,247
7	10661	1.90	0	0	2,944	3,006	422,999	422,999	5,408,248	5,406,351
7	10671	1.89	0	0	2,646	2,695	423,201	423,199	5,406,353	5,408,245
7	10681	1.90	0	0	1,811	1,873	423,403	423,400	5,408,246	5,406,350
7	10691	1.90	0	0	1,404	1,456	423,596	423,594	5,406,350	5,408,245
7	10701	1.89	0	0	555	603	423,799	423,803	5,408,245	5,406,351
6	10711	1.90	0	0	1,077	1,125	424,003	423,996	5,406,351	5,408,246
6	10722	1.90	0	0	266	325	424,204	424,204	5,408,246	5,406,350
6	10731	2.03	0	0	7,393	7,466	424,399	424,417	5,406,351	5,408,247
6	10741	1.90	0	0	6,543	6,608	424,604	424,602	5,408,247	5,406,350
6	10751	1.89	0	0	6,250	6,306	424,799	424,801	5,406,352	5,408,245
6	10761	1.90	0	0	5,117	5,194	425,004	425,003	5,408,246	5,406,351
6	10771	1.90	0	0	4,816	4,899	425,192	425,196	5,406,351	5,408,248
6	10781	1.90	0	0	3,617	3,734	425,402	425,408	5,408,246	5,406,350
6	10791	1.90	0	0	3,272	3,360	425,592	425,594	5,406,351	5,408,246
6	10801	1.90	0	0	2,037	2,172	425,805	425,806	5,408,246	5,406,350
6	10811	1.90	0	0	1,681	1,789	425,993	425,998	5,406,351	5,408,247
5	10821	1.90	0	0	1,344	1,453	426,197	426,202	5,406,351	5,408,248
5	10832	1.90	0	0	359	511	426,400	426,401	5,408,247	5,406,352
5	10841	1.91	0	0	6,086	6,225	426,597	426,600	5,406,352	5,408,247
5	10851	1.91	0	0	5,237	5,403	426,799	426,803	5,408,248	5,406,350
5	10861	1.90	0	0	4,715	4,844	426,994	427,000	5,406,351	5,408,247
12	70011	9.25	0	0	5,391	5,724	427,111	417,879	5,407,603	5,407,594
12	70022	9.24	0	0	4,825	5,215	417,886	427,103	5,407,101	5,407,103
12	70031	9.22	0	0	4,270	4,599	427,094	417,893	5,406,600	5,406,600
12	70045	9.30	0	0	3,598	4,007	417,870	427,117	5,408,006	5,408,005

Summary

Lines : 10011 to 70045	
Number of survey lines :	95
Number of (well defined) lines :	95
Total number of gaps in lines are :	0
Total length of gaps is :	0 km
Total distance is :	206.7 km
Average Line Length is :	2.18 km

APPENDIX 3

Summary of Field Operations

SUMMARY REPORT ON SURVEY OPERATIONS

DOY	DATE	FLIGHT	KMS	REMARKS
310	6 Nov	-	-	Mobilise to Sheffield
311	7 Nov	-	-	Set-up calibration, start production
318	14 Nov	1	98	Production and completion of Moina area
		TOTAL KM:	**98**	

