Wiso & Reynolds Range, Northern Territory
TEMPEST
Airborne Geophysical Survey

Acquisition and Processing Report

for

Toro Energy Ltd.

Prepared by :	M. Wheeler-Carver W. Tran
Authorised for release by :	…………………………..
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Survey flown: November – December 2012

by

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FAS JOB # 2364

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1. SURVEY OPERATIONS AND LOGISTICS

1.1 Introduction

Between the 14th November and the 6th December 2012, Fugro Airborne Surveys Pty. Ltd. (FAS) undertook an airborne TEMPEST electromagnetic survey for Toro Energy Limited, over the Wiso & Reynolds Range Project areas in Nothern Territory. The survey consisted of three areas, Wiso, Reynolds Range 1 & Reynolds Rage 2. Total coverage of the survey areas amounted to 2512 line kilometres flown in 17 flights. The survey was flown using a SHORTS SKYVAN aircraft, registration VH-WGT owned and operated by FAS. This report summarises the procedures and equipment used by FAS in the acquisition, verification and processing of the airborne geophysical data.

1.2 Survey Base

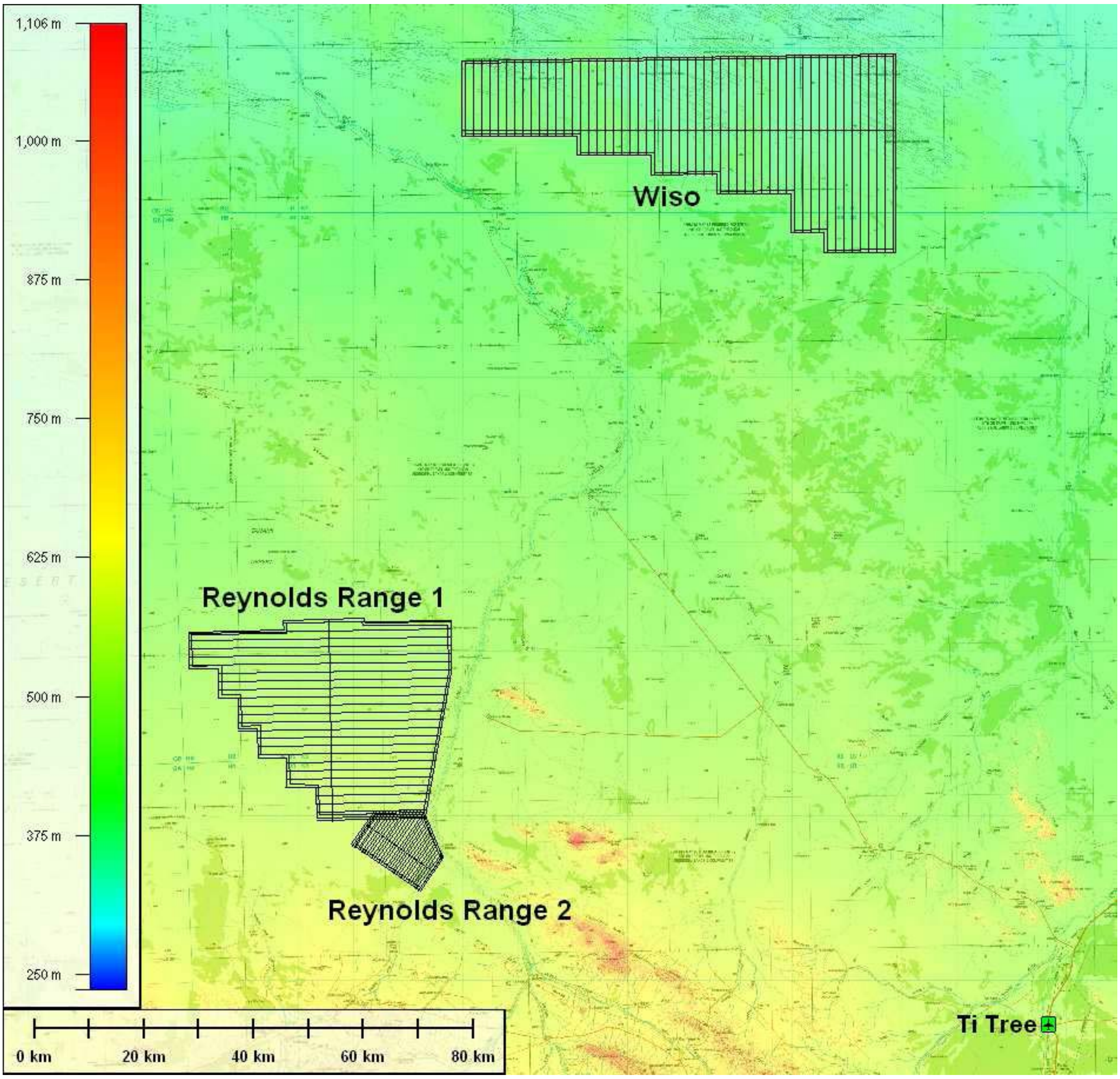
The survey was based out of Alice Springs, Ti Tree and Barrow Creek in the Northern Territory. The survey aircraft was operated from Alice Springs Airport, Ti Tree Airstrip and Barrow Creek Airstrip with the aircraft fuel available on site. A temporary office was set up at the, Best Western Elkira Resort Motel, Ti Tree Roadhouse and Barrow Creek Roadhouse, where all survey operations were run and the post-flight data verification was performed.

1.3 Survey Personnel

The following personnel were involved in this project:

Project Supervision - Acquisition	Richard Butterfield
- Processing	Denis Cowey
On-site Crew Leader	Terry Mondon
Pilot/s	Grant Hamilton
System Operator/s	Terry Mondon
Field Data Processing	Matthew Wheeler-Carver
Office Data Processing	Joanne Cowburn, Doug Gay, Matthew Wheeler-Carver

1.4 Area Map



Wiso & Reynolds Range survey areas
GDA94 MGA 53

1.5 General Disclaimer

It is Fugro Airborne Survey's understanding that the data and report provided to the client is to be used for the purpose agreed between the parties. That purpose was a significant factor in determining the scope and level of the Services being offered to the Client. Should the purpose for which the data and report is used change, the data and report may no longer be valid or appropriate and any further use of, or reliance upon, the data and report in those circumstances by the Client without Fugro Airborne Survey's review and advice shall be at the Client's own or sole risk.

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Where the Services have involved Fugro Airborne Survey's use of any information provided by the Client or third parties, upon which Fugro Airborne Survey was reasonably entitled to rely, then the Services are limited by the accuracy of such information. Fugro Airborne Survey is not liable for any inaccuracies (including any incompleteness) in the said information, save as otherwise provided in the terms of the contract between the Client and Fugro Airborne Survey.

2. SURVEY SPECIFICATIONS AND PARAMETERS

2.1 Area Co-ordinates

The survey areas were located within GDA94 MGA Zone 53S, Central Meridian = 135
(Note - Co-ordinates in GDA94/MGA Zone 53S)

Area 1 (Wiso) – North - South lines

Easting	Northing
230236	7727369
308236	7728537
308236	7693420
296236	7693279
296236	7697046
290236	7696996
290236	7704088
276736	7704065
276736	7707584
264736	7707484
264736	7711080
251236	7711072
251236	7714527
230236	7714535
203473	7595788
198268	7595866
198112	7601227
193062	7601227
192907	7606587
189489	7606509
189333	7612103
185837	7612103
185837	7617541
180477	7617386
180399	7623057
197724	7623446
197646	7625310
211475	7625543
211552	7624805
227168	7624961

Area 2 (Reynolds 1) – 89° - 269° lines

Easting	Northing
227271	7616285
222484	7590416
212248	7590513
212174	7590428
203706	7590272

Area 3 (Reynolds 2) – 35°- 215° lines

Easting	Northing
222099	7577067
210248	7585025
214013	7590416
222442	7590374
225693	7582372

2.2 Survey Area Parameters

Job Number	-	2364
Survey Company	-	Fugro Airborne Surveys Pty Ltd
Date Flown	-	14th November – 6th December 2012
Client	-	Toro Energy Limited
EM System	-	25 Hz TEMPEST
Navigation	-	Real-time differential GPS
Datum	-	GDA94
Projection	-	MGA Zone 53S
Area Names	-	Wiso & Reynods Range 1 & Reynolds Range 2, N.T.
Nominal Terrain Clearance	-	100 m
Traverse Line Spacing	-	1500 m (Area 1 & 2)
	-	500 m (Area 3)
Traverse Line Direction	-	000 – 180 degrees (Area 1)
	-	089 – 269 degrees (Area 2)
	-	035 – 215 degrees (Area 3)
Traverse Line Numbers	-	30001 – 30053 (Area 1)
	-	10001 – 10025 (Area 2)
	-	20001 – 10030 (Area 3)
Line Kilometres Area 1	-	1288 km
Line Kilometres Area 2	-	911 km
Line Kilometres Area 3	-	313 km
Total Survey Line Kilometres	-	2512 km

2.3 Job Safety Plan

A Job Safety Plan was prepared and implemented in accordance with the Fugro Airborne Surveys Occupational Safety & Health Management System.

3. AIRCRAFT EQUIPMENT AND SPECIFICATIONS

3.1 Aircraft

Manufacturer	-	SHORTS
Model	-	SKYVAN
Registration	-	VH-WGT
Ownership	-	Fugro Airborne Surveys Pty Ltd

3.2 TEMPEST System Specifications

Specifications of the TEMPEST Airborne EM System (Lane et al., 2000) are:

- Base frequency - 25 Hz
- Transmitter area - 186 m^2
- Transmitter turns - 1
- Waveform - Square
- Duty cycle - 50%
- Transmitter pulse width - 10 ms
- Transmitter off-time - 10 ms
- Peak current - 300 A
- Peak moment - 55800 Am^2
- Average moment - 27900 Am^2
- Sample rate - 75 kHz on X and Z
- Sample interval - 13 microseconds
- Samples per half-cycle - 1500
- System bandwidth - 25 Hz to 37.5 kHz
- Flying height - 100 m (subject to safety considerations)
- EM sensor - Towed bird with 3 component dB/dt coils
- Tx-Rx horizontal separation - 115 m (nominal)
- Tx-Rx vertical separation - 40 m (nominal)
- Stacked data output interval - 200 ms (~12 m)
- Number of output windows - 15
- Window centre times - 13 μs to 16.2 ms
- Magnetometer - Stinger-mounted cesium vapour
- Magnetometer compensation - Fully digital
- Magnetometer output interval - 200 ms (~12 m)
- Magnetometer resolution - 0.001 nT
- Typical noise level - 1.0 nT
- GPS cycle rate - 1 second

3.2.1 EM Receiver and Logging Computer

The EM receiver computer was an EMFASDAS. The EM receiver computer executes a proprietary program for system control, timing, data acquisition and recording. Control, triggering and timing is provided to the TEMPEST transmitter and Digital Signal Processing (DSP) boards by the timing card, which ensures that all waveform generation and sampling is accomplished with high accuracy. The timing card is synchronised to the Global Positioning System (GPS) through the use of the Pulse Per Second (PPS) output from the system GPS card. Synchronisation is also provided to the magnetometer processor card for the purpose of accurate magnetic sampling with respect to the EM transmitter waveform.

