Open File Envelope No. 12,219

EL 3539

PINE VALLEY

SECOND PARTIAL SURRENDER REPORT FOR THE PERIOD 29/8/2006 TO 18/4/2011

Submitted by
Gold Fields Australasia Pty Ltd
2011

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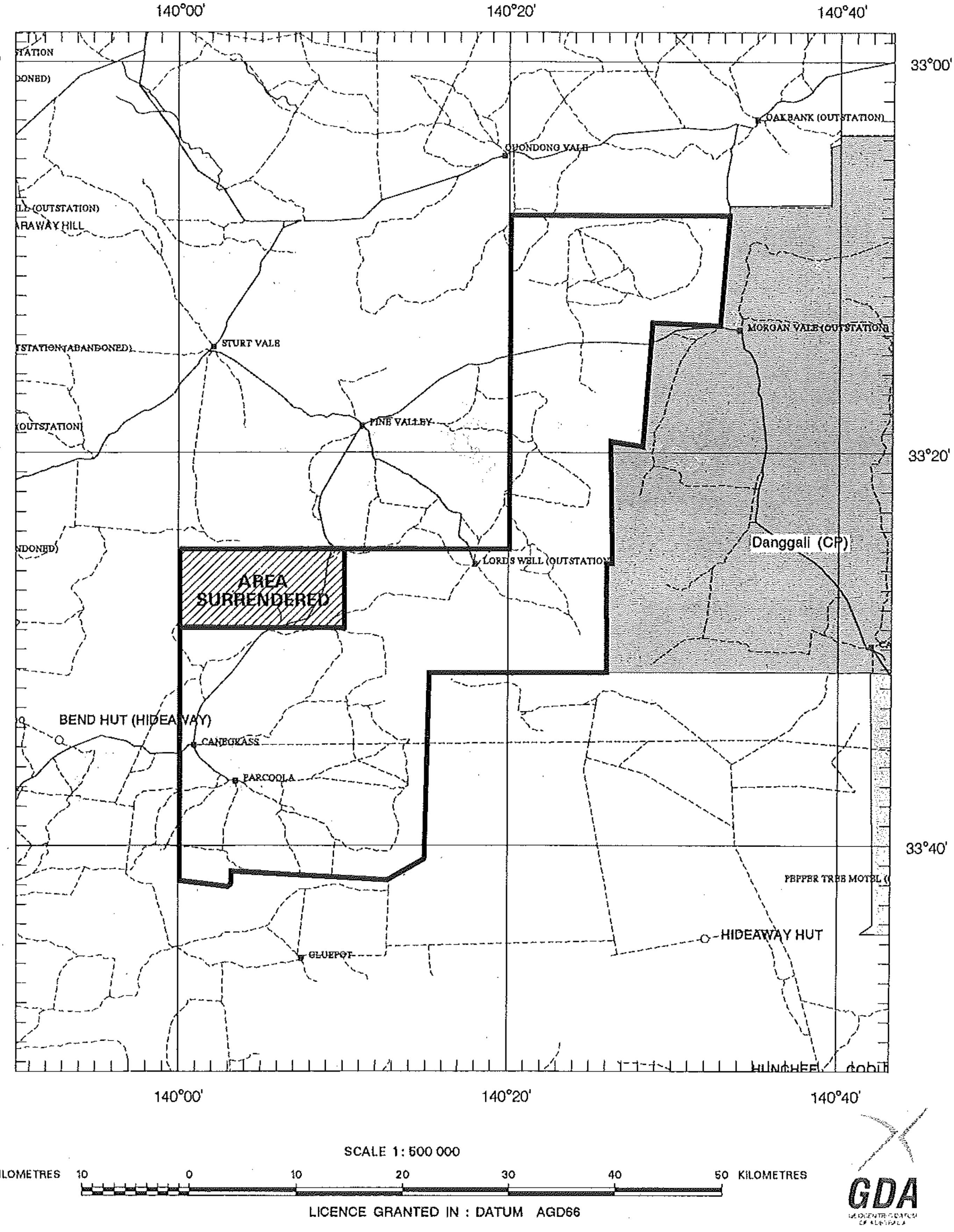
Government of South Australia
Department for Manufacturing, Innovation, Trade, Resources and Energy

SCHEDULE A



APPLICANT : **STEINER HOLDINGS PTY LTD**

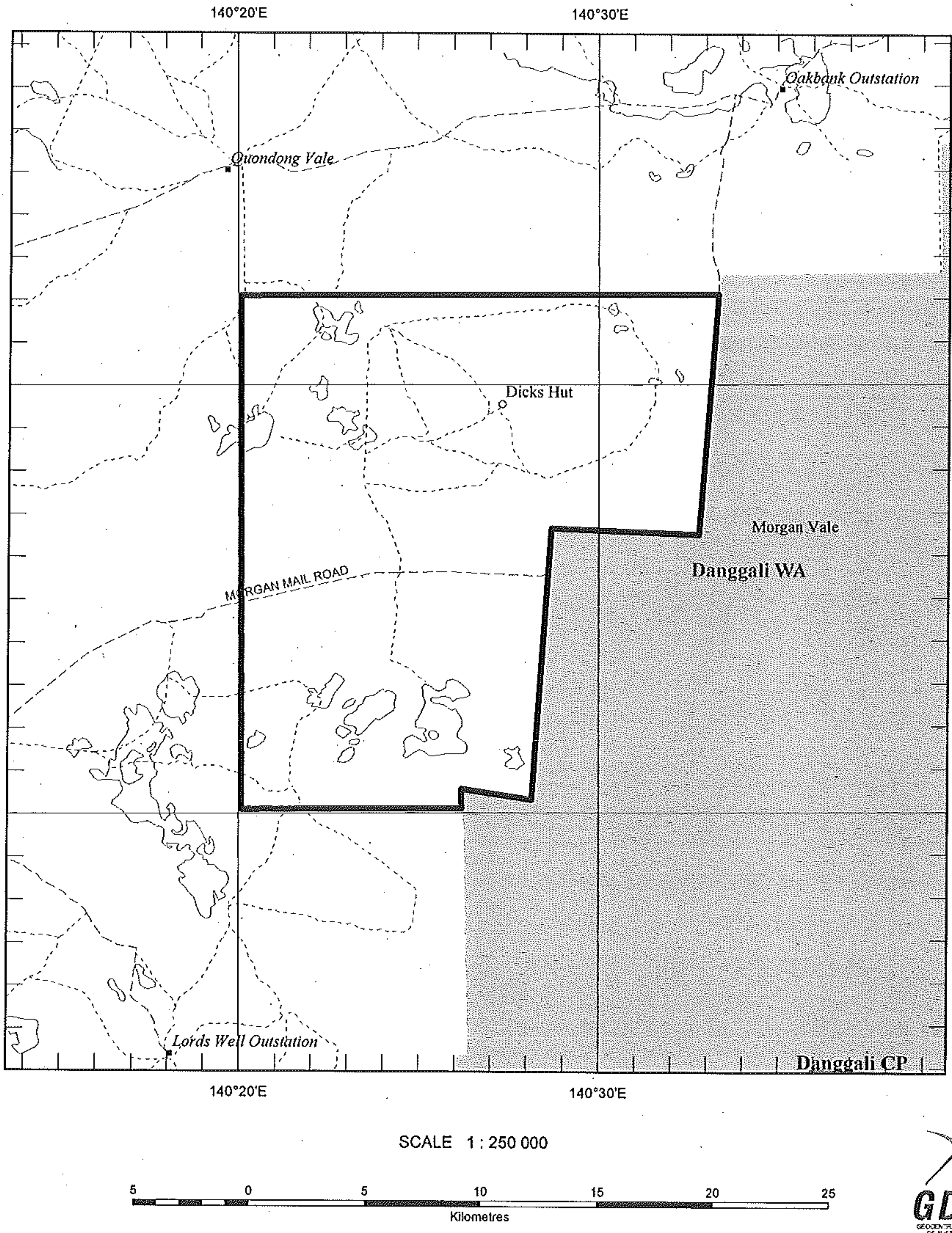
FILE REF : **718/05** TYPE : **MINERAL ONLY** AREA : **1246** km² (approx.)

