ANNEX C

Groundwater Assessment
(Geoterra, 2007)

GeoTerra

INTEGRA COAL OPERATIONS PTY LTD

LONGWALL PANELS 10 TO 17
GROUNDWATER ASSESSMENT

Glennies Creek Colliery, NSW

GC10-R1E

23 JULY, 2007

GeoTerra Pty Ltd ABN 82 117 674 941

77 Abergeldie Street Dulwich Hill NSW 2203

Phone: 02 9560 6583 Fax: 02 9560 6584 Mobile: 0417 003 502 Email: geoterra@iinet.net.au

GC10-R1D (23 JULY, 2007)

GeoTerra

Integra Coal Operations Pty Ltd
PO Box 3060
SINGLETON NSW 2330

Attention: Bob Corbett

Bob,

RE: PANELS 10 TO 17 GROUNDWATER ASSESSMENT

Please find enclosed a copy of the above mentioned report, which incorporates the updated groundwater modelling assessment.

Yours Faithfully

GeoTerra Pty Ltd

Andrew Dawkins
Managing Geoscientist (MAusIMM CP-Enviro)

Distribution:	Original	Geoterra Pty Ltd
	1 electronic copy	Integra Coal Operations Pty Ltd

GeoTerra Pty Ltd ABN 82 117 674 941

77 Abergeldie Street, Dulwich Hill NSW 2203

Phone: 02 9560 6583 Fax: 02 9560 6584 Mobile: 0417 003 502 Email: geoterra@iinet.net.au

Authorised on behalf of Geoterra Pty Ltd:	
Name:	Andrew Dawkins
Signature:	
Position:	Managing Geoscientist
Date:	23.07.2007

Date	Rev	Comments
12.01.2007		Initial Draft
28.02.2007	A	Incorporate review comments
31.05.2007	B	Includes Groundwater Modelling Assessment
26.06.2007	C	Incorporates review comments
20.07.2007	D	Incorporates updated modelling and review comments
23.07.2007	E	Incorporates review comments

DRAWINGS

FIGURES

TABLES

APPENDICES

EXECUTIVE SUMMARY

Field and desktop assessments, as well as analyses of groundwater systems overlying the proposed Longwall Panels 10 to 17 at Glennies Creek Colliery were conducted between April 2005 and June 2007.

The objective of the study was to assess the pre-mining status of groundwater systems overlying the panels and to provide an assessment of monitoring and rehabilitation strategies that may be required.

Maximum subsidence, tilt and strain (tension and compression) over Panels 10 to 17 are anticipated to reach 1.6m, 23mm/m and 6.0/9.3mm respectively after extraction of Panel 17 (SCT, 2006).

The following assessments were made for groundwater systems within the study area.

- The area contains low yielding sedimentary alluvium up to 12m deep in Bettys Creek which has no beneficial users or groundwater dependent ecosystems. The alluvium is a shallow unconfined aquifer with very brackish to saline electrolytical conductivity ranging up to 19,500µS/cm, which makes it unsuitable for beneficial use with domestic or agricultural purposes.
- The underlying coal measures are low yielding (<1L/sec), brackish to saline (<20,900µS/cm) which also have no beneficial users or groundwater dependent ecosystems.
- The alluvial and coal measures groundwater systems have been, and will be, significantly affected by extraction of the Hunter Valley Coal Company open cuts and the diversion of Bettys Creek, as well as extraction of the Ravensworth East, Arties and Barretts open cuts in close proximity to the proposed underground workings.
- A FEFLOW groundwater model was developed that represented the project area through ten layers which incorporated the proposed coal extraction in Glennies Creek Underground Panels 10 to 17. The model indicates the main groundwater depressurisation will occur in the confined Middle Liddell Seam, as well as the overlying goaf and highly fractured overburden. The reduction in groundwater head depressurisation with increasing height in the stratigraphy results from the change from brittle to ductile sagging of the overburden and the resultant variation in fracture development and connection.
- The FEFLOW model indicates that the currently inactive DWE registered bores in coal measures within the study area will not be observably affected by groundwater depressurisation following extraction of Panels 10 to 17.
- Extensional crack formation will also develop in the surficial layer, up to 20m beneath the alluvial / colluvial layer, which will reduce groundwater levels within the shallow weathered overburden.
- Reduction in water levels of up to 15m in the coal measures may occur following extraction of the subject panels. However, this is expected to be over-shadowed by up to 120m of drawdown following mining of the HVCC Mt Owen, Ravensworth East and the Eastern Rail Pits.

- Modelling indicates that depressurisation of the Middle Liddell Seam around the underground workings is limited to a steep drawdown cone area within 1.5km of the panels.
- FEFLOW modelling indicates that no observable adverse effects are anticipated on stream flow in Glennies Creek, Main Creek or Bettys Creek.
- No observed reduction in groundwater levels within the Quaternary alluvium along the creeks is anticipated, with one active well identified within the overall drawdown area in the alluvium of Glennies Creek.
- No Groundwater Dependent Ecosystems (GDEs) have been observed in the study area.
- Total underground mine inflows of up 500m^3/day are modelled at the end of Panel 17, which will be pumped to the former Camberwell North Pit, adjacent to the underground portal.
- Post-mining groundwater levels are anticipated to continue to be affected by mining in adjacent open cuts and underground workings after Panel 17 has been completed.
- Groundwater levels are currently reduced due to a combination of the drought and dewatering effects from local open cut coal mines, with some potential recovery due to the recent rains.
- Refinement and updating of the FEFLOW model will be conducted in association with additional modelling based on the method developed by Winton Gale (Gale, W 2006) prior to commencement of Longwall 10 ie once additional field studies are conducted to update input parameters required for the models.

1. INTRODUCTION

Glennies Creek Coal Management Pty Ltd (GCCM), who manage the Glennies Creek Colliery on behalf of Integra Coal Operations Pty Ltd, propose to extract coal from the Middle Liddell seam by longwall mining Panels 10 to 17. The underground mine is approximately 12km north of Singleton in the Hunter Valley of NSW.

Mining will occur between approximately 375m and 500m below surface in 257m wide (251.3m wide from rib to rib) and 2.4m high panels that range from 472m to 2555m long, with 42m to 48m wide pillars.

Extraction of Panel 10 is anticipated to start in August 2008, with Panel 17 finishing in November 2012 as shown in **Table 1**.

TABLE 1 PROPOSED LONGWALL MINING SCHEDULE

LONGWALL	START	FINISH
8	June 2007	November 2007
9	December 2007	July 2008
10	August 2008	April 2009
11	May 2009	January 2010
12	February 2010	September 2010
13	October 2010	May 2011
14	June 2011	November 2011
15	December 2011	April 2012
16	May 2012	August 2012
17	October 2012	November 2012

This study provides a baseline, pre-Panel 10 to 17 mining assessment of groundwater systems over the proposed Panels 10 to 17 as defined by a 26.5^{o} angle of draw, as well as the areal extent of a groundwater modelling exercise that has been conducted, which will be submitted to the NSW Department of Planning as part of an Environmental Assessment report accompanying an application for approval to extract Panels 10 to 17.

The document assesses the baseline status, potential subsidence effects on groundwater features and potential contingency and management issues relating to the proposal.

The study area underlies undulating to elevated hilly terrain that straddles a NE / SW trending watershed between the Bettys Creek and Main Creek catchments, and subparallels the axis of Panel 11 as shown in **Drawing 1**. The main channel and tributaries of Bettys Creek will be undermined.

Only the northern Schedule 1 (DIPNR, 2005) tributaries of Main Creek which overly Panel 10 are within the proposed mining area, whilst the main channel of Main Creek is not within the 26.5^{o} angle of draw area.

Bettys Creek and its associated shallow alluvial aquifer overlie the proposed panels and lie within the gazetted area of the Hunter Regulated River Water Source Water Sharing Plan (DIPNR, 2004).

The terrain above the proposed panels is drained by ephemeral first and second order (Schedule 1) streams that drain into the fourth order (Schedule 2) channel of Bettys Creek (DIPNR, 2005) as shown in **Drawing 1**.

Bettys Creek flows south, then west into Bowmans Creek and subsequently drains to the Hunter River.

2. ASSOCIATED STUDIES

The Hunter Valley Coal Corporation (2003) commissioned a groundwater study over most of the northern part of the study area as part of an EIS to assess the baseline status and predict the potential effects on the groundwater system through mining the proposed Pit C at the Mount Owen Mine.

SCT Operations Pty Ltd conducted a subsidence assessment for Longwalls 10 to 17 as part of the SMP application process (SCT Operations Pty Ltd 2006).

Geoterra prepared a baseline study of surface water and groundwater systems over Panels 7 to 9, along with a monitoring and management strategy for the anticipated subsidence effects over Panels 4 to 9 (Geoterra, 2005).

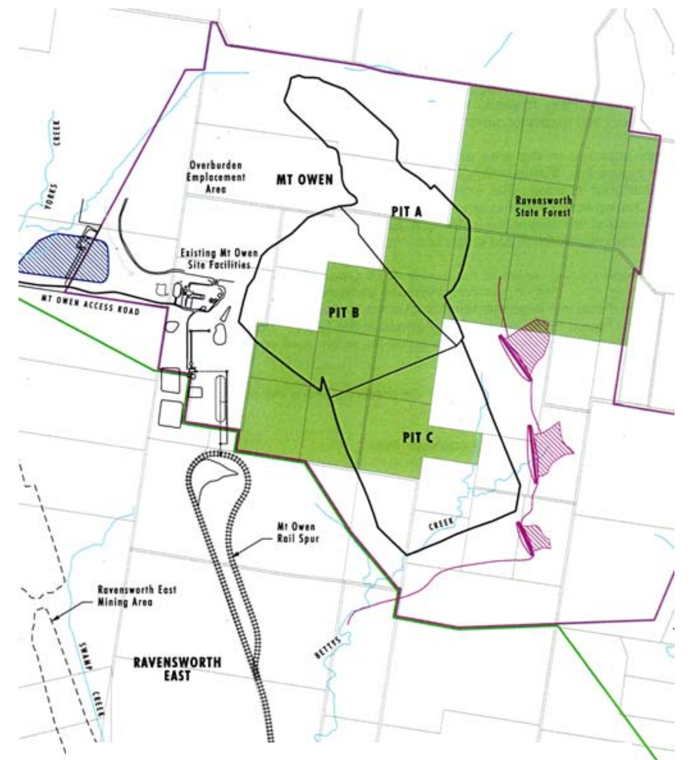
3. HUNTER VALLEY COAL COMPANY (HVCC) PROPOSAL

Open cut mining at Mt Owen commenced in late 1993 with extraction of coal in a narrow pit located at the north-eastern end of the mine lease (Pit A), with mining progressing continuously in a southward direction through Pit B. The Hunter Valley Coal Corporation (HVCC) have approval to extend into the Pit C Mt Owen extension, immediately south of the existing Pit B as shown in **Figure 1**.

Within Pit C it is proposed to extract 11 seams between the Lemington B and Upper Hebden seams, with annual production of up to 10 million ROM coal tonnes over either 17 or 21 years from 2004, with the mine life to be decided depending on a range of possible outcomes over the coming years.

HVCC plan to mine the Middle Liddell Seam, which is the fourth lowest seam to be mined by Pit C.

Pit C will extend the Mt Owen mine a further 500m to 800m south of Pit B and will excavate to 270m below the surface. As part of the proposal, it is intended that Bettys Creek, upstream of and within the Pit C area, will be diverted into Main Creek by the end of 2007.



(Source: Hunter Valley Coal Company, 2003)

FIGURE 1 Mt Owen Pits A, B and C

The Ravensworth East Pit mine will utilise two shallow box cuts up to 35m below surface on the western side of the Mt Owen rail loop, with the pits accessing the Piercefield (Ravensworth) seam. The pits will be excavated to the west of Bettys Creek, as shown in **Drawing 2**, after which they will be filled with washery tailings (HVCC, 2003).

The northern pit is planned to be filled and rehabilitated by the end of HVCC “Year 10”, whilst the southern pit overlying the western end of Panels 15, 16 and 17, will be filled and rehabilitated by HVCC “Year 17” (Umwelt, 2003).

HVCC completed mining the Piercefield (Ravensworth) Seam in the Eastern Rail Pit in May 2007 to 35m below surface on the eastern side of the Mt Owen rail loop along with the associated “West Dump” waste emplacement area.

Excavation and backfilling of waste rock and / or tailings in the Ravensworth East Pit and the Eastern Rail Pit is currently planned to be completed by 2015.

Each of these pits have the potential to attract shallow groundwater seepage during development and to affect groundwater quality during their active and post-mining periods (Mackie Environmental Research, 2003).

The HVCC proposal will or has resulted in:

- open cut mining across existing drainage lines within the Bettys Creek catchment, with diversion of flows in constructed channels around the West Dump and Eastern Rail Pit that discharge flow back into Bettys Creek downstream of the Eastern Rail Pit.
- placement of tailings within the Ravensworth East and waste rock in the Eastern Rail Pit voids;
- construction of a compacted clay lined section of the "Stage 2" diversion over uncompacted waste rock backfill in the Eastern Rail Pit;
- "Stage 3" diversion of flows around Pit C from Bettys Creek to Main Creek by the end of 2007; and
- progression of open cut mining at Mt Owen and disposal of coarse reject and tailings from approximately 2012 onwards into suitable pits as required.

The Ravensworth Pit (south), West Dump and Eastern Rail Pit overlie Panels 13 to 17, with the diverted Stage 1 and 2 channel of Bettys Creek overlying Panels 13 to 15 as shown in **Drawing 2**.

3.1 HVCC Groundwater

The following description of the regional hydrogeology and potential impacts from the extended Xstrata pits is derived from (Mackie Environmental Research, 2003).

3.1.1 Change in Regional Aquifer Pressures

(Mackie Environmental Research, 2003) concluded that excavation of Pit C will result in depressurisation of all exposed coal seams and interburden which may induce widespread dewatering leading to changed groundwater flow directions in the coal measures and increased leakage from surface drainages and water storages.

Re-saturation of spoil emplaced in the pit will promote long term change in recovered groundwater levels and final void water quality.

Pressure losses from the current Mt Owen Pits A and B extend about 2 kilometres from the pit and are predicted to migrate from 3km to 4km at the completion of 17 or 21 years of mining, with the ultimate shape of the depressurised surface governed by the prevailing hydraulic properties of the coal measures, connectivity of strata through jointing and fracturing and the cumulative impacts of the Ravensworth East and Eastern Rail open cuts.

Depressurisation of the coal measures within the Panel 10 to 17 study area due to mining the Mt Owen, Ravensworth East and Eastern Rail Pits was modelled (Mackie Environmental Research, 2003) to range from 10m to 40m, 5 years after Pit C started in 2005 (ie 2010), from 10m to 100m after 10 years (ie 2015), from 10m to 110m after 15 years (ie 2020) and potentially from 10m to 120m after 21 years of operation (ie 2026).

The Ravensworth East Pit and the Eastern Rail Pit are relatively shallow and are anticipated to penetrate the basement water table by 15m to 25m, acting as low seepage sumps until regional levels fall below the shallower pit bases due to development of Pit C. Thereafter they will only attract groundwater seepage from the shallow regolith.

Seepage to the existing Mt Owen pit void was modelled at 0.4 ML/day, whilst the observed rate was estimated at <0.1 ML/day due to the preceding dry period, with seepage loss due to evaporation. Seepage was predicted to increase to a maximum of 0.6ML/day at completion of mining, but could rise to 1.0 ML/day if more permeable strata with increased jointing are encountered.