The EM receiver computer displays information on the main screen during system calibrations and survey line acquisition to enable the airborne operator to assess the data quality and performance of the system.

3.2.2 TEMPEST Transmitter

The transmitted waveform is a square wave of alternating polarity, which is triggered directly from the EM receiver computer. The nominal transmitter base frequency was 25 Hz with a pulse width of 10 ms (50 % duty cycle). Loop current waveform monitoring is provided by a current transformer located directly in the loop current path to allow for full logging of the waveform shape and amplitude, which is sampled by the EM receiver.

3.2.3 TEMPEST 3-Axis Towed Bird Assembly

The TEMPEST 3-axis towed bird assembly provides accurate low noise sampling of the X (horizontal in line), Y (horizontal transverse) and Z (vertical) components of the electromagnetic field. The receiver coils measure the time rate of change of the magnetic field (dB/dt). Signals from each axis are transferred to the aircraft through a tow cable specifically designed for its electrical and mechanical properties.

3.3 FASDAS Survey Computer

The Survey computer executes a proprietary program for acquisition and recording of location, magnetic and ancillary data. Data are presented both numerically and graphically in real time on the Video Graphics Array (VGA) Liquid Crystal Display (LCD) display, which provides an on-line display capability. The operator may alter the sensitivity of the displays on-line to assist in quality control. Selected EM data are transferred from the EM receiver computer to the SURVEY computer for quality control (QC) display.

3.3.1 Cesium Vapour Magnetometer Sensor

A cesium vapour magnetometer sensor is utilised on the aircraft and consists of the sensor head and cable, and the sensor electronics. The sensor head is housed at the end of a composite material tail stinger.

3.3.2 Magnetometer Processor Board

A FASDAS magnetometer processor board is used for de-coupling and processing the Larmor frequency output of the magnetometer sensor. The processor board interfaces with the survey computer, which initiates data sampling and transfer for precise sample intervals and also with the EM receiver computer to ensure that the magnetic samples remain synchronised with the EM system.

3.3.3 Fluxgate Magnetometer

A tail stinger mounted Bartington MAG-03MC three-axis fluxgate magnetometer is used to provide information on the attitude of the aircraft. This information is used for compensation of the measured magnetic total field.

3.3.4 GPS Receiver

A Novatel GPScard 951R is utilised for airborne positioning and navigation. Satellite range data are recorded for generating post processed differential solutions.

3.3.5 Differential GPS Demodulator

The OMNISTAR differential GPS service provides real time differential corrections.

3.4 Navigation System

A FASDAS Navigation Computer was used for real-time navigation. These computers load a pre-programmed flight plan from disk which contains boundary co-ordinates, line start and end co-ordinates, local co-ordinate system parameters, line spacing, and cross track definitions. The World Geodetic System 1984 (WGS84) latitude and longitude positional data received from the Novatel GPS card contained in the SURVEY computer is transformed to the local co-ordinate system for calculation of the cross track and distance to go values. This information, along with ground heading and ground speed, is displayed to the pilot numerically and graphically on a two line LCD display, and on an analogue Horizontal Strip Indicator (HSI). It is also presented on a LCD screen in conjunction with a pictorial representation of the survey area, survey lines, and ongoing flight path.

The Navigation computers are interlocked to the SURVEY computer for auto selection and verification of the line to be flown. The GPS information passed to the navigation computer is corrected using the received real time differential data from the OMNISTAR service, enabling the aircraft to fly as close to the intended track as possible.

3.5 Altimeter System

3.5.1 Radar Altimeter

Model:	Collins RL 50 radio altimeter system
Sample interval:	0.2 second
Accuracy:	+/- 1.5 % of indicated altitude.

The Collins radio altimeter is a high quality instrument whose output is factory calibrated. It is fitted with a test function which checks the calibration of a terrain clearance of 100 feet, and altitudes which are multiples of 100 feet. The aircraft radio altitude is recorded onto digital tape as well as displayed on the aircraft chart recorder. The recorded value is the average of the altimeters output during the previous second.

3.5.2 Laser Altimeter

Model:	Optech 501SB (WGT)
Sample interval:	0.2 second
Accuracy:	± 0.05m at survey altitude

3.5.3 Barometric Altimeter

Output of a Digiquartz 215A-101pressure transducer is used for calculating the barometric altitude of the aircraft. The atmospheric pressure is taken from a gimbal-mounted probe projecting 0.5 metres from the wing tip of the aircraft and fed to the transducer mounted in the aircraft wingtip.

3.6 Video Tracking System

The video file recorded by the digital video system is synchronised with the geophysical record by a digital fiducial display. It is also labelled with GPS latitude and longitude information and survey line number.

3.7 Data Recorded by the Airborne Acquisition Equipment

With the FASDAS acquisition system the raw EM data including fiducial, local time, X and Z axis sensor response, current monitor and bird auxiliary sensor output are recorded on the EM receiver computer as “*.raw” EM files. Logging to the files is continuous, however, a new *.raw EM file is created when the size of the previous one reaches 1Gb.

The FASDAS Survey computer records a continuous MSD file which contains all other ancillary data including magnetic, altimeter, GPS and analogue channels.

4. GROUND DATA ACQUISITION EQUIPMENT AND SPECIFICATIONS

4.1 GPS Base Station

Three independent GPS base logging stations were set up; one at Alice Springs airport, Barrow Creek airport and Ti Tree roadhouse. The sensor was contained in the CF1 unit.

Each GPS base station position was calculated by logging data continuously at the base position over a period of approximately 24 hours. These data were then statistically averaged to obtain the position of the base station using GrafNav software.

The calculated GPS base positions were (in WGS84):

Alice Springs Airport:
Lat: 23° 48' 01.38028" S
Long: 133° 53' 47.90496" E
Height: 561.489 m. (WGS84 Ellipsoidal Height)

Barrow Creek Airport:

Lat: 21° 32' 26.17934" S
Long: 133° 52' 15.75698" E
Height: 545.595 m. (WGS84 Ellipsoidal Height)

Ti Tree Roadhouse:

Lat: 22° 07' 50.52270" S
Long: 133° 25' 00.52541" E
Height: 586.077 m. (WGS84 Ellipsoidal Height)

5. EM AND OTHER CALIBRATIONS AND MONITORING

At the beginning and end of each individual survey flight, the EM system is checked for background noise levels and performance. All of these checks are conducted at a nominal terrain clearance of 600 m (2000 ft) to eliminate ground response.

These checks include:-

5.1 Transmitter-off

These lines are recorded in straight and level flight with the system in standard survey geometry, with the transmitter turned off and bird response turned on to observe ambient noise and to check for noise in the receiver system (bird/coils → tow cable → winch → computer). *Note: FFFF is the flight number and PP is the attempt number.*

Post-Flight Transmitter-off: Line 906FFFFPP

5.2 Noise Additive

These lines are recorded in straight and level flight with the system in standard survey geometry, with the transmitter on and the bird response turned off at the tow cable winch. This is to check the noise contribution from the acquisition system and is used in deconvolution of survey line data. *Note: FFFF is the flight number and PP is the attempt number.*

Pre-Flight Noise Additive: Line 901FFFFPP
Post-Flight Transmitter-off: Line 904FFFFPP

5.3 Zero

These lines are recorded in straight and level flight with the system in standard survey configuration with transmitter and receiver turned on. This is used to determine the system's response in the absence of ground signal and is used to determine a standard waveform for deconvolution of survey lines. *Note: FFFF is the flight number and PP is the attempt number.*

Additionally, through all these calibrations the airborne operator can assess the system and ambient noise levels.

Pre-Flight Zero: Line 902FFFFPP
Post-Flight Zero: Line 905FFFFPP

5.4 Swoops

This line is recorded immediately after the pre-flight zero. During this manoeuvre the pilot conducts a series of 'swoop' manoeuvres (pitch up/pitch down) over approximately 30-40 seconds to vary the position of the towed sensor relative to the aircraft. The EM data are monitored by the airborne operator to confirm correct operation of the system during the manoeuvre. This data is used to determine coefficients used in the processing to compensate for such variations in the survey data. *Note: FFFF is the flight number and PP is the attempt number.*

Pre-Flight Swoop: Line 903FFFFPP

5.5 Parallax Checks

Due to the relative positions of the EM towed bird and the magnetometer instruments on the aircraft and to processing / recording time lags, raw readings from each vary in position. To correct for this and to align selected anomaly features on lines flown in opposite directions, magnetics, EM data and the altimeters are 'parallaxed' with respect to the position information. System parallax is checked occasionally or following any major changes in the aircraft system, which are likely to affect the parallax values.

Variable	Parallax Value
GPS	0 s
Radar Altimeter	0 s
Laser Altimeter	0 s
EM - X	- 9.2 s
EM – Z	- 9.4 s

5.6 Radar Altimeter Calibration

The radar altimeter is checked for accuracy and linearity every 12 months or when any change in a key system component requires this procedure to be carried out. This calibration allows the radar altimeter data to be compared and assessed with other height data (GPS and barometric) to confirm the accuracy of the radar altimeter over its operating range.

Absolute radar and barometric altimeter calibration was carried out over water at Mandurah, Western Australia, and was successful in calibrating the radar altimeter to information provided by the GPS and barometer instrument. Calibration factors were as expected. The calibration procedure also provides parallax information required for positional correction of the radar and GPS altimeters.