APPENDIX 4

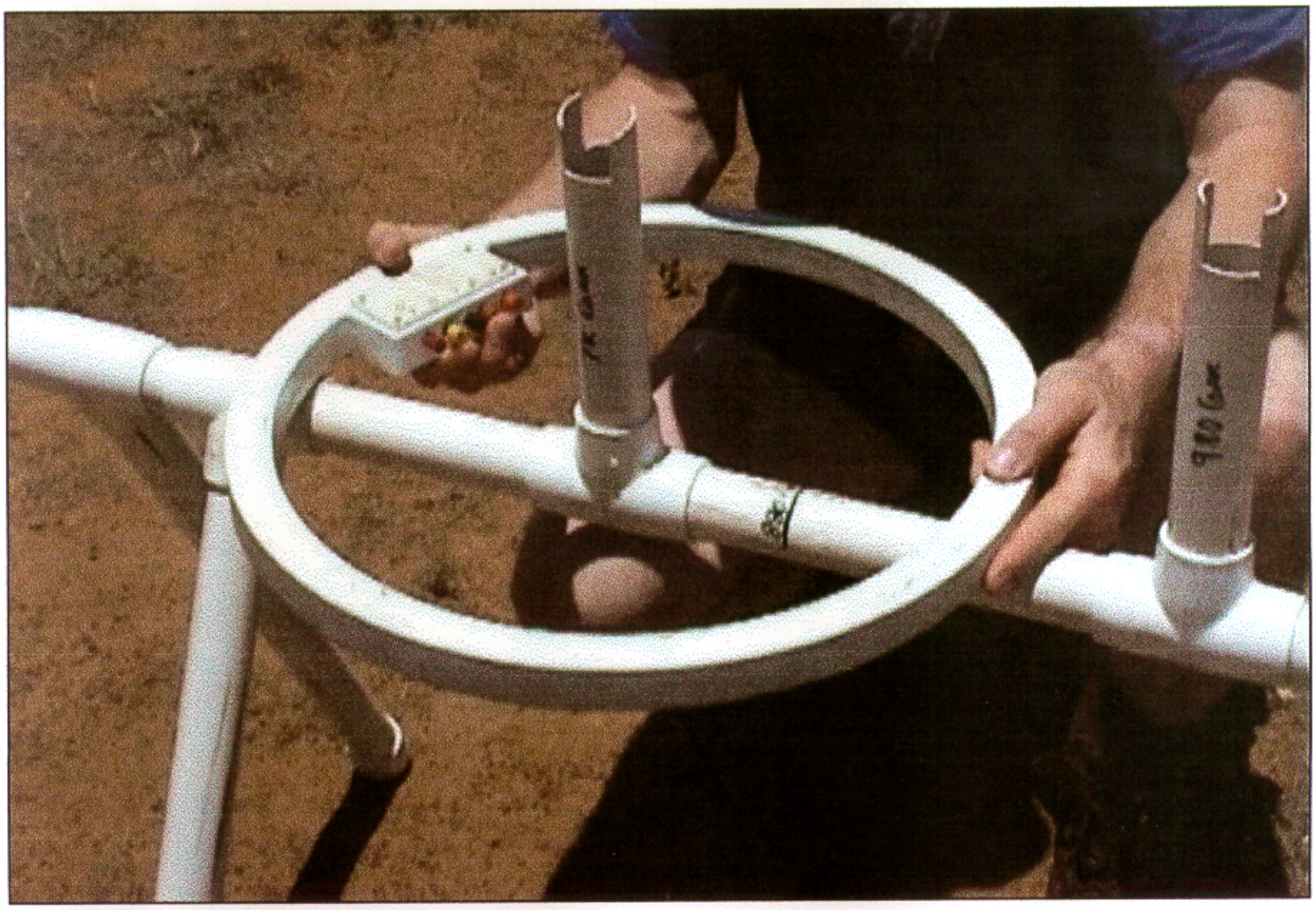
Photographs of HEM Calibration

Geo Instruments' operator conducts Hummingbird calibration

Detail of calibration jig and external Q coil orientation for vertical coils

Calibration of horizontal coils

Detail of Q coil and calibration control box



APPENDIX 5

Digital Data Formats

Raw Data Format Description
Geo Instruments G2002 Acquisition System

Master key file *.geo extension.

Format as per ZDAS version 8.1c 21st February 2001

This file acts as an index for all auxiliary data files as well as storing key data values as per format list below.

Line 1 Header containing the following fields;
Line 2 to end of file containing the following fields;

Field	pos – pos	type	descriptor
1	1 - 67	string	Header info

Field	pos – pos	type	descriptor
1	1 5	integer	Fiducial
2	6 16	float 5.5	Timer
3	17 24	long	mag *1000
4	25 32	long	mag *1000
5	33 40	long	mag *1000
6	41 48	long	mag *1000
7	49 56	long	mag *1000
8	57 61	integer	total count (dtc corr)
9	62 65	integer	potassium (dtc corr)
10	66 69	integer	uranium (dtc corr)
11	70 73	integer	thorium (dtc corr)
12	74 77	integer	cosmic (dtc corr)

Example of first five lines of a .geo file

```
FLT 02 LINE 002 GPSTIME 005408.00  Day  85 10:54:08 WGS84 Zone=56
12317  8845.500057002304570022605700221657002140570020 80  708  55  29  34  60
12318  8846.000057002580570025285700 24   645700240857002364  708  55  29  34  60
12319  8846.500057002764570027645700274457002700570026 40  714  67  27  36  55
12320  8847.000057003028570029205700284457002808570027 76  714  67  27  36  55
12321  8847.500057003508570034165700332457003224570031 24  672  80  18  22  49
```

Raw Data Format Description
Geo Instruments G2002 Acquisition System

Navigation/Position file *.GPS extension

Format as per ZDAS version 8.1c 21st February 2001.

