

Atlas Geophysics Memorandum M201002

Ooratippra Infill Gravity Survey

CKA Resources Pty Ltd

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atlas
G E O P H Y S I C S

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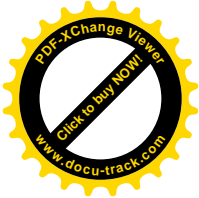
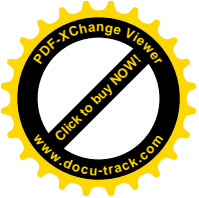
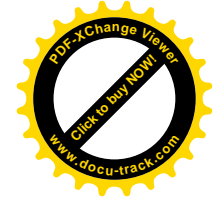
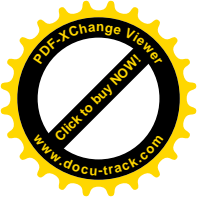


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1.0 Project Brief

Project P2011032 “Ooratippra Infill” required the acquisition and processing of 931 gravity stations over tenements held by CKA Resources Pty Ltd. The gravity survey was located over two areas known as Area A and Area B, about 280km northwest of Alice Springs, in the Northern Territory (Figure 1). The areas can be accessed via the Sandover Highway. The aim of the survey was to infill a regional survey previously conducted by Atlas Geophysics in 2010 over selected areas of interest.

Acquisition commenced on 5th October 2011 but was suspended on 11th October 2011 due to a bushfire in the surrounding areas. Production recommenced on the 15th October and the survey was completed on the 18th October 2011 with final data delivered shortly thereafter.

Gravity data were acquired using grid configurations of 1km x 200m (Area A) and 400m x 200m (Area B). Appendix B contains a plot of the locations of acquired gravity stations.

Acquisition was carried out by a two person UTV-borne crew. The crew were accommodated and messed at a fly camp situated between the two survey areas.

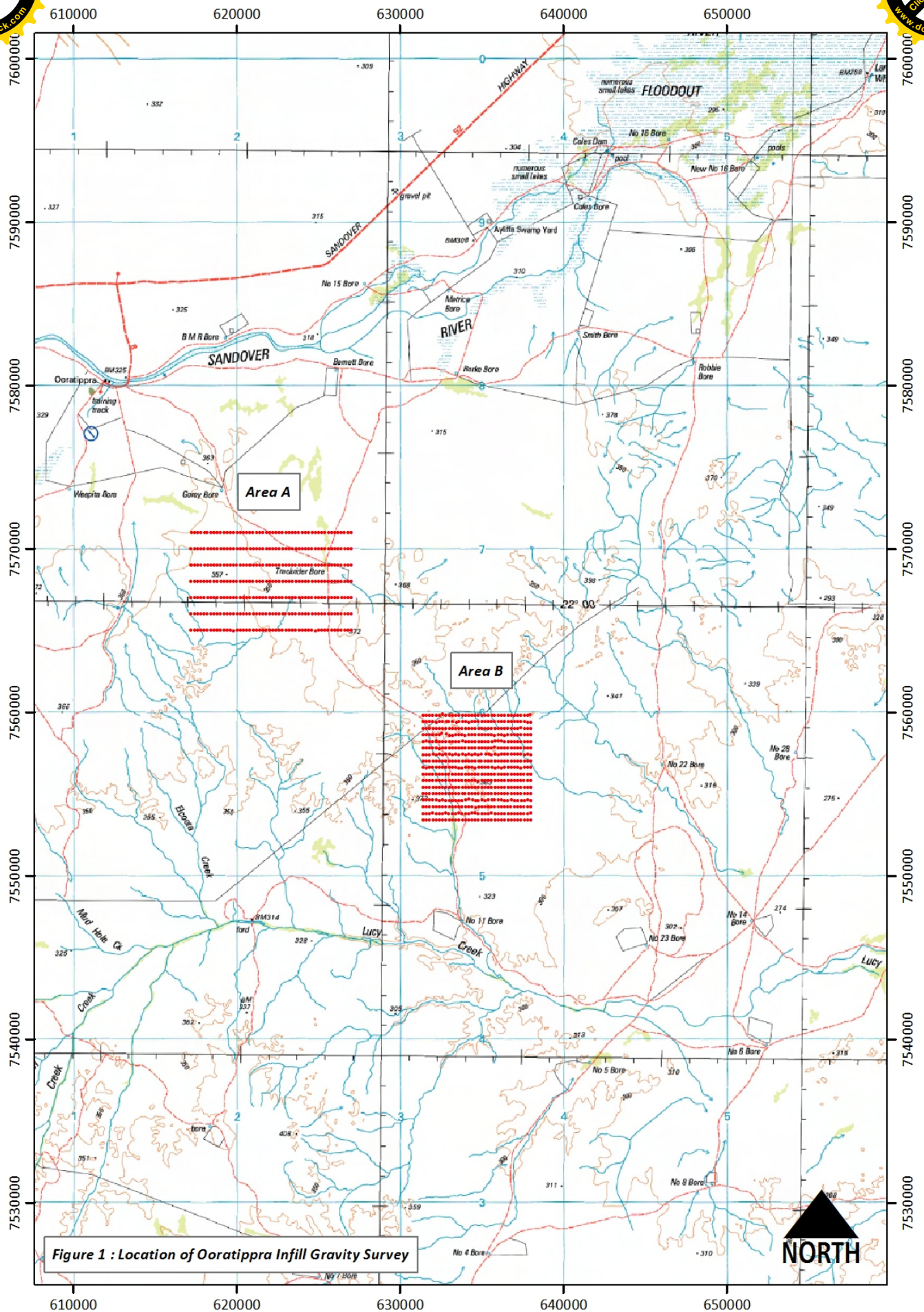
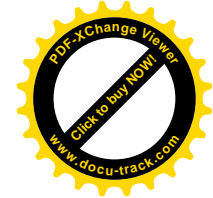
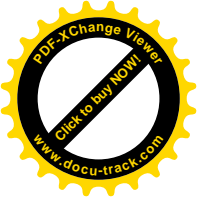