5.7 Heading Error Checks

Historically, heading error checks have been part of the aeromagnetic data acquisition procedure but they are no longer used. Fugro Airborne Surveys now calculates these effects using the aircraft magnetic compensation system and specially developed software. The precision to which these effects are now calculated and corrected for is far in excess of the manual methods used in the past.

6. DATA PROCESSING

6.1 Field Data Processing

6.1.1 Quality Control Specifications

6.1.1.1 Navigation Tolerance

The re-flight specifications applied for the duration of the survey were:

Electronic Navigation - absence of electronic navigation data (e.g. GPS base station fails).

Flight Path - where the flightpath deviates from the flightplan by more than 750 metres for more than 5 km. The line spacing measurements to be used in determining such reflights will be made from the field flight path recovery

Altitude - terrain clearance continuously exceeds the nominal terrain clearance by plus or minus 30 m over a distance of 5 km or more unless to do so would, in the sole opinion of the pilot, jeopardise the safety of the aircraft or the crew or the equipment or would be in contravention of the Civil Aviation Safety Authority regulation such as those pertaining to built up areas.

6.1.1.2 Electromagnetic Data

The quality control checks on the electromagnetic data were:

Noise - where RMS noise in the last channel of the EM data exceeds 0.1 fT over 3 km for B-field (assessed in a resistive region) or where FAS believes an important anomaly is rendered un-interpretable.

Sferics – where sferic activity renders a potential anomaly un-interpretable.

6.1.2 In-Field Data Processing

Following acquisition, multiple copies of the EM data are made onto DVDs or CDs. The EM, location, magnetic and ancillary data are then processed at the field base to the point that the quality of the data from each flight can be fully assessed. Copies of the raw and processed data are then transferred to Perth for final data processing. A more comprehensive statement of EM data processing is given in section 6.2.3.

6.2 Final Data Processing

6.2.1 Derived Topography

Aircraft navigation whilst in survey mode is via real time differential GPS, obtained by combining broadcast differential corrections with on-board GPS measurements. Terrain clearance is measured with a laser altimeter.

The ground elevation, relative to the WGS84 spheroid used by GPS receiver units, is obtained by finding the difference between the terrain clearance (from the final processed and edited laser altimeter) and the aircraft GPS antenna altitude above the ellipsoid (GPS height derived from post-processing of the DGPS data using the field base station data), and taking into account that the laser altimeter is mounted 2.3 metres below the GPS antenna.

The digital elevation model derived from this survey can be expected to have an absolute accuracy of +/- several metres in areas of low to moderate topographic relief. Sources of error include uncertainty in the height of the GPS base station, variations in the laser altimeter characteristics over ground of varying surface characteristics (ie. false and non-returns are more prevalent over dense vegetation and water, respectively), and the finite footprint of the laser altimeter.

Following this, where appropriate, tie line and micro-levelling was applied in order to more subtly level the data. The algorithms are FAS proprietary operations used to remove the small across-line corrugations that may appear in the gridded data. The micro-levelling process attempts to de-corrugate the data without destroying the data's integrity. This is achieved by confining the changes to very small values and applying them as a correction to the along-line data.

An N-Value is then subtracted to correct the final data to the Australian Height Datum (AHD).

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, laser altitude and GPS altitude. The GPS altitude value is dependent on the number of available satellites, plus the accuracy of the averaged GPS base position. Although post-processing of GPS data will yield X and Y accuracies in the order of 0.5 metres, the accuracy of the altitude value is usually much less, but generally still within 1-2 metres. Further inaccuracies may be introduced during the interpolation and gridding process as only 1 out of every 5 points across-line is real data. Furthermore, along line obstructions may cause the pilot to veer laterally and so data interpolated between lines may vary significantly from real topography, and do not show artificial vertical obstructions.

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

6.2.2 Electromagnetic Data Processing

Details of the pre-processing applied to TEMPEST data can be found in Lane et al. (2000).

6.2.2.1 Standard EM Processing

Calibration
High altitude calibration data are used to characterise the system response in the absence of any ground response.

Cleaning and Stacking
Routines to suppress sferic noise, powerline noise, VLF noise, and coil motion noise (collectively termed “cleaning” and to stack the data are applied to the survey line data. Output from the stacking filter is drawn at 0.2 second intervals. The stacked data are saved to file as an internal data management practice.

Deconvolution and Binning
The survey height stacked data are deconvolved using the high altitude reference waveform. The effect of currents in the transmitter loop and airframe (“primary”) are then removed, leaving a “pure” ground response. The deconvolved ground response data are then transformed to B-field response for a perfect 100% duty cycle square wave. Finally, the evenly spaced samples are binned into a number of windows.

Table of TEMPEST window information for 25Hz base frequency

Window #	Start sample	End sample	No of samples	start time (s)	End time (s)	centre time (s)	centre time (ms)
1	1	2	2	0.000007	0.000020	0.000013	0.013
2	3	4	2	0.000033	0.000047	0.000040	0.040
3	5	6	2	0.000060	0.000073	0.000067	0.067
4	7	10	4	0.000087	0.000127	0.000107	0.107
5	11	16	6	0.000140	0.000207	0.000173	0.173
6	17	26	10	0.000220	0.000340	0.000280	0.280
7	27	42	16	0.000353	0.000553	0.000453	0.453
8	43	66	24	0.000567	0.000873	0.000720	0.720
9	67	102	36	0.000887	0.001353	0.001120	1.120
10	103	158	56	0.001367	0.002100	0.001733	1.733
11	159	246	88	0.002113	0.003273	0.002693	2.693
12	247	384	138	0.003287	0.005113	0.004200	4.200
13	385	600	216	0.005127	0.007993	0.006560	6.560
14	601	930	330	0.008007	0.012393	0.010200	10.200
15	931	1500	570	0.012407	0.019993	0.016200	16.200

The data are reviewed after windowing. Any decisions involving re-flights due to AEM factors are made at this point.

Raw and Final EM Data
The “raw” or “uncorrected” EM amplitudes reflect, not only the variations in ground conductivity, but the variations in geometry of the various parts of the EM measurements (i.e. transmitter loop pitch, transmitter loop roll, transmitter loop terrain clearance, transmitter loop to receiver coil horizontal longitudinal separation, transmitter loop to receiver coil horizontal transverse separation, and transmitter loop to receiver coil vertical separation) during the survey. For example, the largest influence on the early time EM amplitude is the terrain clearance of the transmitter loop. The larger the terrain clearance is, the smaller the amplitude. Later window times (larger window number) show diminished variations due to terrain clearance.

"Final" or "geometry-corrected" located data are produced for optimum presentation of the EM amplitude data in image format (e.g. window amplitude images, principal component analysis images derived from the window amplitudes (Green,1998b)). Between "raw" and "final" states, the ground response data undergo an approximate correction to produce data from a nominated standard geometry. A dipole-image method (Green, 1998a) is used to adjust the data to the response that would be expected at a standard terrain clearance (100), standard transmitter loop pitch and roll (zero degrees), and a standard transmitter loop to receiver coil geometry (115m behind and 40m below the aircraft). These variables have been set to their respective standard values in the "final" located data (whereas the "raw" located data file contains the variable field data). Zero parallax is applied to transmitter loop pitch, roll, terrain clearance, X component EM and Z component EM data prior to geometry correction. Over extremely conductive ground (e.g. > 100 S conductance), the estimates for transmitter loop to receiver coil separation determined from the primary field coupling factors may be in error at the metre scale due to uncertainty in the estimation of the primary field. This will influence the accuracy of very early time window amplitude information in the "geometry-corrected" located data. Receiver coil pitch has a significant effect on early time Z component response and late time X component response (Green and Lin, 1996). Receiver coil roll impacts early time Z component response.

Levelling
Limited range micro-levelling may be applied to the final window amplitudes for presentation purposes, principally for multi-flight surveys or when isolated re-flight lines are present.

6.2.2.2 Factors and Corrections

Geometric Factor
The geometric factor gives the ratio of the strength of the primary field coupling between the transmitter loop and the receiver coil at each observation relative to the coupling observed at high altitude during acquisition of reference waveform data. Variations in this factor indicate a change in the attitude and/or relative separation of the transmitter loop and the receiver coil.

Transmitter-Receiver Geometry
Transmitter to receiver geometry values for each observation is derived from the high altitude reference waveforms and knowledge of the system characteristics. These data are available in the located data (see section 6.2.6.1 for "standardised" values)

GPS Antenna, Laser Altimeter and Transmitter Loop Offset Corrections
The transmitter loop was mounted 0.1m above the GPS antenna on the aircraft. The GPS antenna is 3.3m above the belly of the aircraft. The laser altimeter sensor is mounted in the belly of the aircraft. Therefore a total of 3.05m (-0.25m + 3.3m) was added to the laser altimeter data to determine the transmitter loop height above the ground.

Transmitter Loop Pitch and Roll Correction
Measured vertical gyro aircraft pitch and roll attitude measurements are converted to transmitter loop pitch and roll by adding 0.45 degrees for pitch and 0.6 degrees for roll. Nose up is positive for pitch, and left wing up is positive for roll.

6.2.2.3 Primary Sources of EM Noise

A number of "monitor" values are calculated during processing to assist with interpretation. They generally represent quantities that have been removed as far as is practical from the data, but may still be present in trace amounts. These are more significant for interpretation of discrete conductors than for general mapping applications.

Sferic Monitor
Sferics are the electromagnetic signals associated with lightning activity. These signals travel large distances around the Earth. Background levels of sferics are recorded at all times from lightning activity in tropical areas of the world (eg tropical parts of Asia, South America and Africa). Additional higher amplitude signals are produced by "local" lightning activity (ie at distances of kilometres to hundreds of kilometres).

The sferic monitor is the sum of the absolute differences brought about by the sferic filter operations, summed over 0.2 second intervals, normalised by the receiver effective area. It is given in units of uV/sq.m/0.2s. Many sferics have a characteristic form that is well illustrated by figure 2 in Garner and Thiel (2000). The high frequency, initial part of a sferic event can be detected and filtered more easily than the later, low frequency portion. The sferic monitor indicates where at least the high frequency portion of a sferic has been successfully removed, but it is quite possible that lower frequency elements of the sferic event may have eluded detection, passing through to the window amplitude data. Thus, discrete anomalies coincident with sferic activity as indicated by the sferic monitor should be down-weighted relative to features clear of any sign of sferic activity.