1:250000 MAPSHEETS : **CHOWILLA**

LOCALITY : **PINE VALLEY AREA - Approximately 220 km northeast of Adelaide**

DATE GRANTED : **19-Apr-2006** DATE EXPIRED : **18-Apr-2010** EL NO : **3539**

SCHEDULE A



LICENCE BOUNDARIES IN : DATUM AGD66

APPLICANT : **STEINER HOLDINGS PTY LTD**

FILE REF : **2011/00046** TYPE : **MINERAL ONLY** AREA : **359** sq km (approx)

1 : 250 000 MAPSHEETS : **CHOWILLA**

LOCALITY : **PINE VALLEY AREA - Approximately 220 km northeast of Adelaide**

DATE GRANTED: **21-Dec-2011** DATE EXPIRED: **20-Dec-2012** EL NO: **4820**

PINE VALLEY JOINT VENTURE No.1 – SOUTH AUSTRALIA

PARTIAL REDUCTION REPORT

For the period
29 August 2006 to 18 April 2011

FOR
EXPLORATION LICENCE

EL 3539 (Pine Valley)

Owned by
Steiner Holdings Pty Ltd
ACN 009 461 223
Operated by
Australian Zircon NL
ABN 60 063 389 079
Gold Fields Australasia Pty Ltd
ABN 59 097 624 600

Author	**:**	**J.C. Kitto**
Date	**:**	**15/12/2011**

Distribution:
PIRSA (1 Digital Copy)
Gold Fields Australasia Pty Ltd (1 Digital Copy)
Australian Zircon NL (1 Digital Copy)

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SUMMARY

This is a partial reduction report for EL3539 – Pine Valley for the period ending 18 April 2011.

In November 2007 Gold Fields Australasia Pty Ltd entered into an unincorporated joint venture agreement "Pine Valley Gold Joint Venture" with Steiner Holdings Pty Ltd (registered holders of EL3539) and Australian Zircon NL. Under the joint venture agreement Gold Fields Australasia Pty Ltd have a right to explore for gold.

Gold Fields Australasia Pty Ltd has identified the Delamerian sub-province as being prospective for sediment hosted orogenic style gold mineralisation, analogous to Telfer style mineralisation (>26Moz deposit). Work completed over the surrendered portion of EL3539 during the period 29 August 2006 to 18 April 2011 has comprised reprocessing and interpretation of existing open file geophysical (gravity and aeromagnetic) data, review of environmental considerations and geophysical surveying.

Gold Fields completed a detailed gravity survey comprising 94 new gravity stations at 1.5 km spacing over parts of EL3539 held by Steiner Holdings Pty Ltd.

Key Words:

Gold Fields Australasia/ Delamerian/ Cambrian/ Gold/ Orogenic gold/ Nackara Arc/ Murray Basin/ Chowilla/ Steiner Holdings/ Pine Valley/

1. INTRODUCTION, HISTORY AND EXPLORATION RATIONALE

The Delamerian Project comprises twelve exploration licences that are owned and operated by Gold Fields Australasia Pty Ltd (Gold Fields). The tenements are located within the Delamerian sub province along the north-western margin of the Cainozoic Murray Basin. The area was targeted as being prospective for orogenic style gold mineralisation hosted within Cambrian sediments buried under the Cainozoic cover.

Exploration associated with the Delamerian Project also extends onto EL 3627 and EL 3539. These tenements are owned by Australian Zircon NL and Steiner Holdings Pty Ltd (a wholly owned subsidiary of Australian Zircon NL) respectively. In November 2007, GFA executed an agreement (Pine Valley Joint Venture No. 1) with Australian Zircon NL in relation to these tenements. The Agreement entitles GFA as operator to earn an 80% participating interest in gold resources in the joint venture tenements by spending at least $2.0 million in exploration on these tenements within the next 5 years.

This report outlines exploration undertaken on the surrendered portion of EL3539 during the period 29 August 2006 to 15 December 2011. Exploration has comprised the collation and interpretation of public domain data and geophysical surveying (helicopter supported gravity surveying).

1.1 TENURE

EL3586 Pine Valley was granted to Steiner Holdings Pty Ltd on 19 April 2006 over an area of 1246 sq km. The area has been reduced to 359 sq km. A tenement location plan is presented in Figure 1.

1.2 LOCATION and ACCESS

EL3539 – Pine Valley is located in the north eastern pastoral district of South Australia. Access can be gained from the Barrier Highway either via Burra or via Yunta, and from the Thiele Highway in the south via Morgan.

A relatively dense network of roads and unsealed farm tracks provide reasonably good access within the licence areas. The tenements are located on the following Map Sheets:

- 1:250,000 Sheet SI 54-06 (Chowilla)
    - Lilydale (6931), Canopus (7031), Parcoola (6930) 1:100k sheets

1.3 PREVIOUS EXPLORATION

The relinquished portion of EL3539 – Pine Valley has been only sporadically explored in the past with most previous work concentrated on uranium, heavy minerals and coal potential within upper Murray Basin sediments and only very limited exploration for gold and base metals in the underlying basement geology (Figure 2).

A summary of relevant or related previous exploration is outlined below:

1.3.1 TARGET - Heavy Minerals:

ENV 8004, 8025, 8026, 8310	***EL1454, 1502***	***Aberfoyle Resources Ltd***	***1988/1991***

In the period 1988-1991 Aberfoyle carried out regional scale exploration targeting heavy minerals within Tertiary Parilla Sands. They drilled shallow RAB traverses through the Pine Valley-Lords Well area (LW series), and Balah-Canopus area (BL series). No economic concentrations were identified. No holes were reported intersecting basement.

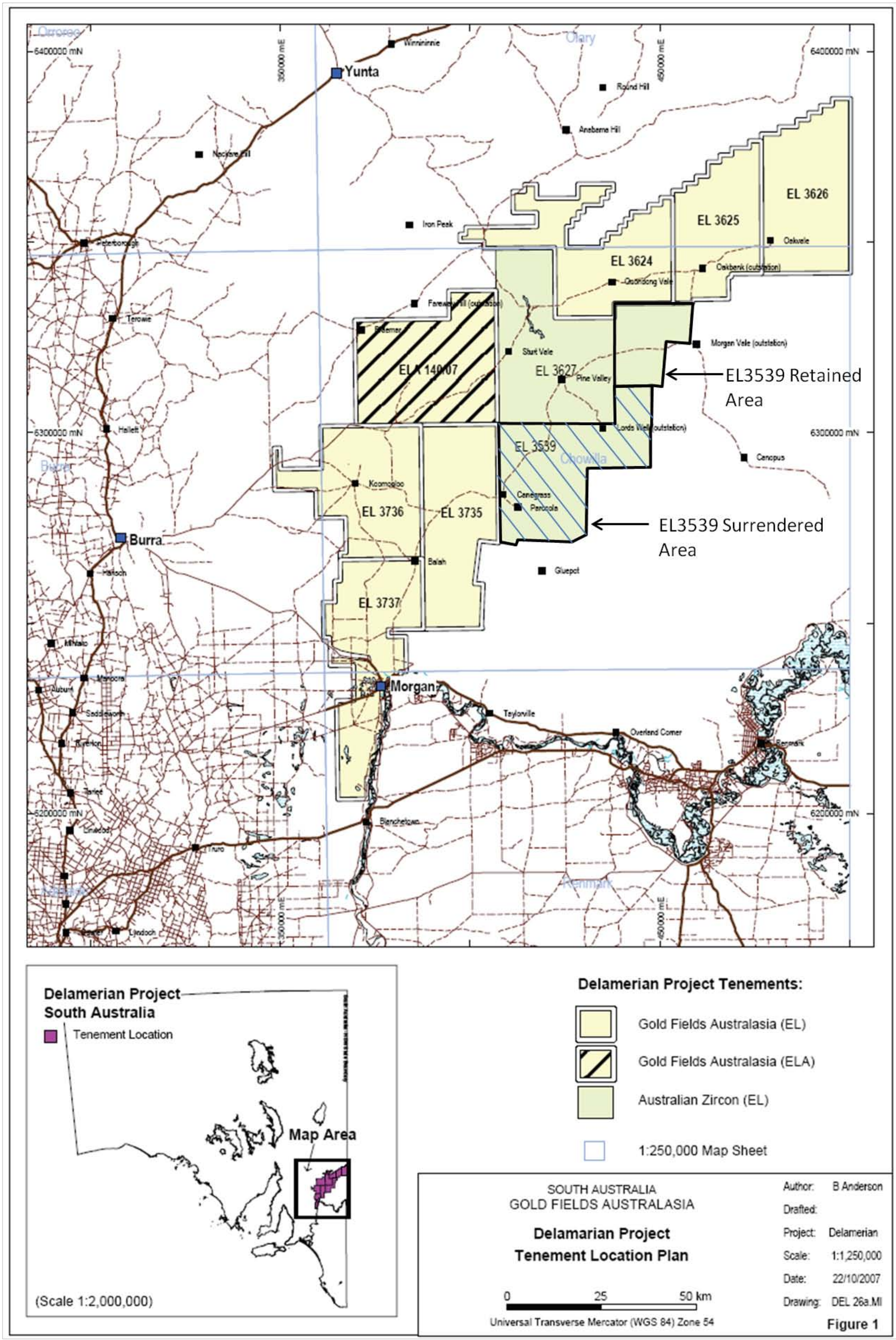
ENV 8347	***EL1674***	***Placer Exploration Ltd***	***1990***