Figure 1 : Location of Oorattippra Infill Gravity Survey



2.0 Equipment and Instrumentation

The following instrumentation was used for acquisition of the gravity data:

- One CG5 Autograv Gravity Meter (Serial Number 40240, SF 1.000000)
- Two Leica System 1200 GPS-Glonass receivers
- One Leica System 500 GPS Receiver

Ancillary equipment included:

- Two HP Laptop computers for data download and processing
- Magellan FX324 autonomous GPS receivers for navigation
- Iridium satellite phones for long distance communications
- Personal Protective Equipment for all personnel
- Batteries, battery chargers, solar cells, UPS System
- Survey consumables
- Tools, engineering and maintenance equipment for vehicle servicing
- First aid and survival kits
- Tyres and recovery equipment
- GeoPro satellite tracking and communication device

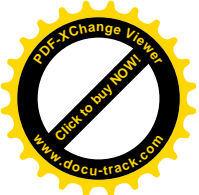
3.0 Calibration and Control

The gravity meter used for survey has been recently calibrated on the Guildford Cemetery – Helena Valley Primary School calibration range (2010990117- 2010990217) in Western Australia. The calibration process has validated the gravity meter's scale factor to ensure reduction of the survey data produces correct Observed Gravities from measured dial reading values.

A single GPS-Gravity control station (201103200001 "Ooratippra Base") was established on 5th October, 2011 to control field observations. Appendix A contains a description for the station.

Primary GPS control was established by submitting static data to Geoscience Australia's AUSPOS processing system to produce first-order geodetic coordinates accurate to better than 10mm for the x, y and z observables. Multiple days of static GPS data have been submitted to ensure accuracy and reliability of the solution. The details of the control process have been summarised in a table included in Appendix C.

Primary gravity control was established at the same location as the primary GPS control station. Once tied to the Australian Fundamental Gravity Network (AFGN), the gravity control station allowed all field gravity observations to be tied to the Australian Absolute Gravity Datum 2007 (AAGD07). An accurate observed or absolute gravity value for the control station was established via "ABA" ties with the project gravity meter to control station GRVGPS0115 Ooratippra on 18th and 19th October 2011, an Atlas Geophysics control station that has been tied in to AFGN station 1964919040, located at Ammaroo airstrip, in September, 2010. Expected accuracy of the tie survey would be 0.01 mGal (0.1gu).



4.0 GPS-Gravity Acquisition

Gravity data were acquired concurrently with GPS data using a Scintrex CG5 gravity meter. Data were acquired in a single shift of 10 hours duration, with each shift consisting of a single loop controlled by observations at the gravity control station. Each loop contained a minimum of two repeated readings so that an interlocking network of closed loops was formed. A total of **3.33%** repeats were acquired for quality control purposes. Repeat readings were evenly distributed on a time-basis throughout each of the gravity loops.

GPS data were acquired with the rover receiver operating in post-process kinematic (PPK) mode. When carrying out acquisition with a UTV, the GPS-Glonass sensor is mounted on the roof the UTV (fixed antenna height of 1.81m) and the PPK data are logged by the receiver inside a protective case mounted to the rear tray of the UTV. Static data were logged at the control stations for submission to AUSPOS for delivery of final coordinates.