Low Frequency Monitor
The Low Frequency Monitor (LFM) makes use of amplitudes at frequencies below the base frequency which are present in the streamed data to estimate the amplitude of coil motion (Earth magnetic field) noise at the base frequency in log10(pV/sqrt(Hz)/sq.m). The coil motion noise below the base frequency is rejected through the use of tapered stacking, but the coil motion noise at the base frequency itself is not easily removed. A sharp spike in the LFM can be an indicator of a coil motion event (eg the bird passing through extremely turbulent air). Note that the LFM will also respond to sferic events with an appreciable low frequency (sub-base frequency) component. This situation can be inferred when both the LFM and sferic monitors show a discrete kick.

Powerline Monitor
The powerline monitor gives the amplitude of the received signal at the powerline frequency (50 or 60 Hz) in log10(pV/sqrt(Hz)/sq.m). Careful selection of the base frequency (such that the powerline frequency is an even harmonic of the base frequency) and tapered stacking combine to strongly attenuate powerline signals. When passing directly over a powerline, the rapid lateral variations in the strength and direction of the magnetic fields associated with the powerline can result in imperfect cancellation of the powerline response during stacking. Some powerline-related interference can manifest itself in a form that is similar to the response of a discrete conductor. The exact form of the monitor profile over a powerline depends on the line direction, powerline direction, powerline current, and receiver component, but the monitor will show a general increase in amplitude approaching the powerline.

Grids (or images) of the powerline monitor reveal the location of the transmission lines. Note that the X component (horizontal receiver coil axis parallel with the flight line direction) does not register any response from powerlines parallel to the flight line direction since the magnetic fields associated with powerlines only vary in a direction perpendicular to the powerline. Note also that the Z component (vertical receiver coil axis) shows a narrow low directly over the powerline where the magnetic fields are purely horizontal.

Very Low Frequency Monitors
Wide area VLF communication signals in the 15 to 25 kHz frequency band are monitored by the TEMPEST system. In the Australian region, signals at 18.2 kHz, 19.8 kHz, 21.4 kHz and 22.2 kHz are monitored as the amplitude of the received signal at these frequencies in log10(pV/sqrt(Hz)/sq.m). The strongest signal comes from North West Cape (19.8 kHz). The signal at 18.2 kHz is often observed to pulse in a regular sequence. These strong narrow band signals have some impact on the high frequency response of the system, but they are strongly attenuated by selection of the base frequency and tapered stacking. The VLF transmissions are strongest in amplitude, in the horizontal direction at right angles to the direction to the VLF transmitter. This directional dependence enables the VLF monitors to be used to indicate the receiver coil attitude.

6.2.2.4 Other Sources of EM Noise

Man-made periodic discharges
If an image of the Z component sferic monitor shows the presence of spatially coherent events, then pulsed cultural interference would be strongly suspected. Since sferic signals are much stronger in the horizontal plane than in the vertical plane, few sferics of significant amplitude are recorded in Z component data. In contrast, evidence of cultural interference is generally swamped by true sferics in X component sferic monitor images.

Electric fences are the most common source of pulsed cultural interference. Periodic discharges (eg every second or so) into a large wire loop (fence) produce very large spikes in raw data. These are attenuated to a large degree by the sferic filter, but a residual artefact can still be present in the processed data.

Coil motion / Earth field noise
A change in coupling between the receiver coil and the ambient magnetic field will induce a voltage in the receiver coil. This noise is referred to as coil motion or Earth field noise. Receiver coils in the towed bird are suspended in a fashion that attempts to keep this noise below the noise floor at frequencies equal to and above the base frequency of the system. Severe turbulence, however, can result in 'coil knock events' that introduce noise into the processed data.

Grounded metal objects
Grounded extensive metal objects such as pipelines and rail lines can qualify as conductors and may produce a response that is visible in processed data. Grounded metal objects produce a response similar to shallow, highly conductive, steeply dipping conductors. These objects can sometimes be identified from good quality topographic maps, from aerial photographs, by viewing the tracking video, from their unusual spatial distribution (ie often a series of linear segments) and in some circumstances from their effect on the powerline monitor. A powerline running close to a long metal object will induce a 50 Hz response in the object.

6.2.3 Conductivity Depth Images (CDI)

CDI conductivity sections for TEMPEST data were calculated using EMFlow and then modified to reflect the finite depth of investigation using an in-house routine, *Sigtime*.

The *Sigtime* routine removes many of the spurious conductive features that appear at depth as a result of fitting long time constant exponential decays to very small amplitude features in the late times. For each observation, the time when the response falls below a signal threshold amplitude is determined. This time is transformed into a diffusion depth with reference to the conductivity values determined for that observation. Anomalous conductivity values below this depth are replaced by background values or set to undefined, reflecting the uncertainty in their origin. The settings and options applied are indicated in the appropriate header files for *Sigtime* output. This procedure is different to that which would be obtained by filtering conductivity values using either a constant time or constant depth across the entire line.

The "final" Z component EM data were input into version 5.10 of EMFlow to calculate Conductivity Depth Images (CDI). Conductivity values were calculated at each point then run through *Sigtime.*

EMFlow was developed within the CRC-AMET through AMIRA research projects (Macnae et al, 1998, Macnae and Zonghou, 1998, Stolz and Macnae, 1998). The software has been commercialised by Encom Technology Pty Ltd. Examples of TEMPEST conductivity data can be seen in Lane et al. (2000), Lane et al. (1999), and Lane and Pracillio (2000).

Conductivity values were calculated to a depth of 500 m below surface at each point, using a depth increment of 5 m and a conductivity range of 0.5-50 mS/m for area 1 and 0.4-225 mS/m for areas 2 and 3.

6.2.4 System Specifications for Modelling TEMPEST Data

Differences between the specifications for the acquisition system, and those of the virtual system for which processed results are given, must be kept in mind when forward modelling, transforming or inverting TEMPEST data.

Acquisition is carried out with a 50% duty cycle square transmitter current waveform and dB/dt sensors.

During processing, TEMPEST EM data are transformed to the response that would be obtained with a B-field sensor for a 100% duty cycle square waveform at the base frequency, involving a 1A change in current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter. Data are given in units of femtotesla (fT = 10^{-15} Tesla). It is this configuration, rather than the actual acquisition configuration, which must be specified when modelling TEMPEST data.

Window timing information is given above (see section 6.2.3).

6.2.4.1 Standard Height and Geometry

The “final” EM data have been standardised through an approximate transformation to a standard transmitter loop terrain clearance, transmitter loop pitch and roll of zero degrees, and a fixed transmitter loop to receiver coil geometry (roughly equal to the average “raw” geometry values). Transmitter loop pitch, transmitter loop roll and transmitter loop terrain clearance values for each observation have been modified to reflect the standard values. Hence, the “final” (fixed) geometry values should be used if modelling with the final X- and Z-component amplitude data - the following table summarises the values used to correct the transmitter height/pitch/roll/geometry to.

Table of values used to standardise transmitter loop height, pitch, roll and geometry

Variable	Standardised value
Transmitter loop pitch	0 degrees
Transmitter loop roll	0 degrees
Transmitter loop terrain clearance	100 metres
Transmitter loop – to – receiver coil geometry	115 m behind and 40 m below the aircraft

6.2.4.2 Parallax

The located data files utilise the following parallax values :-
- radar altimeter = 0 fiducials (0 observations from the zero parallax position),
- EM X-component = -9.2 fiducials (46 observation from the zero parallax position),
- EM Z-component = -9.4 fiducials (47 observations from the zero parallax position),

For the Tempest Airborne EM system, due to the asymmetry in the transmitter loop-receiver coil geometry with respect to flight direction, there is no single EM parallax value which will align the peak response for all conductivity distributions for lines flown in opposite directions.

The choice of EM parallax value depends on the intended usage, but with the predominance of broad, shallowly dipping conductors, and the client’s desire to grid the data, parallax has been applied so that data are optimised for gridding. The ‘optimum’ depends on the conductor depth, the acquisition geometry and the delay time, and hence, the selected value will be a compromise.

(NB negative parallax values are defined in this case as shifting the indicated quantity forward along line to larger fiducial values. Location information remains in the zero parallax state)

6.2.5 Delivered Products

Appendix III contains a complete list of all data supplied digitally.

Digital ascii located data and a Geosoft GDB format was produced, containing the raw and final, X and Z EM data, conductivity data as well as digital terrain.

Stacked CDI sections and CDI-multiplots (Z component) in Adobe PDF format.

Grids (in ER Mapper format) of all X and Z EM windows and digital elevation were produced.

A flight path map was delivered in Oasis “.map” format and “.png” image format.

Acquisition and processing report in hardcopy and digital PDF format.

7. REFERENCES

Garner, S.J., Thiel, D.V., 2000, Broadband (ULF-VLF) surface impedance measurements using MIMDAS: Exploration Geophysics, 31, 173-178.

Green, A., 1998. Altitude correction of time domain AEM data for image display and geological mapping, using the Apparent Dipole Depth (ADD) method. Expl. Geoph. 29, 87-91.

Green, A., 1998. The use of multivariate statistical techniques for the analysis and display of AEM data. Expl. Geoph. 29, 77-82.

Green, A., Lin, Z., 1996. Effect of uncertain or changing system geometry on airborne transient electromagnetic data: CSIRO Expl. and Mining Research News No. 6, August 1996, 9-11, CSIRO Division of Exploration and Mining.

Jupp, D.L.B. and Vozoff, K., 1975, Stable iterative methods for geophysical inversion: Geophysical Journal of the Royal Astronomical Society, vol. 42, pp. 957-976.

Lane, R., 2000, Conductive unit parameters : summarising complex conductivity distributions: Paper accepted for presentation at the SEG Annual Meeting, August 2000.

Lane, R., Green, A., Golding, C., Owers, M., Pik, P., Plunkett, C., Sattel, D., Thorn, B., 2000, An example of 3D conductivity mapping using the TEMPEST airborne electromagnetic system: Exploration Geophysics, 31, 162-172.

Lane, R., Leeming, P., Owers, M., Triggs, D., 1999, Undercover assignment for TEMPEST: Preview, Issue 82, 17-21.

