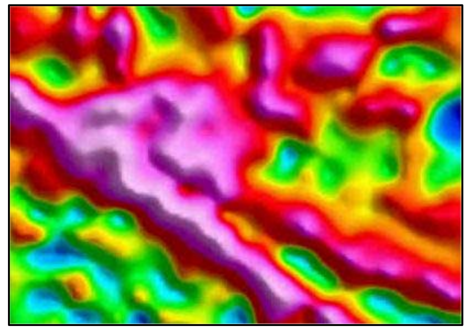
TENNANT CREEK EL23897
DETAILED GRAVITY SURVEY

August 2004



Report Number 04015
LR Mathews

CLIENT
Resources Holdings Ltd

CLIENT CONTACT
Peter N Smith
Principal
Resources Holdings Ltd
PO Box 3184 Nedlands
Western Australia 6009
Tel +61 8 9386 3392

SURVEY CONTRACTOR
DAISHSAT PTY. LTD
P.O. Box 766
MURRAY BRIDGE S.A. 5253
Tel: (08) 8531 0349
Fax: (08) 8531 0684

CONTRACTOR CONTACT
Mr. David. Daish
P.O. Box 766
MURRAY BRIDGE S.A. 5253
Tel: (08) 8531 0349
Fax: (08) 8531 0684
Mob: 0418 800 122
Email:david.daish@daishsat.com

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1. INTRODUCTION

A precision GPS-Gravity survey was carried out between 18th and 28th 2004 September for Resources Holdings Ltd. A total of 2116 stations were surveyed over tenement EL23897, a Resources Holdings tenement located approximately 20 kilometres south-east of the town of Tennant Creek, Northern Territory.

Gravity data were acquired using Scintrex CG3M digital gravity meters. Position and level data were obtained using Leica System 1200 units, to produce precise-real-time-kinematic GPS locations. All data were acquired using Daishsat foot-borne methods.

Gravity data were reduced using standard reductions on the ISOGAL84 gravity network. GPS data were reduced to MGA coordinates with levels expressed as metres above the Australian Height Datum.

2. SURVEY OVERVIEW

A detailed gravity survey was conducted over a Resources Holdings tenement, EL 23897. The tenement was located approximately 20 kilometres south-east of the town of Tennant Creek, Northern Territory. Access to the survey area was via unsealed road and bush tracks (see Figure1).

Initial gravity surveying was conducted on a 25m station spacing, 200m line spacing. Follow-up infill over anomalous areas was conducted on a 25m station spacing, 25m line spacing.

A small GPS control survey was also conducted to locate drill holes and establish a base-line.

Specifications for the survey are contained in Appendix C. Appendix A contains a station plot of the survey.

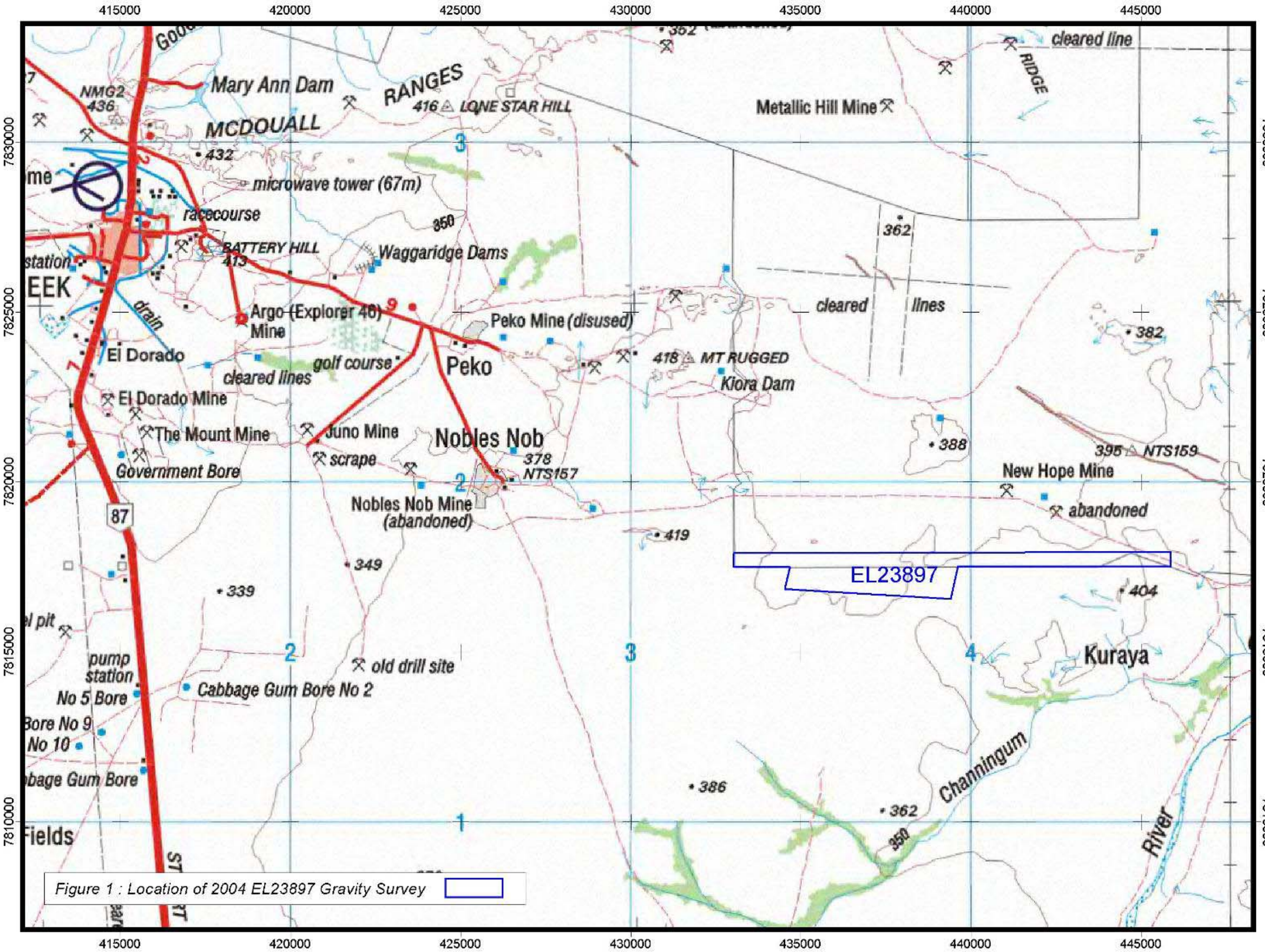


Figure 1 : Location of 2004 EL23897 Gravity Survey

3. PERSONNEL AND EQUIPMENT

3.1 Personnel

The supervisor in charge of the project was Grant Coopes. Grant was responsible for daily management of the job and for nightly data processing to ensure quality and integrity. Gravity and GPS measurements were carried out by Allan Cowie, Ewan Smith, Ben Allsopp, Ron Witt and Sally Callum. Final data reduction and inspection were performed by the company geophysicist, Leon Mathews.