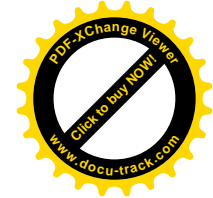
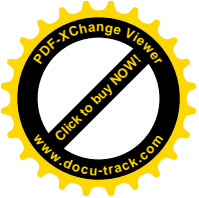
5.0 GPS Processing and QA

The acquired GPS and Glonass raw data were processed nightly in the field using Novatel Waypoint GrafNav v8.3 post-processing software. The resulting data (in Atlas Geophysics PPK standard format) were then imported into Atlas Geophysics Reduction and Interpretation Software (AGRIS) for QA and use in the reduction of the gravity data.

Projection from GPS-Glonass derived WGS84/GDA94 coordinates to Map Grid of Australia (MGA) coordinates was performed in GrafNav. For most practical applications where a horizontal accuracy of only a metre or greater is required, GDA94 coordinates can be considered the same as WGS84. MGA coordinates were obtained by projecting the GPS-derived WGS84 coordinates onto MGA Zone 53S using a Universal Transverse Mercator (UTM) projection. Elevations above the Australian Height Datum (AHD) were modelled using GrafNav software and the AUSGEOID09 geoid model.

A module built into AGRIS allowed the user to import the positional data from GrafNav and examine quality factors such as station repeatability between multiple control stations, coordinate velocity, dilution of precision, coordinate quality factor and standard error for each gravity station location. The procedure is carried out before merging the positional data with gravity data for final reduction to Bouguer anomaly. Comprehensive statistics, repeatability analysis and histogram plotting are also performed.

Quality control procedures were applied to the GPS-Glonass data on a daily basis and any gravity stations not conforming to the quoted specifications were repeated by the company at no cost to the client.



6.0 Gravity Processing and QA

The acquired gravity data were processed using the company's in-house gravity pre-processing and reduction software, AGRIS. This software allows for full data pre-processing, reduction to Bouguer Anomaly, repeatability and statistical analysis, as well as full quality analysis of the output dataset.

Once downloaded from the gravity meter, the data are analysed for consistency and preliminary QA is performed to check that observations meet specification for standard deviation, reading rejection, temperature and tilt values. Once the data are verified, the software averages the multiple readings and performs a merge with the GPS data (which it has also previously verified) and performs a linear drift correction and earth tide correction. Any gravity stations not conforming to the quoted specifications were repeated by the company at no cost to the client.

The following corrections were applied to the dataset to produce Spherical Cap Bouguer Anomalies on the GRS80 ellipsoid and AAGD07 gravity datum. For legacy reasons, Geoidal Bouguer Anomalies on the Australian Height Datum (AHD) and ISOGL84 gravity datum have also been calculated. The formulae below produce data in μms^{-2} or gravity units. To convert to mGal, divide by a factor of 10.

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

$$r_c = 10 \cdot (r \cdot S(r))$$

where,

r_c corrected reading in gravity units
 r gravity meter reading in dial units
 $S(r)$ scale factor (dial units/milliGal)

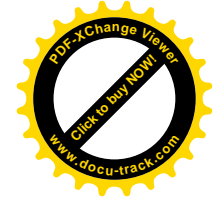
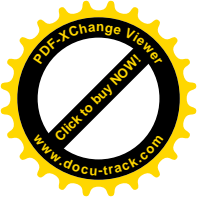
Earth Tide Correction: The earth is subject to variations in gravity due to the gravitational attraction of the Sun and the Moon. These background variations can be corrected for using a predictive formula which utilises the gravity observation position and time of observation. The Scintrex CG5 gravity meter automatically calculates ETC but uses only an approximate position for the gravity observation so is not entirely accurate. For this reason, the Scintrex ETC is subtracted from the reading and a new correction calculated within AGRIS software.

$$r_t = r_c + g_{tide}$$

where,

r_t tide corrected reading in gravity units
 r_c scale factor corrected reading in gravity units
 g_{tide} Earth Tide Correction (ETC) in gravity units

Instrument Drift Correction: Since all gravity meters are mechanical they are all prone to instrument drift. Drift can be caused by mechanical stresses and strains in the spring mechanism as the meter is moved, knocked, reset, subjected to temperature extremes,



subjected to vibration, unclamped etc. The most common cause of instrument drift is due to extension of the sensor spring with changes in temperature (obeying Hooke's law). To calculate and correct for daily instrument drift, the difference between the gravity control station readings (closure error) is used to assume the drift and a linear correction is applied.