Lane, R., Pracilio, G., 2000: Visualisation of sub-surface conductivity derived from airborne EM, SAGEEP 2000, 101-111.

APPENDIX I – Weekly Acquisition Reports

System: Tempest
Aircraft: VH-WGT

Total Job kms: 2508.000 Kms

Plan Kms Remain: 0.000 Kms
% Complete: 100.000 %

AGG Scrubs

-100.0 Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation
100.0 Hrs - The hours the Periodic Inspection is actally due at start of the job

Job Number: 2364
Contract Number: CT 7043 Rev 2
Job Name: Wiso and Reynolds Range
Area Names: REYNOLDS RANGE 1,REYNOLDS RANGE 2, WISO
Client: Toro Energy

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	AGG Scrub	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspection	Job Hrs to Date	Prod. to Date	AGG Scrubs to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc	M/R TTIS Prog.	Periodic Inspection Actually Due
12-November-2012					0.000		14:02:00	16:27:00	2.4				0.000			1.00	MO	Terry and Matt flew to Alice Springs and stayed overnight	-97.6	100.0
Julian Day 317					0.000								0.000				Comment :	WGT ferries Jdkt - Kal	-97.6	100.0
					0.000								0.000						-97.6	100.0
Monday					0.000								0.000						-97.6	100.0
					0.000					197.6	2.4		0.000						-97.6	100.0
Date 13-Nov					0.000		6:22:00	9:24:00	3.0				0.000			0.50	MO	Terry and Matt drove to Ti Tree, but returned to Alice Springs due to work being carried out on the Ti Tree airstrip	-94.6	100.0
Julian Day 318					0.000		10:09:00	12:24:00	2.3				0.000			0.50	MO	Grant ferried WGT Kal - Warburton - Alice Springs	-92.3	100.0
					0.000								0.000						-92.3	100.0
Tuesday					0.000								0.000						-92.3	100.0
					0.000					192.3	7.7		0.000						-92.3	100.0
Date 14-Nov	1	GH	TM		0.000		6:15:00	10:11:00	3.9				0.000			1.00	SETUP	Recce carried out	-88.4	100.0
Julian Day 319					0.000								0.000						-88.4	100.0
					0.000								0.000						-88.4	100.0
Wednesday					0.000								0.000						-88.4	100.0
					0.000					188.4	11.6		0.000						-88.4	100.0
Date 15-Nov	2	GH	TM	217.300	0.000	8.700	5:31:00	9:50:00	4.3				0.000			1.00	P & S	Began production on Reynolds Range 2	-84.1	100.0
Julian Day 320					0.000								0.000						-84.1	100.0
					0.000								0.000						-84.1	100.0
Thursday					0.000								0.000						-84.1	100.0
					0.000					184.1	15.9	217.300	0.000	8.700					-84.1	100.0
Date 16-Nov	3	GH	TM	223.100	0.000	8.900	5:37:00	9:55:00	4.3				0.000			1.00	P & S	Continued production on Reynolds Range 2 and began Range 1	-79.8	100.0
Julian Day 321					0.000								0.000						-79.8	100.0
					0.000								0.000						-79.8	100.0
Friday					0.000								0.000						-79.8	100.0
					0.000					179.8	20.2	440.400	0.000	17.600					-79.8	100.0
Date 17-Nov					0.000								0.000			1.00	PDO	PDO	-79.8	100.0
Julian Day 322					0.000								0.000						-79.8	100.0
					0.000								0.000						-79.8	100.0
Saturday					0.000								0.000						-79.8	100.0
					0.000					179.8	20.2	440.400	0.000	17.600					-79.8	100.0
Date 18-Nov	4	GH	TM		0.000	44.900	5:47:00	8:55:00	3.1				0.000			0.50	P & R & S	Reflew 2364-3, lines 20026 and 20005, Came home early due to high winds, turbulance and sferics.	-76.7	100.0
Julian Day 323					0.000								0.000		0.50	0.50	W	windy conditions limited production flying.	-76.7	100.0
					0.000								0.000						-76.7	100.0
Sunday					0.000								0.000						-76.7	100.0
					0.000					176.7	23.3	440.400	0.000	62.500					-76.7	100.0
			Totals This Week: ►	440.400	0.000	62.500		Week Hours: ►	23.4	▲: A/C Hrs to Next Service					0.50	7.00				

Total Accepted Line Kms This week: ► 440.400

▲

Standby Days This Week: ▲

System:	Tempest		
Aircraft:	VH-WGT	-100.0	Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation
Total Job kms:	2508.000 Kms	100.0	Hrs - The hours the Periodic Inspection is actally due at start of the job
			AGG Scrubs
Plan Kms Remain:	0.000 Kms		
% Complete:	100.000 %		

Job Number:	2364
Contract Number:	CT 7043 Rev 2
Job Name:	Wiso and Reynolds Range
Area Names:	REYNOLDS RANGE 1,REYNOLDS RANGE 2, WISO
Client:	Toro Energy

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	AGG Scrub	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspection	Job Hrs to Date	Prod. to Date	AGG Scrubs to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc	M/R TTIS Prog.	Periodic Inspection Actually Due
19-November-2012					0.000								0.000			0.90	LOG	Matt and Terry travel from Alice Springs to Ti Tree via road	-76.7	100.0
Julian Day 324					0.000		7:55:00	8:55:00	1.0				0.000			0.10	LOG	Grant ferried WGT from Alice Springs to Ti Tree	-75.7	100.0
					0.000								0.000						-75.7	100.0
Monday					0.000								0.000						-75.7	100.0
					0.000					175.7	24.3	440.400	0.000	62.500					-75.7	100.0
Date 20-Nov	5	GH	TM	72.700	0.000	158.000	5:53:00	9:26:00	3.6				0.000			0.50	P & S	Continued production	-72.1	100.0
Julian Day 325					0.000								0.000		0.50	0.50	W	Turbulance forced us to cut short the flight	-72.1	100.0
					0.000								0.000						-72.1	100.0
Tuesday					0.000								0.000						-72.1	100.0
					0.000					172.1	27.9	513.100	0.000	220.500					-72.1	100.0
Date 21-Nov	6	GH	TM	141.400	0.000	103.500	5:25:00	8:25:00	3.0				0.000			0.50	P & S	Continued production	-69.1	100.0
Julian Day 326					0.000								0.000		0.50	0.50	W	Turbulance forced us to cut short the flight	-69.1	100.0
					0.000								0.000						-69.1	100.0
Wednesday					0.000								0.000						-69.1	100.0
					0.000					169.1	30.9	654.500	0.000	324.000					-69.1	100.0
Date 22-Nov	7	GH	TM		0.000	42.900	5:24:00	7:16:00	1.9				0.000			0.50	P & S	Continued production	-67.2	100.0
Julian Day 327					0.000								0.000		0.50	0.50	W	Turbulance forced us to cut short the flight	-67.2	100.0
					0.000								0.000						-67.2	100.0
Thursday					0.000								0.000						-67.2	100.0
					0.000					167.2	32.8	654.500	0.000	366.900					-67.2	100.0
Date 23-Nov	8	GH	TM	118.000	0.000	50.000	5:26:00	7:57:00	2.5				0.000			1.00	P	Continued production	-64.7	100.0
Julian Day 328					0.000								0.000				Comment :	Turbulance/Sferics forced us to cut short the flight	-64.7	100.0
					0.000								0.000						-64.7	100.0
Friday					0.000								0.000						-64.7	100.0
					0.000					164.7	35.3	772.500	0.000	416.900					-64.7	100.0
Date 24-Nov					0.000								0.000			1.00	PDO	PDO	-64.7	100.0
Julian Day 329					0.000								0.000						-64.7	100.0
					0.000								0.000						-64.7	100.0
Saturday					0.000								0.000						-64.7	100.0
					0.000					164.7	35.3	772.500	0.000	416.900					-64.7	100.0
Date 25-Nov	9	GH	TM	337.900	0.000		5:32:00	8:50:00	3.3				0.000			1.00	P & S	Continued production	-61.4	100.0
Julian Day 330					0.000								0.000				Comment :	Sferics forced us to cut short the flight	-61.4	100.0
					0.000								0.000						-61.4	100.0
Sunday					0.000								0.000						-61.4	100.0
					0.000				-	161.4	38.6	1110.400	0.000	416.900					-61.4	100.0
			Totals This Week: ►	**670.000**	0.000	**354.400**		Week Hours: ►	**15.2**	▲: A/C Hrs to Next Service					**1.50**	**7.00**				
			Total Accepted Line Kms This week: ►	**670.000**											▲					

Standby Days This Week: ▲

System:	Tempest
Aircraft:	VH-WGT
Total Job kms:	2508.000 Kms
Plan Kms Remain:	0.000 Kms
% Complete:	100.000 %

-100.0	Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation
100.0	Hrs - The hours the Periodic Inspection is actally due at start of the job
	AGG Scrubs

Job Number:	2364
Contract Number:	CT 7043 Rev 2
Job Name:	Wiso and Reynolds Range
Area Names:	REYNOLDS RANGE 1,REYNOLDS RANGE 2, WISO
Client:	Toro Energy