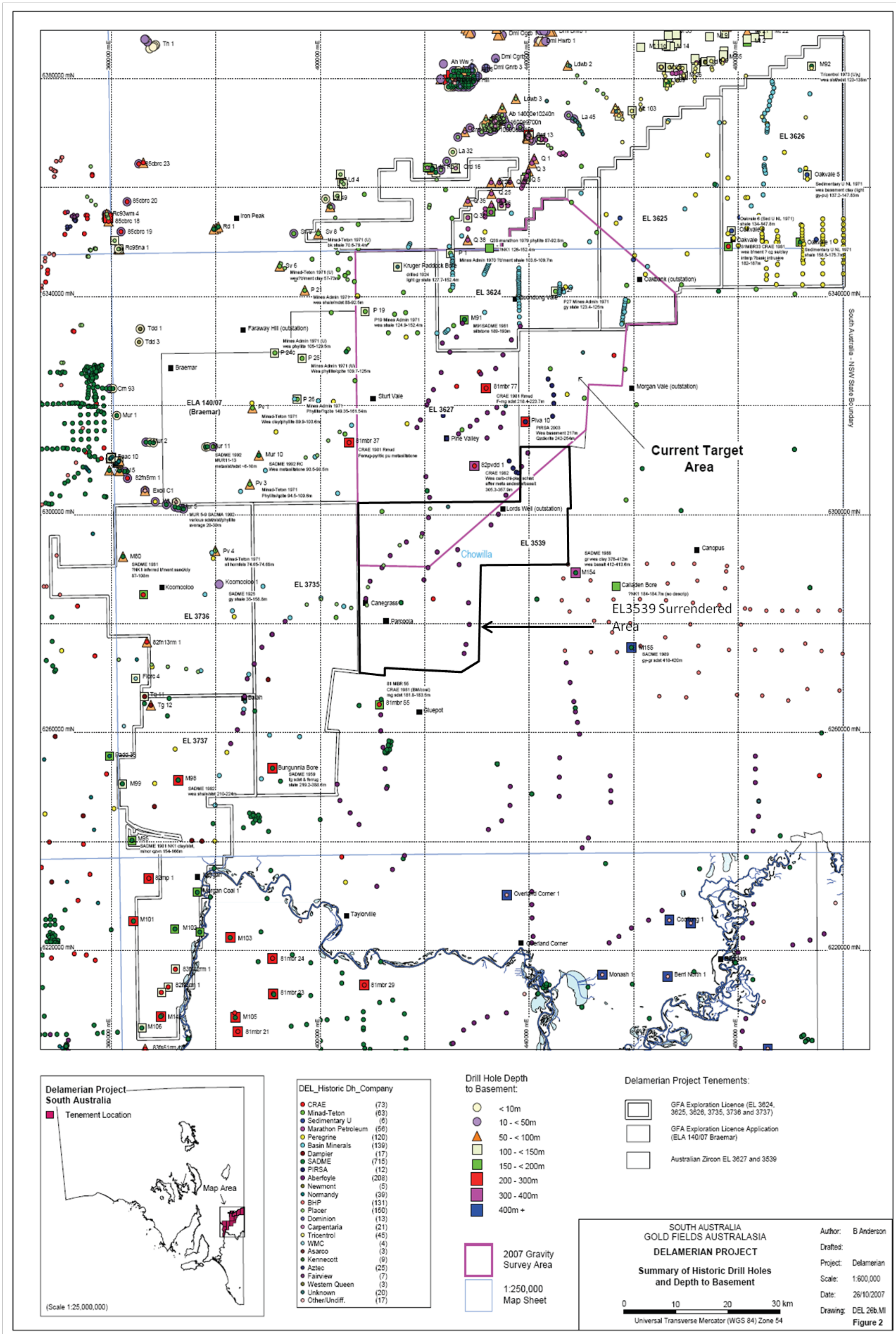
In 1990 Placer targeted possible economic heavy mineral sand deposits formed within the Pliocene Parilla Sand sequence along the north-western margin of the Murray Basin, north of Canegrass. A consultant's review of existing drill hole data was commissioned and, guided by those findings, basin margin air-core RAB and reverse circulation traverse drilling was undertaken along road verges. No anomalous subsurface concentrations of detrital heavy minerals were disclosed.

1.3.2 TARGET – Coal (and base metals and uranium):

ENV 4603	***EL660, 661, 663, 665, 1036, 1038***	***Rio Tinto Exploration Pty Ltd***	***1981***

An initial evaluation of all available data was undertaken. In 1981 CRAE drilled one rotary mud hole 81MBR 54 for 250.8m targeting lignite development in the Tertiary Upper Renmark Beds. 81MBR54 was logged by Century Geophysical Corporation of Australia. Density, gamma, neutron, calliper resistivity and spontaneous potential logs were run. No neutron or spontaneous log was run in borehole 81MBR54 due to equipment malfunction. Thin lignite bands in a lignitic clay unit between 240.4 – 249.23m were intersected. Elevated zinc and copper values were recorded up to 4700ppm Zn and 6400ppm Cu. However, no indication of the intervals from where the samples were taken was recorded.


Yunta
Burra
Morgan
EL 3626
EL 3625
EL 3624
ELA 14007
EL 3627
EL 3539
EL 3736
EL 3735
EL 3737
EL3539 Retained Area
EL3539 Surrendered Area
Delamerian Project South Australia
Tenement Location
Map Area
(Scale 1:2,000,000)
Delamerian Project Tenements:
Gold Fields Australasia (EL)
Gold Fields Australasia (ELA)
Australian Zircon (EL)
1:250,000 Map Sheet
SOUTH AUSTRALIA
GOLD FIELDS AUSTRALASIA
Delamarian Project
Tenement Location Plan
0 25 50 km
Universal Transverse Mercator (WGS 84) Zone 54
Author: B Anderson
Drafted:
Project: Delamerian
Scale: 1:1,250,000
Date: 22/10/2007
Drawing: DEL 26a.MI
Figure 1


Current Target Area
EL3539 Surrendered Area
EL 3626
EL 3625
EL 3624
EL 3627
EL 3539
EL 3735
EL 3736
EL 3737
ELA 140/07 (Braemar)
Chowilla
South Australia - NSW State Boundary
Delamerian Project South Australia
Tenement Location
Map Area
(Scale 1:25,000,000)
DEL_Historic Dh_Company
CRAE (73)
Minad-Teton (63)
Sedimentary U (6)
Marathon Petroleum (56)
Peregrine (120)
Basin Minerals (139)
Dampier (17)
SADME (715)
PIRSA (12)
Aberfoyle (208)
Newmont (5)
Normandy (39)
BHP (131)
Placer (150)
Dominion (13)
Carpentaria (21)
Tricentrol (45)
WMC (4)
Asarco (3)
Kennecott (9)
Aztec (25)
Fairview (7)
Western Queen (3)
Unknown (20)
Other/Undiff. (17)
Drill Hole Depth to Basement:
< 10m
10 - < 50m
50 - < 100m
100 - < 150m
150 - < 200m
200 - 300m
300 - 400m
400m +
2007 Gravity Survey Area
1:250,000 Map Sheet
Delamerian Project Tenements:
GFA Exploration Licence (EL 3624, 3625, 3626, 3735, 3736 and 3737)
GFA Exploration Licence Application (ELA 140/07 Braemar)
Australian Zircon EL 3627 and 3539
SOUTH AUSTRALIA
GOLD FIELDS AUSTRALASIA
DELAMERIAN PROJECT
Summary of Historic Drill Holes and Depth to Basement
0 10 20 30 km
Universal Transverse Mercator (WGS 84) Zone 54
Author: B Anderson
Drafted:
Project: Delamerian
Scale: 1:600,000
Date: 26/10/2007
Drawing: DEL 26b.MI
Figure 2

2. REGIONAL GEOLOGY

EL3539 – Pine Valley is located along the northwestern margin of the Cenozoic Murray Basin. Basin stratigraphy comprises a thin blanket of Quaternary sediments overlying Tertiary fluvial to shallow marine sediments that are flanked to the west and south by Neoproterozoic to Cambrian rocks of the Adelaide Geosyncline and Kanmantoo Group, and to the north by Palaeo and Mesoproterozoic rocks of the Curnamona Craton/Willyama Complex.

Basement geology under the Murray Basin is poorly understood and largely reliant on interpretation of aeromagnetic and gravity geophysical data. The project area basement is interpreted as largely comprising Cambrian Kanmantoo metasediments intercalated with magnetic volcanic and intrusive rocks, and intruded by Cambro-Ordovician felsic intrusive and mafic to intermediate intrusive and extrusive (gabbro, diorite, basalt and dolerite) rocks.

GFA has identified the Delamerian fold and thrust belt sub-province, and in particular the region of maximum flexure (oroclinal bending) through the Nackara Arc region, as being highly prospective for sediment hosted orogenic style gold mineralization, potentially analogous to Telfer style mineralization (>26Moz deposit).