After mining, regional water levels/pressures are predicted to recover at a rate depending on the remaining water held in storage in the coal measures, as well as hydraulic properties of the spoil, rainfall recharge through spoils and runoff entering the final void (Mackie Environmental Research, 2003).

Spoils emplaced within the pit will have a hydraulic conductivity of 10m/day and a consolidated drainable porosity of 20%. Modelled contributions via spoil infiltration were assigned at 50 mm/year (8.3% of annual rainfall) or approximately half that of the relatively flat lying alluvial lands.

Mackie Environmental Research (2003) predicted that Pit C will become an evaporative sink in the long term with water levels unlikely to rise above 0mAHD, or approximately 110m below ground level (bgl) after 100 years unless accelerated by increased contributions from rainfall runoff or other sources.

3.1.2 Leakage of Groundwater from Alluvial Lands

Mining Pit C will induce increased leakage from Bettys Creek within the depressurisation halo at an estimated 8 KL/day or 11.8 mm/m^2 over the modelled 67.2ha area. While low, this rate was considered as an over-estimate since the model consolidated the alluvial and basement strata (Mackie Environmental Research, 2003).

Pit C will, and the Eastern Rail Pit has, directly intersected the alluvium of Bettys Creek, with lateral shallow groundwater leakage from the channel alluvium entering the pits as highwall seepage, which may be mitigated by installing an impervious bund in the channel.

3.1.3 Loss of Groundwater Yield at Existing Bores

Loss of pressure within the coal measures may indirectly affect existing boreholes depending upon location, aquifer conditions and the prevailing permeability of the underlying coal measures within the depressurised zone.

Approximately 8m to 26m of depressurisation is predicted at GW056703, which is currently abandoned (AGE Pty Ltd, 2007) and is approximately 2.5km outside the Panel 10 to 17 mining area.

No private bores are currently located within the Panel 10 to 17 mining area.

3.1.4 Change in Groundwater Quality

It was assessed unlikely that any measurable change in groundwater quality will be observed in regional coal measures during the mining or recovery periods in Pit C (Mackie Environmental Research, 2003) and that shallow alluvial groundwater quality in Bettys Creek, upstream of Pit C, was not predicted to change significantly.

Alluvial groundwater quality in Bettys Creek, downstream of the Eastern Rail Pit, may be adversely affected, particularly in terms of salinity, by runoff infiltration and Bettys Creek channel alluvium flow through the West Dump and Eastern Rail Pit backfill, i.e. if water discharges out of the Eastern Rail Pit after the Stage 2 diversion.

3.2 Potential Groundwater Effects From HVCC and Other Mines on the Study Area

3.2.1 Ravensworth East and Mt Owen Pits

Mining the 35m deep Ravensworth East Pit will lower the shallow coal measures piezometric surface to the pit base in close proximity to the pit.

The Ravensworth East Pit may not have a significant effect on shallow alluvial groundwater in Bettys Creek, although there may be some partial dewatering of the channel alluvium due to the lowered regional piezometric surface during its excavation, with subsequent partial recovery following pit backfill and re-saturation.

Excavation of the 270m deep Mt Owen Pit C will further lower the piezometric surface in a 4km drawdown area, which in turn will lower groundwater levels over the Ravensworth East, Eastern Rail Pit and GCCM mining areas. Backfilling of Pit C followed by re-saturation of the filled void will partially resurrect the groundwater table over an extended time period to approximately 0mAHD (110mbgl) in the vicinity of Pit C (Mackie Environmental Research, 2003).

3.2.2 Adjacent Mines

Additional nearby mines that may currently be affecting groundwater levels in the vicinity of the GCCM underground operation are the Ashton Coal Operations Pty Ltd Barrett's and Arties pits (HLA Envirosciences 2001), which are excavating the Barrett Seam, approximately 1.5km southwest of Panels 10 to 17 and the Camberwell open cut which is approximately 2.2km south-east of the GCCM Panel 1. The Camberwell pit may be sufficiently distant to have no observable effect on the Panel 10 to 17 mining area (Mackie Environmental Research, 2003).

The operational Ashton Underground Longwalls 1 to 4 in the Pikes Gully seam, south-east of Camberwell village will reduce the piezometric surface in the overlying and regional overburden, and may also influence groundwater systems over the GCCM longwall operation (P Dundon, 2006).

The proposed Glennies Creek Coal open cut located to the north of the Camberwell open cut will reduce the piezometric surface in the overlying and regional overburden, and may influence groundwater systems over the GCCM longwall operation (AGE, 2006).

4. STUDY AREA DESCRIPTION

The topography of the study area is shown in **Drawing 3** and consists of undulating, elevated hills with pasture and isolated woodland areas.

The country overlying Panels 10 to 17 contains tributaries of Bettys Creek and Main Creek, as well as the main channel of Bettys Creek.

4.1 Bettys Creek

Bettys Creek is an ephemeral fourth order, Schedule 2 stream (DIPNR, 2005) that extends from the confluence of Bowmans Creek and Swamp Creek to north of the Ravensworth State Forest. In its current state, it exhibits prolonged periods without flow with small semi-permanent waterholes that typically exhibit moderate to high salinity.

Bettys Creek flows into Bowmans Creek and is located in a rural cattle grazing landscape with low hills in the north-east to low hills and limited alluvial flats along the main channel.

In the upper sections of Bettys Creek, along Panel 15, the creek is typically a Schedule 1 stream (DIPNR, 2005) characterised by a V shaped channel some 50m wide with little to no floodplain and bed slopes of the order of 0.6% to 1%. As the creek traverses Panel 14 to Panel 10, the creek is a Schedule 2 stream (DIPNR, 2005) with bed slope decreasing to about 0.3% to 0.6%, whilst the main channel becomes more sinuous and floodplain width increases.

A number of first order streams also cross the study area with catchments up to $0.5km^2$ and stream lengths of 0.5km to 1km. Bed slopes are 1.5% to 2.5% with erosion evident along most of the streams.

To date, the Bettys Creek channel and its tributaries have not been undermined by any longwall mining.

Current and proposed open cut waste rock areas associated with Ravensworth East and the completed Eastern Rail Pit are located over the proposed Panels 13 to 17, with the Mt Owen Pit C located approximately 700m north-east of the proposed panels.

Stream flow in Bettys Creek and its tributaries has been essentially absent due to the prevailing drought during the study period apart from short lived ponding, with no stream flow following isolated, short lived storm events. Recent storm events have generated flooding and ponding with significant stream flow in the very late stage of the study (June 2007).

One groundwater seepage area was observed, with a small (<10m long) semi-persistent pool of saline water present over Panel 14 at Site C5 **(Drawing 2),** near where the Stage 2 diversion re-enters Bettys Creek. At that location, the eastern bank of the creek has been noted at times to be "greener" with a relatively persistent grass cover.

The catchment area slopes vary from 3% to 4% in the south of the catchment to 20% on upper slopes in the north.

4.1.1 Bettys Creek Tributaries and Secondary Overbank Channels

Three main tributaries drain north-west into Bettys Creek from the watershed that subparallels Panel 11, with a smaller channel (Tributary 4) being an overbank meander channel as shown in **Drawing 3**.

Tributaries 1, 2 and 4 are well vegetated and exhibit limited erosion, whilst Tributary 3 has extensive bed and bank erosion principally due to the effect of increased stream flow from the Forest Road culvert (**Drawing 2**).

The east bank of Bettys Creek, north of Tributary 1, has been extensively revegetated by tree plantings by Xstrata, whilst the other tributaries are not revegetated.

Numerous, generally dry, shallow reed/sedge filled billabongs are present in overbank meander channels along Bettys Creek and exhibit flows that can last for a few weeks after sufficient rain. When filled, the billabongs form temporary ponded aquatic habitats.

4.1.2 Bettys Creek Water Quality

Monitoring indicates that during dry periods, Bettys Creek is highly saline due to groundwater seepage. During the study period, ponded water was present in isolated small pools, with field salinity, pH and laboratory analyses shown in **Tables 2** and **3** that are collected from locations shown in **Drawing 2**.

TABLE 2 BETTYS CREEK WATER CHEMISTRY (major ions mg/L)

Stream Site	pH	EC µS/cm	TDS	Na	Ca	K	Mg	Cl	F	NO_3	SO_4	HCO_3	PO_4
C1*	6.11	117	-	-	-	-	-	-	-	-	-	-	-
C2*	5.86	**1457**	910	110	86	25	53	110	0.16	**1.8**	510	16	<0.1
C3*	6.37	222	-	-	-	-	-	-	-	-	-	-	-
C4*	6.53	214	-	-	-	-	-	-	-	-	-	-	-
C5*	7.85	**12270**	7050	2050	105	12	300	3470	0.41	**0.31**	800	480	<0.1
C6*	6.86	304	135	252	8.2	5.2	7.2	31	0.31	**4.3**	20	55	0.15
C7*	6.55	243	-	-	-	-	-	-	-	-	-	-	-
C8*	6.58	**361**	-	-	-	-	-	-	-	-	-	-	-
ANZECC*	6.5-7.5	30 – 350	-	-	-	-	-	-	-	0.015	-		

* ANZECC default trigger values for risk of adverse effects from physical and chemical stressors in SE Aust. Upland Rivers **(Shading indicates values outside ANZECC 2000 criteria)**

all samples collected on 17/1/05

With distance downstream, the creek is SO_4>Na>Mg dominant at C2, Cl>Na>Mg dominant at C5 and Na>HCO_3>Cl dominant at C6, with a significant imbalance of cations to anions in the C6 analysis.

TABLE 3 BETTYS CREEK WATER CHEMISTRY (metals µg/L)

Stream Site	Date	Cu	Pb	Zn	Cd	Mn	Fe_{tot}	Se_{tot}
C2	17/1/05	**3**	1	**9**	<0.2	210	70	<10
C5	17/1/05	<1	<1	2	<0.2	<10	<10	<10
C6	17/1/05	**4**	<1	3	<0.2	<10	290	<10
ANZECC		1.4	3.4	8	0.2	1900	-	11

NOTES : ANZECC 95% trigger values for toxicants **(Shading denotes values above ANZECC2000 criteria)**

4.2 Main Creek Tributaries

The primary channel of Main Creek does not lie within the Panel 9 to 17 subsidence area.

The headwaters of two small tributaries drain in a southerly direction to Main Creek from a watershed that subparallels Panel 11 as shown in **Drawing 3**. The tributaries are moderately vegetated and exhibit some headward erosion and bank undercutting, but were dry during the study period.

The central Main Creek tributary catchment over Panels 9 to 11 dissipates into colluvium or is regulated by ten small to medium sized earth walls dams with low to moderate water levels. The eastern tributary catchment over Panels 9 to 11 drains into Main Creek, with one small earth wall dam (D 9/7) located in a gully to the east of Panel 9.

4.3 Geology

The study area is predominantly covered by shallow hillslope-based alluvial and colluvial Quaternary clay and sand. These are in turn sequentially underlain by coal measures of the Burnamwood Formation, Archerfield Sandstone, Bulga Formation and Foybrook Formation. The sequence contains interlayered sandstone, conglomerate, mudstone, siltstone and coal (Beckett 1988).

The main valleys contain Quaternary unconsolidated and variably saturated sediments in thin alluvial deposits along Bettys Creek (which may reach up to 12m deep) (MER, 2003) and comprise loams overlying silty and clayey sands with occasional cleaner sand zones, with basal gravels overlying weathered coal measures.

The main structural feature in the area is the northward plunging Rix's Creek syncline, which terminates in the north against the north-west trending Hebden Fault.

Minor exposed conglomerate bedrock is present within the stream bed and banks of the study area with coal measures exposed at surface on the hills comprising the Jerry's Plains Subgroup of the Wittingham Coal Measures.

Sheet wash and hill slope runoff contribute colluvial deposits in localised fans and braids along Bettys Creek.

4.4 Hydrogeology

Two types of aquifer systems are present, namely:

- unconsolidated alluvium in Bettys Creek, and;
- shallow and deep basement coal measures comprising a variable sequence of aquicludes (mudstones and shales), aquitards (sandstones) and low yielding aquifers (generally coal seams).

Neither the coal measures nor creek alluvium are listed as vulnerable aquifers under the current Aquifer Risk Assessment Report (DLWC, 1998). However, they are covered, as appropriate, by the generic State Groundwater Policy (DLWC, 1997), Groundwater Quality Protection Policy (DLWC, 1998) and Groundwater Dependent Ecosystem Policy (DLWC, 2002).

4.4.1 DWE Registered Bores, Wells and Springs in the Panel 10-17 Drawdown Area

The drawdown area in the Panel 10 to 17 vicinity contains two shallow bores (<23m deep), three abandoned and one current well (GW67291) along Glennies Creek and a group of three spring fed dams on the Noble property as shown in **Table 4** from locations shown in **Drawing 1**.

TABLE 4 DWE LICENSED BORES, WELLS AND SPRINGS IN THE PANEL 10 -17 DRAWDOWN AREA

Groundwater Source	East / North	Status	Depth (mbgl)	SWL (mbgl)	Aquifer Intake
Overburden					
GW56703	325310 / 6413361	Bore (abandoned)	22.9	N.A.	Basalt / coal
GW45084	322029 / 6406833	Bore	18.9	N.A.	Sandstone
Quaternary	**Alluvium**				
GW11543	324313 / 6407613	Well (abandoned)	5.5	4.6	Glennies Ck alluvium
GW49285	324873 / 6408486	Well (abandoned)	9.1	6.7	Glennies Ck alluvium
GW67291	326263 / 6408140	Well	27.4	N.A.	Glennies Ck alluvium
Gardner Well	324873 / 6408466	Well (abandoned)	N.A.	N.A.	Glennies Ck alluvium
Noble Dams	322758 / 6408765	Spring fed dams	1	1 - 2	Main Ck colluvium

4.4.2 Monitoring Piezometers

Information relating to both groundwater systems has been gained through site specific and regional observations at a limited number of bores and wells in the area.

Piezometer GCP1 was installed to 12m in the alluvium of Main Creek to the south-west of Panel 2 .The shallow piezometer (GCP2) was installed in the alluvium of Main Creek over Panel 6 in a shallow backfilled drillers pit in 2005. Dual nested piezometers were installed between 5.4m and 48.6m deep into the alluvium and coal measures near Bettys Creek over the maingate south-west of Panel 10 (GCP3S / 3D) and over the chain pillar between Panels 13 and 14 (GCP4S / 4D) in April 2005 (Geoterra, 2005) with piezometer locations shown in **Drawing 1**.

Pre-Panel 10 monitoring of alluvium and coal measures groundwater level and water chemistry along Bettys Creek has been conducted by Integra Coal since April 2005, with piezometer locations and lithologies outlined in **Table 5** (Geoterra, 2005).

TABLE 5 INTEGRA PIEZOMETER SUMMARY

SITE	Location (m)	Intake (m)	Panel	FORMATION
GCP1	6409344 / 323447*	N.A. – 12m	450m w of Panel 3	Alluvium
GCP2	6408387 / 320945	0 - 2.7	Eastern section - Panel 6	Coarse gravelly sand
GCP3S (alluv)	6408389 / 320924	3.4 – 5.4	NW of Panel 9	Clay / silty clay / sandy gravelly clay
GCP4S (alluv)	6409804 / 320838	40.5 - 48.5	P13 / 14 chain pillar	Clay / gravelly clay
GCP3D	6409800 / 320838	4.0 – 6.1	NW of Panel 9	Medium grain sandstone
GCP4D	6409344 / 323447*	13.5 – 35.8	P13 / 14 chain pillar	Fine to medium grain sandstone

Note: * co-ordinates supplied by GCCM

HVCC also monitor 6 piezometers in the vicinity of Panels 10 to 17 on Xstrata-owned land (Geoterra, 2005).

