AIRBORNE GEOPHYSICAL SURVEY

HELEN SPRINGS
NORTHERN TERRITORY

SURVEY DETAILS, TECHNICAL SPECIFICATIONS
AND
SURVEY LOGISTICS REPORT

PREPARED BY
WORLD GEOSCIENCE CORPORATION LIMITED
FOR

NORTHER TERRITORY
DEPARTMENT OF MINES AND ENERGY

GS 93/5

NOVEMBER / DECEMBER 1993

WGC Ref: # 1358.3 6

Compiled by G.A. Stewart
Field Procedures Manager
World Geoscience Corporation Ltd.

CONTENTS

1. SURVEY AREA

1.1 SURVEY AREA COORDINATES

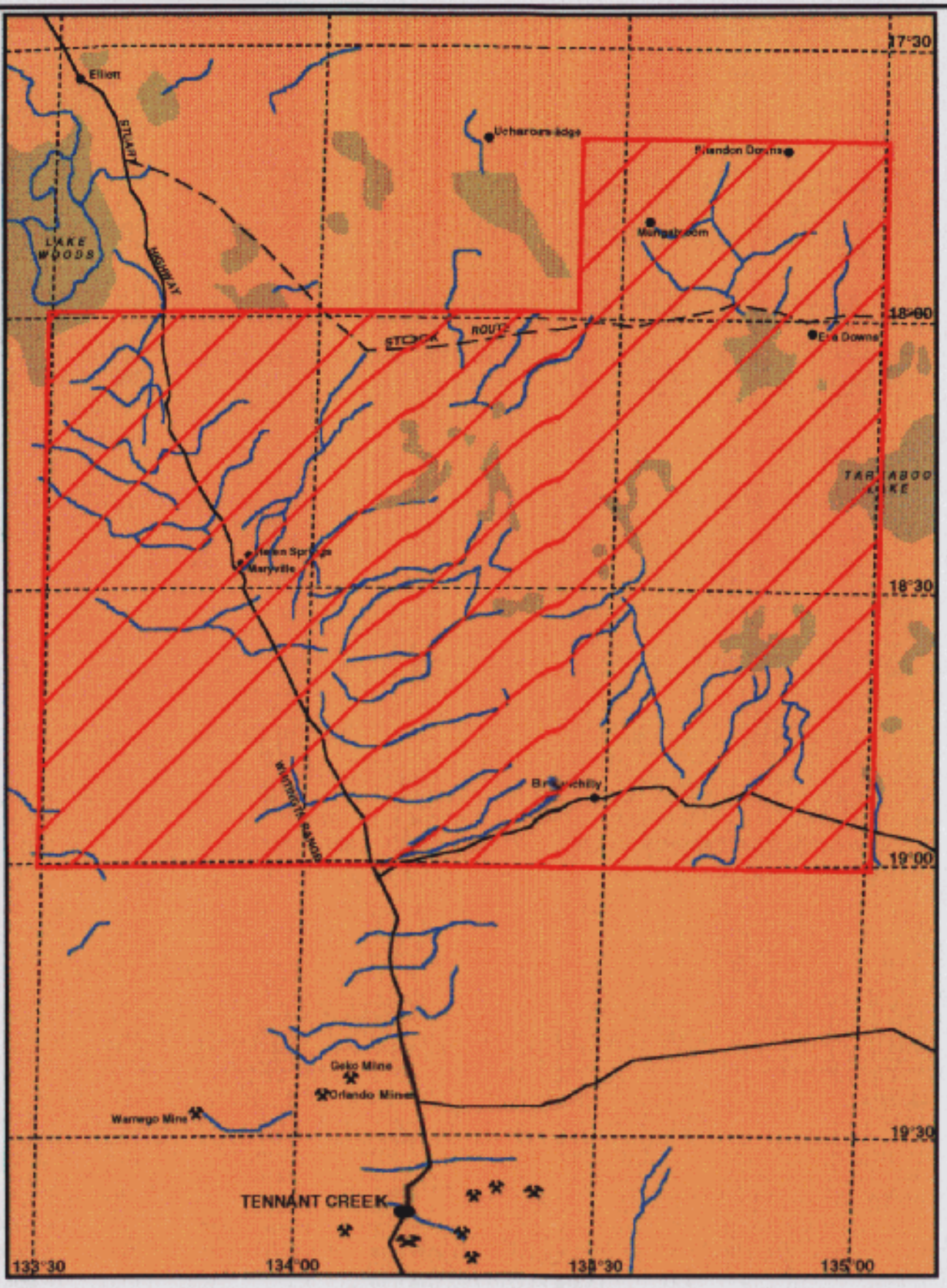
AGD-84 ZONE 53

EASTING	NORTHING
340190	8010710
437245	8010710
437130	8047590
501000	8047685
501000	7897492
340500	7897492
340190	8010710