Parameters considered important for the formation of large orogenic gold deposits, such as Telfer, that are evident within the Delamerian sub province, include:

- The deep marine host sediments of the Cambrian age Kanmantoo Group which have been inverted, folded and faulted in response to at least one major orogenic event, the Cambro-Ordovician Delamerian Orogeny.

- A second orogenic event, the Ordovician Benambran Orogeny, is also likely to have impacted on the Delamerian Sub-province. This second orogenic event is responsible for the vein hosted orogenic gold deposits in the Bendigo Zone of central Victoria (approximately 50Moz of gold production to date).

- The Delamerian Sub-province or Fold Belt takes the form of an oroclinal bend in response to cratonic buttressing from the Archaean to Proterozoic Gawler and Curnamona Cratons located to the west and north. This oroclinal bending is thought to focus deformation and thus potential gold bearing orogenic fluids towards the axis of the bend.

- Other important parameters include major cratonic margin mantle tapping structures, open folding of the thick sequence of back-arc basin turbidites (the Kanmantoo Group) which are interpreted to include reduced fine grained sediments, along with sub marine lavas and intrusive, Greenschist Facies metamorphism, major orocline subparallel fault structures, long lived intersecting large scale lineaments or cross-orogen structures and the potential for syn to post-orogenic granitoid intrusions.

3. 2006/2007 EXPLORATION

Exploration undertaken by Gold Fields during the reporting period has comprised the following:

- Reprocessing and interpretation of existing open file geophysical (gravity and aeromagnetic) data.
- Regional grid based helicopter supported gravity surveying.
- Review of environmental considerations.

A summary of recent work is presented in Figure 3.

3.1 GEOPHYSICS

3.1.1 Reprocessing of aeromagnetic and gravity data

Open file aeromagnetic data coverage of the region was acquired from PIRSA as gridded and located data. Data sets relating to the region of interest are listed in Table 2.

Table 1: Public domain aeromagnetic data sets

Survey Name	Company/Flown For	Line Spacing & Direction	Year
*B3	PIRSA SAEI	400 EW	1993
*E1	PIRSA Teisa mag		
*Cottage Bore 84 SA11	CRA Exploration	250 EW	1984
*Florieton North 80 SA11	CRA Exploration	300 EW	1980
*Florieton South 80 SA10	CRA Exploration	300 EW	1980
Kia Ora 79 SA35	Dampier	250 EW	1979
Quondong Vale 88 SA14	Peregrine Resources	500 NE/SW	1988
Lilydale 88 SA02	Placer	200 135 deg	1988
Mutooroo 90 SA03	Southern Venture/Dominion	200 NW/SE	1990
84 SA03	Utah	250 EW	1984
Murray Basin Survey 78 SA05	MESA/BMR	3000 EW	1978
Chowilla	SADME/BMR	1600 EW	
Burra – Whyalla	SADME/BMR	1600 EW	
Orroroo - Parachilna	SADME/BMR	1600 EW	
Burra	SADME/BMR	1600 EW	

3.1.2 Gravity Surveying

A regional (1.5 x 1.5 km) helicopter supported gravity survey encompassing parts 3539 (surveyed with the permission of Australian Zircon Pty Ltd) was carried out by Daishsat Surveying of Adelaide between 19 and 29 April 2007. A total of 94 new gravity stations were surveyed on EL3539.

Gravity data were acquired using Scintrex CG3M automated gravity meters. Position and level data were obtained using an Ashtech Z12 geodetic grade GPS receiver operating in post-processed kinematic mode.

Survey stations are shown in Figure 3. Imaged Bouguer gravity data in shown in Figure 4.

Survey specifications and results are presented in Report No 07015, Appendix 1 and 2.

3.2 ENVIRONMENT AND LAND USE

A review of land use tenure type and environmental issues associated with the Delamerian Project was compiled to assist in preparation of an Environmental Legal Obligations Register for the Delamerian Project. The aim was to highlight areas of environmental (and other) sensitivity and restricted lands that occur within and on the margins of the project area.

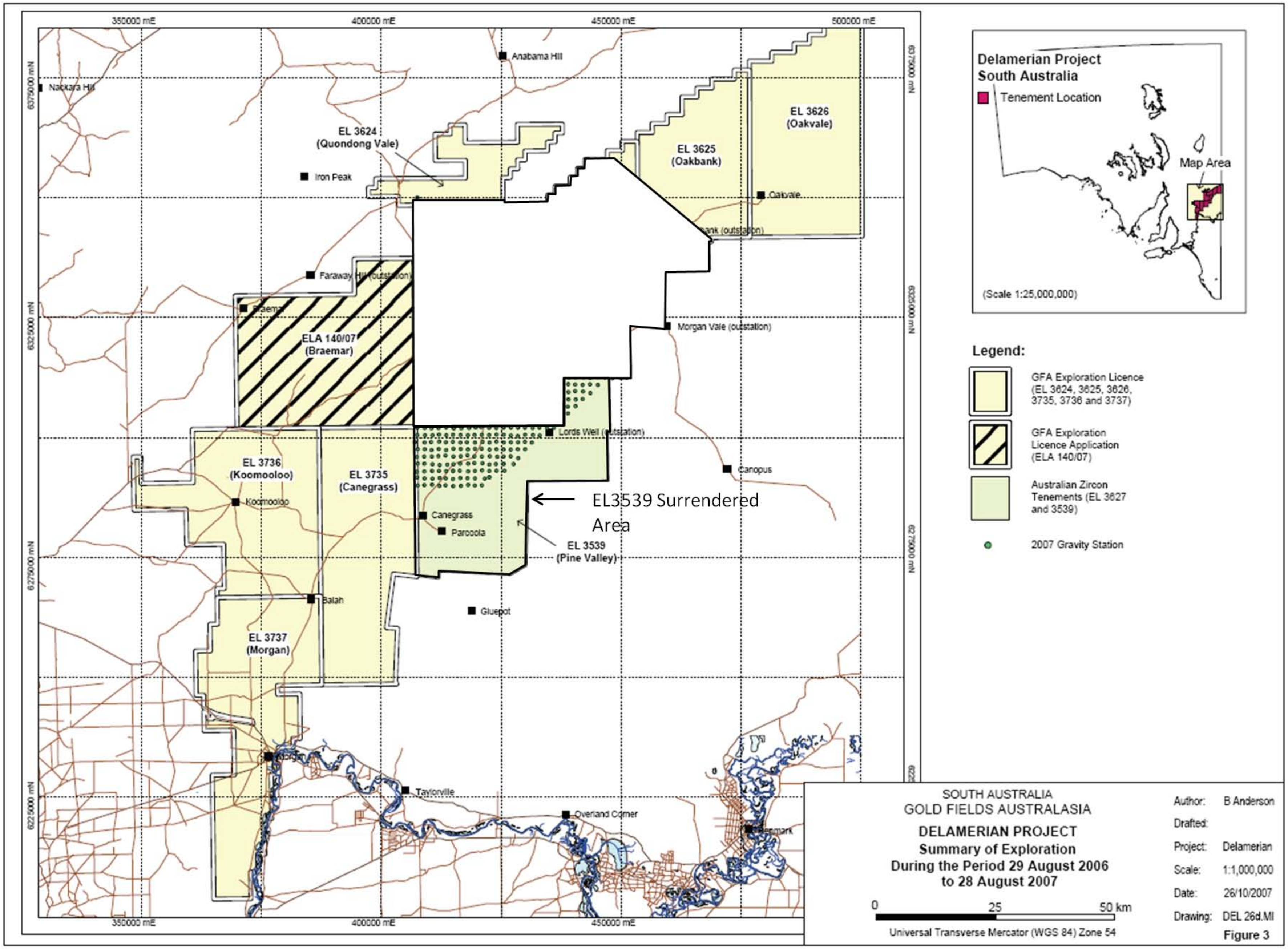
A summary of Aboriginal and Environmental Heritage factors identified within the project tenements is documented in Table 2. A land use tenure type and environmental and cultural heritage sensitivity plan is presented as Figure 5.