The nearest registered bore with an abstraction licence is located along Main Creek approximately 2.5 kilometres northeast of the study area (GW056703) as shown in **Drawing 2**, with a depth of 23m in coal measures (Geoterra, 2005).

4.4.3 Bettys Creek Alluvium

Hydraulic connection within the Bettys Creek alluvium is anticipated to be relatively efficient due to the high permeability of sands and gravels and adjacent bank deposits, with groundwater levels rising with flows in the creek.

Based on available data, groundwater in the alluvium occurs predominantly in a basal gravel sequence or within overlying sands, with groundwater storage and transmission via a porous interstitial matrix. The local water table has a shallow hydraulic gradient both towards Bettys Creek and in a downstream (southerly) direction resulting from interaction of rainfall recharge in weathered bedrock and direct infiltration through alluvium. Measurements in the alluvial piezometers has indicated a saturated thickness ranging from 5m to 7m (Geoterra, 2005).

Alluvium in the minor tributaries typically exhibits a more silty, shallower profile and significantly reduced saturated thickness. Basal gravels of 1m to 2m thickness are noted to depths of 5m to 8m close to Bettys Creek.

Groundwater quality within the alluvium can vary significantly as a function of drainage source area, extent of leakage from underlying coal measures, hydraulic gradients and streamflow, with salinities up to 19,500µS/cm. This trend is consistent with saline bank storage conditions generated by upward leakage from underlying coal measures (Mackie

Environmental Research, 2003).

The high salinity water associated with Bettys Creek has no beneficial users or groundwater dependent ecosystems.

4.4.4 Coal Measures

The coal measures represent an assemblage of aquifers, aquitards and aquicludes, with very low intrinsic or inter-granular hydraulic conductivities, and groundwater flow confined mostly to the coal seams (aquifers) where cleats provide an enhanced secondary permeability. Sandstones and tuffs provide a measure of porous storage with very low transmitting capacity, while mudstones, siltstones and shales effectively impede vertical and horizontal flows (Mackie Environmental Research, 2003).

Hydraulic connectivity between strata is only provided through fracturing and jointing and, where vertical connectivity is present, more laterally uniform pressure distributions are exhibited.

Regional water levels within the coal measures result from interaction between rainfall recharge and topography over a very long period of geological time. Rainfall percolation has elevated the water table while drainage channels have incised the water table and provided leakage pathways that constrain groundwater levels to drainage bed elevations or deeper. In rainfall recharge periods, water levels in shallow aquifers respond by rising several metres. During dry periods, levels are lowered through seepage to the local watercourses. At these times salinity in surface drainages normally rises as leakage contributions from the coal measures increase (Mackie Environmental Research, 2003).

Pre-2003 water level monitoring in 6 of the nearest piezometers to the proposed longwall panels have exhibited generally static water levels to date, although this is mostly attributed to their relatively shallow depth (Mackie Environmental Research, 2003). Since that time, water levels have declined in five of the six deeper piezometers monitored near Mt Owen, with the rate of decline suggesting a depressurisation zone extending 1km to 2km from the existing pit.

More recent data following preparation of the Mt Owen EIS (post-2003) indicates a general decline in standing water levels due to the long term drought during the data period, with an additional influence of coal measures depressurisation due to adjacent mining activities.

Flow directions are likely along seepage pathways towards the existing mine pits or main drainages (Mackie Environmental Research, 2003).

Data derived from different test methods indicate a wide range of hydraulic conductivities attributed to lithological variation at a regional scale, and/or to inherent inaccuracies in test measurement or methodology. In areas where bedding dip and flexure increase markedly, joint frequency and connectivity through interburden can often be higher than for undisturbed measures (Mackie Environmental Research, 2003).

The coal measures are generally low yielding with highest yields from coal seams or igneous intrusions, whilst the sandstones are commonly relatively low yielding.

Based on available monitoring records, it is interpreted that groundwater levels are currently reduced due to the effect of the drought along with the effect from open cut and underground mining in the area.

Local, mine scale small faults and dykes may be present in the study area. However, they are not anticipated to be of a size sufficient to enable loss of stream flow into the workings if they are dislocated by subsidence.

Isolated initial inflows of up to 20L/sec were observed during installation of a ventilation shaft located on the south-western edge of Panel 6 and during installation of one gas drainage well (Geoterra, 2004). To date, groundwater inflows of around 300m^3/day have been observed from extraction of Panels 1 to 7 (PSM Australia Pty Ltd, 2007).

Groundwater in the coal measures is of poor quality due to the presence of terrestrial salts. Water quality is known to vary regionally both within and between coal seams and interburden and is attributed to the complexities of groundwater flow within the coal measures, interaction of surface and groundwaters and the sampling regime. Many piezometers are exposed to multiple seams that invariably generate composite water samples, with water quality being poor, mostly brackish to saline and of a sodium-chloride-bicarbonate type (Mackie Environmental Research, 2003).

The coal measures groundwater is generally brackish to saline and is important locally only for stock water supply or use in coal washeries.

4.4.5 Groundwater Levels

Monitoring of GCP1 since January 2002 in the alluvium of Main Creek indicates standing water levels have fallen 5.73m as shown in **Figure 2**, which coincides with the lack of rainfall recharge due to the drought during the majority of the monitoring period, whilst the recent rise in standing water levels occurred after the flooding rains during June 2007.

Water levels in GCP2, which is located in a backfilled pit in the alluvium of Main Creek over Longwall 6, have fallen by 0.57m since December 2005, whilst piezometers in Bettys Creek alluvium (GCP3S and GCP4S) have fallen by 0.96m and 1.38m respectively since April 2005.

Groundwater levels in the coal measures (GCP3D) have fallen by 4.42m in the same period, whilst GCP4D has risen by 5.64m. The initial rise in GCP4D, as well as the rise and fall in mid 2006 are anomalous to the rest of the bore suite, however its water levels are now responding to the drought and mining conditions in a similar manner as the remainder of the suite of bores. The reason for the anomalous response in GCP4D has not yet been ascertained.

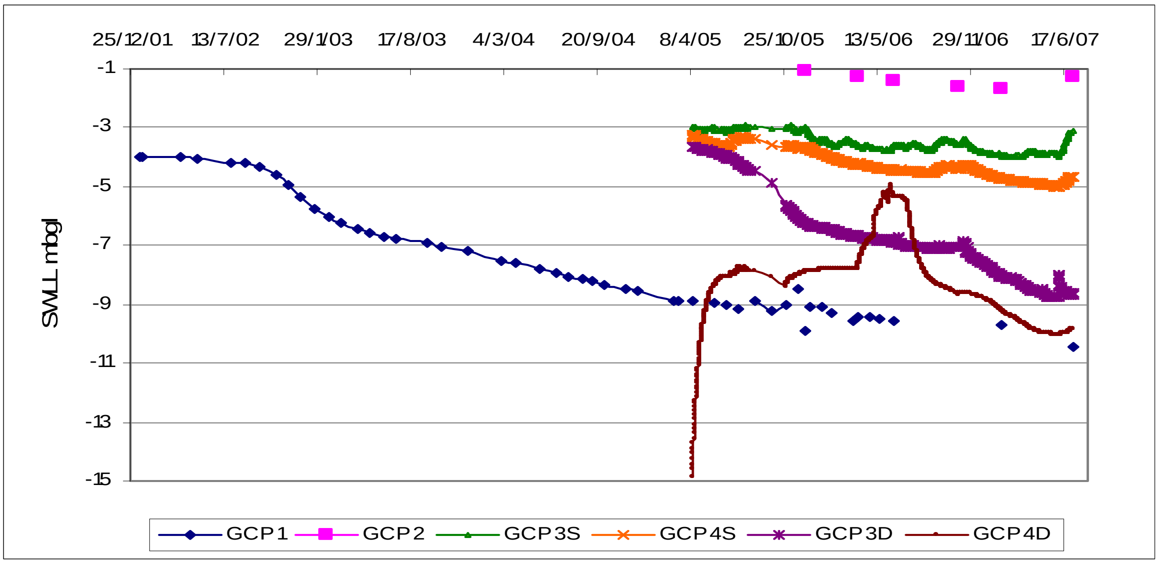


FIGURE 2 Panels 10 to 17 Groundwater Levels

4.4.6 Groundwater Chemistry

Groundwater quality shown in **Table 6, Table 7** and **Appendix A** indicate both the coal measures and alluvial groundwater is Cl>Na>Mg dominant. Longer term data available for GCP1 indicates the Main Creek alluvial aquifer contains brackish water with between 3,110µS/cm and 3,720µS/cm, whilst GCP3S and GCP4S can reach 19,500µS/cm, which is too saline for drinking or stock use. Salinity in the coal measures (GCP3D, GCP4D) can reach 17,300µS/cm, which is also too saline for drinking or stock use. Sample locations are shown in **Drawing 1**.

TABLE 6 GROUNDWATER CHEMISTRY (mg/L) (January 2002 – May 2005)

Piezometer	pH	EC µS/cm	TDS	Na	Ca	K	Mg	Cl	F	NO_3	SO_4	HCO_3	PO_4
ALLUVIUM													
GCP1!	-	**3110-3720**	-	-	-	-	-	-	-	-	-	-	-
GCP2*	6.8	340	-	52	2.7	-	-	64	-	-	104	-	-
GCP2#	**6.31**	**578**	290	66	23	2.4	14	66	0.16	<0.1	10	200	0.52
GCP3S	7.28	**14,180**	10600	2950	230	6	550	5590	0.41	**0.13**	450	1100	<0.1
GCP4S*	6.68	**8,610**	4420	1300	72	3.5	200	2230	0.54	<0.1	210	640	<0.1
COAL MEASURES													
GCP3D+	**7.54**	**12,840**	6850	2120	105	9	230	3340	0.32	<0.1	550	830	<0.1
GCP4D+	7.24	**20,900**	11600	3150	230	15	630	6290	0.6	<0.1	620	930	<0.1
ANZECC	6.5-7.5	30 – 350	-	-	-	-	-	-	-	0.015	-		0.02(TP)

Source : ANZECC default trigger values for risk of adverse effects from physical and chemical stressors in SE Aust. Upland Rivers [Sampling dates (! Jan02-Apr05 / *7/4/05 / +19/4/05 / # 27/5/05)]

(Shading indicates values outside AZECC 2000 criteria)

TABLE 7 GROUNDWATER CHEMISTRY (mg/L) (April – June 2006)

Piezometer	pH	EC µS/cm	TDS	Na	Ca	K	Mg	Cl	F	SO_4	HCO_3	N_{tot}	P_{tot}
GCP3S	6.8 / **6.38**+	**18700 / 19500**+	11900	3660	215	13	540	6700	0.53	450	1220	**1.1**	**0.18**
GCP4S*	7.2 / 6.72+	**8910 / 13600**+	5800	1500	140	15	370	3160	0.75	225	710	**1.4**	**0.19**
GCP3D+	7.2 / 6.88+	**11400 / 13100**+	7490	2480	90	20	170	3600	0.29	815	760	**5.3**	**0.20**
GCP4D+	7.2 / 6.64+	**16800 / 17300**+	11100	3200	220	23	520	6070	0.53	640	720	**3.5**	**<0.1**
ANZECC	6.5-7.5	30 – 350	-	-	-	-	-	-	-	-	-	0.25	0.02

NOTE: analyses from samples collected on 1/4/06 except as shown (+ 15/6/06)

ANZECC default trigger values for risk of adverse effects from physical and chemical stressors in SE Aust. Upland Rivers **(Shading indicates values outside AZECC 2000 criteria)**

Total nitrogen and total phosphorous generally exceed ANZECC 2000 criteria.

Figure 3 indicates pH can occasionally be outside criteria for GCP2, GCP3S or GCP3D, whilst EC is generally outside ANZECC 2000 criteria for South East Australian Upland Streams.

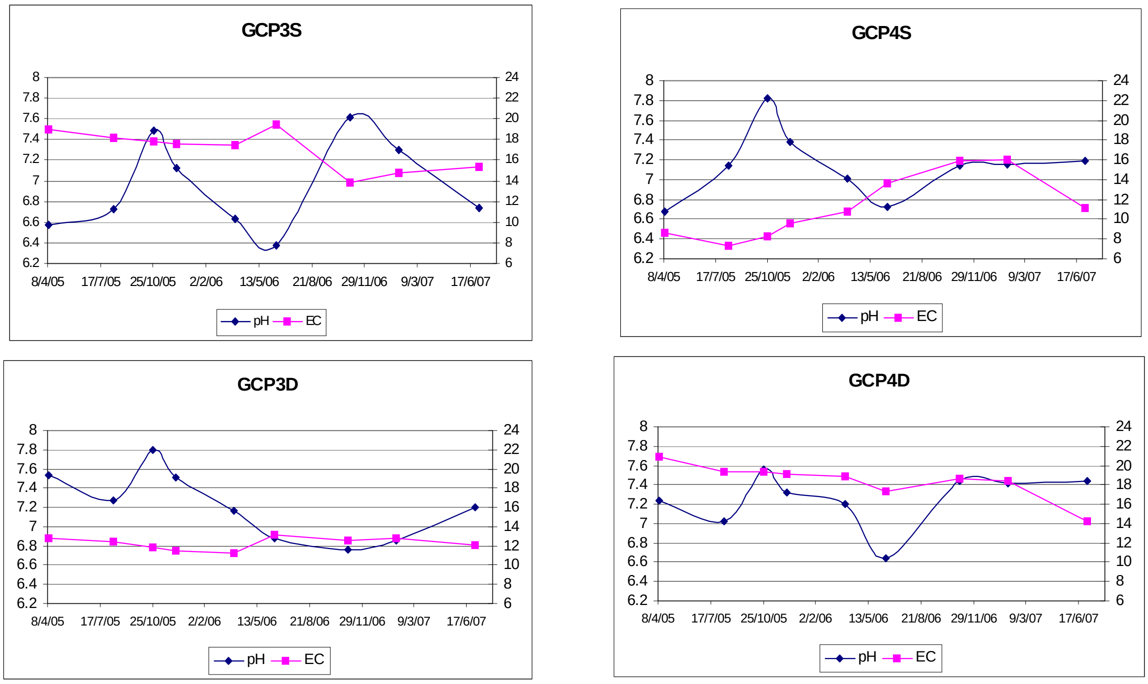


FIGURE 3 Field Groundwater Quality

Recharge from the heavy rains in June 2007 have notably reduced the salinity in the deeper bores compared to the piezometers monitoring Bettys Creek alluvium.

Table 8 indicates groundwater from the four piezometers generally exceeds the ANZECC 2000 copper criteria and GCP3S / GCP4S criteria for zinc.

Sample locations are shown in **Drawing 1**.