3.2 Survey equipment

- Three Scintrex CG-3M digital gravity meters (SN 408275, 711410, 704365)
- Three Leica System 1200 dual frequency GPS receivers (Two Rovers and Base)
- Four UHF Pacific Crest Data Modem/Radios
- Garmin Handheld GPS receivers for navigation
- Two laptop computers for data processing and backup
- Various chargers, solar cells and batteries

Photo 1 : Crew and equipment at a GPS Base station

3.3 Vehicles

Due to the type of terrain to be encountered, 4wd Landcruiser vehicles were used for the duration of the job. To maintain the high Daishsat safety record, vehicles were fitted with a range of safety equipment including:

- One 20l jerry can of water
- Dual fuel tanks
- Two spare tyres
- HF radio
- Self-recovery equipment including a hand winch, snatch straps and rope
- Tyre pliers to effect tyre repairs in the field
- Tools and spares to enable field repairs as necessary
- Survival kit with EPIRB emergency locator beacon

3.4 Camp

The crew stayed at Tennant Creek for the duration of the project.

3.5 Communications

The survey crew was equipped with hand-held Iridium satellite phones, as well as UHF transceivers. Skeds were made at regular intervals to ensure crew safety.

4. GPS SURVEYING AND PROCESSING

4.1 Set out of the grid

This was done concurrently with the gravity data acquisition using Leica RTK GPS. Where possible, the readings were taken as close to the ideal coordinates as possible. Some stations were offset or omitted due to the nature of the terrain, e.g. hilly or thickly vegetated areas. As the Leica System was operating in precise RTK mode, set out accuracy was better than 2cm. At the repeat stations, a washer tied to pink flagging, marked with the station number, was used for identification. At each station, the station number, position and RL were recorded digitally by the GPS crew.

4.2 Survey datum and control

The gravity surveying, and hence any gravity reductions, used the Australian Height Datum (AHD) as the reference datum. All GPS/Gravity base stations were established using two days worth of static data, and connections to ITRF stations using AUSLIG's online GPS processing system, AUSPOS. For more information on this system, please visit http://www.auslig.gov.au/geodesy/sgc/wwwgps/. Final deviations of better than 5mm were obtained for x,y and z, for all occupations.. Appendix D contains the GPS base station information.

4.3 Processing of the position and level data

The real-time kinematic GPS data were recorded on 2Mb Flashcards, which were downloaded onto computers daily. All data is processed in real time, so no further processing was required.

Simple transformations to MGA and AHD were done using the GPS derived WGS84 positions.

MGA94 coordinates were obtained by simply projecting the GPS-derived WGS84 coordinates using a UTM projection with zone 53S. For all practicable purposes, the WGS84 geodetic coordinates are equivalent to GDA94 geodetic coordinates, so no transformation is necessary. For more information about GDA94 and MGA94, please visit http://www.auslig.gov.au/ausgda/gdastrat.htm.

AHD heights were calculated in real-time on the fly using Leica algorithms and the latest geoid model for Australia, AUSGEOID98. Information about the geoid, and the modeling process used to extract separations (N values) can be found at http://www.auslig.gov.au/geodesy/ausgeoid/geoid.htm. To obtain AHD height, the modeled N value is subtracted from the GPS derived WGS84 ellipsoidal height (Figure 2).

$$H_{AHD}=h_{WGS84}-N$$

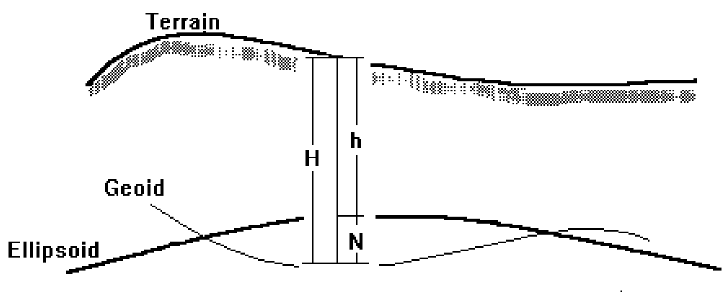


Figure 2: Geoid-Ellipsoid separation

4.4 GPS Performance

Performance from the Leica RTK system was excellent, with minimal downtime due to poor geometry and/or trees.

5. GRAVITY ACQUISITION AND PROCESSING

5.1 Gravity data acquisition

Gravity observations were made on the regular grid previously set out by real-time GPS (see Photo 2). Two observations were made for each station. Each observation consisted of a 20-second or greater stacking time. Two observations were made at each station so that any seismic or instrumental noise could be immediately detected. The accepted tolerance between readings was limited to 0.02 milliGals to ensure accuracy. Vertical and horizontal levels were restricted to 5 arc seconds at all times. At each station, the station number, time and two gravity readings (in dial units) were recorded in DAISHSAT carbon-copy gravity field books. The Scintrex CG3 also automatically records the station, time and readings digitally to allow for downloading to computer.

Photo 2 - Gravity Acquisition

5.2 Gravity base stations

The Australian Fundamental Gravity Network (AFGN) station (6793 0134) at Tennant Creek was used as the base station for the duration of the survey. The station was used for calculation of absolute gravity and drift determination during the survey. Details of the gravity base are contained in Appendix D. When in the field, a base station reading was taken in the morning before observing, and at evening after the last observation. When taking a base station reading, the observed gravity values were stacked over 120 seconds to ensure accuracy. Two observations of 120 seconds were taken at each base reading. Observations were repeated until the readings repeated to 0.01 of a dial reading or less.