$$ID = \frac{r_{cs2} - r_{cs1}}{t_{cs2} - t_{cs1}}$$

where,

ID	Instrument Drift in gu/hour
r_{cs2}	control station 2nd reading in gravity units
r_{cs1}	control station 1st reading in gravity units
t_{cs2}	control station 2 time
t_{cs1}	control station 1 time

Observed Gravity: The preceding corrections are applied to the raw gravity reading to calculate the earth's absolute gravitational attraction at each gravity station. The corrections produced Observed Gravities on the AAGD07 and ISOGAL84 datums.

$$G_o = g_{cs1} + (r_t - r_{cs1}) - (t - t_{cs1}) \cdot ID$$

where,

G_o	Observed Gravity in gravity units (ISOGAL84 or AAGD07)
g_{cs1}	control station 1 known Observed Gravity in gravity units
r_t	tide corrected reading in gravity units
r_{cs1}	control station 1 reading in gravity units
t	reading time
t_{cs1}	control station 1 time
ID	instrument drift in gravity units/hour

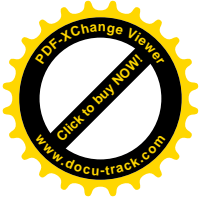
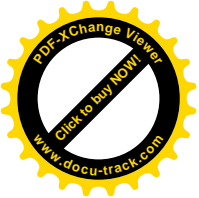
Theoretical Gravity 1980: The theoretical (or normal) gravity value at each gravity station is calculated based on the assumption that the Earth is a homogeneous ellipsoid. The closed form of the 1980 International Gravity Formula is used to approximate the theoretical gravity at each station location and essentially produce a latitude correction. Gravity values vary with latitude as the earth is not a perfect sphere and the polar radius is much smaller than the equatorial radius. The effect of centrifugal acceleration is also different at the poles versus the equator.

$$G_{t80} = 9780326.7715((1 + 0.001931851353(\sin^2 l))/(SQRT(1 - 0.0066943800229(\sin^2 l)))$$

where,

G_{t80}	Theoretical Gravity 1980 in gravity units
l	GDA94 latitude at the gravity station in decimal degrees

Theoretical Gravity 1967: The theoretical (or normal) gravity value at each gravity station is calculated based on the assumption that the Earth is a homogeneous ellipsoid. The 1967 variant of the International Gravity Formula is used to approximate the theoretical gravity at each station location and essentially produce a latitude correction. Gravity values vary with latitude as the earth is not a perfect sphere and the polar radius is much smaller than the



equatorial radius. The effect of centrifugal acceleration is also different at the poles versus the equator.

$$G_{t67} = (9780318.456 \cdot (1 + 0.005278895 \cdot \sin^2(l) + 0.000023462 \cdot \sin^4(l)))$$

where,

G_{t67} Theoretical Gravity 1967 in gravity units

l GDA94 latitude at the gravity station in decimal degrees

Atmospheric Correction: The gravity effect of the atmosphere above the ellipsoid can be calculated with an atmospheric model and is subtracted from the theoretical gravity.

$$AC = 8.74 - 0.00099 \cdot h + 0.0000000356 \cdot h^2$$

where,

AC Atmospheric Correction in gravity units

h elevation above the GRS80 ellipsoid in metres

Ellipsoidal Free Air Correction: Since the gravity field varies inversely with the square of distance, it is necessary to correct for elevation changes from the reference ellipsoid (GRS80). Gravitational attraction decreases as the elevation above the reference ellipsoid increases.

$$EFAC = -(3.087691 - 0.004398 \sin^2 l) \cdot h + 7.2125 \cdot 10^{-7} \cdot h^2$$

where,

$EFAC$ Ellipsoidal Free Air Correction in gravity units

l GDA94 latitude at the gravity station in decimal degrees

h elevation above the GRS80 ellipsoid in metres

Geoidal Free Air Correction: Since the gravity field varies inversely with the square of distance, it is necessary to correct for elevation changes from the reference geoid (AHD). Gravitational attraction decreases as the elevation above the reference geoid increases.