TABLE 8 GROUNDWATER CHEMISTRY (metals - mg/L) 30/3/06

Piezometer	Fe_{tot}	Fe_{filt}	Cu	Pb	Zn	Ni	Al	Mn	As	Se
GCP3S	2.3	0.04	**0.004**	0.001	**0.025**	<0.01	<0.1	0.29	<0.01	<0.01
GCP4S*	2.9	0.02	**0.004**	<0.001	**0.016**	<0.01	<0.1	0.34	<0.01	<0.01
GCP3D+	1.0	0.07	**0.002**	<0.001	0.006	<0.01	<0.1	0.30	<0.01	<0.01
GCP4D+	1.5	0.18	**0.003**	<0.001	0.003	<0.01	<0.1	0.21	<0.01	<0.01
ANZECC	-	-	0.0014	0.0034	0.008	0.011	0.055	1.9	0.024	0.011

Source : ANZECC trigger values for protection of 95% of freshwater aquatic species

(Shading indicates values outside AZECC 2000 criteria)

4.5 Soils

The area is predominantly within the Hunter (hu) alluvial landscape in the alluvial valleys and to a lesser extent, the Bayswater (bz) solodic soil landscape in the Bettys Creek tributaries (Geoterra, 2003A).

Rock outcrop is generally absent in the study area for Panels 10 to 17.

Soils of the Bettys Creek catchment area are Yellow and Brown Podzolics on the mid to upper slopes with non-calcic brown soils along the base of the creek and surrounding lands upslope of the proposed Mt Owen West Dump. Gradational soils are found along the base of the creek and surrounding lands downstream of the proposed West Dump (Umwelt, 2003).

4.5.1 Hunter Landscape

The Hunter landscape develops brown clays and black earths on prior stream channels and tributary flats. Alluvial soils occur on levees and flats adjacent to the Hunter River, with red podzolic and lateritic podzolic soils located on old terraces, as well as non calcic brown soils and yellow solodic soils in drainage lines.

The soil has a high permeability with a high water holding capacity and high erodibility.

4.5.2 Bayswater Landscape

The Bayswater landscape generally develops over sandstone, shales and mudstones in undulating low hills. The main soils are yellow solodics on slopes with some brown and yellow earths and prairie soils in drainage lines. Red and yellow podzolic and brown podzolic soils occur on slopes.

The soils are shallow with high permeability and erodibility, particularly in the yellow solodic soils.

4.6 Climate

The regional climate is temperate and is influenced by both coastal weather patterns and conditions within the Upper Hunter region generally. Rainfall averages about 603 mm per annum as measured at Jerry's Plains.

Daily rainfall has been recorded at Mt Owen between September 1995 and December 2002 however, no evaporation data is available. The closest Bureau of Meteorology stations used for evaporation and rainfall data are at Singleton and Scone, with an average assessed rainfall between 1995 and 2002 of 657 mm which is approximately 90% of the 724 mm/year average recorded at Mt Owen. Considerable fluctuations in rainfall occur during each calendar year.

The study area has a semi arid inland subtropical climate with average diurnal temperatures ranging from 18^{o}C to 31^{o}C in summer and 5^{o}C to 17^{o}C in winter.

Rainfall is relatively evenly spread over the year, although heavier falls can occur in summer. Dry periods can last up to 6 months or more, with the area being in drought since 2002.

Approximately 154mm of rain fell in the six months from January 2006, with the period since February 2002 being a long term drought where the creeks have been dry.

Rainfall infiltration and recharge to the shallow weathered coal measures is inferred to be very low to negligible based upon measured hydraulic conductivities of different strata and observed water level movements. Infiltration to alluvial deposits is observed to be fairly rapid due to the predominantly sandy nature of these sediments (MER, 2003).

A number of periods during the last decade have witnessed below average annual rainfalls with moderately dry years occurring from 1994 to 1997 and exceptionally dry conditions occurring throughout 2002-2005. Rainfall during these years was not conducive to significant recharge and resulted in regional water table declines in the alluvial aquifer systems. Falling water tables may also be accompanied by an increase in groundwater salinity as contributions increase from upward leaking coal measures groundwater (MER, 2003).

5. GROUNDWATER MODELLING

The model structure, modelling approach and simulations generated by Golder Associates Pty Ltd in association with Geoterra Pty Ltd are detailed in **Appendix B**, with a summary of the modelled potential impacts summarised below.

Modelling was carried out on the basis that the assessment is preliminary in nature and that the model represents the Panel 10 to 17 project area based on reasonable and representative assumptions, despite limited data availability. The assumptions and conclusions that follow from the model analysis reflect these understandings and assumptions. The model is, however, highly flexible and can be modified in response to new interpretations or further data that emerge as the project develops.

Limited Integra and adjacent mine groundwater data restricted assessment of the model to a "quasi steady state" set up, as transient assessment was limited by insufficient verification of groundwater levels and assumptions relating to pre and post-subsidence hydraulic conductivity distributions.

There is a degree of uncertainty over the level of pre and post-subsidence interaction and hydraulic connection between layers for the hydraulic conductivity estimates applied to represent the formations overlying and underlying the Middle Liddell Seam. In addition, certain assumptions were incorporated into the model regarding the interactive effect of adjoining mines on the overburden and alluvial strata within the study area. Current, proposed or completed coal mines present within the local area are the;

- Camberwell Open Cut and the proposed Glennies Creek Open Cut) to the south;
- Barretts Open Cut and proposed Ashton underground to the south-west,
- Ravensworth and Eastern Rail Open Cuts to the north-west; and
- Mt Owen Open Cut to the north.

All of these mines are extracting coal from higher relative levels (RLs) than the proposed Panels 10 to 17 as they are, or will be, mining either stratigraphically higher seams or mining the Middle Liddell Seam where it rises up the flanges on the outer region of the synform.

5.1 Conceptual Hydrogeological Model

A conceptual hydrogeological system was developed to enable set up of the FEFLOW model. The overburden stratigraphy is sub-divided into a series of coal seam, interburden, overburden and alluvial / colluvial layers which form a general synformal structure within the model area, with the proposed Panels 10 to 17 located in the general basal middle section of the structure.

The model boundaries were placed along the Camberwell Anticline to the west, the contact zone between Singleton Coal Measures and Wallaringa Formation to the east and the boundary between the Singleton Coal Measures and Mulbring Siltstone to the south-east. All boundaries were set as no-flow boundaries due to their structural and hydrogeological (i.e. very low hydraulic conductivities) characteristics.

Coal seams were combined into three major groups represented by the Arties Seam, Liddell Seams and combined Barrett and Hebden Seams.

The numerical model comprises 10 layers as described below :

- Layer 1 - alluvial deposits along the main creeks and weathered bedrock outside the alluvial channels. The layer has an uniform thickness of 8m across the model, with the Quaternary alluvial channels represented by increased hydraulic conductivities to segregate it from the lower conductivity hillslope colluvium;
- Layer 2 - weathered bedrock, with a uniform thickness of 20m across the model. The layer base corresponds to the assumed base of surface extensional post-subsidence fracturing;
- Layer 3 - overburden extending from the base of surface fracturing zone to 150m above the Middle Liddell Seam;
- Layer 4 - overburden from 150m above the Middle Liddell Seam to the Arties Seam;
- Layer 5 - the Arties Seam with a nominal thickness of 3m;
- Layer 6 - interburden between the Arties Seam and Middle Liddell Seam;
- Layer 7 - the Middle Liddell Seam with a layer thickness of 3m;
- Layer 8 - represents interburden between the Middle Liddell seam and the combined Barrett and Hebden Seams;
- Layer 9 – the combined Barrett and Hebden Seams, with a nominal thickness of 8m; and
- Layer 10 - bedrock underlying combined Barrett and Hebden Seams.

Cross sections of the layers are presented in **Figure 4, Figure 5** and **Appendix B**.

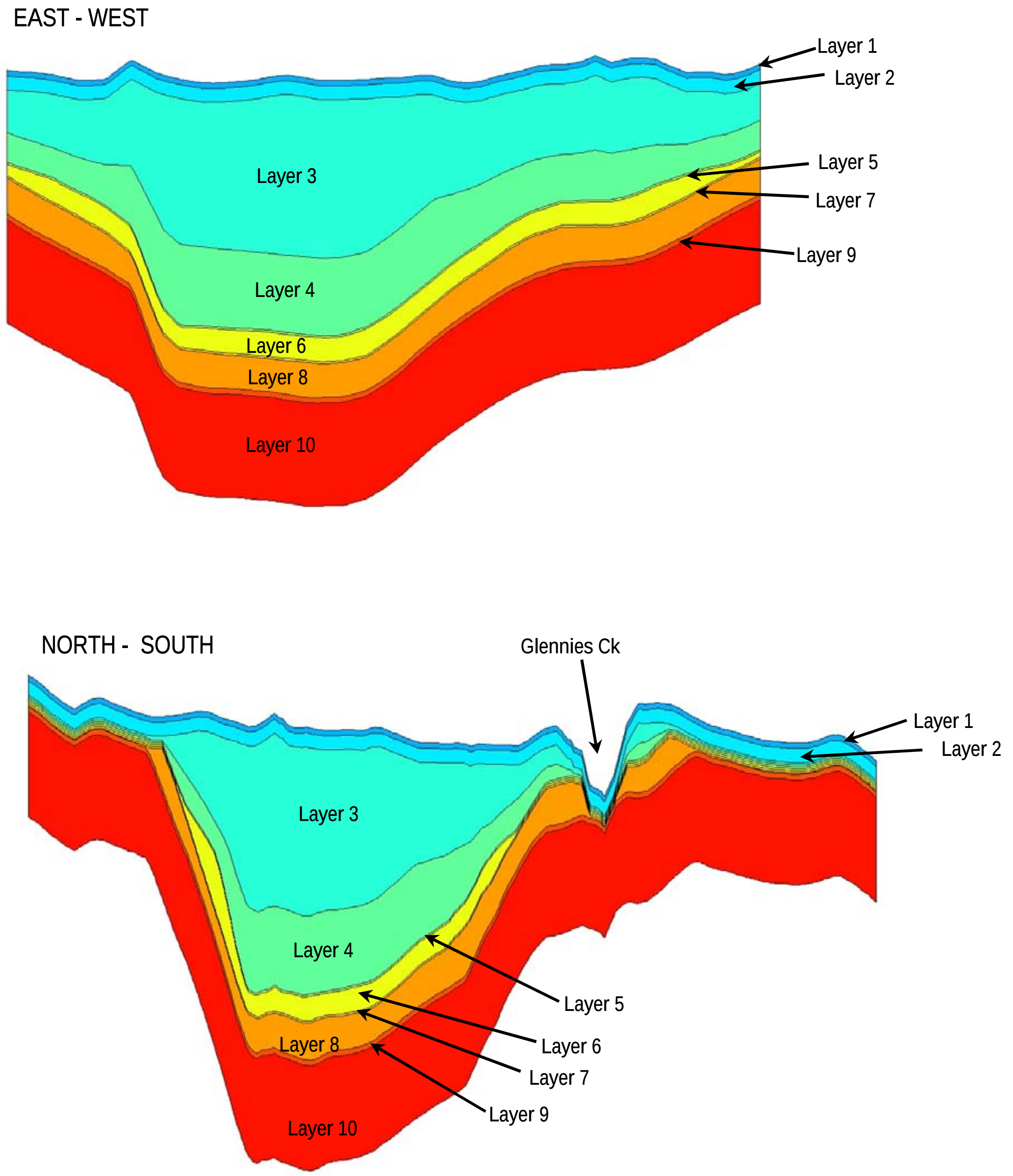


FIGURE 5 MODEL AREA CROSS SECTIONS

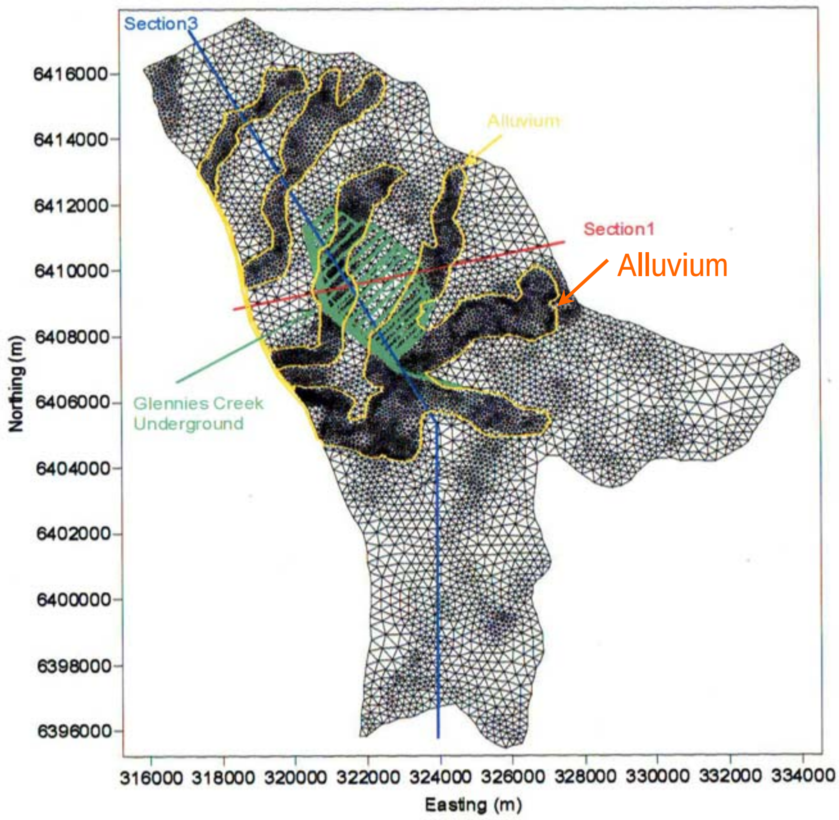


FIGURE 5 MODEL AREA CROSS SECTION LOCATIONS

Measurement of the standing water levels in the Middle Liddell Seam have not been conducted to date within the immediate Panel 10 to 17 area due to the depth of the seam (380-500mbgl), however the flow in the confined Middle Liddell Seam is assumed to be toward the base of the synform, along with modification for topographical effects where the seam subcrops.

Shallow groundwater flow in the unconfined and semi-confined weathered overburden and alluvial / colluvial systems is assumed to be dominated by topographical effects, with general flow under gravity from north-east to south-west along the creek lines. To date, there are insufficient piezometers over the Panel 10 to 17 extraction area to confirm this premise.

5.2 Modelling Code

The conceptual understanding of the hydrogeology of the study area provided a basis for a numerical groundwater model using the FEFLOW package (Version 5.2) which was developed by the WASY Institute for Water Resources Planning and Systems Research, Berlin, Germany. FEFLOW has become an industry standard in the context of finite element models for groundwater flow and mass and contaminant transport simulations.

5.3 Model Structure and Parameters

The model mesh consists of 180,380 elements as shown in **Figure 5**, and was refined along the Quaternary alluvial channel deposits to appropriately represent the impact of mine dewatering and post-subsidence effects on the alluvial groundwater systems. Mesh refinement was carried out within and around the footprint of the proposed panels and along the alluvial channels where increased detail was required to ensure that surface water flow and alluvial groundwater processes were adequately accommodated.

Underground dewatering was represented by a simulated progression of the workings combined with associated changes in hydraulic conductivity, with consideration of appropriate constraints allowing for inflow of water to the underground. Hydraulic conductivity values used in the model were based on limited field measurements along with modelled parameters used in adjacent or similar mine studies as shown in **Appendix B**.

The hydraulic parameters used were based on available reports describing similar or related investigations conducted for Mt Owen Open Cut (Mackie Environmental Research, 2003A), Ashton Underground (Peter Dundon and Associates Pty Ltd, 2006), Glennies Creek Open Cut (Australasian Groundwater and Environmental Consultants Pty Ltd, 2006) and Camberwell Open Cuts (Mackie Environmental Research, 2000).