5.3 Gravity data processing

Raw gravity data were processed on a daily basis to check for quality and integrity. This interim process produced a set of Bouguer Gravity values which were contoured and imaged to provide a check for any anomalous readings that would need repeating. Geosoft GRAVRED software was used for the gravity reduction in the field. Upon conclusion of the job, data were reprocessed using the standard GA formulae (see below).

Instrument scale factor: This correction was used to correct a gravity reading (in dial units) to a relative milliGal value based on the meter calibration.

Tidal correction: This correction was used to correct for background variations due to changes in the relative position of the moon and sun. The Scintrex calculated ETC was removed and a new ETC calculated using Geosoft Formulae and the surveyed GPS latitude. The formula is too complex to list here.

Instrument Drift: Since gravity meters are mechanical, they are prone to drift (extension of the spring with heat, obeying Hooke's law). If two base readings are taken one can assume that the drift between the two readings is linear and can therefore be calculated. The drift and tidal corrected value is referred to as the *observed gravity*.

Theoretical Gravity: The theoretical value of gravity was calculated using the 1967 variant of the International Gravity Formula and used to latitude correct the observed gravity.

$$Gt=9,780,318.456*(1+0.005\ 278\ 895*\sin^2\phi+0.000\ 023\ 462*\sin^4\phi)$$

where ϕ represents degrees of latitude;

Free-Air Correction: Since gravity varies inversely with the square of distance, it is necessary to correct for changes in elevation between stations to reduce field readings to a datum surface (in this case, AHD).

$$(3.08768 - 0.00440 \sin^2\phi)*h - 0.000001442*h^2 \quad \mu ms^{-2} \text{ per metre}$$

Bouguer Correction: This correction accounts for the attraction of material between the station and datum plane that is ignored in the free-air calculation. A value of 2.67 gm/cc was used in the correction.

$$0.4191*\rho \quad \mu ms^{-2} \text{ per metre}$$

where ρ = density 2.67 tm^{-3}

Terrain Correction: This correction accounts for the attraction of material above the assumed Bouguer slab and for the over-correction made by the Bouguer correction when in valleys. This correction was not applied as the area was relatively flat.

Free Air Gravity: This is obtained by applying the free air correction (FAC) to the observed gravity reading.

$$FAG=G_{OBSG84}-Gn+FAC$$

Bouguer Gravity: This is obtained when all the preceding reductions or corrections have been applied to the observed gravity reading.

$$BG267=G_{OBSG84}-Gn+FAC-BC$$

5.4 Gravity meter calibration and scale factors

The gravity meter used had previously been calibrated over a number of calibration ranges in WA and SA. Derived scale factors from these calibrations are shown below:

CG3M	408275	SF = 1.000000
CG3M	704365	SF = 1.000000
CG3M	711410	SF = 1.000000

5.5 Gravity meter drift calibration

While the survey was in progress, the meter was cycled overnight as a check on instrument drift. Changes were made to the drift constant where appropriate.

6. DRILLHOLE SETOUT AND BASE LINE ESTABLISHMENT

A small setout survey was conducted using System 1200 GPS operating in RTK mode. The survey involved setting out several drill holes and base-lines in MGA53 coordinates. For the base-line and cross-line, 1.3m length star pickets were driven into the ground and marked with stamped aluminum tags. The drill-hole locations were marked with aluminum fence separators, with coordinates written on with black paint pen.

As the survey was conducted in RTK mode, all coordinates are accurate to better than 5cm for x, y and z.

A listing of the final surveyed coordinates is contained in Table 1 below. Figure 2 contains a plot of the station locations.

STATION	MGA53_EAST	MGA53_NORTH	AHD
1003	438250.567	7817200.095	348.372
1002	438200.062	7817200.023	348.184
1001	438149.993	7817200.020	347.898
1000	438100.026	7817200.002	347.245
1004	438299.989	7817200.024	348.623
1005	438350.064	7817200.072	349.255
1006	438400.158	7817200.099	352.804
1007	438250.068	7817250.038	348.003
1008	438250.032	7817300.086	347.803
1009	438250.116	7817350.034	347.680
1010	438250.014	7817400.011	347.560
1018	438275.093	7817330.079	347.753
1021	438300.037	7817313.104	347.812
1013	438225.000	7817313.169	347.657
1011	438200.169	7817288.506	347.725
1012	438225.090	7817273.110	347.837
1015	438250.022	7817279.022	347.862
1017	438275.052	7817264.140	347.996
1014	438250.117	7817259.014	347.933
1016	438275.048	7817239.380	348.163
1020	438300.012	7817250.041	348.132
1019	438300.039	7817225.043	348.443