$$GFAC = (3.08768 - 0.00440 \sin^2(l)) \cdot h - 0.000001442 \cdot h^2$$

where,

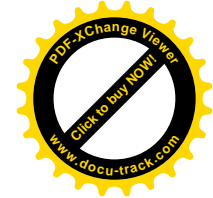
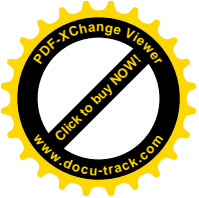
$GFAC$ Free Air Correction in gravity units

l GDA94 latitude at the gravity station in decimal degrees

h elevation above the reference geoid (AHD) in metres

Spherical Cap Bouguer Correction: If a gravity observation is made above the reference ellipsoid, the effect of rock material between the observation and the ellipsoid must be taken into account. The mass of rock makes a positive contribution to the gravity value. The correction is calculated using the closed form equation for the gravity effect of a spherical cap of radius 166.7km, based on a spherical Earth with a mean radius of 6,371.0087714km, height relative the ellipsoid and rock densities of 2.67, 2.40 and 2.20 tm^{-3} (gm/cc).

$$SCBC = 2\pi G\rho((1 + \mu) \cdot h - \lambda R)$$



where,

SCBC Spherical Cap Bouguer Correction in gravity units

G gravitational constant = $6.67428 \cdot 10^{-11} \text{m}^3 \text{kg}^{-1} \text{s}^{-2}$

ρ rock density (2.67, 2.40 and 2.20 t m^{-3})

h elevation above the GRS80 ellipsoid in metres

R ($R_o + h$) the radius of the earth at the station

R_o mean radius of the earth = 6,371.0087714 km (on the GRS80 ellipsoid)

μ & λ are dimensionless coefficients defined by:

$$\mu = ((1/3) \cdot \eta^2 - \eta)$$

where,

$$\eta = h/R$$

$$\lambda = (1/3)\{(d + f\delta + \delta^2)[(f - \delta)^2 + k]^{\frac{1}{2}} + p + m \cdot \ln(n/(f - \delta + [(f - \delta)^2 + k]^{\frac{1}{2}}))\}$$

where,

$$d = 3 \cdot \cos^2 \alpha - 2$$

$$f = \cos \alpha$$

$$k = \sin^2 \alpha$$

$$p = -6 \cdot \cos^2 \alpha \cdot \sin(\alpha/2) + 4 \cdot \sin^3(\alpha/2)$$

$$\delta = (R_o/R)$$

$$m = -3 \cdot k \cdot f$$

$$n = 2 \cdot [\sin(\alpha/2) - \sin^2(\alpha/2)]$$

$$\alpha = S/R_o \text{ with } S = \text{Bullard B Surface radius} = 166.735 \text{ km}$$

Geoidal Bouguer Correction: If a gravity observation is made above the reference geoid, the effect of rock material between the observation and the ellipsoid must be taken into account. The mass of rock makes a positive contribution to the gravity value. The slab of rock makes a positive contribution to the gravity value. Rock densities of 2.67, 2.40 and 2.20 t m^{-3} (gm/cc) were used in the correction.

$$GBC = 0.4191 \cdot \rho \cdot h$$

where,

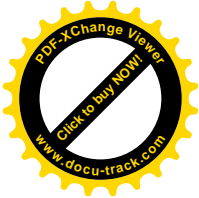
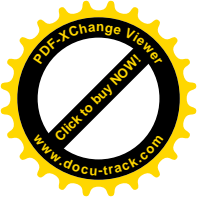
GBC Geoidal Bouguer Correction in gravity units

ρ rock density (2.67, 2.40 and 2.20 t m^{-3})

h elevation above the reference geoid (AHD) in m

Terrain Correction: The terrain correction accounts for variations in gravity values caused by variations in topography near the observation point. The 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. The terrain correction is positive regardless of whether the local topography consists of a mountain or a valley.

Terrain corrections were applied on Area B only. Terrain corrections were carried out with both RASTERTC and SCATerrainCalc (John Paine's software) using a digital elevation model



created from SRTM data. These yielded almost identical results and RASTERTC was used to produce the Complete Bouguer Anomaly (see below).

Ellipsoidal Free Air Anomaly: The Ellipsoidal Free Air Anomaly is the difference between the observed gravity and theoretical gravity that has been computed for latitude and corrected for the elevation of the gravity station above or below the reference ellipsoid.

$$EFAA = G_{oAAGD07} - (G_{t80} - AC) - EFAC$$

where,

EFAA Ellipsoidal Free Air Anomaly in gravity units

G_o Observed Gravity on the AAGD07 datum in gravity units

G_{t80} Theoretical Gravity 1980 in gravity units

AC Atmospheric Correction in gravity units

EFAC Ellipsoidal Free Air Correction in gravity units

Geoidal Free Air Anomaly: The Geoidal Free Air Anomaly is the difference between the observed gravity and theoretical gravity that has been computed for latitude and corrected for the elevation of the gravity station above or below the reference geoid.