Limited, direct, in-situ hydraulic parameter data in the Integra lease area was available for depths beneath 48.5mbgl down to the Middle Liddell Seam from which to generate the model due to the limited groundwater focused drilling conducted over Panels 10 to 17 area. Pre-subsidence hydraulic parameters for the deeper layers were generated from published and associated previous studies (Mackie Environmental Research, 2003B).

Hydraulic permeabilities within the Middle Liddell Seam, the overburden and underlying lithologies may potentially be enhanced in regions of faulting and structural discontinuities associated with the NW-SE trending Hebden Thrust in the northeast and the unnamed NW-SE trending fault in the southwest, as well as more localised NNE-SSW trending faults under Glennies Creek, to the south of panels 10 to 17. Additional higher hydraulic conductivities may also be associated with the more folded edges of the synform to the east and west of Panels 10 to 17.

The post-subsidence effects alter the hydraulic characteristics of the mined and overlying strata, with the actual distribution of hydraulic conductivities within the Panel 10 to 17 subsidence area not being accurately known at this stage. The post-subsidence parameter distribution applied in the model was based on the conceptual understanding of longwall mine subsidence geomechanics and fracture development. Anticipated post-subsidence hydraulic conductivity and specific yield / storage parameters used for the overburden and Middle Liddell Seam are shown in **Table 9**.

TABLE 9 CASE 3 POST SUBSIDENCE HYDRAULIC PARAMETERS

Layer	Horizontal Hydraulic Conductivity (m/s)	Vertical Hydraulic Conductivity (m/s)	Specific Yield / Storage (L/m)
PRE-SUBSIDENCE			
Alluvium	5.8×10^{-5}	2.9×10^{-5}	0.25 / -
Weathered Sandstone	5.0×10^{-8}	5.0×10^{-9}	0.005 / 5×10^{-6}
Fresh Sandstone / Shale	5.0×10^{-9}	5.0×10^{-10}	0.005 / 5×10^{-6}
Arties / Middle Liddell Seams	1.0×10^{-7}	1.0×10^{-8}	0.03 / 5×10^{-6}
Hebden / Barrett Seams	8.0×10^{-8}	8.0×10^{-9}	0.03 / 5×10^{-6}
POST-SUBSIDENCE			
Alluvium to 8mbgl	No change	No change	-
Overburden (8 to 28mbgl)	1×10^{-6}	1×10^{-4}	-
150m above MLS to 28mbgl	1×10^{-7}	No change	-
Arties Seam to 150m above MLS	1×10^{-4}	1×10^{-6}	-
Goaf Zone (above MLS to Arties Seam)	1×10^{-2}	1×10^{-2}	-
Middle Liddell Seam	1×10^{-2}	1×10^{-2}	-

NOTE: MLS Middle Liddell Seam

In the model it was assumed that hydraulic conductivity within the underground, following extraction of Panel 17, increases to approximately 1×10^{-2} m/sec. This allows for essentially unrestricted groundwater movement within the extracted and collapsed workings and in the goaf up to approximately 150m above the seam, compared to pre-extraction / subsidence conditions.

The horizontal and vertical hydraulic conductivity of the subsided overburden used in the model was based on an assumed vertical gradation of;

- goaf development, along with bed sagging and brittle vertical / horizontal connected fracturing to 150m above the seam
- bed sagging with increased horizontal conductivity in a plastic deformation zone, although without an increase in post-subsidence vertical conductivity, from 150m above the seam to 20m beneath the alluvial / colluvial surface layer (ie 28mbgl)
- no change in hydraulic conductivity within the subsided, unconfined, unconsolidated alluvium and colluvium from surface down to 8m below ground level

Rainfall recharge is expected to occur over the alluvial sediments of the major creeks and along coal seam outcrops. For the post-subsidence conditions, an increased recharge was incorporated over the area to be affected by surface cracking due to the subsidence.

The actual recharge distribution is assumed based on the conceptual model and analysis of measured groundwater heads.

Recharge is also assessed to occur within outcropping / subcropping shallow seams within the Glennies Creek alluvial channel. Rainfall recharge was applied along the alluvial channels and coal seam outcrops at 8mm/year in the alluvium and 2mm/year on coal outcrops. The post-subsidence fracturing of the surface was assumed to recharge at 10mm/year.

5.4 Model Runs

Three cases were modelled, as shown in **Appendix B**:

- Case 1 - with hydraulic conductivity and storativity values at the higher end of those quoted in similar studies, and
- Case 2 - employing lower hydraulic conductivity and storativity values.
- Case 3 – using hydraulic conductivity values based on an extrapolated relationship between depth of a lithology and its hydraulic conductivity (AGE, 2006) as detailed in **Appendix B**.

For each of the modelled cases, the assessment was carried out in the following manner:

- Development of a quasi "current state" model set to represent the current situation of dewatering of the nearby mines including the Mt Owen Open Cut, Ashton Open Cut, Glennies Creek Underground Panels 1 to 10 and the Camberwell Open Cuts. The model underwent crude calibration focused on matching measured (or previously modelled) groundwater inflow rates into Glennies Creek Underground and Mt Owen Open Pit with the current model results.
- Running two predictive scenarios from the present till the end of Panel 17, one with and one without the Glennies Creek Underground extension to asses a "net" impact of Panels 10 to 17 dewatering and to assess the post-subsidence effects on the surrounding hydrogeological environment.

The model was calibrated for quasi steady-state conditions to match observed groundwater heads in the Integra and adjoining lease areas with modelled heads. The results of the calibration were compared to the measured and calibrated groundwater heads for available observation bores.

To validate the model generated outputs, model generated inflow rates in year 2012 were compared to results obtained for Mt Owen (Mackie Environmental Research, 2003) and the Glennies Creek Open Cut (Australasian Groundwater and Environmental Consultants Pty Ltd).

No post Panel 17 runs have been conducted to date as the Mt Owen Pit and other proposed open cut and underground coal mines will be in existence in close proximity to the Glennies Creek Underground. As a result, the post extraction recovery of the Panel 10 to 17 drawdown area will be significantly affected by the continued development and operation of coal mining across the area.

5.5 Summary of Modelling Calibration Results

Model generated inflow rates for Case 1 were considered too high as they exceeded modelled predictions prepared for Mt Owen and known mine inflows to Panels 1 to 7. As a consequence, Case 1 was considered as a conservative case.

Case 2 inflow rates were in reasonable agreement with other studies and mine inflow rates, and therefore Case 2 was initially considered to be a likely scenario.

Case 3 inflow rates were calibrated to average net measured groundwater inflows to the Glennies Creek Underground, with Case 3 taken to represent the most likely scenario

Based on measured and modelled underground and open cut mine pump out rates in the model area, the higher inflow Cases 1 and 2 are less likely to develop than Case 3, which is calibrated to known underground mine inflows.

6. POTENTIAL PANEL 10 TO 17 SUBSIDENCE IMPACTS

The following sections on potential subsidence impacts due to extraction of Panels 10 to 17 have been compiled from the observation of prior subsidence monitoring over Panels 1 to 7, subsidence experience from similar longwall operational situations and computer based FEFLOW modelling simulations.

In addition to the above, Integra Coal are committed to undertake additional modelling based on the approach developed by Winton Gale (Gale W, 2006) prior to commencing Panel 10, as well as to updating the FEFLOW model as monitoring information becomes available (Kovac, S, 2006 pers comm).

6.1 Previous Subsidence Observations

No direct measurable effect was noted due to extraction of Panels 1 to 7 on either the alluvial or coal measure groundwater levels or quality. However, a reduction in standing water levels in the alluvial system would have resulted from the prolonged drought.

Subsidence related effects may have occurred in GCP1 around late 2002 to early 2003 as well as regional depressurisation from all mining operations in the Glennies Creek Colliery area within the coal measures. Due to limited data, the degree of alluvium depressurisation due to mining can not be separately quantified from drought effects in the Main Creek sediments.

6.2 Measured and Predicted Subsidence

Glennies Creek Colliery has extracted coal from Longwall Panels 1 to 7, with the changeover from Panel 7 to Panel 8 occurring during June 2007.

Monitored subsidence for Panels 1 to 5 and predicted subsidence within the Panel 10 to 17 study area are shown in **Table 10** (SCT Operations, 2006).

TABLE 10 SUBSIDENCE MONITORING AND PREDICTIONS

LW	Panel Width (m)	Pillar Width (m)	Ovbdn (m)	Pred. Max Subsid. S_{max} (m)	Actual S_{max} (m)	Pred. Max Tilt (mm/m)	Meas. Max Tilt (mm/m)	Pred. Max Strain (Tens / Comp.) (mm/m)	Meas. Max Strain (Tens / Comp.) (mm/m)
1	100	30	270-290	<0.24	-	0	0	0	0
2	141	30	280-300	0.76	0.87	13	5	3.4 / 5.2	2 – 3
3	167	30	290-320	0.96	0.95	15	5	3.9 / 5.9	2 – 3
4	151	35	300-330	0.82	>0.75	13	>2	3.3 / 5.1	> 1 / 0.5
5	147	35	300-350	0.82	>0.42	13	-	3.4 / 5.2	-
6	242	35	300-360	1.55	-	22	-	5.7 / 8.8	-
7	260	38	310-380	1.56	-	23	-	6.0 / 9.3	-
8	260	40	320-400	1.47	-	23	-	5.9 / 9.1	-
9	260	42	320-420	1.56	-	21	-	5.5 / 8.5	-
10	256.5	42	380-450	1.56	-	12*	-	6.0* / 9.0*	-
11	256.5	45	390-470	1.56	-	12*	-	6.0* / 9.0*	-
12	256.5	46	400-480	1.56	-	12*	-	6.0* / 9.0*	-
13	256.5	48	400-500	1.56	-	12*	-	6.0* / 9.0*	-
14	256.5	48	410-500	1.56	-	12*	-	6.0* / 9.0*	-
15	256.5	46	410-490	1.56	-	12*	-	6.0* / 9.0*	-
16	256.5	48	430-490	1.56	-	12*	-	6.0* / 9.0*	-
17	256.5	30	430-490	0.78	-	12*	-	6.0* / 9.0*	-

Notes: Predicted S_{max} based on (Mills 1998) * Predicted strains / tilts based on 1.6m of subsidence

Longwall (LW) locations shown in Drawing 1

Troughs of up to a maximum of 1.6m deep and approximately 260m wide may develop (SCT, 2006) as shown in **Drawing 4**, with the deepest subsidence occurring over the panel centres.

Based on observations of previous predicted and observed subsidence measurements, it is anticipated that the actual subsidence, tilts and strains will develop to around 50% to 80% of the maximum predicted values used for assessment purposes (SCT, 2006).

Remnant relative “highs” will remain over chain pillars within the overall subsidence trough, with a high of around 0.4m developing over the Panel 10 / 11 chain pillar, reducing to around 0.1m between Longwall 16 and 17 due to the increased depth of cover.

Maximum tensile strain is estimated to be 6mm/m and maximum compressive strain is estimated at 9mm/m, whilst maximum tilt is estimated to be 12mm/m (SCT, 2006). Maximum tilts will initially be along the axis of each panel and, as subsequent panels are extracted, the tilt will align perpendicular to Bettys Creek over Panels 10 to 13, and be sub parallel to the creek line over Panels 14 to 17.

The maximum strain may be higher than predicted in steeper terrain and in the vicinity of geological structures.

To date, maximum strains over Longwalls 1 to 5 have been measured at between 2mm/m to 3.5mm/m and maximum tilts have been around 5mm/m to 6mm/m

6.3 Effect of Subsidence on Ravensworth East, Eastern Rail Pit and West Dump

Based on information supplied by HVCC, either or both of the pits will be backfilled with waste rock or tailings and rehabilitated before they are undermined by Panels 13 to 17. It is also understood that the West Dump, which overlies the eastern edge of Panel 16, may be completed and rehabilitated before it is undermined.

Subsidence of the backfilled / rehabilitated waste rock and tailings in the pit voids and West Dump of up to 1.6m is not anticipated to have significant adverse effects on the integrity or stability of the backfilled rehabilitated structures. However, some surface cracking may develop which may require ripping or grading and revegetation.

Stabilised surface water runoff drainage channels on the rehabilitated structures may also require additional management after subsidence.

6.4 Subsidence Effects on Groundwater

6.4.1 Potential Impact on Local Groundwater Users

The potential drawdown effect on private bores, wells and spring fed dams within the Case 3, Panel 10 to 17 drawdown area is shown in **Table 11**.

TABLE 11 POTENTIAL EFFECTS ON PRIVATE BORES, WELLS AND SPRING FED DAMS IN THE PANEL 10-17 DRAWDOWN AREA

Water Source (see Dwg 1)	East / North	Status	Depth (mbgl)	SWL (mbgl)	Aquifer Intake	Potential Post Panel 17 Drawdown (m)
Overburden						
GW56703	325310 / 6413361	Bore (abandoned)	22.9	N.A.	Basalt / coal	< 1
GW45084	322029 / 6406833	Bore (status?)	18.9	N.A.	Sandstone	< 0.5
Quaternary	**Alluvium**					
GW11543	324313 / 6407613	Well (abandoned)	5.5	4.6	Glennies Ck alluvium	< 0.5
GW49285	324873 / 6408486	Well (abandoned)	9.1	6.7	Glennies Ck alluvium	< 0.5
GW67291	326263 / 6408140	Well	27.4	N.A.	Glennies Ck alluvium	< 0.5
Gardner Well	324873 / 6408466	Well (abandoned)	N.A.	N.A.	Glennies Ck alluvium	< 0.5
Noble Dams	322758 / 6408765	spring fed dams	1	1 - 2	Main Ck colluvium	< 0.5

No groundwater level depletion is anticipated to occur in any current private bores due to subsidence and it is not anticipated that any groundwater supplies from the overburden will be adversely affected in the study area.

As the one bore (GW56703) within the modelled drawdown area extracts groundwater from stratigraphically above the Middle Liddell Seam, and draws water from the more plastic deformed shallower strata rather than the Middle Liddell Seam, its groundwater supply is not anticipated to be affected by extraction of Panels 10 to 17.

A significantly lower degree of drawdown will occur for the shallow strata around the private bore compared to the head depressurisation occurring within the Middle Liddell Seam. The FEFLOW model also interprets a low post-subsidence connectivity between the Seam and the strata around the private bore due to its distance from the underground workings and shallower depth. The bore is also listed as abandoned (AGE, 2006).

In addition, there are no known beneficial users or groundwater dependent ecosystems within the study area that will be adversely affected.

The underground mining subsidence effects on groundwater within the vicinity of Panels 10 to 17 will be significantly impacted by the dewatering effects from mining the 270m deep Mt Owen Pit, as well as, to a lesser degree, the Ravensworth East and Eastern Rail Pits.

Groundwater modelling (MER, 2003) indicates that excavation of Mt Owen Pit C, Ravensworth East and the Eastern Rail Pit could reduce the groundwater levels within the coal measures over Panels 10 to 17 by between 10m to 40m, 5 years after Pit C commences, with up to 120m of drawdown 21 years after Pit C starts. The degree of depressurisation within the study area depends on both radial distance from the three pits and timing of pit excavation.

Drawdown in the vicinity of Ravensworth East and the Eastern Rail Pit will lower shallow groundwater levels around the two pits to a significantly lesser degree than Pit C. However, they could reduce throughflow in the alluvium of Bettys Creek downstream of the pits, and overlying Panels 10 to 13.