1.2 GENERAL SURVEY DESCRIPTION

The area lies in the mostly dry semi arid central Australian desert of the Georgina Basin. The southern most boundary is situated to the north of Tennant Creek in the Northern Territory. To the north, the area enters the sub tropical zone. Black soil plains and natural wetlands lie in the eastern region. Large areas of outcropping escarpment ridges run through the central part of the area, folowing the Stuart Highway. During the survey one day was lost due to heavy rain over the survey area.
A total of 47,560 kms, including overfly, was flight planned and flown for this project.

1.3 AREA MAP



HELEN SPRINGS
GEOPHYSICAL SURVEY
for
NORTHERN TERITORY DEPT
OF MINES AND ENERGY

SURVEY AREA

2. SUMMARY OF TECHNICAL SPECIFICATIONS

2.1 SURVEY PARAMETERS

2.1.1 LINE SPACING & HEADING

Traverse line spacing	:500m
Traverse line direction	:090° - 270°
Tie line spacing	:5000m
Tie line direction	:000° - 180°
Navigation	:Autonomous GPS for aircraft, :navigation and Differentially :Post Processed GPS, :(DGPS) for final positions.
Navigation Tolerances	: Flight lines NOT to exceed :150% of spacing for > 5kms. :Tie lines NOT to exceed :150% of spacing for > 5kms

2.1.2 MAGNETIC SENSOR HEIGHT

Sensor Height	:100m (nominal)
Height Tolerance	:+/- 20m :NOT to exceed +/- 20m : for > 5kms

2.1.3 DATA CYCLE / SAMPLE INTERVALS

Magnetometer	:10Hz (0.1sec.) / less than 7m
Radar altimeter	:10Hz (0.1sec.) / less than 7m
GPS	:1. Hz (1.0sec.) / less than 70m

3. SURVEY EQUIPMENT & SPECIFICATIONS

3.1 AIRBORNE MAGNETOMETER

The aircraft uses a Scintrex VIW 2321 H8 optically pumped caesium vapour magnetometer.
This sensor consists of the sensor optics and the sensor electronics which are connected by a cable assembly. The caesium sensor is an oscillator which produces a frequency that is directly proportional to the total field intensity. The proportional constant is 3.4986 Hz per gamma. Over the specified operating range of the instrument, the output frequency will vary from 69,972 Hz (20,000 nT.= nano Teslas) to 349,860 Hz (100,000 nT).

SPECIFICATIONS

Model	:VIW 2321 H8
Working Range	:20,000-100,000 nT
Output "Larmor" Frequency	:69,972 Hz @ 20,000 :nT, 349,860 Hz @ :100,000 nT
Sensor orientation	:Optimum angle 45deg :between sensor head :axis and magnetic field :vector.
Sensitivity	:0.005 nT
Resolution	:<0.02 nT @ 0.1sec :cycle rate.

3.2 RADAR ALTIMETER

The aircraft recorded both radar and barometric altimeters. The Radar Altimeter is a commercially available unit (Sperry RT-100), which works on the send / receive principle. The voltage output is proportional to flying height and measured for any given height. The altimeter is calibrated prior to project commencement using W.G.C.'s software to determine the relationship between the analog output and the true altitude in ft./metres. The raw output in millivolts is also recorded. The calibration software outputs a set of coefficients to compensate for any slope change in the analog output. These coefficients are then used to digitally record the aircraft height each 0.1 of a second.

SPECIFICATIONS

Model (type)	:Sperry RT-100
Accuracy	:40 to 200 ft: +/-6 ft :200 to 500 ft: +/- 3% :500 to 2000 ft: +/- 3.5% :2000 to 2500 ft: +/- 4.5%

3.3 BAROMETRIC ALTIMETER

The Barometric Altimeter is a pressure transducer type, which measures the varying altitude pressure while on survey.
The barometric height of the airport, (QNH) is input by the operator prior to survey commencement to compensate for changes in daily air density pressure.