Table 1 : Listing of drill-hole and base-line coordinates

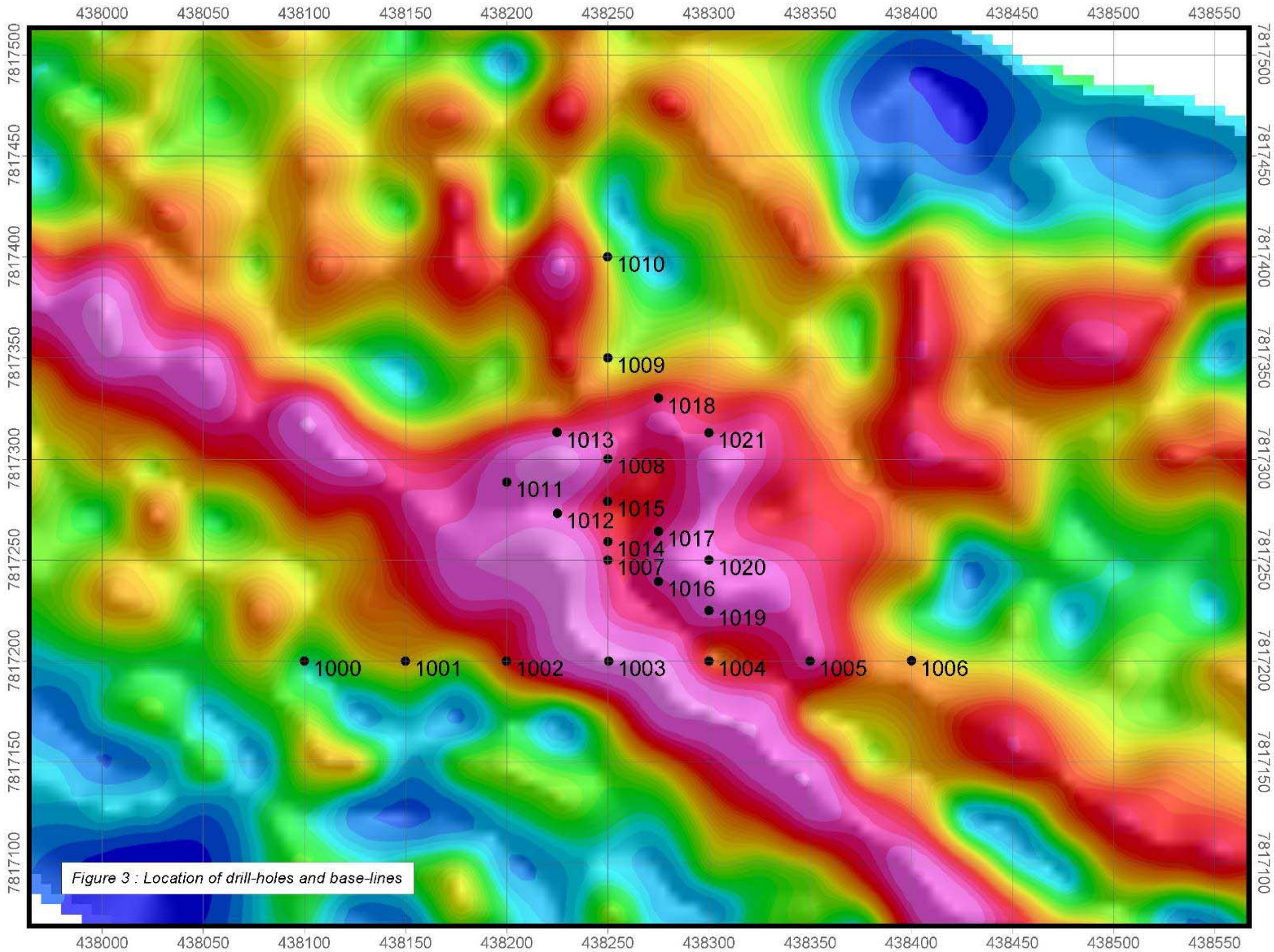


Figure 3 : Location of drill-holes and base-lines

7. RESULTS

Raw and processed GPS and gravity data are contained on CDROM as Appendix E. Hardcopy plots of station location/images are contained in Appendix A.

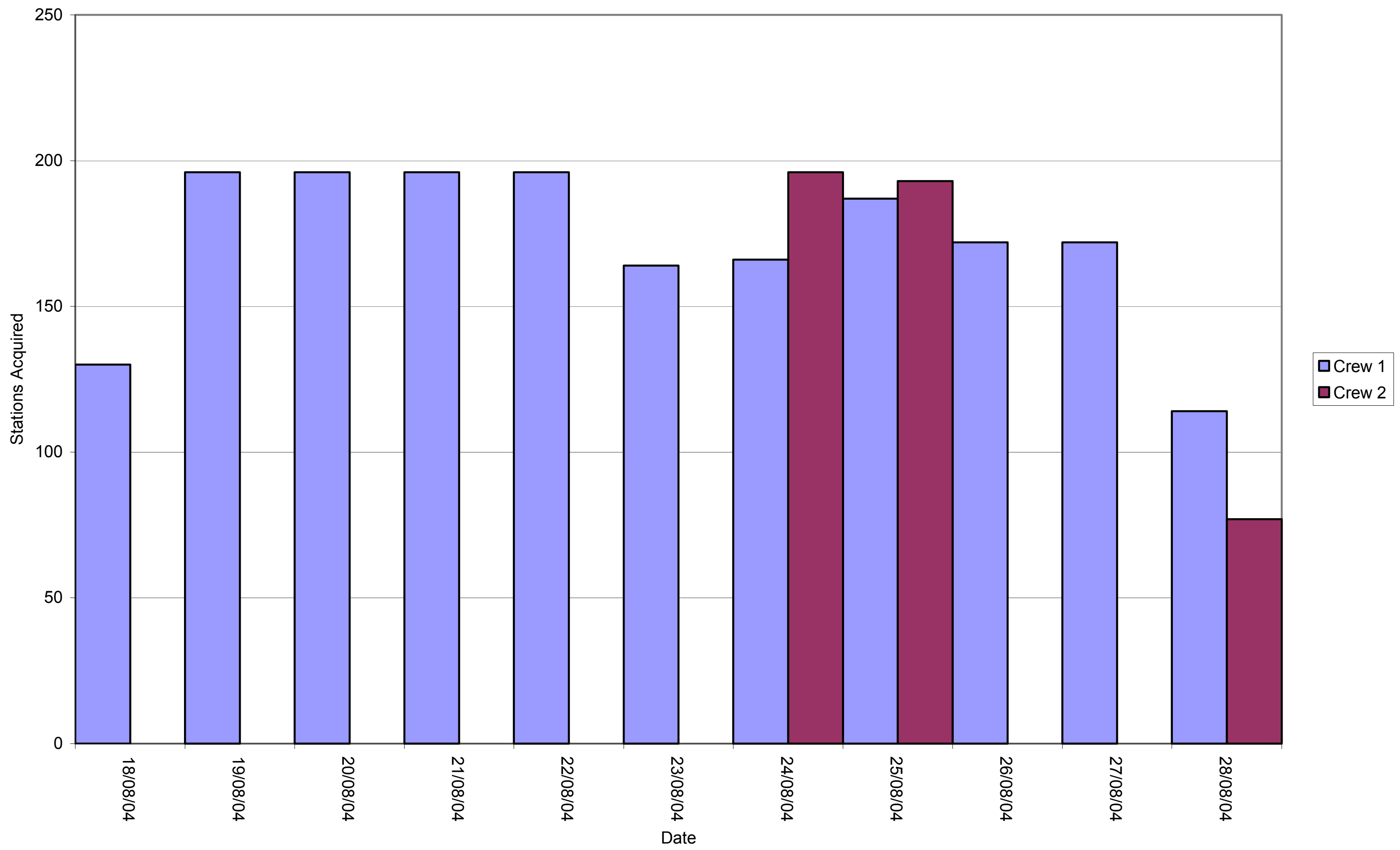
8.1 Stations Surveyed and Survey Progress

In total, 2116 new stations were acquired during the survey. A brief production summary for each area is shown in Table 2 below. Figure 4 shows the production rates attained over the duration of the job.