Groundwater level and water quality monitoring in the GCCM suite of piezometers will enable an assessment of subsidence effects within the vicinity of Panels 10 to 13 prior to mining / completion of the HVCC / Xstrata pits.

6.4.2 Bettys Creek, Main Creek and Glennies Creek Alluvium

No significant alluvial aquifers are present over Panels 10 to 17, with only shallow (<12m deep) alluvium located along Bettys Creek.

Groundwater level, stream flow as well as ground surface subsidence and crack development monitoring over Panels 1 to 7 under Main Creek, which has a similar alluvial aquifer system to Bettys Creek, have not indicated any direct, adverse, observable effect on the shallow alluvial system of Main Creek.

The Quaternary alluvium of Bettys Creek will be undermined by Panels 10 to 17, whilst Main Creek has been undermined by Panels 1 to 7.

The alluvium of Glennies Creek will not be undermined by secondary workings, and has only been undermined by the access drive connecting the Camberwell North Pit portal to the underground workings. No subsidence has been observed over these first workings.

The FEFLOW model predicts that for all Cases 1, 2 and 3, subsidence over Panels 10 to 17 has an indiscernible impact on alluvial shallow groundwater levels in Glennies Creek, Main Creek and Bettys Creek. Hydrographs for alluvium observation bores for Case 3 indicate there is essentially no change in pre and post-subsidence water levels in the available monitoring bores within the alluvium of Bettys Creek, Main Creek and Glennies Creek as presented in **Figure 6**.

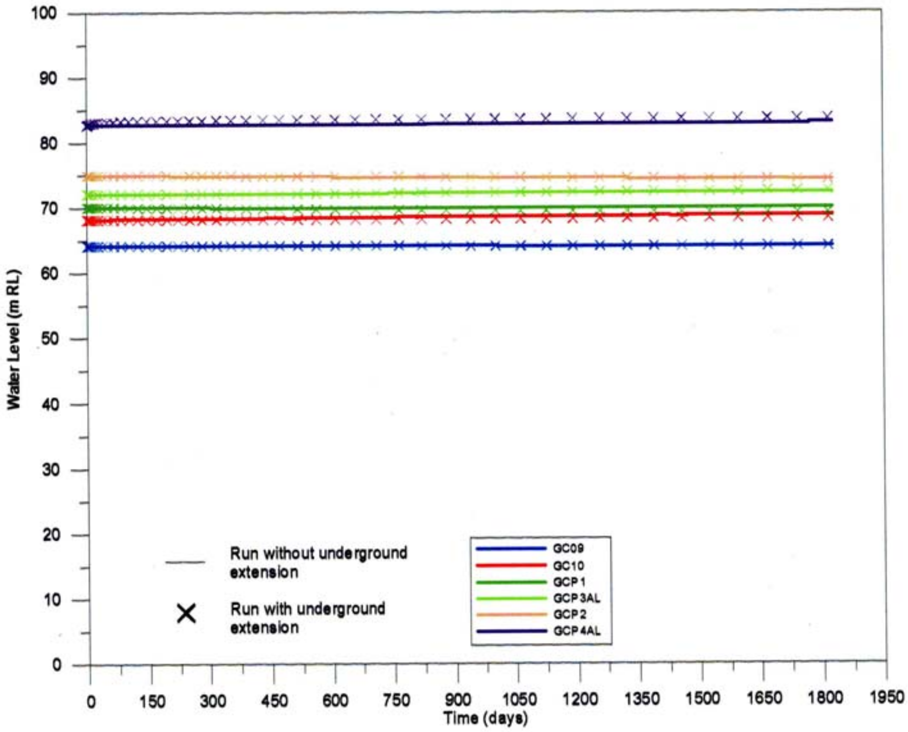


FIGURE 6 PRE AND POST PANELS 10 TO 17 SUBSIDENCE ALLUVIUM HYDROGRAPHS

It is interpreted that the private wells within the alluvial aquifer of Glennies Creek will not be observably affected by subsidence following extraction of Panels 10 to 17.

The Main Creek and Bettys Creek systems are very similar as they both are regionally small systems with no beneficial users or groundwater dependent ecosystems. As the proposed mining will be conducted with similar levels of subsidence effects to Panels 6 and 7, no observable adverse effect is anticipated on the Bettys Creek alluvial system or stream baseflow through increased subsurface aquifer hydraulic permeability changes or Coal Measure groundwater level reduction. This is primarily due to;

- the lack of observed subsidence effects in Main Creek, which has similar levels of subsidence to the proposed Panel 10 to 17 subsidence zone,
- only one groundwater seepage area has been observed within Bettys Creek, which does not currently maintain flow in Bettys Creek, and;

- the seepage area is within the Eastern Rail Pit Bettys Creek Diversion affected area, which will have a substantially greater effect on stream baseflow compared to that generated by subsidence.

There may be some minor loss of stream flow in Bettys Creek due to subsidence cracking through:

- lowering the coal measures water table;
- reduction in spring seep flow to the creek; or by
- reduction in overland runoff due to interception and infiltration into cracked soil.

This minor loss of stream flow would be difficult to detect from the other variables affecting stream flow.

Cracking of soil may reduce overland recharge in dry periods. However, once the soil profile is saturated after heavier rain periods, runoff is not anticipated to be adversely affected. Soil cracking may also lead to reduced variability of overland runoff to streams, leading to more homogenised stream flows compared to the pre-subsidence situation.

Subsidence induced cracking within the sandy clay based stream sediments is not anticipated to adversely affect the alluvial groundwater system, and it is not anticipated that adverse loss of alluvial groundwater will occur if cracking enables enhanced vertical or lateral connection to underlying or adjacent strata. The degree of loss will relate to the balance of upstream inflow from the creek compared to vertical or lateral outflow from the alluvium.

6.4.3 Shallow Coal Measures Overburden

Based on experience in similar mining environments and alluvial systems in the Hunter Valley, the shallow groundwater systems within the study area should not be observably, adversely affected by subsidence.

Previous observations as well as research projects (ACARP, 2000, 2003, 2006-in prep) indicate post-mining hydraulic conductivity increases and depressurisation of shallow coal measures (within 50m of the surface) may reduce standing water levels by up to 15m directly over the mined panels.

At present, shallow groundwater systems are experiencing reduced levels due to the extended drought, but are anticipated to recover once wetter rainfall patterns return, excluding the effect of the adjacent pit drawdowns.

Soil and shallow bedrock cracking have been observed to extend to around 20m below surface, occurring as faceline or ribline cracks, whilst the degree of permeability change relates to the original nature of crack development, followed by the degree of permeability reduction on re-closing of post-subsidence fractures (Geoterra 2005).

Sediment soil profiles may be restored to near their original permeability / porosity through soil remobilisation into the cracks by either natural or assisted processes, such as deep ripping.

Shallow weathered coal measures may return to near, albeit above, their original permeability depending on the degree of crack closure and infiltration of overlying sediment, however, the original permeability is generally not regained.

6.4.4 Deeper Coal Measures Overburden

Regional groundwater drawdown in overburden above the Middle Liddell Seam is not interpreted to extend into the drawing area of the one (abandoned) private bore located approximately 2.7km north east of Panels 10 to 17.

Based on investigations conducted to date, there are no aquifers that provide a beneficial use or sustain groundwater dependent ecosystems within the coal measures in the 20mm subsidence zone, with highly brackish to saline water contained in the low permeability sandstone or coal seams. Coal seams provide the higher permeability formations in the overburden. However, the aquifers do not have suitable quality or permeability to be beneficial.

The pre-subsidence coal measure aquifers over Panels 10 to 17 have a low recharge rate, with proportionally lower recharge in deeper aquifers.

Post-subsidence cracking can significantly enhance the vertical and horizontal permeability and enhance interconnection of aquifers, aquicludes and aquitards in the shallower cracked strata.

Subsidence will also lower standing water levels in the deeper strata to a depth where plastic deformation occurs with de-lamination through bedding plane separation and generation of enhanced horizontal post-subsidence permeabilities, rather than increases in vertical interconnection of aquifers and aquitards.

Preferential groundwater flow pathways may be dominantly vertical in the shallow, brittle fractured coal measures, whilst it will be dominantly horizontal in the deeper, plastically deformed, bedding plane separation zone. This zone will be underlain by a vertical flow dominated system in the subsided goaf and brittle deformed zone between the extracted workings and the plastic deformation zone.

Reduction in coal measure water levels is relatively instantaneous after subsidence and, if there is no exit route out of the groundwater system such as through surface seeps or flow into the underlying workings, the water table may re-establish with sufficient recharge. However, the time-frame for this is highly dependent on the nature and longevity of the recharge and the post-subsidence interconnection of aquifers, aquicludes and aquitards.

Far field horizontal displacement of the coal measures may occur up to 1.5km out from a panel edge (Strata Engineering, 2003). However, as there is only one shallow registered extraction bore which is outside the study area, it is unlikely to be observably affected by subsidence in isolation from the effect of HVCC open cut pit dewatering.

In the more elevated, steeper terrain, new seeps may form at lower elevations if subsidence cracking enables shallow groundwater to discharge to surface where there was no pre-subsidence seepage.

The actual presence and hydraulic nature of faults within the study area is not known at this stage and has not been assessed in the model. If the hydraulic conductivity of the faults is higher than the surrounding pre-subsidence strata, they may act as water conduits resulting in higher inflows to the workings. By contrast, if the hydraulic conductivities of the faults are lower than the overburden, they may act as pre subsidence barriers which could result in lower than estimated inflow rates into the underground.

In any case, following extraction and subsidence of Panels 10 to 17, it is assumed that fracture propagation up to 150m above the workings and in the top 20m of overburden beneath the surface will override the influence of any faults that may be present in those depth intervals.

6.4.5 Middle Liddell Seam

Groundwater levels within the Middle Liddell Seam aquifer will be drawn down to seam level, with the overburden being significantly affected within the goaf and overlying highly fractured strata between 30m and 60m above the workings. Partial dewatering will occur above the highly fractured zone within dilated strata that may extend between 100m to 150m above the workings.

Extraction of Panels 10 to 17 will depressurise the Middle Liddell Seam and immediate overburden. The actual drawdown of the piezometric surface is not anticipated to migrate further than approximately 150m above the seam, due to the limited extent of brittle failure above the workings. For the purpose of modelling, it is assumed that plastic deformation of the strata will occur from 150m above the workings to approximately 20m beneath the alluvial / colluvial layer. Within this layer, it is assumed that the vertical permeability is unchanged, however there is an increase in post-subsidence horizontal permeability due to bed separation.

Figure 7 shows the model generated loss of piezometric head in the Middle Liddell Seam for Case 3, which represents the "net" loss of piezometric head due to the development of Panels 10 to 17 only.

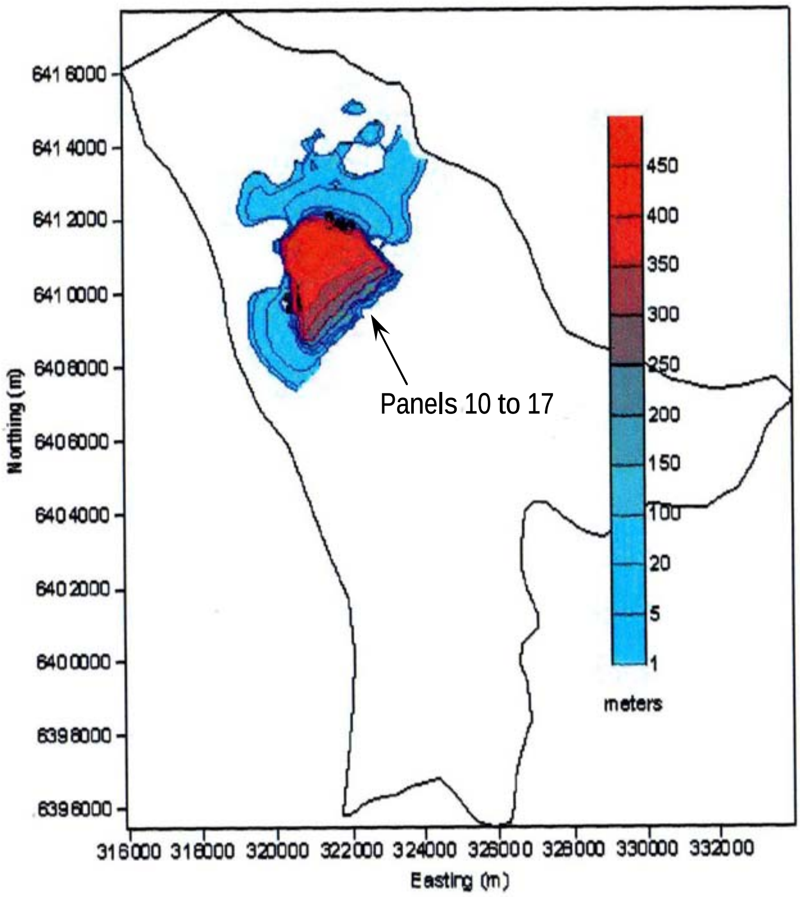


FIGURE 7 MIDDLE LIDDEL SEAM PANELS 10 TO 17 "NET" DEPRESSURISATION

Drawdowns for both cumulative loss due to all mines considered in the model as well as "net" loss due only to Panels 10 to 17 are shown in **Appendix B**.

6.5 Potential Impact on Local Streams

It is not anticipated that stream flow in Bettys, Main or Glennies Creeks will be observably reduced based on the modelled response to subsidence over Panels 10 to 17.

6.6 Mine Water Supply, Underground Inflows and Groundwater Extraction

The Glennies Creek Colliery is licensed by the DWE (20BL169862) with an annual entitlement of 450ML of groundwater per year for mine dewatering purposes.

Water supply for the mine originates from seepage into the underground workings, seepage into the Camberwell Open Cut, which is now part of the Integra Coal Pty Ltd group of operations (including the Glennies Creek underground), incident rainfall on dirty water catchments, rainfall within the former Camberwell North Pit, as well as return flows from the coal handling and preparation plant / tailings dam system.

Based on mine pumping data, overburden groundwater inflow to the underground workings reached up to 2000m^3/day during the initial main headings and panel development, which has reduced to around 300m^3/day (approx. 110ML/yr) up to and including extraction of Panel 7 (PSM Australia, 2007).

Overburden inflow of up to an approximate total of 500m^3/day at the end of Panel 17 extraction may occur as the underground mine expands, with ongoing mine pumping data records being collected to better define the potential inflows.

The current groundwater inflow to the workings of 300m^3/day (0.3ML/day), as well as the potential change up to a net total groundwater inflow of 500m^3/day (0.5ML/day or 182.5ML/year) is within the mine's annual extraction entitlement of 450ML/yr. It should be noted that modelled inflow rates in previous, similar underground longwall mine studies have generally exceed actual inflows to longwall mines once the mine is in operation.

The potential inflows to the underground workings are planned to be further assessed prior to mining Longwall 10 through ongoing mine pumping record monitoring and additional geomechanical / hydrogeological modelling (Gale, W 2006).

No bores are used to extract groundwater out of the licensed workings or aquifers overlying the workings.

6.7 Regional Cumulative Effects

6.7.1 Alluvial and Shallow Coal Measures

Drawdown within the Quaternary alluvium of Bettys Creek and the underlying shallow Coal Measures due to subsidence over Panels 1 to 17 will interact with the regional drawdown generated through extraction of the Eastern Rail and Ravensworth East Pits.