SPECIFICATIONS

Model (Baro)	:Sensyn Transducer :LX1501A
Range	:0 to 30,000ft
Accuracy	:+/- 2.75% of Full Scale
Resolution	:0.1 foot

3.4 MAGNETIC BASE STATION

Two Geometrics G-856 memory magnetometers were used for this survey. Both units were located at the Tennant Creek airport. A small area surrounding these locations were "mini surveyed" to determine a magnetically quiet position. The units were time checked prior to each survey flight commencement against the GPS receiver time, which is the time base for all acquired data.

SPECIFICATIONS

Model	:G-856 memory magnetometer
Displays	:Six digit display of :Magnetic field to resolution :of 0.1 nT or time to :nearest second. :Additional three digit display :of station, day of year,and :record number.
Resolution	:Typically 0.1 nT in :average conditions.
Absolute accuracy	:One nT, limited by :remnant magnetism in :sensor and :crystal oscillator ccuracy.
Clock	:Julian clock with stability :of ~2 seconds per day.
Memory	:Approx. 12,500 readings.
Output	:Plays data out in :standard :RS-232 format :at selected baud rates.

3.5 TRACKING CAMERA

A video camera is located in the under-side of the aircraft pointing directly down with a wide angle lens to record any cultural anomalies which may register erroneous magnetic data, for example, townships, buildings, power lines, mining activity ect.

SPECIFICATIONS

Model	:Sony wide view CL-352
Lens	:Auto iris wide angle

3.6 VIDEO RECORDER

The camera is coupled to a commercially available standard video cassette recorder unit. Video tapes are long play with 180 minutes per tape. The recorder has a digital counter to measure remaining tape. The line attempt number, heading, position and fiducial number are super-imposed upon the tape at the top and bottom of the display. The operator has the facility to input an event marker with comments upon the video image to manually mark any features of interest, such as the above mentioned cultural anomalies.
The operator has a small format CRT monitor displaying the image imediately below the aircraft in real time.

SPECIFICATIONS

Model	:National Panasonic
Format	:VHS

3.7 NAVIGATION

Aircraft navigation was performed using GPS autonomous positioning. Differential corrections were applied in post processing. The GPS base station was located in the field office at Alyangula. This GPS base station was initially positioned using commercially available Ashtech "RANGER" software. This entails logging the receiver for a period of approximately 4 hours, then averaging the reference site, this was done on several occasions during the survey to satisfy position repeatability. The GPS base station antenna was located on the roof of the field crews accommodation and office facilities.

SPECIFICATIONS

Receiver(s)	:Ashtech XII, auto all in :view, 12 channel C/A :code tracking
Position accuracy	:Differential mode = 1-10m : (PDOP<6) :**S**pherical **E**rror **P**robability :(**SEP**)
Receiver(s) update rate	:2 per second
Velocity	:>1200m / sec.
Antenna	:Kinematic

3.8 DIGITAL RECORDING

The survey was conducted using a PICODAS digital recording system, This system comprises of a PC based computer with internal hard disk, 3½" micro disk and a 40Mb DC 2000 tape drive. The software used has been developed by W.G.C. and is proprietary software. All data recorded is in binary format and stored onto hard disk then copied to DC 2000 thetamat media, then down loaded onto a field personal computer, verified and checked before being shipped to W.G.C.s office for final processing.

SPECIFICATIONS

Model	:*PDAS-1000 (Digital :Acquisition System) :*IBM/PC/AT compatible
Processor	:*80386 (with maths co- :processor)
Speed	:25 MHz
Operating System	:*MS DOS 5.0
Analog to Digital channels	:12 channels with 16 bit :resolution (expandable)
Display	:Electro-luminescent :640 x 400 :pixel resolution
Recording Media	:80Mb Hard Disk / 40Mb :¼" streaming tape :3½" Floppy Disk

* registered trade marks

3.9 ANALOG RECORDING

World Geoscience uses RMS Instruments GR-33A Graphic Recorders (thermal print). This instrument is a microcomputer based 32 channel chart recorder with alphanumeric annotation. The analog output is as follows from left to right across the full 12 inches of chart;