EL23897 Survey		
Gravity stations acquired (including repeats)	**2270**	**stations**
Gravity station repeats	**154**	**6.7%**
New gravity stations acquired	**3086**	**stations**
Total accidents	**0**	**accidents**
Total hours lost from accidents	**0**	**hours**

Table 2 : Gravity Production Summary

EL23897 Gravity Production



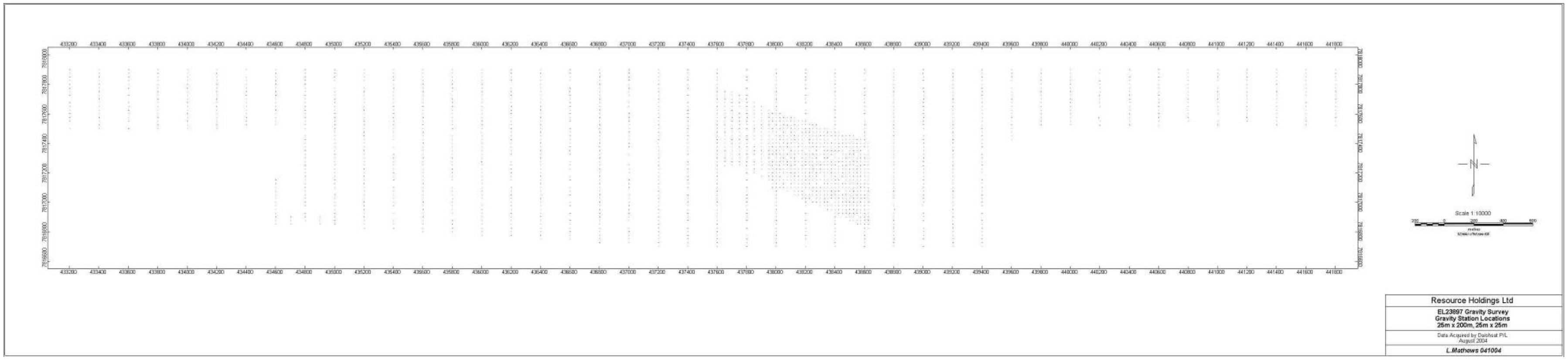
8.2 Data Repeatability

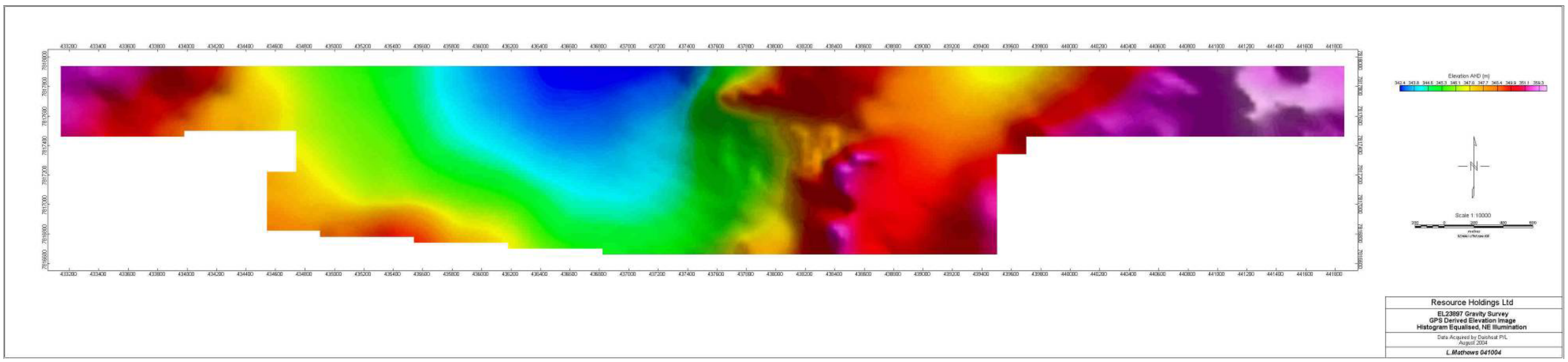
Analysis of the repeat data shows that measurement repeatability is excellent for both GPS and Gravity observations. An analysis for the survey is included in Appendix B. Based on the repeat data, one can assume the following typical accuracies for the observables:

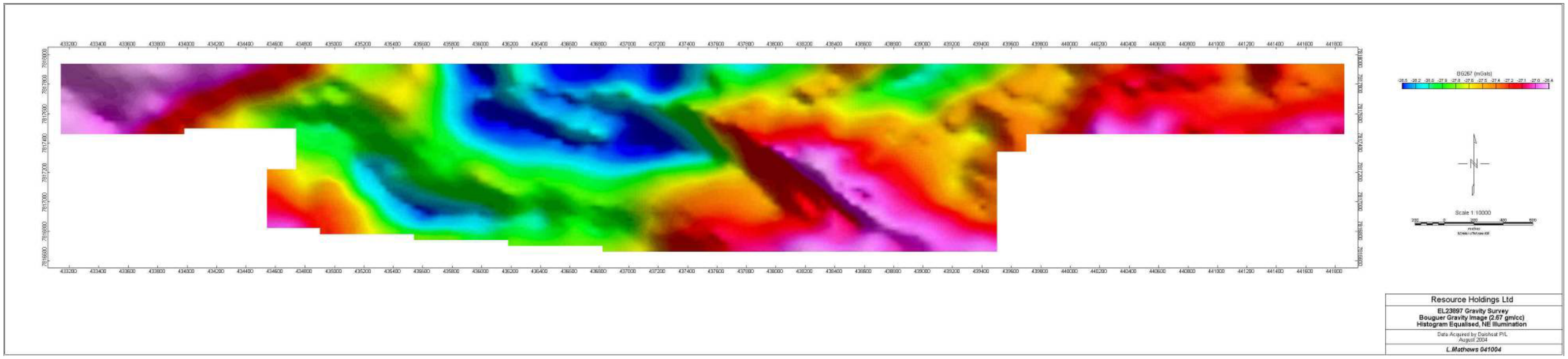
Z position observation : < 0.02 m
Gravity observation : < 0.02 mGals