$$GFAA = G_{oISOGAL84} - G_{t67} + GFAC$$

where,

GFAA Free Air Anomaly in gravity units

G_o Observed Gravity on the ISOGAL84 datum in gravity units

G_{t67} Theoretical Gravity 1967 in gravity units

GFAC Geoidal Free Air Correction in gravity units

Spherical Cap Bouguer Anomaly: The Spherical Cap Bouguer Anomaly is computed from the Ellipsoidal Free Air Anomaly above by removing the attraction of the spherical cap calculated by the Spherical Cap Bouguer Correction.

$$SCBA = EFAA - SCBC$$

where,

SCBA Spherical Cap Bouguer Anomaly in gravity units

EFAA Ellipsoidal Free Air Anomaly in gravity units

SCBC Bouguer Correction in gravity units

Geoidal Bouguer Anomaly: The Geoidal Bouguer Anomaly is computed from the Geoidal Free Air Anomaly above by removing the attraction of the slab calculated by the Geoidal Bouguer Correction.

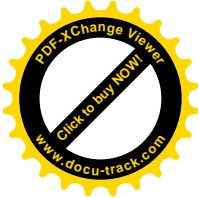
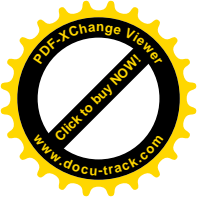
$$GBA = GFAA - GBC$$

where,

GBA Geoidal Bouguer Anomaly in gravity units

GFAA Geoidal Free Air Anomaly in gravity units

GBC Geoidal Bouguer Correction in gravity units



Complete Bouguer Anomaly: This is obtained by adding the terrain correction to the Bouguer Anomaly (Spherical Cap or Geoidal). The Complete Bouguer Anomaly is the most interpretable value derived from a gravity survey as changes in the anomaly can be directly attributed to lateral density contrasts within the geology below the observation point.

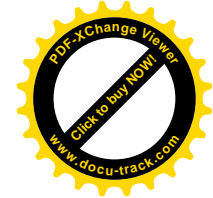
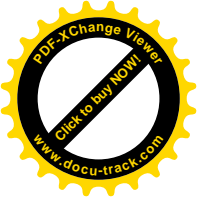
$$CBA = BA + TC$$

where,

CBA Complete Bouguer Anomaly in gravity units

BA Bouguer Anomaly in gravity units

TC Terrain Correction in gravity units



7.0 Results

The gravity survey was completed with nine days of acquisition over a fourteen day period. The survey was halted for a few days due to an approaching bushfire which put safety in jeopardy. The crew was forced to return to Alice Springs whilst the fire burnt out. During acquisition, minor delays arose from bogging, steep edges on creek crossings and hilly terrain. An average acquisition rate of 103 stations per day of production was achieved over the duration of the project. A copy of the full production report is contained on the data DVD.

Final raw data have met and exceeded quoted project specifications. Repeatability of the data was good, with the standard deviation of the elevation repeats at **0.070m** and the standard deviation of the gravity repeats at **0.024 mGals**. The production report contains summary statistics and histograms for repeatability.

8.0 Data Formats and Deliverables

Final reduced ASCII data for the project have been delivered in standard Atlas format, Geosoft .gdb format and ASEG-GDF2 compliant format. Table 2 overleaf details the format of the final gravity database supplied. All fields are comma delimited.

Appendix B contains plots of final station locations, images of GPS Derived Elevation (GRS80), Spherical Cap Bouguer Anomaly and first vertical derivative of Spherical Cap Bouguer Anomaly. In addition, images of the Complete Spherical Cap Bouguer Anomaly and first vertical derivative of Complete Spherical Cap Bouguer Anomaly are included for Area B.

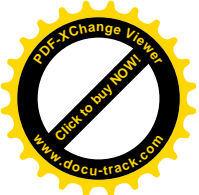
Raw GPS-GNSS and gravity data in their respective native formats have been included on the data DVD as Appendix D. Table 1 below summarises the deliverables.