4. SUMMARY OF WORK COMPLETED

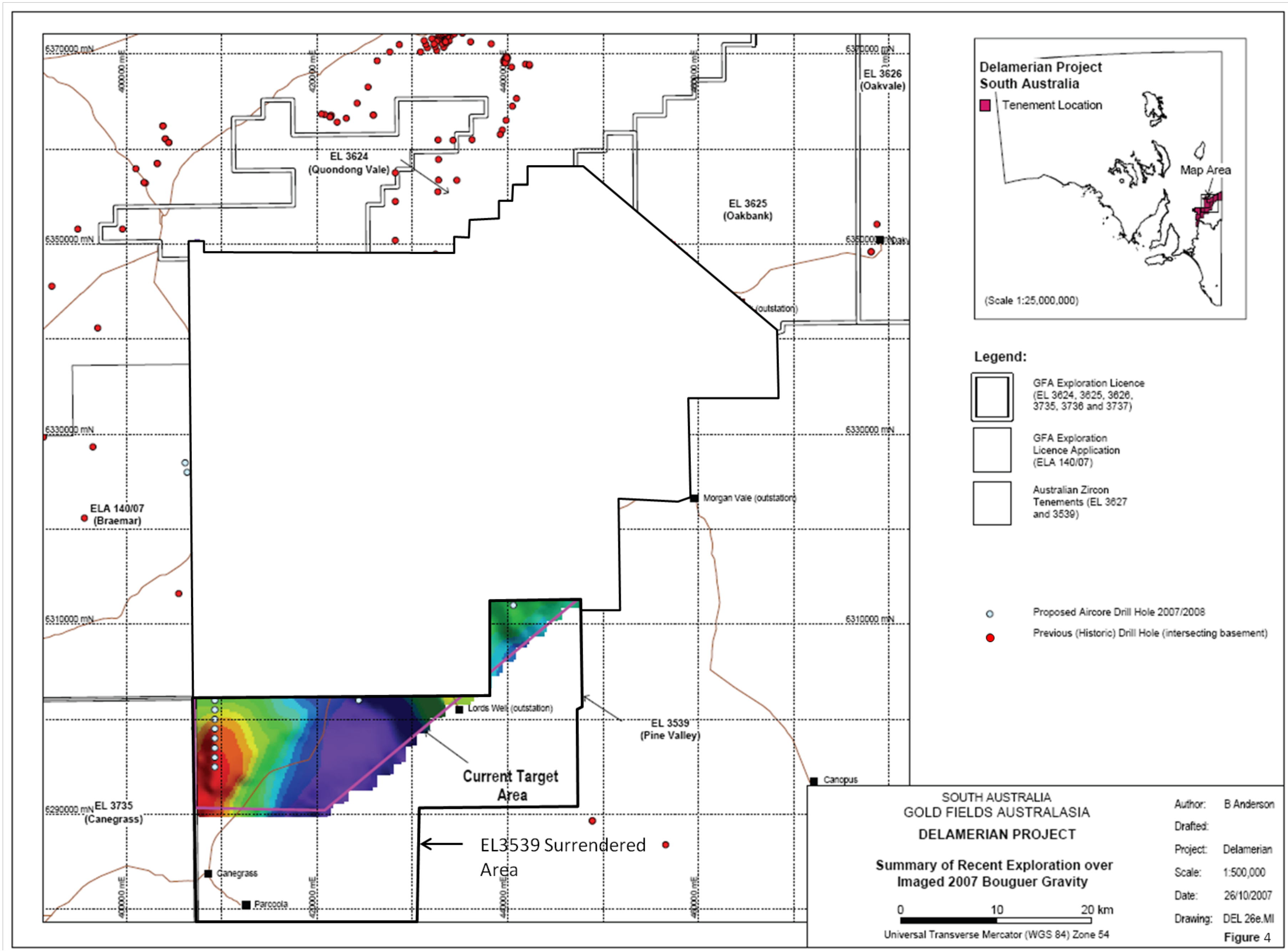
- Reprocessing and interpretation of existing open file geophysical (gravity and aeromagnetic) data.
- Regional grid based helicopter supported gravity surveying.
- Review of environmental considerations.

5. CONCLUSIONS

The area surrendered is considered to have low exploration potential for gold due to the thickness of the overlying Murray Basin cover.



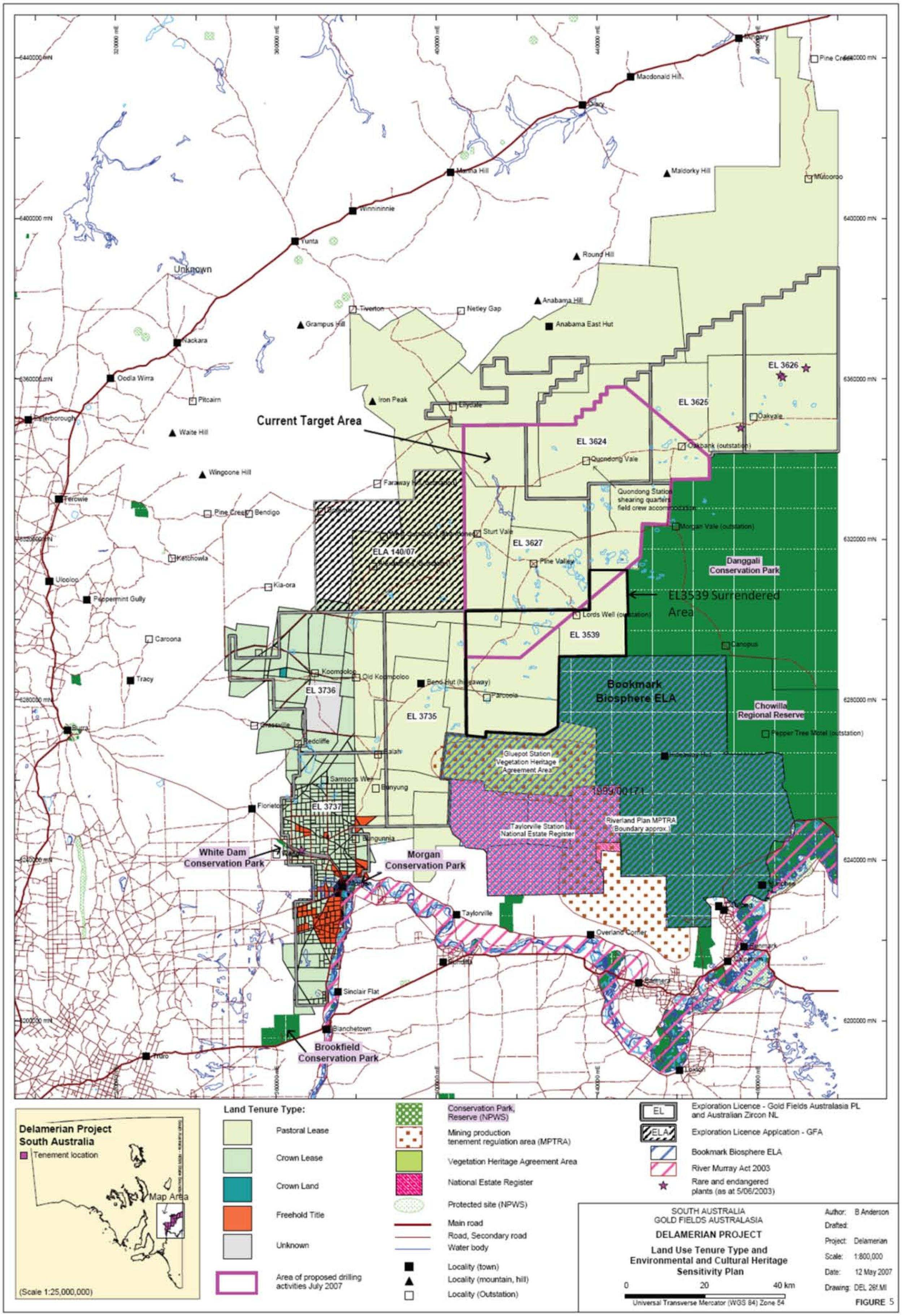
350000 mE
400000 mE
450000 mE
500000 mE
Anabama Hill
Nackara Hill
EL 3624
(Quondong Vale)
Iron Peak
EL 3625
(Oakbank)
EL 3626
(Oakvale)
Oakvale
Faraway Hill (outstation)
ELA 140/07
(Braemar)
Morgan Vale (outstation)
Lords Well (outstation)
Canopus
EL 3736
(Koomooloo)
Koomooloo
EL 3735
(Canegrass)
Canegrass
Paracoola
EL3539 Surrendered
Area
EL 3539
(Pine Valley)
Balah
Gluepot
EL 3737
(Morgan)
Morgan
Taylorville
Overland Corner
Renmark
Delamerian Project
South Australia
Tenement Location
Map Area
(Scale 1:25,000,000)
Legend:
GFA Exploration Licence
(EL 3624, 3625, 3626,
3735, 3736 and 3737)
GFA Exploration
Licence Application
(ELA 140/07)
Australian Zircon
Tenements (EL 3627
and 3539)
2007 Gravity Station
SOUTH AUSTRALIA
GOLD FIELDS AUSTRALASIA
DELAMERIAN PROJECT
Summary of Exploration
During the Period 29 August 2006
to 28 August 2007
0
25
50 km
Universal Transverse Mercator (WGS 84) Zone 54
Author: B Anderson
Drafted:
Project: Delamerian
Scale: 1:1,000,000
Date: 26/10/2007
Drawing: DEL 26d.MI
Figure 3