In addition, the reduced stream flow over Panels 9 to 17, along with the reduced alluvial recharge effects due to extraction of Mt Owen Pit C and the diversion of Bettys Creek will have an additional cumulative effect on the alluvial system as well as the shallow coal measures. This cumulative effect will be greater than any stream flow or groundwater level drawdown that would be imposed solely through Panel 10 to 17 subsidence.

6.7.2 Deep Coal Measures

Depressurisation of the coal measures has progressively advanced since mining at Mt Owen commenced in late 1993. Prior to that time, dewatering of shallow coal measures had been initiated through mining in the Ravensworth East (old Swamp Creek) void which affected areas to the east towards Mt Owen. Historical underground operations at Liddell Colliery (in the Liddell seams) may also have marginally affected water levels in the Ravensworth East area, although measured levels suggest the impact was negligible (Mackie Environmental Research, 2003).

Drawdown within the deeper Coal Measures due to subsidence over Panels 10 to 17 will interact with the regional drawdown generated through extraction of the Eastern Rail, Ravensworth East, Pit C, Ashton and Camberwell Open Cuts, as well as the proposed Glennies Creek Open Cut and the Ashton underground workings.

Drawdown from the combined effect of the regional mines will be added to by drawdown due to subsidence over Panels 10 to 17, however the GCCM underground operations will not affect the beneficial use of the groundwater system to either water users or the environment.

6.8 Regional Groundwater Level Recovery

Re-saturation of the Panel 1 to 17 workings will be minimised through post extraction dewatering to surface as it is planned to extract the directly underlying Barrett and Hebden Seams.

In addition, as ongoing and proposed open cut and underground mines within the Longwall 1 to 17 drawdown area will still be operating once Panel 17 is completed, it is not possible, at this stage, to assess the potential groundwater level recoveries following completion of Panel 17, due to the effect from continuing operations in the area.

6.9 Subsidence Effect on Groundwater Quality

No adverse effect on the Bettys Creek stream, alluvial or coal measures water quality or beneficial uses of groundwater over Panels 10 to 17 is anticipated.

Alluvial groundwater in Bettys Creek is relatively brackish (8,600 µS/cm to 14200µS/cm), whilst the coal measures are brackish to saline (12,840 µS/cm to 19,500µS/cm) and are not suitable for domestic or agricultural use, with the groundwater system having a low beneficial use.

7. MONITORING, REHABILITATION, CONTINGENCY MEASURES & REPORTING

The proposed/recommended groundwater monitoring, rehabilitation, contingency measures and reporting are described below.

7.1 Monitoring

7.1.1 Integra Monitoring Suite Groundwater Levels and Groundwater Quality

The current monitoring program in the GCP1 to GCP4 suite of piezometers that utilises water level loggers reading at 12 hourly intervals, quarterly measurement of field pH and EC, and annual laboratory analysis of groundwater samples will be continued, with periodic reports documenting and interpreting the collected data.

Groundwater samples will be collected from locations GCP1, 2, 3S, 3D, 4S and 4D and analysed at a NATA registered laboratory for major ions and selected metals. It is anticipated that the groundwater program will be maintained in its current status, with a review and possible modification of the program after 12 months of data is interpreted.

Additional piezometers may be added to the existing suite as studies continue within the project area.

Sampling and testing procedures will be conducted according to the Australian Guidelines for Water Quality Monitoring and reporting (ANZECC, 2000).

The groundwater monitoring program is anticipated to be extended beyond the active mine life in order to assess the potential long term change in groundwater repressurisation and quality, with the program continuing for a period agreed with the DWE / DMR after closure of the relevant mining operations.

7.1.2 Private Bore and Well Groundwater Levels, Yield and Groundwater Quality

There is only one known operational private well that may be affected within the potential drawdown area which is extracting water from the Glennies Creek alluvium.

Modelling indicates that an observable adverse effect on water levels or water quality will not occur within the Glennies Creek alluvium, however, quarterly measurement of the standing water level within the well as well as field assessment of pH and EC and annual laboratory analysis of groundwater samples will be conducted, with periodic reports documenting and interpreting the collected data.

If requested by a landowner, the pre-mining (pre-Panel 10 to 17) yield of a private bore or well will be tested in the field via a pump out test to determine its current yield, with a follow up test, if required, if the yield of the well is thought to be adversely affected due to subsidence effects.

The private well monitoring program will be initiated at least 12 months prior to extraction of Panel 10, with ongoing review and possible modification of the program as further data is interpreted.

Groundwater samples will be collected annually from the private well and analysed at a NATA registered laboratory for major ions and selected metals.

7.1.3 Mine Water Pumping

The volume of water pumped into and out of the underground workings will be monitored to enable the differential groundwater seepage into the workings to be assessed.

7.1.4 Ground Survey

The ground surface over Panels 10 to 17 will be surveyed in accordance with DPI-MR requirements.

7.1.5 Rainfall

Rainfall will be monitored daily at the Glennies Creek Colliery weather station for the duration of longwall mining.

7.1.6 Ongoing Monitoring

All results should be reviewed after Panel 10 has been completed and an updated monitoring and remediation program developed, if required, in association with DWE and DPI-MR.

7.1.7 Quality Assurance and Control

QA/QC should be attained by calibrating all measuring equipment, ensuring that sampling equipment is suitable for the intended purpose, using NATA registered laboratories for chemical analyses and ensuring that site inspections and reporting follow procedures outlined in the ANZECC 2000 Guidelines for Water Quality Monitoring and Reporting.

7.2 Impact Assessment Criteria

7.2.1 Integra and Private Bore or Well Groundwater Levels and Yield

There are no specific groundwater level or aquifer depressurisation criteria developed at this stage for either the coal measures or Quaternary alluvium, and it is difficult to develop them as there is no monitoring data available prior to all forms of mining in the area.

Consequently, impact assessment criteria investigation trigger levels will be initially set at an overall 15% reduction in monitored groundwater levels over a 12 month period. In addition, the actual rate of change of water levels will be investigated to determine whether the change is solely subsidence induced or due to a range of other potential factors, such as variation in climate, effects from adjacent mining operations or altered groundwater extraction by a landowner.

It is proposed that the water level monitoring data will be plotted and interpreted every twelve months, and if there is a significant increase in the rate of rise or fall in aquifer water levels, based on interpretation by a qualified hydrogeologist, then an assessment will be conducted to determine the cause of the change and to consider potential contingency measures that may be adopted.

As outlined in Section 7.1.2, if requested, the yield of a private bore or well will be tested in the field prior to extracting Panel 10. If the bore or well is subsequently thought by a landowner to be adversely affected due to subsidence effects from extracting Panels 10 to 17, an initial “desk top” assessment will be made as to whether the potential adverse effects may be due to subsidence. The well yield will be re-tested and the cause of the yield decline will be assessed.

7.2.2 Integra Suite and Private Bore or Well Groundwater Quality

Groundwater quality impact assessment criteria are sourced from the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 2000) for Primary Industries (Irrigation Water) as shown in **Table 12**, as the water is too saline to be used for stock and domestic or drinking use and is not discharged to the local streams**.**

Table 12 Groundwater Quality Impact Assessment Criteria

Indicator	**Irrigation Criteria**
pH	<6.5 or >8.5 or >10% variation over 3 months compared to previous 12 months data
Conductivity	>10% variation over 3 months compared to previous 12 months data
TDS	>13,000mg/L or >10% variation compared to previous 12 months data
Na	>460mg/L or >10% variation compared to previous 12 months data
K	>10% variation compared to previous 12 months data
Ca	>1000mg/L or >10% variation compared to previous 12 months data
Mg	>10% variation compared to previous 12 months data
Cl	>700mg/L or >10% variation compared to previous 12 months data
HC03	>10% variation compared to previous 12 months data
N03	>400mg/L or >10% variation compared to previous 12 months data
S04	>1000mg/ or >10% variation compared to previous 12 months data

A trigger to assess the cause and effects on groundwater quality will be implemented when there is a prolonged and extended non-conformance of the outlined criteria at a particular piezometer. If a field parameter (pH, conductivity) is outside the designated criteria for at least six months in a sequence, or alternatively, exceeds its previous range of results by greater than a 10% variation for at least 6 months, then the cause will be investigated, and a remediation strategy will be proposed, if warranted.

The criteria and triggers outlined in Section 7.2.1 will be reviewed after the initial 12 month of data is interpreted and may be modified as appropriate, depending on the results.

If the impacts on the groundwater system resulting from future underground operations are demonstrated to be greater than anticipated, the company will:

- assess the significance of these impacts;
- investigate measures to minimise these impacts; and,
- describe what measures would be implemented to reduce, minimise, mitigate or remediate these impacts in the future to the satisfaction of the Director-General and the landowner.

7.3 Contingency Procedures

Contingency procedures will be developed as required, with the measures to be developed being dependent on the issue that requires addressing.

The procedures will be used to manage any impacts identified by monitoring that demonstrate the groundwater management strategies may not have adequately predicted or managed the groundwater system's anticipated response to mining.

Activation of contingency procedures will be linked to the assessment of monitoring results, including water quality, aquifer hydrostatic pressure levels and the rate of water level changes.

Performance indicators will be identified prior to extraction of Panel 10 and a statistical assessment will be undertaken to detect when, or if, a significant change has occurred in the groundwater system which will benchmark the natural variation in groundwater quality and standing water levels.

7.4 Piezometer Maintenance and Installation

The current network will be maintained by protecting the wellhead from damage by cattle and from scrub fires by maintaining their steel sealed wellheads.

If required, the piezometers may be cleaned out by air sparging if they become clogged.

In the event that any new bores, wells or piezometers are required, they will be installed by suitably licensed drillers after obtaining the relevant bore licence from DWE.

7.5 Rehabilitation

Remedial action may be required for any operational groundwater extraction bores that may be developed during extraction of, and within, the Panel 10 to 17 drawdown area, if monitoring results indicate the agreed standards or performance indicators are not being achieved.

Examples of potential remedial actions, where the cause is shown to be due to Panel 10 to 17 extraction, could include;

- deepening of pumps if water level drawdown occurs beneath an installed pump depth,
- replacement / redrilling or deepening of a bore, or
- providing an alternate, equivalent, water supply

Due to the significant regional dewatering effect from the proposed 270m deep Mt Owen pit and the lack of beneficial use for groundwater in the Panel 10 to 17 study area, it is not anticipated that groundwater system rehabilitation will be required.

7.6 Reporting

At the completion of extraction of each panel, a report should be prepared for all prior panels that summarises all relevant monitoring to date. The report should outline any changes in the groundwater, creeks, dams and hillslope land over the mined out areas.

Reporting will contain an interpretation of the data along with:

- a basic statistical analysis (mean, range, variable, standard deviation) of the results for the parameters measured;
- interpretation of water quality and standing water level changes supported with graphs or contour plots; and,
- interpretation and review of the results in relation to the impact assessment criteria.

Relevant monitoring and management activities for each year will also be reported in the AEMR.

8. CONCLUSIONS

Field and desktop assessments, as well as analyses of groundwater systems overlying the proposed Longwall Panels 10 to 17 at Glennies Creek Colliery were conducted between April 2005 and June 2007.

The objective of the study was to assess the pre-mining status of groundwater systems overlying the panels and to provide an assessment of monitoring and rehabilitation strategies that may be required.

Maximum subsidence, tilt and strain (tension and compression) over Panels 10 to 17 are anticipated to reach 1.6m, 23mm/m and 6.0/9.3mm respectively after extraction of Panel 17 (SCT, 2006).

The following assessments were made for groundwater systems within the study area.

- The area contains low yielding sedimentary alluvium up to 12m deep in Bettys Creek which has no beneficial users or groundwater dependent ecosystems. The alluvium is a shallow unconfined aquifer with very brackish to saline electrolytical conductivity ranging up to 19,500µS/cm, which makes it unsuitable for beneficial use with domestic or agricultural purposes.
- The underlying coal measures are low yielding (<1L/sec), brackish to saline (<20,900µS/cm) which also have no beneficial users or groundwater dependent ecosystems.
- The alluvial and coal measures groundwater systems have been, and will be, significantly affected by extraction of the Hunter Valley Coal Company open cuts and the diversion of Bettys Creek, as well as extraction of the Ravensworth East, Arties and Barretts open cuts in close proximity to the proposed underground workings.
- A FEFLOW groundwater model was developed that represented the project area through ten layers which incorporated the proposed coal extraction in Glennies Creek Underground Panels 10 to 17. The model indicates the main groundwater depressurisation will occur in the confined Middle Liddell Seam, as well as the overlying goaf and highly fractured overburden. The reduction in groundwater head depressurisation with increasing height in the stratigraphy results from the change from brittle to ductile sagging of the overburden and the resultant variation in fracture development and connection.

- The FEFLOW model indicates that the currently inactive DWE registered bores in coal measures within the study area will not be observably affected by groundwater depressurisation following extraction of Panels 10 to 17.
- Extensional crack formation will also develop in the surficial layer, up to 20m beneath the alluvial / colluvial layer, which will reduce groundwater levels within the shallow weathered overburden.
- Reduction in water levels of up to 15m in the coal measures may occur following extraction of the subject panels. However, this is expected to be over-shadowed by up to 120m of drawdown following mining of the HVCC Mt Owen, Ravensworth East and the Eastern Rail Pits.
- Modelling indicates that depressurisation of the Middle Liddell Seam around the underground workings is limited to a steep drawdown cone area within 1.5km of the panels.
- FEFLOW modelling indicates that no observable adverse effects are anticipated on stream flow in Glennies Creek, Main Creek or Bettys Creek.
- No observed reduction in groundwater levels within the Quaternary alluvium along the creeks is anticipated, with one active well identified within the overall drawdown area in the alluvium of Glennies Creek.
- No Groundwater Dependent Ecosystems (GDEs) have been observed in the study area.
- Total underground mine inflows of up 500m^3/day are modelled at the end of Panel 17, which will be pumped to the former Camberwell North Pit, adjacent to the underground portal.
- Post-mining groundwater levels are anticipated to continue to be affected by mining in adjacent open cuts and underground workings after Panel 17 has been completed.
- Groundwater levels are currently reduced due to a combination of the drought and dewatering effects from local open cut coal mines, with some potential recovery due to the recent rains.
- Refinement and updating of the FEFLOW model will be conducted in association with additional modelling based on the method developed by Winton Gale (Gale, W 2006) prior to commencement of Longwall 10 ie once additional field studies are conducted to update input parameters required for the models.