This file contains raw GPS positions returned from the primary positioning receiver against fiducial/timer counter. The precision and accuracy of the values is dependent on the mode in which the primary GPS is operating. If the RTCM value in the RTCM field is valid (greater than zero and less than 60) then the position can be related to a ground station or network. If the RTCM value is invalid then the positional accuracy is defined by the autonomous mode nominal accuracy values.

Line 1 Header containing the following fields;

Field	pos – pos	type	descriptor
1	1 - 67	string	Header info

Line 2 to end of file containing the following fields;

Field	pos – pos		type	descriptor
1	1	10	float 5.5	timer
2	11	19	float 6.2	GPS Time (hhmmss.ss)
3	20	28	float 7.1	metres easting UTM
4	29	37	float 7.1	metres northing UTM
5	38	43	float 4.1	metres ellipsoid height
6	44	49	integer	metres error Xtrack
7	50	56	float 4.1	seconds RTCM correction latency

Example of a .GPS file (subset)

```
FLT 02 LINE 004 GPSTIME 225625.00  Day  85 08:56:25 WGS84 Zone=56
 1782.5000225625.00 360426.46349622.1  87.0     3    6.0
 1783.0000225625.50 360428.86349634.1  86.4     3    6.0
 1783.5000225626.00 360431.16349647.1  85.1     4    7.0
 1784.0000225626.50 360434.86349659.7  83.7     4    7.0
 1784.5000225627.00 360439.76349672.3  82.5     2    7.0
 1785.0000225627.50 360443.36349684.8  81.6     2    7.0
```

Raw Data Format Description
Geo Instruments G2002 Acquisition System

Navigation/Position file *.POS extension

Format as per ZDAS version 8.1c 21st February 2001.

This file contains raw GPS positions returned from the primary positioning receiver against GPS time.. The *.POS files are a direct recording of the NMEA message from the GPS receiver of the type GPGGA. As such, the format is fully described in the user's manual for the specific GPS receiver. The GPGGA message is generic and is adhered to loosely by some manufacturers, so it is advisable to verify the exact format with the actual type of GPS receiver used on the survey. This file is not normally used for any data merging post flight but is included for data redundancy and archival traceability purposes.

Line 1 Header containing the following fields;

Field	pos – pos	type	descriptor
1	1 - 67	string	Header info

Line 2 to end of file containing the following fields which are separated by commas;

Field	type	descriptor
1	string	$GPGGA NMEA label
2	numeric	GPS Time
3	numeric	Latitude of posn
4	label	Hemisphere of Latitude (N/S)
5	numeric	Longitude of posn
6	label	Hemisphere of Longitude (E/W)
7	flag	Receiver mode (1= autonomous, 2=RTCM corr)
8	numeric	Number of satellites used in solution
9	flag	Solution OK (1=yes 0=no)
10	numeric	Height above ellipsoid
11	indicator	M=metres
12	numeric	Separation between geoid and ellipsoid
13	indicator	M=metres
14	numeric	RTCM latency
15	string	*checksum

Example of two lines from a file of *.POS

FLT 02 LINE 001 GPSTIME 225133.00 Day 85 08:51:34 WGS84 Zone=56
$GPGGA,225133.00,3254.78039,S,15131.72567,E,2,8,1,125.15,M,25,M,6,100*7E
$GPGGA,225133.50,3254.78800,S,15131.72310,E,2,8,1,123.30,M,25,M,6,100*7E

Digital Data Readme File

GENERAL

Project:	Heli EM Survey
Client:	Jervois Mining N L
Client Rep:	Anthony Jannink
Survey By:	Geo Instruments
Job Number:	2113
Survey date:	November 2001
Survey Base:	Sheffield
Survey Areas:	Moina

DATA ACQUISITION

AIRBORNE SURVEY SPECIFICATIONS

Survey flown	November 2001
Traverse line spacing	200 metres
Traverse line direction	000 / 180 degrees
Tie line spacing	1,200 metres
Tie line direction	90 / 270 degrees
Survey height	EM towed bird at 30m agl
Electromagnetic System	Hummingbird 5 frequency EM system.
Data acquisition	Geo Instruments Model G2002 system
	Geotech Hummingbird system
Aircraft	AS350BA Squirrel helicopter

MAGNETOMETER

Type	Geometrics G822A Caesium vapour
Resolution	0.001 nT
Recording interval	0.1 sec (approx. 3.5 metres sampling)
Installation	Magnetometer sensor mounted in HEM bird.