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	AGG Scrub	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspection	Job Hrs to Date	Prod. to Date	AGG Scrubs to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc	M/R TTIS Prog.	Periodic Inspection Actually Due
26-November-2012	10	GH	TM	295.600	0.000		5:23:00	8:42:00	3.3				0.000			1.00	P	Continued production	-58.1	100.0
Julian Day 331					0.000								0.000						-58.1	100.0
					0.000								0.000						-58.1	100.0
Monday					0.000								0.000						-58.1	100.0
					0.000					156.1	41.9	1406.000	0.000	416.900					-58.1	100.0
Date 27-Nov	11	GH	TM	560.000	0.000		5:25:00	9:41:00	4.3				0.000			1.00	P	Continued production	-53.8	100.0
Julian Day 332					0.000								0.000						-53.8	100.0
					0.000								0.000						-53.8	100.0
Tuesday					0.000								0.000						-53.8	100.0
					0.000					153.8	46.2	1966.000	0.000	416.900					-53.8	100.0
Date 28-Nov		GH			0.000		7:38:00	8:03:00	0.4				0.000			1.00	LOG	Grant flew WGT ferry from Ti Tree to Barrow Creek	-53.4	100.0
Julian Day 333					0.000								0.000				Comment :	Matt and Terry drove truck to Barrow Creek	-53.4	100.0
					0.000								0.000						-53.4	100.0
Wednesday					0.000								0.000						-53.4	100.0
					0.000					153.4	46.6	1966.000	0.000	416.900					-53.4	100.0
Date 29-Nov	12	GH	TM	251.100	0.000	36.900	5:25:00	9:22:00	4.0				0.000			1.00	P & R & S	Continued production and re-flights	-49.4	100.0
Julian Day 334					0.000								0.000						-49.4	100.0
					0.000								0.000						-49.4	100.0
Thursday					0.000								0.000						-49.4	100.0
					0.000					149.4	50.6	2217.100	0.000	453.800					-49.4	100.0
Date 30-Nov	13	GH	TM	243.700	0.000		5:22:00	8:27:00	3.1				0.000			1.00	R	Continued re-flights	-46.3	100.0
Julian Day 335					0.000								0.000				Comment :	Returned to base due to Sferics	-46.3	100.0
					0.000								0.000						-46.3	100.0
Friday					0.000								0.000						-46.3	100.0
					0.000					146.3	53.7	2460.800	0.000	453.800					-46.3	100.0
Date 1-Dec					0.000								0.000			1.00	PDO	PDO	-46.3	100.0
Julian Day 336					0.000								0.000						-46.3	100.0
					0.000								0.000						-46.3	100.0
Saturday					0.000								0.000						-46.3	100.0
					0.000					146.3	53.7	2460.800	0.000	453.800					-46.3	100.0
Date 2-Dec	14	GH	TM	129.800	0.000		5:23:00	8:16:00	2.9				0.000		1.00	1.00	P	Weather day - too windy to fly	-43.4	100.0
Julian Day 337					0.000								0.000						-43.4	100.0
					0.000								0.000						-43.4	100.0
Sunday					0.000								0.000						-43.4	100.0
					0.000					143.4	56.6	2590.600	0.000	453.800					-43.4	100.0
			Totals This Week: ►	1480.200	0.000	36.900		Week Hours: ►	17.9	▲: A/C Hrs to Next Service					1.00	7.00				
			Total Accepted Line Kms This week: ►	1480.200											▲					

Standby Days This Week: ▲

System:	Tempest
Aircraft:	VH-WGT
Total Job kms:	2506.000 Kms
Plan Kms Remain:	0.000 Kms
% Complete:	100.000 %

AGG Scrubs

-100.0 Hrs - Progressive M/R Hrs at the start of job, prior to mobilisation

100.0 Hrs - The hours the Periodic Inspection is actally due at start of the job

Job Number:	2364
Contract Number:	CT 7043 Rev 2
Job Name:	Wiso and Reynolds Range
Area Names:	REYNOLDS RANGE 1,REYNOLDS RANGE 2, WISO
Client:	Toro Energy

Date	Flt	Pilot initials	On board Oper initials	Production inc. Reflights Exc. Scrubs	AGG Scrub	FAS Scrub	Time Start	Time End	Engine Hours on M/R	Hours to Periodic Inspection	Job Hrs to Date	Prod. to Date	AGG Scrubs to Date	FAS Scrubs to Date	Stdby Days	Activity Contribution	Activity	COMMENTS Weather, Data delivery Aircraft movement, etc	M/R TTIS Prog.	Periodic Inspection Actually Due
03-December-2012	15	GH	TM		0.000		5:21:00	6:23:00	1.0				0.000			1.00	E	Failed swoops test, transmitter power level was found to be too low, can't find a reason why	-42.4	100.0
Julian Day 338					0.000								0.000						-42.4	100.0
					0.000								0.000						-42.4	100.0
Monday					0.000								0.000						-42.4	100.0
					0.000					142.4	57.6	2590.600	0.000	453.800					-42.4	100.0
Date 4-Dec	16	GH	TM		0.000		5:24:00	6:13:00	0.8				0.000			1.00	E	Again failed swoops test due to low transmitter power	-41.6	100.0
Julian Day 339					0.000								0.000						-41.6	100.0
					0.000								0.000						-41.6	100.0
Tuesday					0.000								0.000						-41.6	100.0
					0.000					141.6	58.4	2590.600	0.000	453.800					-41.6	100.0
Date 5-Dec		GM			0.000		14:45:00	15:55:00	1.2				0.000			0.50	MA	Grant flew ferry flight from Barrow Creek to Alice Springs	-40.4	100.0
Julian Day 340					0.000								0.000			0.50	MO	Matt and Terry de-mobed, and drove from Barrow Creek to Alice Springs	-40.4	100.0
					0.000								0.000						-40.4	100.0
Wednesday					0.000								0.000						-40.4	100.0
					0.000					140.4	59.6	2590.600	0.000	453.800					-40.4	100.0
Date 6-Dec	17	GM	TM		0.000		13:12:00	14:07:00	0.9				0.000			1.00	TF	Test flight following loop repair	-39.5	100.0
Julian Day 341					0.000								0.000						-39.5	100.0
					0.000								0.000						-39.5	100.0
Thursday					0.000								0.000						-39.5	100.0
					0.000					139.5	60.5	2590.600	0.000	453.800					-39.5	100.0
Date 7-Dec					0.000								0.000			1.00	MO	Client confirmation that we are clear to demobilise	-39.5	100.0
Julian Day 342					0.000								0.000						-39.5	100.0
					0.000								0.000						-39.5	100.0
Friday					0.000								0.000						-39.5	100.0
					0.000					139.5	60.5	2590.600	0.000	453.800					-39.5	100.0
Date 8-Dec					0.000								0.000			1.00	MO	All crew fly back to Perth	-39.5	100.0
Julian Day 343					0.000								0.000						-39.5	100.0
					0.000								0.000						-39.5	100.0
Saturday					0.000								0.000						-39.5	100.0
					0.000					139.5	60.5	2590.600	0.000	453.800					-39.5	100.0
Date 9-Dec					0.000								0.000						-39.5	100.0
Julian Day 344					0.000								0.000						-39.5	100.0
					0.000								0.000						-39.5	100.0
Sunday					0.000								0.000						-39.5	100.0
					0.000					139.5	60.5	2590.600	0.000	453.800					-39.5	100.0
			Totals This Week: ►		0.000			Week Hours: ►	3.9	▲: A/C Hrs to Next Service						6.00				
			Total Accepted Line Kms This week: ►																	

Standby Days This Week: ▲

APPENDIX II – Located Data Formats

Headers for final data files

FINAL EM

AREA 1

```
COMM FAS PROJECT NUMBER                                           2364
COMM AREA NUMBER:                                                    1
COMM SURVEY COMPANY:                               Fugro Airborne Surveys
COMM CLIENT:                                             Toro Energy Ltd.
COMM SURVEY TYPE:                                     25Hz TEMPEST Survey
COMM AREA NAME:                                                   Wiso
COMM STATE:                                                         NT
COMM COUNTRY:                                                Australia
COMM SURVEY FLOWN:                            November to December 2012
COMM LOCATED DATA CREATED:                               February 2012
COMM
COMM DATUM:                                                      GDA94
COMM PROJECTION:                                                   MGA
COMM ZONE:                                                          53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                     1500 m
COMM TRAVERSE LINE DIRECTION:                              0 - 180 deg
COMM TIE LINE DIRECTION:                                  90 - 270 deg
COMM NOMINAL TERRAIN CLEARANCE:                                  100 m
COMM FINAL LINE KILOMETRES:                                    1288 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                        L3000101 - L3005301
COMM TIE LINE NUMBERS:                                        T3900101
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                     SHORTS SKYVAN, VH-WGT
COMM
COMM MAGNETOMETER:                              Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                        Stinger mounted
COMM RESOLUTION:                                                0.001 nT
COMM RECORDING INTERVAL:                                           0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                25Hz TEMPEST
COMM INSTALLATION:                  Transmitter loop mounted on the aircraft
COMM                                         Receiver coils in a towed bird
COMM COIL ORIENTATION:                                               X,Z
COMM RECORDING INTERVAL:                                           0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:    -115.0 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:      -40.0 m
COMM
COMM RADAR ALTIMETER:                                      Collins RL-50
COMM RECORDING INTERVAL:                                           0.2 s
COMM
COMM LASER ALTIMETER:                                      Optech 501SB
COMM RECORDING INTERVAL:                                           0.2 s
COMM
COMM NAVIGATION:                               Real-time differential GPS
```

```
COMM RECORDING INTERVAL:                                                 1.0 s
COMM
COMM ACQUISITION SYSTEM:                                                FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                        0.0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                        0.0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                         0.0 s
COMM
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM    X-COMPONENT EM DATA                                             -9.2 s
COMM    Z-COMPONENT EM DATA                                             -9.4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED                      EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                                      000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                                           5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM -------------------------------------------------------------------------
COMM DISCLAIMER
COMM -------------------------------------------------------------------------
COMM It is Fugro Airborne Survey’s understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
```

```
COMM altitude value is primarily dependent on the number of available
satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM ---------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START       END      CENTRE
COMM    1        0.007      0.020      0.013
COMM    2        0.033      0.047      0.040
COMM    3        0.060      0.073      0.067
COMM    4        0.087      0.127      0.107
COMM    5        0.140      0.207      0.173
COMM    6        0.220      0.340      0.280
COMM    7        0.353      0.553      0.453
COMM    8        0.567      0.873      0.720
COMM    9        0.887      1.353      1.120
COMM   10        1.367      2.100      1.733
COMM   11        2.113      3.273      2.693
COMM   12        3.287      5.113      4.200
COMM   13        5.127      7.993      6.560
COMM   14        8.007     12.393     10.200
COMM   15       12.407     19.993     16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                         UNITS            NULL                FORMAT
COMM Line                                           -99999999           I10
COMM Flight                                         -99                 I4
COMM Fiducial                                       -999999.9           F8.1
COMM Project_FAS                                    -9999               I6
COMM Date                                           -9999999            I9
COMM Time                           s               -9999.9             F8.1
COMM Bearing                        deg             -99                 I4
COMM Latitude                       deg             -99.9999999         F12.7
COMM Longitude                      deg             -999.9999999        F13.7
COMM Easting                        m               -99999.99           F10.2
```

```
COMM Northing                m          -999999.99      F11.2
COMM Tx_Elevation            m          -999.99         F8.2
COMM Lidar                   m          -999.99         F8.2
COMM DTM                     m          -999.99         F8.2
COMM Tx_Pitch                deg        -999.99         F8.2
COMM Tx_Roll                 deg        -999.99         F8.2
COMM Tx_Clearance            m          -999.99         F8.2
COMM HSep_Raw                m          -999.99         F8.2
COMM VSep_Raw                m          -999.99         F8.2
COMM Tx_Clearance_std        m          -999.99         F8.2
COMM HSep_std                m          -999.99         F8.2
COMM VSep_std                m          -999.99         F8.2
COMM EMX_nonhprg[1:15]       fT         -999.999999     F12.6
COMM EMX_hprg[1:15]          fT         -999.999999     F12.6
COMM X_Sferics                          -9999.999       F10.3
COMM X_LowFreq                          -9999.999       F10.3
COMM X_Powerline                        -9999.999       F10.3
COMM X_VLF1                             -9999.999       F10.3
COMM X_VLF2                             -9999.999       F10.3
COMM X_VLF3                             -9999.999       F10.3
COMM X_VLF4                             -9999.999       F10.3
COMM X_Geofact                          -9999.999       F10.3
COMM EMZ_nonhprg[1:15]       fT         -999.999999     F12.6
COMM EMZ_hprg[1:15]          fT         -999.999999     F12.6
COMM Z_Sferics                          -9999.999       F10.3
COMM Z_LowFreq                          -9999.999       F10.3
COMM Z_Powerline                        -9999.999       F10.3
COMM Z_VLF1                             -9999.999       F10.3
COMM Z_VLF2                             -9999.999       F10.3
COMM Z_VLF3                             -9999.999       F10.3
COMM Z_VLF4                             -9999.999       F10.3
COMM Z_Geofact                          -9999.999       F10.3
COMM COND_Z[1:100]           mS/m       -9999.999       F10.3
COMM COND_Z_DEPTH[1:100]     m          -99999          I5
```