TRACE ID	*DESCRIPTION*	*Position / Value / Span*
FDD1	Fourth Digital Difference (MAG)	centred =50pT per 1"
MAG1	RAW MAG Coarse Scale	base = 2nT per 1"
CMA1	COMPENSATED MAG Fine	base = 20nT per 1"
FGAT	Total of three axisfluxgate MAG	centred = 5mV per 1"
BARO	Barometric Altimeter	base = 500ft / 1"
RAD	Radar Altimeter	base = 500ft / 1"
TC	Total Counts per sec.	base = 2000 cps / 1"
Kst	Potasium (stripped)	base = 200 cps / 1"
Ust	Uranium (stripped)	base = 200 cps / 1"
Th	Thorium	base = 200 cps / 1"

(These values are NOT absolute and may have been modified at times during the survey period. This was dependant on the activity of the traces in a particular part of the survey area, OR, the client may have requested changes to the scales for readability purposes.)

The values of full scale deflection are operator selectable and these were found to give the most comprehensible displays and enabled the operator to visually interpret the incoming data in real time. Acquisition time is displayed along the left side (top) and fiducials (events in seconds) are displayed along the right side (bottom).
When the acquisition system is initialised, a print out of year, month, day, type of magnetometer, software version and aircraft identifier are displayed. Then followed by, flight number., job number., client, aircraft, operators name, pilot, magnetometer type, survey altitude, RMS chart recorder speed and a remarks line, which the operator can input any relevant information. At the start of any recorded acquisition, the full scale deflection values are displayed for each channel, following this is the line No., direction, start fid, video number. date, and start time. After a line has been recorded and terminated, the operator has the option of making any relevant notes in the remarks; this is then followed by the binary file name, actual line number., heading, end time, end fiducial and lastly a list of last values for each trace is output.

SPECIFICATIONS

Model	:RMS GR-33A Graphic Recorder
Type	:Fully programmable 32 :channel microprocessor non- :mechanical, thermal printing :system.
Size	:315mm (12.4 ") record on :321mm (12.625 ") paper
Resolution	:100 X 100 dots / inch :(approx. 4 X 4 dots)
Recording Method	:Fixed position monolithic :thermal print-head
Speed	:~ 2mm per second. :Alphanumeric - 3 lines per sec.

3.10 GENERAL DESCRIPTION of DATA ACQUISITION SYSTEM

The main body of this system is the PICODAS (PDAS) computer referenced above in section 3.8. This is coupled to the Ashtech GPS receiver for timing. This GPS receiver is connected to a PICODAS navigation console (PNAV) which displays to the pilot a graphical representation of the line being flown, this PNAV has a flight plan of the area boundaries and start and end of the line coordinates loaded into memory via a pre recorded flight plan. The PNAV outputs to the acquisition computer the position coordinates and other relevant GPS information. The magnetometer, fluxgate magnetometer, barometric altimeter and other analog channels are powered by a PICODAS 1000A interface console. The acquisition computer also outputs line numbers, direction, current position and fiducials, to a VHS video recorder which records each line. The acquisition PDAS also converts the digital data into analog form and outputs this information to the RMS chart recorder to graphically display each channel in the form of a labelled trace onto a paper hard copy in real time.

3.11 TIME BASE

The time base for this survey was the ATOMIC clock output of the GPS satellites in all aspects of data acquisition. The aircraft acquisition system software is set to GPS time, then adjusted to the LOCAL area time each time the system is initialised. The system utilises the *"PULSE PER SECOND"* output from the Ashtech Ranger XII GPS receiver(s), which is chronologically synchronised to the ATOMIC clock output of the satellites. The G-856 base station magnetometers are also syncronised to GPS time, setting each unit manually prior to survey commencement.

4. EQUIPMENT CALIBRATIONS AND DATA ACQUISITION CHECKS

Prior to commencement of the survey, a series of calibrations were performed by the following;

4.1 HEADING ERROR

HELMHOLTZ coil adjustments to compensate for heading error were performed prior to project commencement and upon completion. This comprises of a series of flying runs over the same visually prominent feature in a clover-leaf pattern in a magnetically quiet location while adjusting the current (mAmps) for each axis (X,Y,Z) of a spherical set of copper coils surrounding the sensor, therby creating an induced magnetic field around the sensor and removing the magnetic influence of the aircraft. The magnetic base station, is also recorded while these calibrations are being performed and the diurnal effect is taken into consideration. This heading error was within 1 nT. on traverse line headings.