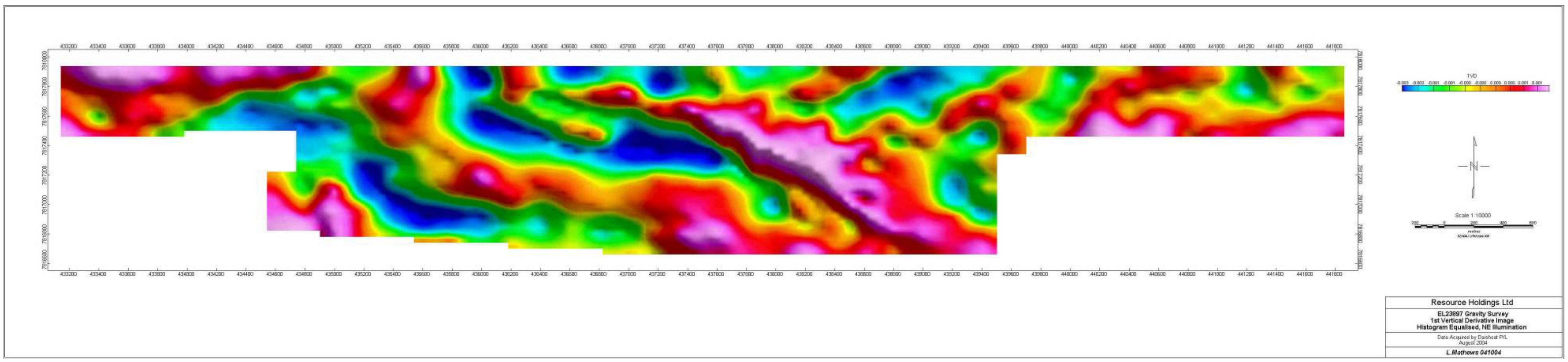
APPENDIX A

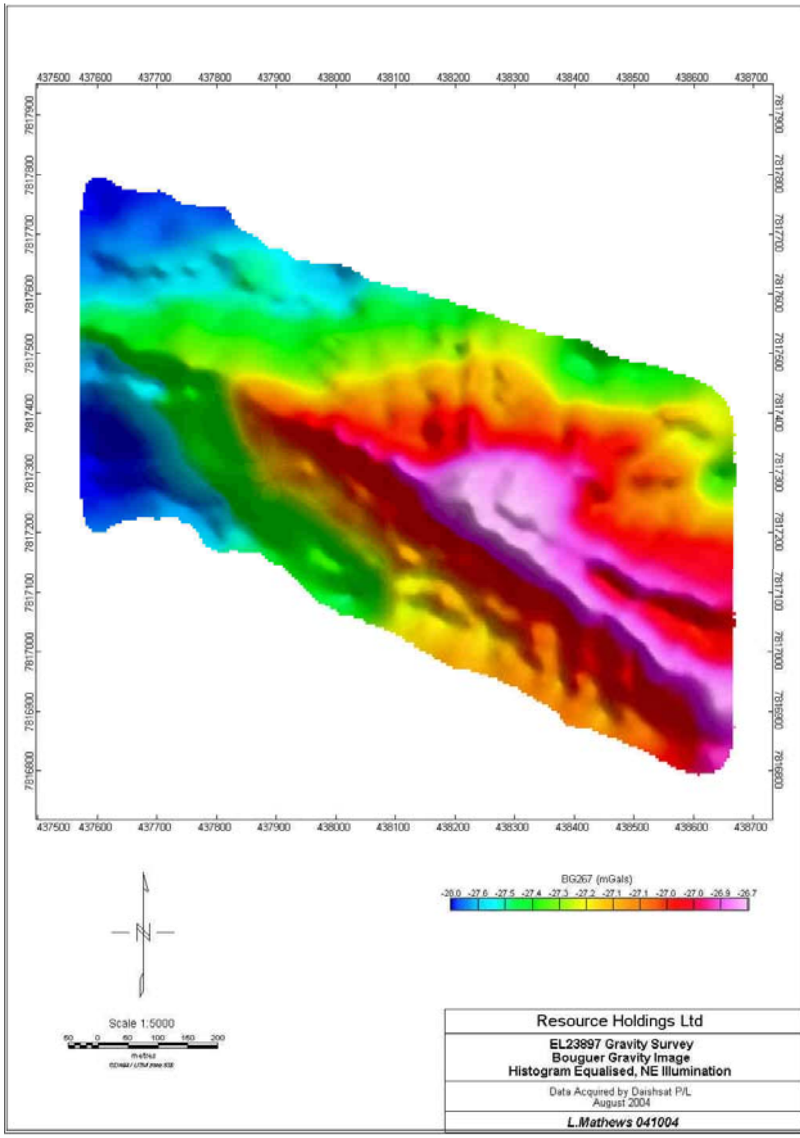
Plots of station location / Images

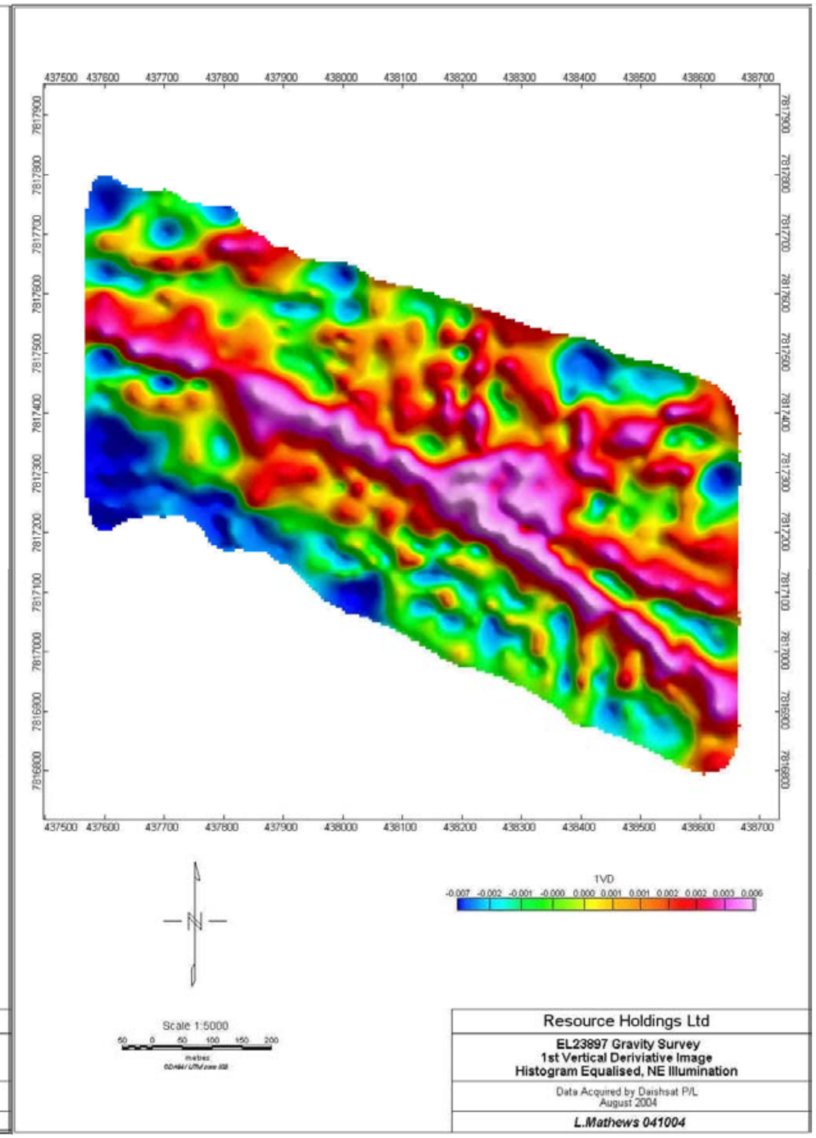

Scale 1:10000
Resource Holdings Ltd
EL23897 Gravity Survey
Gravity Station Locations
25m x 200m, 25m x 25m
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004


Scale 1:10000
Resource Holdings Ltd
EL23897 Gravity Survey
GPS Derived Elevation Image
Histogram Equalised, NE Illumination
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004


Scale 1:10000
Resource Holdings Ltd
EL23897 Gravity Survey
Bouguer Gravity Image (2.67 gm/cc)
Histogram Equalised, NE Illumination
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004


1VD
Scale 1:10000
Resource Holdings Ltd
EL23897 Gravity Survey
1st Vertical Derivative Image
Histogram Equalised, NE Illumination
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004


BG267 (mGals)
Scale 1:5000