Final Delivered Data	Format	Data DVD	Hardcopy
Gravity Database	Comma Space Delimited .csv	•	
Gravity Database	Geosoft Databse .gdb	•	
Gravity Database	Point located data ASEG-GDF2	•	
Raw Positional Data	AGRIS format, comma delimited	•	
Raw Gravity Data	Scintrex CG5 format	•	
Final Grids	ER Mapper Grids .ers	•	
Final Images	Mapinfo Compatible .tif	•	•
Acquisition Memo	PDF .pdf	•	•

Table 1: Final Deliverables

Field Header	Field Description	Format	Units
PROJECT	Atlas Geophysics Project Number	A9	None
STATION	Unique Station ID	I8	None
STATIONCODE	Unique Station Code	A13	None
LINE	Line ID	I8	None
TYPE	Observation Type : Base, Field or Repeat	A8	None
MGA94EAST	Coordinate Easting MGA94/GDA94	F11.3	m
MGA94NORTH	Coordinate Northing MGA94/GDA94	F12.3	m
ZONE	MGA Zone Number	F8.0	NA
GDA94LAT	Coordinate Latitude GDA94	F15.10	DD
GDA94LONG	Coordinate Longitude GDA94	F15.10	DD
ORTHOHTM	Coordinate Elevation Orthometric	F9.3	m
GRS80HTM	Coordinate Elevation Ellipsoidal	F9.3	m
NAG09	Geoid Separation	F8.3	m
AMG84EAST	Coordinate Easting AMG84	F11.3	m
AMG84NORTH	Coordinate Northing AMG84	F12.3	m
DATE	Observation Date	I8	None
TIME	Observation Time	I8	None
DIALMGAL	Gravity Dial Reading	F9.3	mGal
ETCMGAL	Earth Tide Correction (Longman)	F8.3	mGal
SCALE	Scale Factor Applied to Dial Reading	F9.6	None
OBSG84MGAL	Observed Gravity ISO84L84	F11.3	mGal
OBSG84GU	Observed Gravity ISO84L84	F11.2	gu
OBSGAAGD07GU	Observed Gravity AAGD07	F13.2	gu
OBSGAAGD07MGAL	Observed Gravity AAGD07	F16.3	mGal
DRIFTMGAL	Drift Applied to Dial Readings	F10.3	mGal
TGRAV67GU	Theoretical Gravity 1967	F11.2	gu
TGRAV67MGAL	Theoretical Gravity 1967	F12.3	mGal
TGRAV80GU	Theoretical Gravity 1980	F11.2	gu
GFACGU	Geoidal Free Air Correction	F8.2	gu
GFACMGAL	Geoidal Free Air Correction	F9.3	mGal
GFAAGU	Geoidal Free Air Anomaly	F8.2	gu
GFAAMGAL	Geoidal Free Air Anomaly	F9.3	mGal
GBC267GU	Geoidal Bouguer Correction 2.67 tm ⁻³	F9.2	gu
GBC240GU	Geoidal Bouguer Correction 2.40 tm ⁻³	F9.2	gu
GBC220GU	Geoidal Bouguer Correction 2.20 tm ⁻³	F9.2	gu
GBC267MGAL	Geoidal Bouguer Correction 2.67 tm ⁻³	F11.3	mGal
GBC240MGAL	Geoidal Bouguer Correction 2.40 tm ⁻³	F11.3	mGal
GBC220MGAL	Geoidal Bouguer Correction 2.20 tm ⁻³	F11.3	mGal
GBA267GU	Geoidal Bouguer Anomaly 2.67 tm ⁻³	F9.2	gu
GBA240GU	Geoidal Bouguer Anomaly 2.40 tm ⁻³	F9.2	gu
GBA220GU	Geoidal Bouguer Anomaly 2.20 tm ⁻³	F9.2	gu
GBA267MGAL	Geoidal Bouguer Anomaly 2.67 tm ⁻³	F11.3	mGal
GBA240MGAL	Geoidal Bouguer Anomaly 2.40 tm ⁻³	F11.3	mGal
GBA220MGAL	Geoidal Bouguer Anomaly 2.20 tm ⁻³	F11.3	mGal
TGRAV80ACGU	Theoretical Gravity 1980 Atmospheric Corrected	F11.2	gu
EFACGU	Ellipsoidal Free Air Correction	F9.2	gu
EFAAGU	Ellipsoidal Free Air Anomaly	F8.2	gu
SCBC267GU	Spherical Cap Bouguer Correction 2.67 tm ⁻³	F10.2	gu
SCBC240GU	Spherical Cap Bouguer Correction 2.40 tm ⁻³	F10.2	gu
SCBC220GU	Spherical Cap Bouguer Correction 2.20 tm ⁻³	F10.2	gu
SCBA267GU	Spherical Cap Bouguer Anomaly 2.67 tm ⁻³	F10.2	gu
SCBA240GU	Spherical Cap Bouguer Anomaly 2.40 tm ⁻³	F10.2	gu
SCBA220GU	Spherical Cap Bouguer Anomaly 2.20 tm ⁻³	F10.2	gu
SCBA267MGAL	Spherical Cap Bouguer Anomaly 2.67 tm ⁻³	F12.3	mGal
SCBA240MGAL	Spherical Cap Bouguer Anomaly 2.40 tm ⁻³	F12.3	mGal
SCBA220MGAL	Spherical Cap Bouguer Anomaly 2.20 tm ⁻³	F12.3	mGal
TCINNERGU	Inner Terrain Correction	F8.2	gu
TCINNERMGAL	Inner Terrain Correction	F8.3	mGal
QFINNER	Quality Factor Inner TC	I2	None
TCOUTERGU	Outer Terrain Correction	F8.2	gu
TCOUTERMAL	Outer Terrain Correction	F8.3	mGal
QFOUTER	Quality Factor Outer TC	F2	None
TCTOTALGU	Total Terrain Correction	F8.2	gu
TCTOTALMGAL	Total Terrain Correction	F8.3	mGal
CGBA267GU	Complete Geoidal Bouguer Anomaly 2.67 tm ⁻³	F11.3	gu
CGBA267MGAL	Complete Geoidal Bouguer Anomaly 2.67 tm ⁻³	F11.3	mGal
CSCBA267GU	Complete Spherical Cap Bouguer Anomaly 2.67 tm ⁻³	F12.2	gu
CSCBA267MGAL	Complete Spherical Cap Bouguer Anomaly 2.67 tm ⁻³	F12.2	mGal
DIFFEASTM	Repeat Error for Easting Observation	F8.3	m
DIFFNORTHM	Repeat Error for Northing Observation	F8.3	m
DIFFHTM	Repeat Error for Elevation Observation	F8.3	m
DIFFOBSMGAL	Repeat Error for Observed Gravity	F8.3	mGal
DIFFOBSGU	Repeat Error for Observed Gravity	F8.2	gu
METERSN	Serial Number of Gravity Instrument	I8	None
CLOSUREGU	Loop Closure in gu	F8.2	gu
CLOSUREMGAL	Loop Closure in mGal	F8.3	mGal
GRVBASE	Gravity Base	A11	None
GPSBASE	GPS Base	A11	None