4.2 SYSTEM PARALLAX

The aircraft parallax is also checked when heading checks are done. This parallax error is simply the delay caused by the physical distance from the magnetic sensor, at the tail of the aircraft, to the centre of the video image.
The heading error and parallax error are recorded and therefore are known. Any error is removed during processing.

4.3 MAGNETIC, REAL TIME COMPENSATION COEFFICIENTS

Also performed are a series of aircraft compensation tests flown on survey line heading and also 5° to 20° either side to accommodate cross wind flying conditions. The data for each heading consists of a series of aircraft manoeuvres, pitches, rolls and yaws. This is done to artificially create the worst possible attitude the aircraft may encounter whilst on survey and compensate for any magnetic noise caused by the aircraft's attitude in the naturally occuring magnetic field. This data is processed to obtain the best possible magnetic *REAL TIME COMPENSATION* coefficients from 32 mathamatical terms. These coefficients may be applied in real time, or post processing. The compensated magnetic data was demonstrated to be less than 0.5nT. peak to peak.

4.4 RADIOMETRIC CALIBRATIONS and QUALITY CONTROL

Prior to project commencement and upon completion, resolution checks of the spectrometer were performed to ensure accuracy to contract specifications. Aircraft background and height attenuation tests were performed prior to commencement of this project.
Uranium and Thorium hand sample calibrations were carried out each production flight (pre and post flight). These were within 10% of initial calibrations. A low and high level test line were recorded each production flight (pre and post flight) as per contract specifications.
The low level test line coordinates are as follows;

	AGD-84 ZONE 54	
EASTING		NORTHING
411650	START	7850800
423700	END	7850000

4.5 RADIOMETRIC CORRECTION PROCEDURES

Radiometric correction procedures are as follows;

Parallax Correction			Coefficient;	0.3
Radon Corrected				
Background Corrected				
Height Attenuation Correction				
"	"	Total Counts	Coefficient;	0.006382
"	"	K	" ;	0.008370
"	"	Ur	" ;	0.005138
"	"	Th	" ;	0.006440
Stripped	Th into Ur		Coefficient;	0.3047
"	Th into K		"	0.3314
"	Ur into K		"	0.6343
"	Ur into Th		"	0.0242
Tie Line Leveled				
Micro Leveled				

4.6 DIGITAL DATA FORMATS

Descriptive digital data formats as follows;

"F6"	:line No.
"F3"	:flight No.
"F7"	:date
"F8-2"	:time
"F9-2"	:fiducial No.
"F2"	:recovery flag
"F10-1"	:easting
"F10-1"	:northing
"F1"	:final mag flag
"F9-2"	:raw magnetic intensity
"F9-2"	:corrected magnetic intensity
"F9-2"	:diurnal
"F9-2"	:igrf
"F6"	:total count
"F6"	:potassium
"F4"	:uranium
"F4"	:thorium
"F4"	:cosmic
"F1"	:data flag
"F8-1"	:total count corrected
"F8-1"	:potassium corrected
"F6-1"	:uranium corrected
"F6-1"	:thorium corrected
"F6-1"	:radar altitude

5. AIRCRAFT AND EQUIPMENT

Type	:Shrike Aerocommander AC-500S
Registration	:VH-MEH
Ownership	:W.G.C. Corporation Ltd
	:Aerodata Holdings Ltd.
Serial No.	:3258
Date of Manufacture	:1975
Engines	:Twin, IO540-E185 Lycoming
	:Piston type
Propellers	:Twin, 3 blade variable pitch
	:Hartzell HC-C3YR-2F
Dimensions	:Wingspan 49ft.
	:Length 36ft.
	:Height 14ft. 6"
Fuel	:AVGAS 100
Fuel Capacity	:Main Tanks 156 US gals - 593Lts
	:Boot Tank 50 US gals - 190Lts
Endurance	:at 24 US gals/Hr = 8.5Hrs
Total Airframe Time	:~15300Hrs at 30 June 1993
Total Survey Time	:~13000Hrs at 30 June 1993
Seating	:Survey Configuration - 3 Pax.
Flight Instruments	:Century III auto pilot
Radio Equipment	:Codan HF multi-channel radio
	:Collins 331-3S HSI
	:Sperry RT-100 Radar Altimeter
	:DigiQuartz 223-AS-002
	:pressure transducer
	:King KMA 20-04 marker beacon
	:King K x 175B/KN72 Nav/Com VHF
	: " " " " " "
	:King KN75 Glideslope
	:King KR87 ADF
	:King KR85 ADF
	:AWA Domestic Van 10 DME
	:King KN65A International DME
	:King KT76A ATC-SSR