metres
Resource Holdings Ltd
EL23897 Gravity Survey
Bouguer Gravity Image
Histogram Equalised, NE Illumination
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004

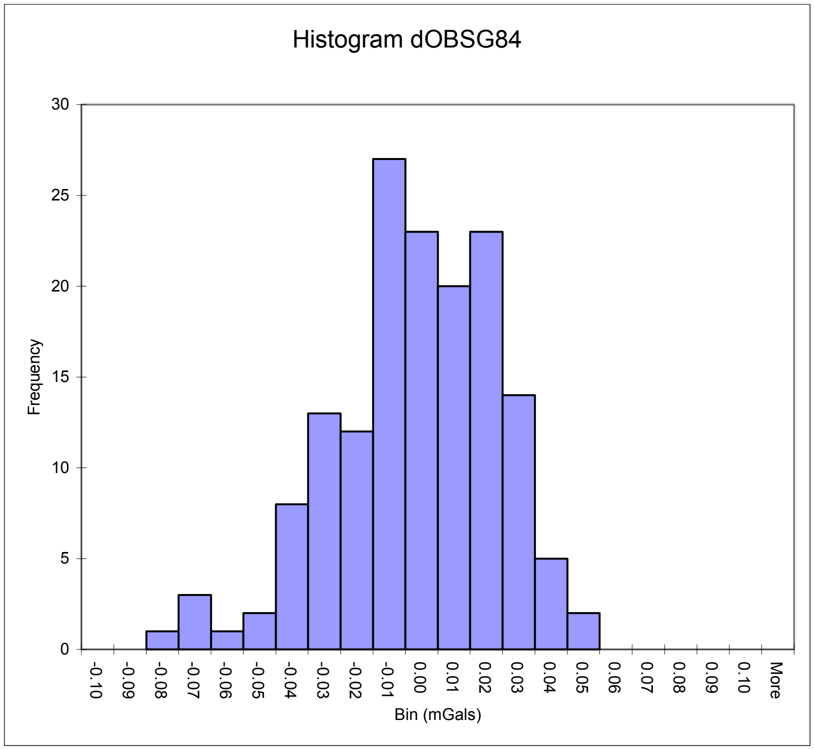

1VD
Scale 1:5000
metres
Resource Holdings Ltd
EL23897 Gravity Survey
1st Vertical Deriviative Image
Histogram Equalised, NE Illumination
Data Acquired by Daishsat P/L
August 2004
L.Mathews 041004

APPENDIX B

Repeat Tabulation and Analysis

Repeatability of OBSG84

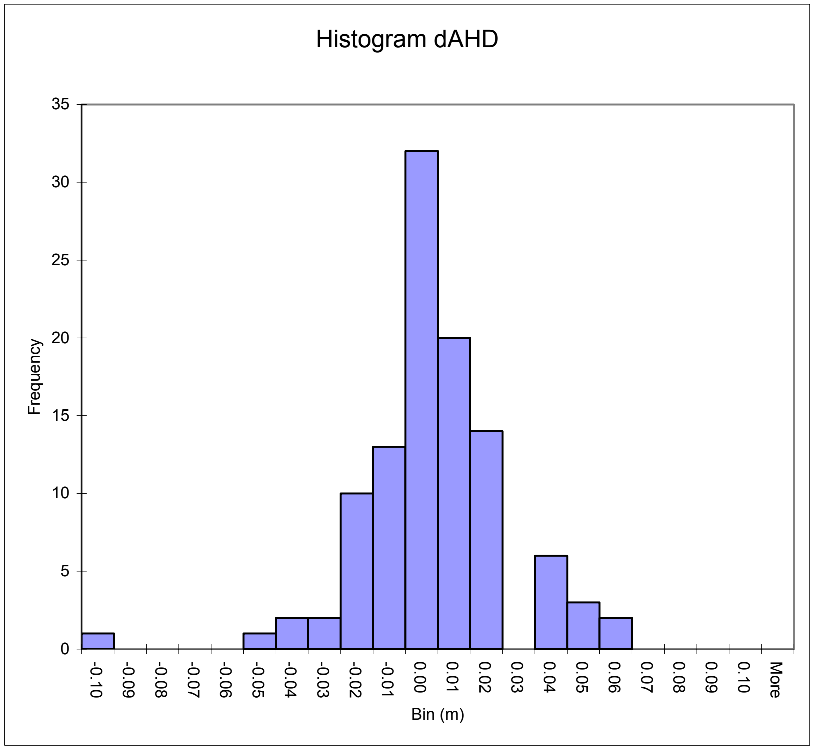
Bin	*Frequency*
-0.10	0
-0.09	0
-0.08	1
-0.07	3
-0.06	1
-0.05	2
-0.04	8
-0.03	13
-0.02	12
-0.01	27
0.00	23
0.01	20
0.02	23
0.03	14
0.04	5
0.05	2
0.06	0
0.07	0
0.08	0
0.09	0
0.10	0
More	0



	dOBSG84
Mean	-0.006
Standard Error	0.002
Median	-0.001
Mode	0.010
Standard Deviation	0.024
Sample Variance	0.001
Kurtosis	0.754
Skewness	-0.696
Range	0.125
Minimum	-0.080
Maximum	0.045
Sum	-0.901
Count	154