EL 3626
(Oakvale)
EL 3624
(Quondong Vale)
EL 3625
(Oakbank)
ELA 140/07
(Braemar)
Morgan Vale (outstation)
Lords Well (outstation)
EL 3539
(Pine Valley)
Current Target
Area
EL 3735
(Canegrass)
Canegrass
Parcoola
Canopus
EL3539 Surrendered
Area
Delamerian Project
South Australia
Tenement Location
Map Area
(Scale 1:25,000,000)
Legend:
GFA Exploration Licence
(EL 3624, 3625, 3626,
3735, 3736 and 3737)
GFA Exploration
Licence Application
(ELA 140/07)
Australian Zircon
Tenements (EL 3627
and 3539)
Proposed Aircore Drill Hole 2007/2008
Previous (Historic) Drill Hole (intersecting basement)
SOUTH AUSTRALIA
GOLD FIELDS AUSTRALASIA
DELAMERIAN PROJECT
Summary of Recent Exploration over
Imaged 2007 Bouguer Gravity
0
10
20 km
Universal Transverse Mercator (WGS 84) Zone 54
Author: B Anderson
Drafted:
Project: Delamerian
Scale: 1:500,000
Date: 26/10/2007
Drawing: DEL 26e.MI
Figure 4

Table 2: EL3539 – Summary of Identified Aboriginal and Environmental Heritage Factors

‘Tenement	Holder	PIRSA/DWLBC	Aboriginal Heritage	Department of Environment & Heritage	Natural Resourse Management Services	Significant Species - Flora	Significant Species - Fauna	Common Name	SA Status	Aust
EL3539	AZ	Potential for two aquifer systems identified - deeper aquifers are confined and may be artesian. * GFA required to contact DWLBC Drilling Inspector 7 days prior to drilling and 24 hrs prior to any cementing operations. * In event of artesian conditions a DWLBC Drilling Inspector must be notified immediately on (08) 8463 6872 or mb. 0428 828 569. * Holes must be abandoned in accordance with general specifications (Info Sheet G11). * Request for water samples to be sent to DWLBC - with assoc. info. (advice from DWLBC Groundwater Group).	No Aboriginal Sites identified.	* East and southern boundary are part of the Riverland Biosphere Reserve (IUCN Category IV, Habitate and Species Management Area. * Request **500 m buffer** btw Danggali CP on part of eastern boundary, as for EL 3625 * Gluepot Station = Heritage Agreement Area on south/eastern margin * Species of conservation significance under NPWA and EPBCA = Black eared Miner and Malleefowl. * Salt and clay pans.		Daviesia benthamii ssp. Humilis		Mallee Bitter-pea	R	
							Manorina flavigula melanotis	Black-eared Miner	E	E
							Leipoa ocellate	Malleefowl	V	V
							Nyctophilus timoriensis	Greater long-eared Bat	V	V
							Amytornis striatus	Striated Grasswren	V	
							Ardeotis australis	Australian Bustard	V	
							Cacatua leadbeateri	Major Mitchell's Cockatoo	V	
							Cinclosoma castanotus	Chestnut Quail-thrush	R	
							Climacteris affinis	White-browed Treecreeper	R	
							Falco peregrinus	Peregrine Falcon	R	
							Plectorhyncha lanceolata	Striped honeyeater	R	
							Pyrrholaemus brunneus	Redthroat	R	



Current Target Area
EL 3626
EL 3625
EL 3624
EL 3627
EL 3539
EL3539 Surrendered Area
ELA 140/07
EL 3736
EL 3735
EL 3737
Bookmark Biosphere ELA
Danggali Conservation Park
Chowilla Regional Reserve
Gluepot Station Vegetation Heritage Agreement Area
Taylorville Station National Estate Register
Riverland Plan MPTRA (Boundary approx.)
White Dam Conservation Park
Morgan Conservation Park
Brookfield Conservation Park
Unknown
Macdonald Hill
Manna Hill
Yunta
Nackara
Oodla Wirra
Terowie
Ulooloo
Burra
Truro
Blanchetown
Sinclair Flat
Taylorville
Overland Corner
Maldorky Hill
Round Hill
Anabama Hill
Anabama East Hut
Grampus Hill
Iron Peak
Waite Hill
Wingoone Hill
Tiverton
Netley Gap
Pitcairn
Pine Creek
Bendigo
Ketchowla
Kia-ora
Caroona
Peppermint Gully
Tracy
Koomooloo
Old Koomooloo
Florieton
Redcliffe
Samsons Well
Banyung
Bungunnia
Sturt Vale
Pine Valley
Lords Well (outstation)
Quondong Vale
Quondong Station shearing quarters field crew accommodation
Morgan Vale (outstation)
Canopus
Parcoola
Oakvale
Oakbank (outstation)
Mutooroo
Pepper Tree Motel (outstation)
Delamerian Project South Australia
Tenement location
Map Area
(Scale 1:25,000,000)
Land Tenure Type:
Pastoral Lease
Crown Lease
Crown Land
Freehold Title
Unknown
Area of proposed drilling activities July 2007
Conservation Park, Reserve (NPWS)
Mining production tenement regulation area (MPTRA)
Vegetation Heritage Agreement Area
National Estate Register
Protected site (NPWS)
Main road
Road, Secondary road
Water body
Locality (town)
Locality (mountain, hill)
Locality (Outstation)
Exploration Licence - Gold Fields Australasia PL and Australian Zircon NL
Exploration Licence Application - GFA
Bookmark Biosphere ELA
River Murray Act 2003
Rare and endangered plants (as at 5/06/2003)
SOUTH AUSTRALIA
GOLD FIELDS AUSTRALASIA
DELAMERIAN PROJECT
Land Use Tenure Type and Environmental and Cultural Heritage Sensitivity Plan
0
20
40 km
Universal Transverse Mercator (WGS 84) Zone 54
Author: B Anderson
Drafted:
Project: Delamerian
Scale: 1:800,000
Date: 12 May 2007
Drawing: DEL 26f.MI
FIGURE 5

GOLDFIELDS AUSTRALIA
PINE VALLEY GRAVITY SURVEY
PROJECT 07015

April 2007

Report Number 07015
GA Coopes

CLIENT
GOLDFIELDS AUSTRALIA

CLIENT CONTACT
Barbara Anderson
Project Manager
(08) 8271 8116

SURVEY CONTRACTOR

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

CONTRACTOR CONTACT

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

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TABLE OF CONTENTS

1. INTRODUCTION

A precision GPS-Gravity survey was carried out between the 19th and 29th of April 2007 for Goldfields Australia. A total of 1210 new gravity stations were surveyed in Eastern South Australia.

Gravity data were acquired using Scintrex CG3M automated gravity meters. Position and level data were obtained using Ashtech Z12 geodetic grade GPS receivers operating in post-processed kinematic mode. Data were acquired using Daishsat helicopter-borne methods.

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

2. SURVEY OVERVIEW

The regional gravity survey was based out of Pine Valley Station. The survey area was located adjacent to the Danggali Conservation Park approximately 200km North East of Adelaide. (Figure 1).

The survey area was centred around Pine Valley Station and covered approximately 2500 square kilometers. Station roads provided vehicle access to helicopter refueling locations.

Photo 1: Pine Valley station.

The terrain encountered during the survey was relatively flat rangeland covered by bluebush scrub and grassland with dense bush in some parts of the survey area. (Photos 2 and 3).

Gravity surveying was conducted on a 1.5km x 1.5km spaced square grid configuration. Appendix A contains a plot of the final station locations.

Photo 2: Typical thick scrub covering the survey area.

Photo 3: Bluebush vegetation at a gravity station.