AREA 2

```
COMM FAS PROJECT NUMBER                                      2364
COMM AREA NUMBER:                                               2
COMM SURVEY COMPANY:                       Fugro Airborne Surveys
COMM CLIENT:                                    Toro Energy Ltd.
COMM SURVEY TYPE:                           25Hz TEMPEST Survey
COMM AREA NAME:                             Reynolds Range One
COMM STATE:                                                    NT
COMM COUNTRY:                                           Australia
COMM SURVEY FLOWN:                    November to December 2012
COMM LOCATED DATA CREATED:                          February 2012
COMM
COMM DATUM:                                                 GDA94
COMM PROJECTION:                                              MGA
COMM ZONE:                                                     53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                1500 m
COMM TRAVERSE LINE DIRECTION:                        89 - 269 deg
COMM TIE LINE DIRECTION:                            179 - 359 deg
COMM NOMINAL TERRAIN CLEARANCE:                             100 m
COMM FINAL LINE KILOMETRES:                                911 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                   L1000101 - L1002501
COMM TIE LINE NUMBERS:                                   T1900102
```

```
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                         SHORTS SKYVAN, VH-WGT
COMM
COMM MAGNETOMETER:                               Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                           Stinger mounted
COMM RESOLUTION:                                                   0.001 nT
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                   25Hz TEMPEST
COMM INSTALLATION:                 Transmitter loop mounted on the aircraft
COMM                                         Receiver coils in a towed bird
COMM COIL ORIENTATION:                                                  X,Z
COMM RECORDING INTERVAL:                                              0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:      -115.0 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:        -40.0 m
COMM
COMM RADAR ALTIMETER:                                         Collins RL-50
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM LASER ALTIMETER:                                          Optech 501SB
COMM RECORDING INTERVAL:                                              0.2 s
COMM
COMM NAVIGATION:                                Real-time differential GPS
COMM RECORDING INTERVAL:                                              1.0 s
COMM
COMM ACQUISITION SYSTEM:                                             FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                     0.0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                     0.0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                      0.0 s
COMM
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM    X-COMPONENT EM DATA                                          -9.2 s
COMM    Z-COMPONENT EM DATA                                          -9.4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED                   EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                                   000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                                        5 m
COMM CONDUCTIVITIES CALCULATED USING HPRG CORRECTED EMZ DATA
COMM
COMM ---------------------------------------------------------------------
COMM DISCLAIMER
COMM ---------------------------------------------------------------------
COMM It is Fugro Airborne Survey’s understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
```

```
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM ----------------------------------------------------------------------
COMM
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START       END      CENTRE
COMM    1        0.007      0.020      0.013
COMM    2        0.033      0.047      0.040
COMM    3        0.060      0.073      0.067
COMM    4        0.087      0.127      0.107
COMM    5        0.140      0.207      0.173
COMM    6        0.220      0.340      0.280
COMM    7        0.353      0.553      0.453
COMM    8        0.567      0.873      0.720
COMM    9        0.887      1.353      1.120
COMM   10        1.367      2.100      1.733
COMM   11        2.113      3.273      2.693
COMM   12        3.287      5.113      4.200
COMM   13        5.127      7.993      6.560
COMM   14        8.007     12.393     10.200
COMM   15       12.407     19.993     16.200
COMM
```

```
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                     UNITS            NULL                FORMAT
COMM Line                                       -99999999           I10
COMM Flight                                     -99                 I4
COMM Fiducial                                   -999999.9           F8.1
COMM Project_FAS                                -9999               I6
COMM Date                                       -9999999            I9
COMM Time                       s               -9999.9             F8.1
COMM Bearing                    deg             -99                 I4
COMM Latitude                   deg             -99.9999999         F12.7
COMM Longitude                  deg             -999.9999999        F13.7
COMM Easting                    m               -99999.99           F10.2
COMM Northing                   m               -999999.99          F11.2
COMM Tx_Elevation               m               -999.99             F8.2
COMM Lidar                      m               -999.99             F8.2
COMM DTM                        m               -999.99             F8.2
COMM Tx_Pitch                   deg             -999.99             F8.2
COMM Tx_Roll                    deg             -999.99             F8.2
COMM Tx_Clearance               m               -999.99             F8.2
COMM HSep_Raw                   m               -999.99             F8.2
COMM VSep_Raw                   m               -999.99             F8.2
COMM Tx_Clearance_std           m               -999.99             F8.2
COMM HSep_std                   m               -999.99             F8.2
COMM VSep_std                   m               -999.99             F8.2
COMM EMX_nonhprg[1:15]          fT              -999.999999         F12.6
COMM EMX_hprg[1:15]             fT              -999.999999         F12.6
COMM X_Sferics                                  -9999.999           F10.3
COMM X_LowFreq                                  -9999.999           F10.3
COMM X_Powerline                                -9999.999           F10.3
COMM X_VLF1                                     -9999.999           F10.3
COMM X_VLF2                                     -9999.999           F10.3
COMM X_VLF3                                     -9999.999           F10.3
COMM X_VLF4                                     -9999.999           F10.3
COMM X_Geofact                                  -9999.999           F10.3
COMM EMZ_nonhprg[1:15]          fT              -999.999999         F12.6
COMM EMZ_hprg[1:15]             fT              -999.999999         F12.6
COMM Z_Sferics                                  -9999.999           F10.3
COMM Z_LowFreq                                  -9999.999           F10.3
COMM Z_Powerline                                -9999.999           F10.3
COMM Z_VLF1                                     -9999.999           F10.3
COMM Z_VLF2                                     -9999.999           F10.3
COMM Z_VLF3                                     -9999.999           F10.3
COMM Z_VLF4                                     -9999.999           F10.3
COMM Z_Geofact                                  -9999.999           F10.3
COMM COND_Z[1:100]              mS/m            -9999.999           F10.3
COMM COND_Z_DEPTH[1:100]        m               -99999              I5
```