Repeatability of AHD

Bin	*Frequency*
-0.10	1
-0.09	0
-0.08	0
-0.07	0
-0.06	0
-0.05	1
-0.04	2
-0.03	2
-0.02	10
-0.01	13
0.00	32
0.01	20
0.02	14
0.03	0
0.04	6
0.05	3
0.06	2
0.07	0
0.08	0
0.09	0
0.10	0
More	0



	dHT
Mean	-0.001
Standard Error	0.002
Median	0.000
Mode	0.000
Standard Deviation	0.022
Sample Variance	0.000
Kurtosis	4.909
Skewness	-0.873
Range	0.167
Minimum	-0.108
Maximum	0.060
Sum	-0.106
Count	106

APPENDIX C
Survey Specifications

EL23897 Gravity Survey

Survey Name	EL23897
Operators	GC, BA, SC, ES, AC
Techniques Employed	GPS, Gravity
Station Spacing	25m
Line Spacing	200m and 25m infill
Gravity Meter	Scintrex CG3 SN 408275, 711410, 704365
GPS	Leica 1200

APPENDIX D

Base Station Information

Gravity Base 0034 – Tennant Creek Airport

MGA94

EASTING
NORTHING
ZONE
HEIGHT (AHD) NA

GDA94

LATITUDE -19.64167
LONGITUDE 134.18167

OBSERVED GRAVITY

978514.583 mGals (ISOGAL84)

SURVEYED BY

AGSO station 6793 0134

MISCELLANEOUS DETAILS

Station is located underneath the verandah of the terminal building at Tennant Creek airport. Station is witnessed by a brass AGSO plaque, numbered 6793 0134.

Photo of Gravity Base 0034 with distinguishing features in background.

GPS Base 0175 – GOOSE RIVER

MGA94

EASTING	435896.467
NORTHING	7817515.003
ZONE	53
HEIGHT (AHD)	344.041

GDA94

LATITUDE	19 44 12.91571 S
LONGITUDE	134 23 17.53855 E
HEIGHT(GDA94)	377.246

OBSERVED GRAVITY

NA

SURVEYED BY

Coordinates were obtained via AUSPOS over consecutive days. Accuracy of x,y,z better than 5mm.

MISCELLANEOUS DETAILS

The base is located off the north side of the fenceline track. It is marked by a small steel pin protruding a few centimetres above ground level. It is witnessed by a Daishsat witness plate attached to a large star picket found approximately 30cm to the East.

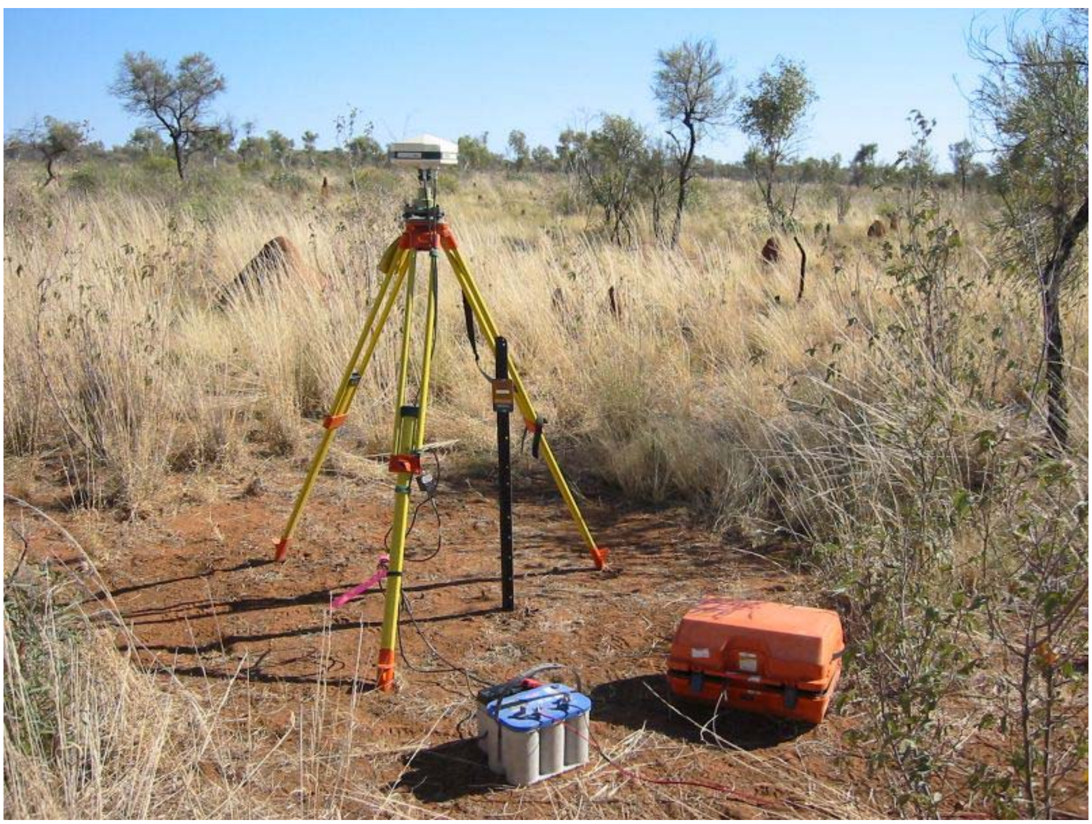


Photo of GPS Base 0175 with distinguishing features in background.