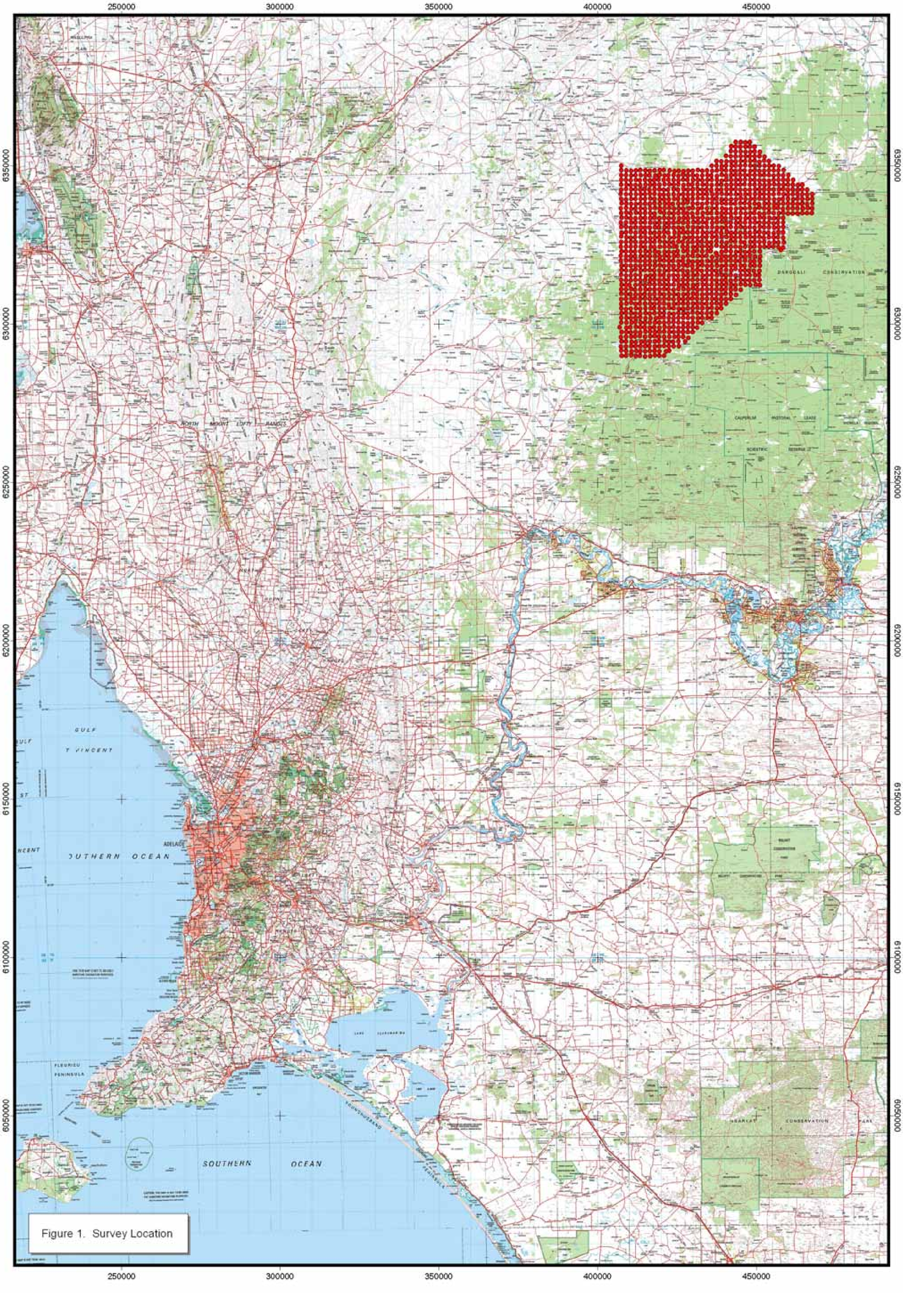


Figure 1. Survey Location

3. PERSONNEL AND EQUIPMENT

3.1 Personnel

The supervisor in charge of the project was David Daish. David was responsible for daily management of the job and for nightly data processing to ensure quality and integrity. Gravity and GPS measurements were carried out by:

David Daish, Senior Surveyor
Harley Jones, Senior Surveyor
Andrew McCarthy, Surveyor
Matt Hunter, Surveyor

Two helicopter pilots were used for the helicopter surveying:

Nathan Ward – Chief Pilot
Jo Murphy

Final data reduction, inspection and reporting were performed by the company Geophysicist, Grant Coopes.

3.2 Survey equipment

The following survey equipment was utilised on the gravity survey:

- Two Scintrex CG-3M digital gravity meters:
  SN 711410 S
  SN 303204 P
- Ashtech Z12 dual frequency GPS receivers
- Trimble 4000 GPS receiver
- Notebooks for data processing and backup
- Magellan FX324 GPS receivers for helicopter navigation
- Garmin Handheld GPS receivers for vehicle navigation
- Notebook computers for data processing and backup
- Various chargers, solar cells and batteries

3.3 Vehicles

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

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

3.4 Helicopter

Ferry between the gravity stations was necessitated by a Robinson R-44 Clipper – call sign VH-HEM (Photo 5). This particular helicopter was well suited to the project as changeable air filters allowed for dusty landings.

Photo 4: – Daishsat refueling vehicle and Robinson R-44

Photo 5: Robinson R-44 Helicopter VH-HEM

3.5 Camp

The helicopter crew camped in buildings located at the Pine Valley Homestead. The station was well serviced with electricity and water and catering provided by the station. Fuel was supplied by Daishsat.

3.6 Communications

All survey crews and support vehicles were equipped with hand-held Globalstar satellite phones as well as UHF and VHF transceivers. “Omnitrack” satellite based tracking was used on all vehicles (including helicopters) to enable asset monitoring via a web interface.

Scheduled communications were made by all crews to the communications centre at the base camp at hourly intervals. Communication with the Perth and Murray Bridge offices was ongoing for the duration of the job.

4. GPS SURVEYING AND PROCESSING

4.1 Set out of the grid

This was done concurrently with the gravity data acquisition using navigation grade receivers operating in autonomous mode. Where possible, the readings were taken as close to the ideal coordinates as possible. As the receivers were operating in autonomous mode, set out accuracy was usually better than 10m.

Raw kinematic GPS data were logged by a dual-frequency Ashtech Z-12 receiver inside the helicopter cabin, with the GPS antenna mounted on the rear tail shaft boom. Static GPS data were logged at each of the base stations using a Trimble 4000 GPS receiver for later post-processing.

At the repeat stations, a washer tied with flagging and marked with the station number was used for identification. At each station, the station number, position and RL were recorded digitally by the crew.

4.2 Survey datum and control

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

4.3 Processing of the position and level data

The raw GPS data were recorded onto the internal RAM of the GPS receivers. The data were downloaded nightly onto laptop computer for post processing using Waypoint Grafnav v7.00.

Waypoint combines the processing components, GrafNav and GrafNet, in a complete package.
GrafNav processes data for one baseline (e.g. one base and one remote). GrafNav is normally used for kinematic data which it is extremely well suited for. It can also process single static baselines. Receiver types can be mixed and matched via the use of a common format. This component of Waypoint was used for processing the kinematic data acquired each day.

GrafNav and GrafNet share the same processing engine that has been under continuous development since its original inception by Waypoint in 1992. The core of this robust engine is its carrier phase kinematic (CPK) Kalman filter. Some of the major advantages of Waypoint's kernel are:

Fast processing - The GrafNav kernel is one of the fastest on the market. It will process ~0.8 epochs per MHz per second on a Pentium II.
Robust Kalman filter - From experience with processing GPS data from fast jets and NASA sounding rockets, the processing kernel has become extremely robust. Efforts have been made to account for all of the various data error possibilities given the different types of GPS receivers that GrafNav/GrafNet can handle.
Reliable OTF - Waypoint's on-the-fly (OTF) algorithm, called Kinematic Ambiguity Resolution (KAR), has had years of development and stresses reliability. Variations are implemented for both single and dual frequencies, and numerous options are available to control this powerful feature
Accurate Static Processing - Three modes of static processing are implemented in the processing kernel. Fixed static is the most accurate. A quick static solution is also available as an alternative, while the float and iono-free float solution is useful for long baselines.
Dual Frequency - Full dual frequency support comes with GrafNav/GrafNet. For ambiguity resolution, this entails wide/narrow lane solutions for KAR, fixed static and quick static. Ionospheric processing is very important with the peak of the ionosphere's cycle occurring in 2000. The GrafNav kernel implements two ionospheric processing modes including the iono-free and relative models. The relative model is especially useful for airborne applications where initialization is near the base station, and this method is much less susceptible to L2 phase cycle slips.
Forward and Reverse - Processing can be performed in both the forward and reverse directions. Both GrafNav and GrafNet also have the ability to combine these two solutions to obtain a globally optimum one.
Velocity Determination - Since the GrafNav kernel includes the L1 Doppler measurement in its Kalman filter, velocity determination is very accurate. In addition to this, a considerable about of code has been added specifically for the detection and removal of Doppler errors.
Long Baseline - Because precise ephemeris and dual frequency processing is supported, long baselines accuracies can be as good as 0.1 PPM.

For more information about Waypoint processing software, and in particular, Grafnav, please visit the Waypoint http://www.waypnt.com/grafnav_d.html.

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

MGA94 coordinates were obtained by simply projecting the GPS-derived WGS84 coordinates using a UTM projection with zone 54S. For all practicable purposes, the WGS84 geodetic coordinates are equivalent to GDA94 geodetic coordinates, so no transformation is necessary. For more information about GDA94 and MGA94, please visit http://www.ga.gov.au/geodesy/datums/gda.jsp.

AHD heights were calculated via Waypoint software using the latest geoid model for Australia, AUSGEOID98. Information about the geoid and the modeling process used to extract separations (N values) can be found at http://www.ga.gov.au/geodesy/ausgeoid/. To obtain AHD heights, the modeled N value is subtracted from the GPS derived WGS84 ellipsoidal height (Figure 2).