6. SURVEY OPERATIONS AND LOGISTICS

6.1 SURVEY BASE

The base of operations used for this project was Tennant Creek. Although this site was outside the survey area, some 50 kms from the southern boundary, it was the only site available to accomodate aircraft and crew. Air conditioned accommodation and field office facilities were set up at the Desert Sands Motel situated on the Stuart Highway on the northern side of town. Facilities were good, with inter-city freight agents and large stocks of aviation fuel available.

Airport details as follows;

Airport	:Tennant Creek
Elevation	:1236
Runway Length	:1959m
No. of runways	:2
Airport facilities	:PA Lighting 120.6
	:VOR 112.9
	:NDB 272
	:DME 11
	:CTAF 126.7
Aviation Fuel	:Shell - Northern Territory Fuels

6.2 SURVEY FIELD CREW

The following personnel were employed on this project;

Project Co-ordinator - Sydney	:Dick Butler
Logistics & Operations - Perth	:Tony McCambridge
Project Manager(s) - On Site	:Ray Skeet
Pilot(s)	:Capt. Jeff Ibbotson
	:Capt. Dominic Walsh
	:Capt. Grant Hamilton
Electronics Engineer / Data Tech	:Daniel Maddocks
Electronics Tech / Data Tech / Operator	:Paul Eddington
Data Tech / Operator	:Ben Trevenen
Geophysicist / Data Processing - Sydney	:Alan Willmore
Geophysicist / Programmer - Sydney	:Ian Cambell
Data Quality Control - Perth	:Kevin Harrinton

6.3 FLYING SUMMARY

Date	FLT. No.	FLT. Hrs	Kms	Progressive Total	Comments
05/11/93	002	3.0	0000	00000	Comp box, heading chks.
06/11/93	003	3.5	0000	00000	Active diurnal, half day standby.
07/11/93	000	0.0	0000	00000	Mag storms, full day standby.
08/11/93	004	2.5	325	325	
09/11/93	005	3.5	325	650	A/C engine oil leak
10/11/93	006	11.3	2112	2762	
11/11/93	007	10.4	1803	4565	
12/11/93	008	11.1	1913	6478	
13/11/93	009	11.4	1984	8462	
14/11/93	010	11.7	2233	10695	
15/11/93	011	11.8	2320	13015	Active diurnal
16/11/93	012	3.0	0000	00000	Rain in survey area Full day standby.
17/11/93	013	11.5	2223	15238	Active diurnal
18/11/93	014	4.5	797	16035	A/C departs for 100hrly,
23/11/93	015	4.8	899	16934	A/C arrives back early pm
24/11/93	016	11.2	1904	18838	
25/11/93	017	12.5	2213	21051	
26/11/93	018	11.6	2060	23111	Active diurnal
27/11/93	019	12.1	2323	25434	Active diurnal
28/11/93	020	11.3	1535	26969	
29/11/93	021	11.1	2023	28992	
30/11/93	022	11.9	2186	31178	
01/12/93	023	11.7	2185	33363	A/C departs for 100hrly
04/12/93	024	6.9	823	34186	A/C arrives early pm.
05/12/93	025	12.0	2179	36365	
06/12/93	026	12.4	2277	38642	
07/12/93	027	11.7	2116	40758	
08/12/93	028	6.7	944	41702	Active diurnal, half day standby.
09/12/93	029	12.4	2439	44141	
10/12/93	030	11.8	2280	46421	
11/12/93	031	7.7	1139	47560	Project complete.

TOTAL

Actual survey days (full days) = 26 days
Scheduled aircraft maintenance = 08 days
Un-scheduled aircraft maintenance = 0.5days
Stand-by days due weather/diurnal = 03 days

Total survey duration = **37 days**