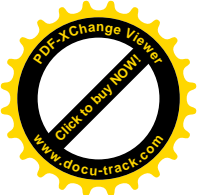
Table 2: Final Gravity Database Format



9.0 Project Safety

Prior to survey commencement, a Hazard Identification and Risk Assessment (HIRA) was carried out for all new tasks not covered under Atlas Geophysics Standard Operating Procedures (SOP's) or the company's Health Safety Environment (HSE) field manual.

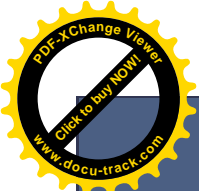
Weekly toolbox meetings were held to discuss project safety and address any staff member concerns. The only incident to speak of was the bushfire in the area mid-survey. All necessary precautions were taken to prevent injury or damage to equipment. Safety was always the main priority.



APPENDIX A

Control Station Description





201103200001 – Ooratippra Base

GDA94/GRS80		MGA Z53		AMG Z53	
Latitude	-21 58 52.4157	Easting	625,527.435	Easting	625,398.854
Longitude	136 12 57.1657	Northing	7,568,752.404	Northing	7,568,581.357
Ellipsoidal Height	360.198	Orthometric Height	328.975	Orthometric Height	328.975

OBSERVED GRAVITY

Date established: 5/10/2011

gu AAGD07	9786946.99	
mGal ISO GAL84	978694.777	

Occupation Method/Location Details

At this control station, the GPS control point consists of a steel picket driven into the ground with approximately 15cm protruding. The gravity control point consists of a small concrete slab set into the ground, opposite the GPS control point. The control station is witnessed by an Atlas Geophysics survey plaque (reading 201103200001) attached to a 1.5 metre steel picket placed within 0.5m of the both control points.

Gravity Control was established via multiple ABA loops with the project meter to control station GRVGPS0115 on 18th and 19th October, 2011. This station has been previously tied in to AFGN 1964919040, located at Ammaroo airstrip in September 2010. Expected accuracy would be better than 0.01 mGal.

GPS Control was established using AUSPOS. Three separate 10 hour sessions were submitted to AUSPOS's online processing systems where returned coordinates were accurate to better than 0.01m.

The control station can be found as follows. Turn south off the Sandover Highway down a track sign posted towards "Ooratippra". Travel approximately 7.5km's along this track until you take a track leading east that runs along the creek line. Follow this track for approximately 20km's. After passing through a gate that leads past the second windmill the control station will be on your left hand side about 300m east of the windmill.



Photograph of Control Station 201103200001 and surrounds