NAVIGATION

Flight path navigation	Real time satellite
	Differential GPS system
Navigation equipment	Fugro OMNISTAR GPS receivers
Flight path record	WGS84 Easting/ Northing coordinates
Radar altimeter	Collins Alt50
GPS base station	Fugro OMNISTAR (Real Time DGPS)

HUMMINGBIRD COIL SPECIFICATIONS:

Channel	:	1	2	3	4	5
Freq (Hz)	: 7000	6600	980	875	34000	
Orientation	:	CX	CP	CX	CP	CP
Coil Separation (m)	:	6.26	6.26	6.01	6.01	4.93

DATA PROCESSING

MAGNETIC DATA

The magnetic data has been corrected for regional gradient by subtraction of IGRF model 2001.9 and secular variation model 1995-2000. Diurnal variations have been removed. System parallax has been removed. Tieline levelling has been applied. Microlevelling has been applied. The mean diurnal value and the IGRF base value have been added to the data.

ELECTROMAGNETIC DATA

The electromagnetic data has been filtered to remove the effects of sferics and other noise sources. Data has been corrected for system drift by subtraction of background zero levels determined from high altitude calibration data. System parallax has been removed. Apparent resistivities and depths have been calculated using both the Nomogram and Inversion techniques using the Geosoft HEM module. Inphase and quadrature channels have been levelled to remove residual flight line features in apparent resistivities. Microlevelling has been applied.

GRIDDING -	Electromagnetics (Resistivities):
Algorithm	Minimum Curvature
Grid mesh size	20 x 20 metres
Grid filter	None

GRIDDING -	Magnetics:
Algorithm	Minimum Curvature
Grid mesh size:	20 x 20 metres
Grid filter	None

GRIDDING -	Digital Terrain:
Algorithm	Minimum Curvature
Grid mesh size	20 x 20 metres
Grid filter	3 x 3 mean

LINE NUMBERING
Line numbers are in the form 'TLLLA' where
T = Line type (1 = traverse, 7 = tie)
LLL = Line sequence number
A = Line attempt number
eg: 10021 is traverse line 2 attempt 1
70482 is tie lie 48 attempt 2

BIBLIOGRAPHIC REFERENCE

Surveyed by	Geo Instruments Pty Ltd, Sydney
Processed by	Geo Instruments Pty Ltd
Grid production by	Geo Instruments Pty Ltd

PROCESSED LOCATED DATA :

Format:	Geosoft GDB
Database Files:	Ax_IL_DB.GDB

MAGNETIC & DTM DATA

Field	Description
X	Easting (AGD84 metres, TMAMG Zone 54)
Y	Northing (AGD84 metres, TMAMG Zone 54)
Line	Line number (10000+ for Trav, 70000+ for Tie Lines)
Fid_Hum	Fiducial of HEM System
Fid_GEO	Fiducial Geo Instruments system
Julian	Julian_day (DDD, year 2001)
Time_HH	Time (decimal hours)
FlightNo	Flight number
Linetype	Linetype 2=Traverse, 4= Tie
Radalt	Radar altimeter (metres) Aircraft height; bird 30m less.
Baroalt	Barometric altimeter
GPSalt	Gps height (metres)
DTM	Final digital terrain model (metres)
Diurnal	Diurnal magnetic field (nanoTeslas)negative values
Mag_raw	Compensated raw magnetics (nanoTeslas)
TMI_Corrected	Corrected magnetics (nanoTeslas)
TMI_FINAL	Final magnetics (micro Levelled) (nanoTeslas)

EM DATA: Nomenclature for field name / processing relationship:

'_ppm'	Raw data unlevelled
'_F_L'	Filtered and levelled data.
'_F_LD'	Filtered, levelled and microlevelled data.
'_AResist'	Apparent resistivity calculated using nomogram technique.
'_AResistINV'	Apparent resistivity calculated using inversion technique.
'_Depth'	Apparent depth calculated using the nomogram technique.

GRIDDED DATA FILES:

Files:	Extensions as for processed data above.
Format:	ER Mapper
Cell size:	20 metres
Datum:	AGD84
Projection:	TMAMG
Zone:	55