AREA 3

```
COMM FAS PROJECT NUMBER                                                 2364
COMM AREA NUMBER:                                                          3
```

```
COMM SURVEY COMPANY:                                    Fugro Airborne Surveys
COMM CLIENT:                                                  Toro Energy Ltd.
COMM SURVEY TYPE:                                          25Hz TEMPEST Survey
COMM AREA NAME:                                            Reynolds Range Two
COMM STATE:                                                                 NT
COMM COUNTRY:                                                        Australia
COMM SURVEY FLOWN:                                November to December 2012
COMM LOCATED DATA CREATED:                                    February 2012
COMM
COMM DATUM:                                                              GDA94
COMM PROJECTION:                                                           MGA
COMM ZONE:                                                                  53
COMM
COMM SURVEY SPECIFICATIONS
COMM
COMM TRAVERSE LINE SPACING:                                              500 m
COMM TRAVERSE LINE DIRECTION:                                   35 - 215 deg
COMM TIE LINE DIRECTION:                                        125 - 305 deg
COMM NOMINAL TERRAIN CLEARANCE:                                          100 m
COMM FINAL LINE KILOMETRES:                                             313 km
COMM
COMM LINE NUMBERING
COMM
COMM TRAVERSE LINE NUMBERS:                              L2000101 - L2003001
COMM TIE LINE NUMBERS:                                                T2900101
COMM
COMM SURVEY EQUIPMENT
COMM
COMM AIRCRAFT:                                         SHORTS SKYVAN, VH-WGT
COMM
COMM MAGNETOMETER:                                 Scintrex Cs-2 Cesium Vapour
COMM INSTALLATION:                                             Stinger mounted
COMM RESOLUTION:                                                     0.001 nT
COMM RECORDING INTERVAL:                                                 0.2 s
COMM
COMM ELECTROMAGNETIC SYSTEM:                                      25Hz TEMPEST
COMM INSTALLATION:                  Transmitter loop mounted on the aircraft
COMM                                          Receiver coils in a towed bird
COMM COIL ORIENTATION:                                                     X,Z
COMM RECORDING INTERVAL:                                                 0.2 s
COMM SYSTEM GEOMETRY:
COMM HPRG CORRECTED RECEIVER DISTANCE BEHIND THE TRANSMITTER:      -115.0 m
COMM HPRG CORRECTED RECEIVER DISTANCE BELOW THE TRANSMITTER:        -40.0 m
COMM
COMM RADAR ALTIMETER:                                            Collins RL-50
COMM RECORDING INTERVAL:                                                 0.2 s
COMM
COMM LASER ALTIMETER:                                             Optech 501SB
COMM RECORDING INTERVAL:                                                 0.2 s
COMM
COMM NAVIGATION:                                  Real-time differential GPS
COMM RECORDING INTERVAL:                                                 1.0 s
COMM
COMM ACQUISITION SYSTEM:                                                FASDAS
COMM
COMM DATA PROCESSING
COMM
COMM TERRAIN CLEARANCE DATA
COMM LASER ALTIMETER: PARALLAX CORRECTION APPLIED                        0.0 s
COMM RADAR ALTIMETER: PARALLAX CORRECTION APPLIED                        0.0 s
COMM
COMM GPS ALTITUDE DATA
COMM PARALLAX CORRECTION APPLIED                                         0.0 s
COMM
```

```
COMM DIGITAL TERRAIN DATA
COMM DTM CALCULATED [DTM = GPS ALTITUDE - (LASER ALT + SENSOR SEPARATION)]
COMM DATA CORRECTED TO AUSTRALIAN HEIGHT DATUM
COMM DATA HAVE BEEN MICROLEVELLED
COMM
COMM ELECTROMAGNETIC DATA
COMM SYSTEM PARALLAX REMOVED, AS FOLLOWS:
COMM    X-COMPONENT EM DATA                                          -9.2 s
COMM    Z-COMPONENT EM DATA                                          -9.4 s
COMM DATA CORRECTED FOR TRANSMITTER HEIGHT, PITCH AND ROLL
COMM DATA CORRECTED FOR TRANSMITTER-RECEIVER GEOMETRY VARIATIONS
COMM DATA HAVE BEEN MICROLEVELLED
COMM CONDUCTIVITY DEPTH INVERSION CALCULATED                   EMFlow V5.10
COMM CONDUCTIVITY DEPTH RANGE                                   000 - 500 m
COMM CONDUCTIVITY DEPTH INTERVAL                                        5 m
COMM CONDUCTIVITIES CALCULATED USING LEVELLED HPRG CORRECTED EMZ DATA
COMM
COMM -----------------------------------------------------------------------
COMM DISCLAIMER
COMM -----------------------------------------------------------------------
COMM It is Fugro Airborne Survey’s understanding that the data provided to
COMM the client is to be used for the purpose agreed between the parties.
COMM That purpose was a significant factor in determining the scope and
COMM level of the Services being offered to the Client. Should the purpose
COMM for which the data is used change, the data may no longer be valid or
COMM appropriate and any further use of, or reliance upon, the data in
COMM those circumstances by the Client without Fugro Airborne Survey's
COMM review and advice shall be at the Client's own or sole risk.
COMM
COMM The Services were performed by Fugro Airborne Survey exclusively for
COMM the purposes of the Client. Should the data be made available in whole
COMM or part to any third party, and such party relies thereon, that party
COMM does so wholly at its own and sole risk and Fugro Airborne Survey
COMM disclaims any liability to such party.
COMM
COMM Where the Services have involved Fugro Airborne Survey's use of any
COMM information provided by the Client or third parties, upon which
COMM Fugro Airborne Survey was reasonably entitled to rely, then the
COMM Services are limited by the accuracy of such information. Fugro
COMM Airborne Survey is not liable for any inaccuracies (including any
COMM incompleteness) in the said information, save as otherwise provided
COMM in the terms of the contract between the Client and Fugro Airborne
COMM Survey.
COMM
COMM With regard to DIGITAL TERRAIN DATA, the accuracy of the elevation
COMM calculation is directly dependent on the accuracy of the two input
COMM parameters laser altitude and GPS altitude. The laser and radar altitude
COMM value may be erroneous in areas of heavy tree cover, where the
altimeters
COMM reflect the distance to the tree canopy rather than the ground. The GPS
COMM altitude value is primarily dependent on the number of available
satellites.
COMM Although post-processing of GPS data will yield X and Y accuracies in
the
COMM order of 1-2 metres, the accuracy of the altitude value is usually
COMM much less, sometimes in the ±5 metre range.  Further inaccuracies
COMM may be introduced during the interpolation and gridding process.
COMM Because of the inherent inaccuracies of this method, no guarantee is
COMM made or implied that the information displayed is a true
COMM representation of the height above sea level.  Although this product
COMM may be of some use as a general reference,
COMM THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.
COMM -----------------------------------------------------------------------
COMM
```

```
COMM ELECTROMAGNETIC SYSTEM
COMM
COMM TEMPEST IS A TIME-DOMAIN SQUARE-WAVE SYSTEM,
COMM TRANSMITTING AT A BASE FREQUENCY OF 25Hz,
COMM WITH 2 ORTHOGONAL-AXIS RECEIVER COILS IN A TOWED BIRD.
COMM FINAL EM OUTPUT IS RECORDED 5 TIMES PER SECOND.
COMM THE TIMES (IN MILLISECONDS) FOR THE 15 WINDOWS ARE:
COMM
COMM WINDOW      START       END      CENTRE
COMM    1        0.007      0.020      0.013
COMM    2        0.033      0.047      0.040
COMM    3        0.060      0.073      0.067
COMM    4        0.087      0.127      0.107
COMM    5        0.140      0.207      0.173
COMM    6        0.220      0.340      0.280
COMM    7        0.353      0.553      0.453
COMM    8        0.567      0.873      0.720
COMM    9        0.887      1.353      1.120
COMM   10        1.367      2.100      1.733
COMM   11        2.113      3.273      2.693
COMM   12        3.287      5.113      4.200
COMM   13        5.127      7.993      6.560
COMM   14        8.007     12.393     10.200
COMM   15       12.407     19.993     16.200
COMM
COMM PULSE WIDTH: 10 ms
COMM
COMM TEMPEST EM data are transformed to the response that would be
COMM obtained with a B-field sensor for a 100% duty cycle square
COMM waveform at the base frequency, involving a 1A change in
COMM current (from -0.5A to +0.5A to -0.5A) in a 1sq.m transmitter.
COMM It is this configuration, rather than the actual acquisition
COMM configuration, which must be specified when modelling TEMPEST data.
COMM
COMM
COMM LOCATED DATA FORMAT
COMM
COMM Output field format : ASCII ASEG-GDF
COMM
COMM FIELD                      UNITS           NULL                FORMAT
COMM Line                                       -99999999           I10
COMM Flight                                     -99                 I4
COMM Fiducial                                   -999999.9           F8.1
COMM Project_FAS                                -9999               I6
COMM Date                                       -9999999            I9
COMM Time                        s              -9999.9             F8.1
COMM Bearing                     deg            -99                 I4
COMM Latitude                    deg            -99.9999999         F12.7
COMM Longitude                   deg            -999.9999999        F13.7
COMM Easting                     m              -99999.99           F10.2
COMM Northing                    m              -999999.99          F11.2
COMM Tx_Elevation                m              -999.99             F8.2
COMM Lidar                       m              -999.99             F8.2
COMM DTM                         m              -999.99             F8.2
COMM Tx_Pitch                    deg            -999.99             F8.2
COMM Tx_Roll                     deg            -999.99             F8.2
COMM Tx_Clearance                m              -999.99             F8.2
COMM HSep_Raw                    m              -999.99             F8.2
COMM VSep_Raw                    m              -999.99             F8.2
COMM Tx_Clearance_std            m              -999.99             F8.2
COMM HSep_std                    m              -999.99             F8.2
COMM VSep_std                    m              -999.99             F8.2
COMM EMX_nonhprg[1:15]           fT             -999.999999         F12.6
COMM EMX_hprg[1:15]              fT             -999.999999         F12.6
```

COMM X_Sferics		-9999.999	F10.3
COMM X_LowFreq		-9999.999	F10.3
COMM X_Powerline		-9999.999	F10.3
COMM X_VLF1		-9999.999	F10.3
COMM X_VLF2		-9999.999	F10.3
COMM X_VLF3		-9999.999	F10.3
COMM X_VLF4		-9999.999	F10.3
COMM X_Geofact		-9999.999	F10.3
COMM EMZ_nonhprg[1:15]	fT	-999.999999	F12.6
COMM EMZ_hprg[1:15]	fT	-999.999999	F12.6
COMM Z_Sferics		-9999.999	F10.3
COMM Z_LowFreq		-9999.999	F10.3
COMM Z_Powerline		-9999.999	F10.3
COMM Z_VLF1		-9999.999	F10.3
COMM Z_VLF2		-9999.999	F10.3
COMM Z_VLF3		-9999.999	F10.3
COMM Z_VLF4		-9999.999	F10.3
COMM Z_Geofact		-9999.999	F10.3
COMM COND_Z[1:100]	mS/m	-9999.999	F10.3
COMM COND_Z_DEPTH[1:100]	m	-99999	I5

APPENDIX III – List of all Supplied Data and Products

STANDARD DELIVERABLES

- **Raw Products**
  - **Raw Grids** (Georeferenced TIFF format)
    - Raw CDI's for all of the survey lines
    - Raw EM Channels (X and Z) for all 15 windows

- **Preliminary Products**
  - **Preliminary Grids** (ERMapper format GDA94 MGA53S)
    - Digital Terrain Model
    - 15 channels of X-component
    - 15 channels of Z-component
    - EM Time Constant for X-component
    - EM Time Constant for Z-component

- **Final Products**
  - **Final Located Data** (ASEG-GDF II Format)
    - 2364_[1,2,3]_Final.des **-** header file describing the contents of the located data
    - 2364_[1,2,3]_Final.asc - flat ascii file containing located EM and digital terrain data
    - 2364_[1,2,3]_Final.gdb - Geosoft database file containing located EM and digital terrain data

  - **Final Grids** (ERMapper format GDA94 MGA53S)
    - Digital Terrain Model
    - 15 channels of X-component
    - 15 channels of Z-component
    - EM Time Constant for X-component
    - EM Time Constant for Z-component

  - **Final Digital Products**
    - Flight Path map (PNG format)
    - Z-Component Conductivity Depth Image (CDI) Multiplots & Stacked sections (PDF format)

  - **Acquisition and Processing Report**
    - Delivered as hardcopy and digitally in PDF format

- **Additional Products**
  - **Additional Grids**
    - Georeferenced CDI in Georeferenced TIFF [TIF], Enhanced Compression Wavelet [ECW] and Geosoft Grid [GRD] formats