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

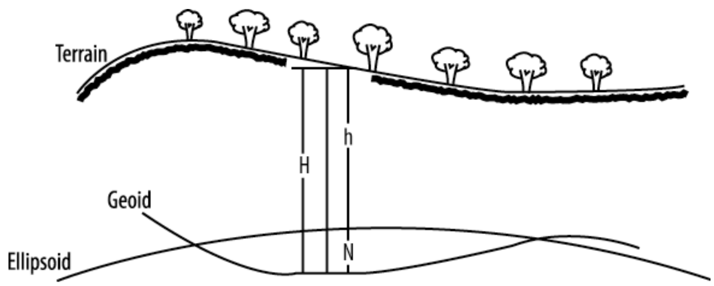


Figure: 2: Geoid-Ellipsoid separation

4.4 GPS Performance

Performance from the Ashtech receivers was varied with dense vegetation hindering GPS signals in some areas. There were no stations that required repeating due to GPS failure or poor coordinate quality.

5. GRAVITY SURVEYING AND PROCESSING

5.1 Gravity data acquisition

Gravity observations were made concurrently with the GPS measurements (Photo 6). Two observations were made for each station, with each observation consisting of a 20-second or greater stacking time. Multiple observations were made at each station so that any seismic or instrumental noise could be immediately detected. The tolerance between readings was set at 0.03 of a dial reading (0.03 mGals). Vertical and horizontal levels were restricted to 5 arc seconds at all times. At each station, the station number, time and two gravity readings (in dial units) were recorded in DAISHSAT carbon-copy gravity field books. The Scintrex meters also automatically record the station, time and readings digitally to allow for downloading to computer.

Photo 6: Survey operator taking a gravity observation

5.2 Gravity base station

A gravity base station was used for calculation of absolute gravity and drift determination. Details of the gravity base are contained in Appendix D. When in the field, a base station reading was taken in the morning before observing and at evening after the last observation. When taking a base station reading, the observed gravity values were stacked over 60 seconds to ensure accuracy. Observations were repeated until the readings repeated to 0.010 of a dial reading or less.

The gravity base station was set up at Pine Valley Station proximal to the homestead buildings as well as the helicopter pad. The station was established via ABA ties with the AFGN station at Mannahill racecourse using a single meter on two separate days. Expected accuracy of the tie control surveys would be better than 0.01 mGals. Table 1 below summarizes the base station established and the tie survey conducted:

Station	Location	AFGN Station	Dates Surveyed
0305	Pine Valley	1995901327	19/04/2007
	Homestead	Mannahill Racecourse	20/04/2007

Table 1: Gravity base station establishment

5.4 Gravity data processing

Raw gravity data were processed on a daily basis to check for quality and integrity. This interim process produced a set of Bouguer Anomaly values which were contoured and imaged to provide a check for any anomalous readings that would need repeating. Geosoft GRAVRED software was used for the gravity reduction in the field. Upon conclusion of the job, the data were reprocessed using the contract specified GA formulae with Daishsat proprietary software. Other software used on this project includes Arcview, ChrisDBF, RasterTC, Waypoint and ERMapper. The formulae used for final processing are listed below:

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

Tidal correction: This correction was used to correct for background variations due to changes in the relative position of the moon and sun. The Scintrex calculated ETC was removed and a new ETC calculated using Geosoft Formulae and the surveyed GPS latitude. The formulae used are contained in Appendix G.

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

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

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

where ϕ represents degrees of latitude;

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

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

Bouguer Correction: This correction accounts for the attraction of material between the station and datum plane that is ignored in the free-air calculation. A value of 2.67 tm^3 was used in the correction.

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

where ρ = density 2.67 tm^3

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

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

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

$$BA267 = G_{OBSG84} - Gn + FAC - BC$$

5.5 Gravity meter drift calibration

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

6. RESULTS

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

6.1 Stations Surveyed and Survey Progress

In total, 1,210 new stations were acquired during the survey. A brief production summary for the survey is show in Table 2 below.

Generally, production was excellent with the crew reliably achieving over 120 stations per day. Production was only hampered by poor weather. The crew used this downtime to conduct the gravity control survey. There was no downtime due to geophysical/GPS equipment failure.

Pine Valley Survey		
Gravity stations acquired (including repeats)	1307	stations
Gravity station repeats	97	8.0%
New gravity stations acquired	1210	stations
Total accidents	0	accidents
Total hours lost from accidents	0	hours

Table 2: Gravity Production Summary

6.2 Data Repeatability

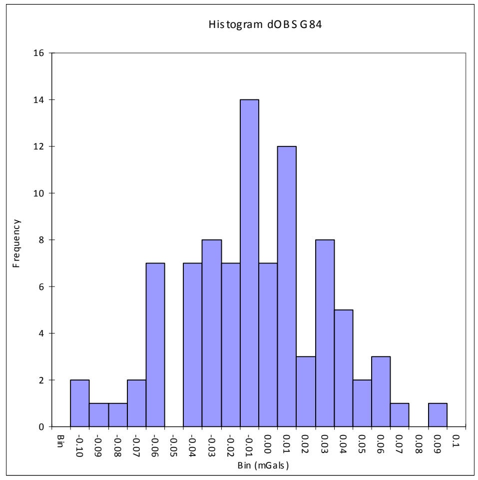
Analysis of the repeat data shows that measurement repeatability is excellent for both GPS and gravity observations. Appendix B contains histograms and summary statistics from the analysis. Based on the repeat data, one can assume the following typical accuracies for the observables:

Z position observation : < 0.081 m
Gravity observation : < 0.055 mGals

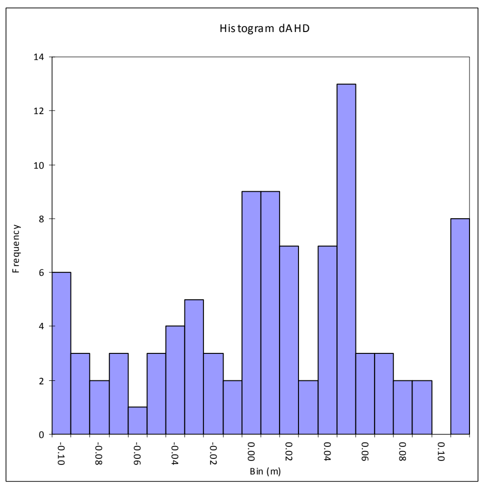
APPENDIX A

Repeat Tabulation and Analysis

Histogram dAHD



Histogram dOBSG84



Summary Statistics

	dAHD	*dOBSG*
Mean	0.004	-0.002
Standard Error	0.008	0.006
Median	0.007	-0.010
Mode	0.001	-0.012
Standard Deviation	0.081	0.055
Sample Variance	0.007	0.003
Kurtosis	6.729	3.017
Skewness	-1.275	1.260
Range	0.621	0.325
Minimum	-0.411	-0.122
Maximum	0.210	0.203
Sum	0.426	-0.163
Count	**97**	**97**

APPENDIX B
Survey Specifications

Client	GOLDFIELDS AUSTRALIA
Survey Name	Pine Valley
Operators	DD, HJ, AM, MH
Techniques Employed	GPS, Gravity
Station Spacing	1.5km
Line Spacing	1.5km
Gravity Meter	Scintrex CG-3M (S-meter & P-meter)
GPS	Ashtec Z12, Trimble 4000
Number of Points Surveyed	1307
Gravity Base	Daishsat Base 0305
Date of Survey	19th to 29th April

APPENDIX C
Base Station Information

GPS Gravity Base 0305 Pine Valley

MGA94		GDA94	
EASTING (m)	424084.981	LATITUDE (DMS)	-33 -18 -36.0239
NORTHING (m)	6314048.129	LONGITUDE (DMS)	140 11 4.1647
ZONE (UTM)	54	GDAHT (m)	101.482
HEIGHT (AHD, m)	94.575	N (AUSGEOID98, m)	6.908

OBSERVED GRAVITY	SURVEYED BY
979563.736 mGals	GPS - Daishsat using a multiple static sessions and the AUSPOS online GPS Processing system. Expected accuracy of station coordinates better than 0.005m. Gravity – ABA ties with Mannahill Racecourse AGFN 1995901327 Expected accuracy better than 0.01 mGals

MISCELLANEOUS DETAILS

This base station consists of a small star picket protruding 5cm out of the ground, and is witnessed by a larger stat picket positioned 30cm to the right. A circular concrete slab is also located beside these star pickets and is the gravity base.

The base station is located in on the Northern side of the shearers quarters on the fence line running east west between the road and the entrance to Pine Valley Station. The base lines up with the verandah poles on the western side of the kitchen / dining block.

Photo of Daishsat Base 0305 showing distinguishing features

APPENDIX D

Data CD

(Attached To Back Cover)