9. REFERENCES

ACARP, 2000 The Influence of Subsidence Cracking on Longwall Extraction. Project No. C5016

ACARP, 2003 Review of Industry Subsidence Data in Relation To the Influence of Overburden Lithology on Subsidence and an Initial Assessment of a Sub-Surface Fracturing Model for Groundwater Analysis. Project No. C10023

ACARP, 2006 (in prep) Techniques to Predict and Measure Subsidence and Its Impacts on the Groundwater Regime Above Shallow Longwalls. Project No. C23020

AGE Pty Ltd 2006 Glennies Creek Coal Management Pty Ltd Proposed Glennies Creek Open Cut Coal Mine

DIPNR, 2004 Water Sharing Plan For The Hunter Regulated River Water Source

DIPNR, 2005 Management of Stream / Aquifer Systems in Coal Mining Developments, Hunter Region, Version 1

DIPNR, 2005 Implementation Manual, Management of Stream / Aquifer Systems in Coal Mining Developments, Hunter Region, Version 1

DLWC, 1997 NSW State Groundwater Policy Framework Document

DLWC, 1998 NSW State Groundwater Quality Protection Policy

DLWC, 1998 Aquifer Risk Assessment Report

DLWC, 2002 NSW State Groundwater Dependent Ecosystems Policy

Dundon, PJ, 2006 Ashton Coal Operations Ltd Ashton Coal Mine Longwall Panels 1 to 4 Subsidence Management Plan Groundwater Assessment

Gale, W, 2006 Water Inflow Issues Above Longwall Panels, Proc. 2006 Coal Operators Conference, Uni. Of Wollongong, AuSIMM Illawarra Branch, pp 175-179

Geoterra, 2005 Longwall Panels 7 to 9 Surface Water and Groundwater Subsidence Management Plan, Report GC7-R1C, unpub

Hunter Valley Coal Corporation, 2003 Environmental Impact Statement, Mt Owen Operations

HLA Envirosciences Pty Ltd, 2001 Ashton Coal Project Groundwater Hydrology and Impact Assessment

Mackie Environmental Research, 2000 Camberwell Coal Water Management Studies Final Report July 2000

Mackie Environmental Research, 2003A Mt Owen Operations EIS Hydrogeological Studies

Mackie Environmental Research, 2003B Bulga Coal Continued Underground Operations Hydrogeological Studies, May 2003

PSM Australia Pty Ltd 2007 Proposed Glennies Creek Open Cut Coal Mine Surface Water Assessment

SCT Operations Pty Ltd 2006 Subsidence Assessment for Longwalls 10 to 17 at Glennies Creek Colliery

Umwelt, 2003 MT Owen Operations Surface Water Assessment

DISCLAIMER

To the best of our knowledge the report presented herein accurately reflects the client's intentions when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

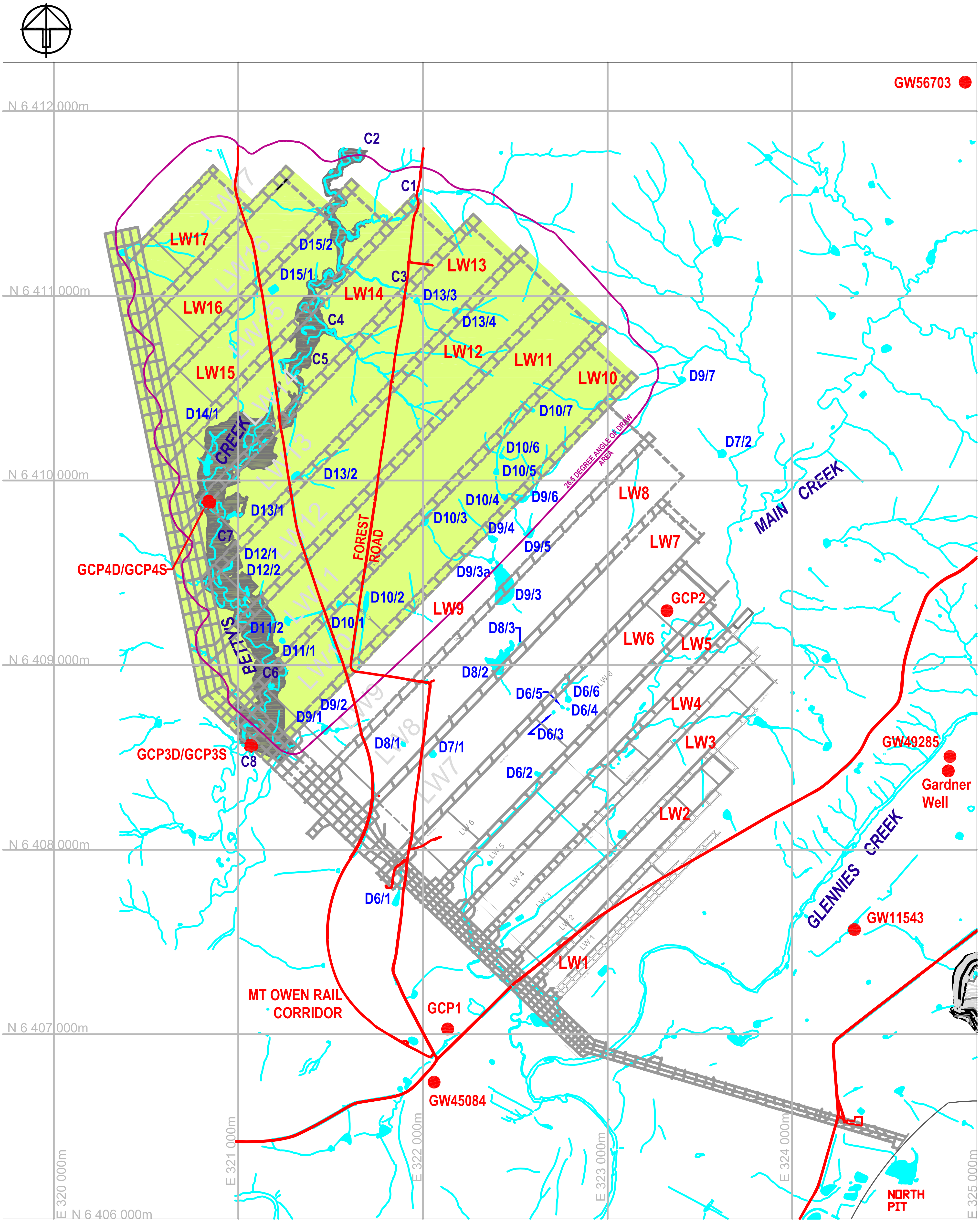
The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site / sites in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site / sites at all points. Should information become available regarding conditions at the site, Geoterra reserve the right to review the report in the context of the additional information.

In preparing this report, Geoterra has relied upon certain verbal information and documentation provided by the client and / or third parties. Geoterra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. Geoterra assume no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Geoterra.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of Geoterra is solely to its client and it is not intended that this report be relied upon by any third party, who should make their own enquiries.

The advice herein relates only to this project and all results, conclusions and recommendations made should be reviewed by a competent and experienced person with experience in environmental and / or hydrological investigations before being used for any other purpose. The client should rely on its own knowledge and experience of local conditions in applying the interpretations contained herein.

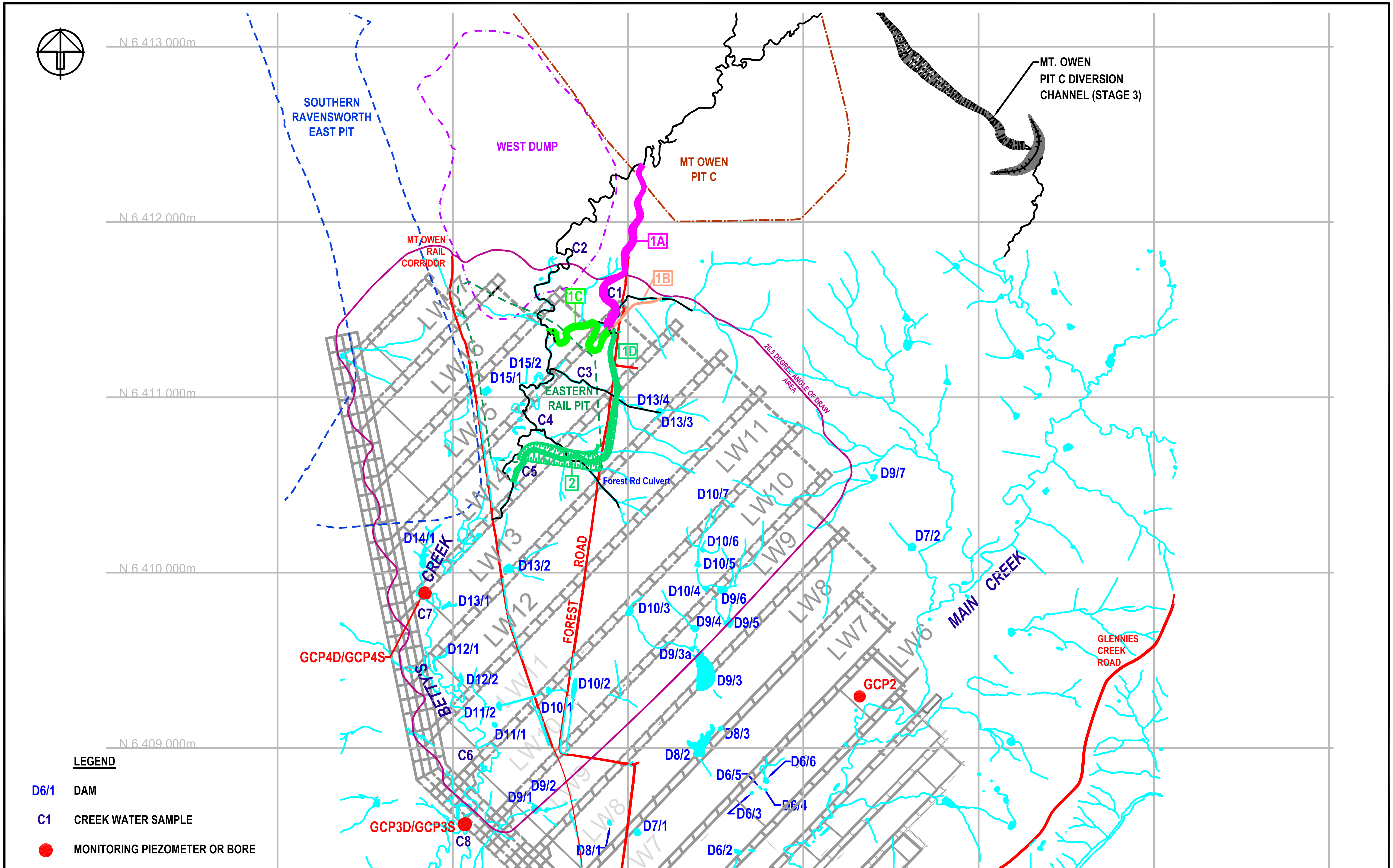
To the extent permitted by law, Geoterra, excludes all warranties and representations relating to the report. Nothing in these terms will exclude, restrict or modify any condition, warranty, right or remedy implied or imposed by any statute or regulation to the extent that it cannot be lawfully excluded, restricted or modified. If any condition or warranty is implied into this license under a statute or regulation and cannot be excluded, the liability of Geoterra for a breach of the condition or warranty will be limited to the supply of the service again.



LEGEND

D6/1	DAM		PROPOSED WORKINGS
C1	CREEK SAMPLE		EXISTING WORKINGS
●	PIEZOMETER, BORE OR WELL		
■	1:100 ARI PRE SUBSIDENCE FLOOD EXTENT		
～	DRAINAGE LINES		

PROJECT:	GC10	GLENNIES CREEK COAL MANAGEMENT PANELS 10 TO 17	GeoTerra
DRAWN:	A. DAWKINS		
DATE:	23 JULY 2007	GENERAL MINE LAYOUT	DRAWING 1
SCALE:	1:20 000		



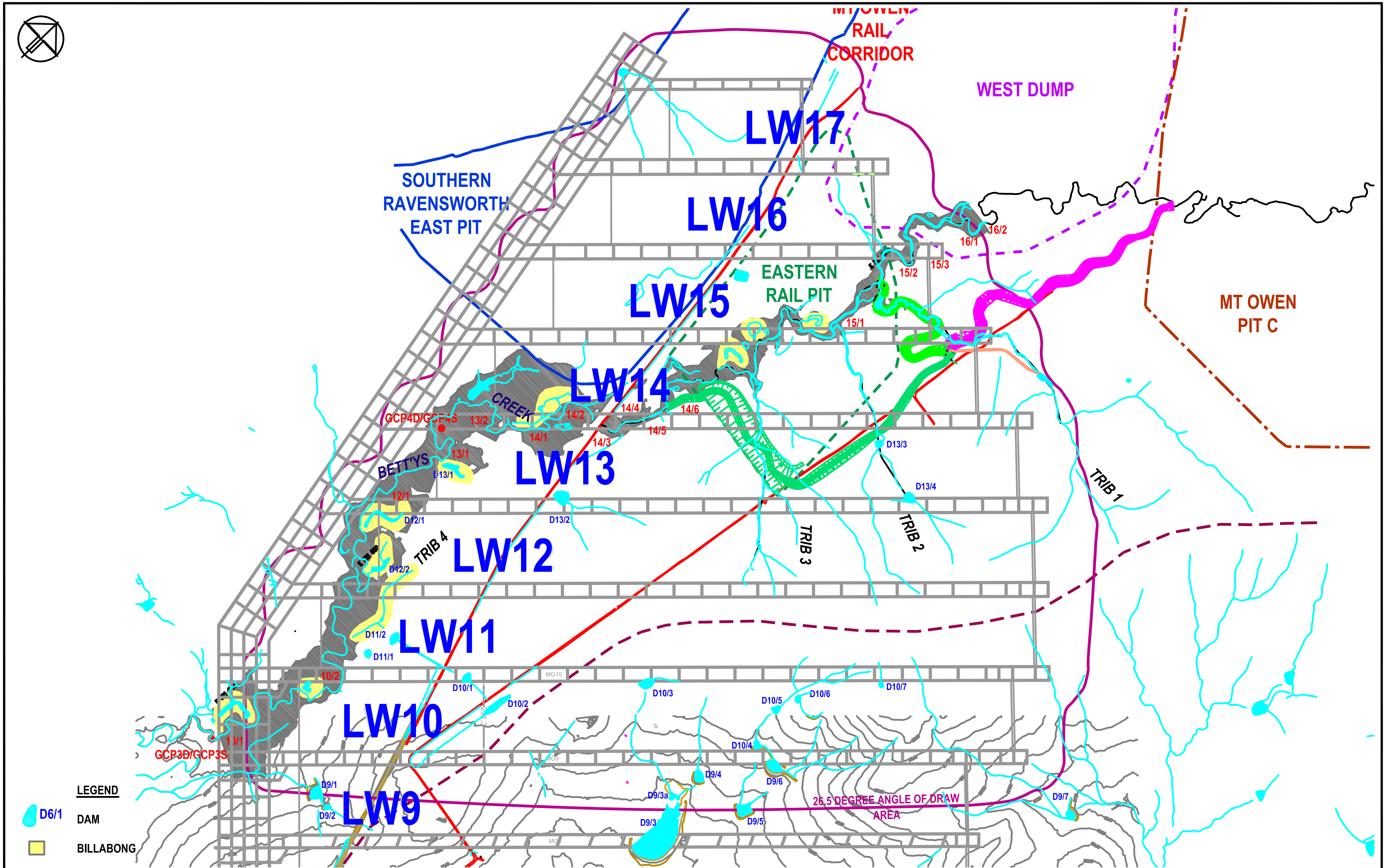
PROJECT:	GC10
DRAWN:	A. DAWKINS
DATE:	23 JULY 2007
SCALE:	1:20 000

GLENNIES CREEK COAL MANAGEMENT
PANELS 10 TO 17

HVCC PITS, DUMPS AND DIVERSIONS

GeoTerra

DRAWING 2



LEGEND

D6/1	DAM
	BILLABONG
	PIEZOMETERS
	1:100 ARI PRE SUBSIDENCE FLOOD EXTENT
	WATERSHED
P1	BETTYS CREEK PHOTO LOCATION
	SURFACE CONTOURS (5m Intervals)
	DRAINAGE LINE
	PROPOSED WORKINGS

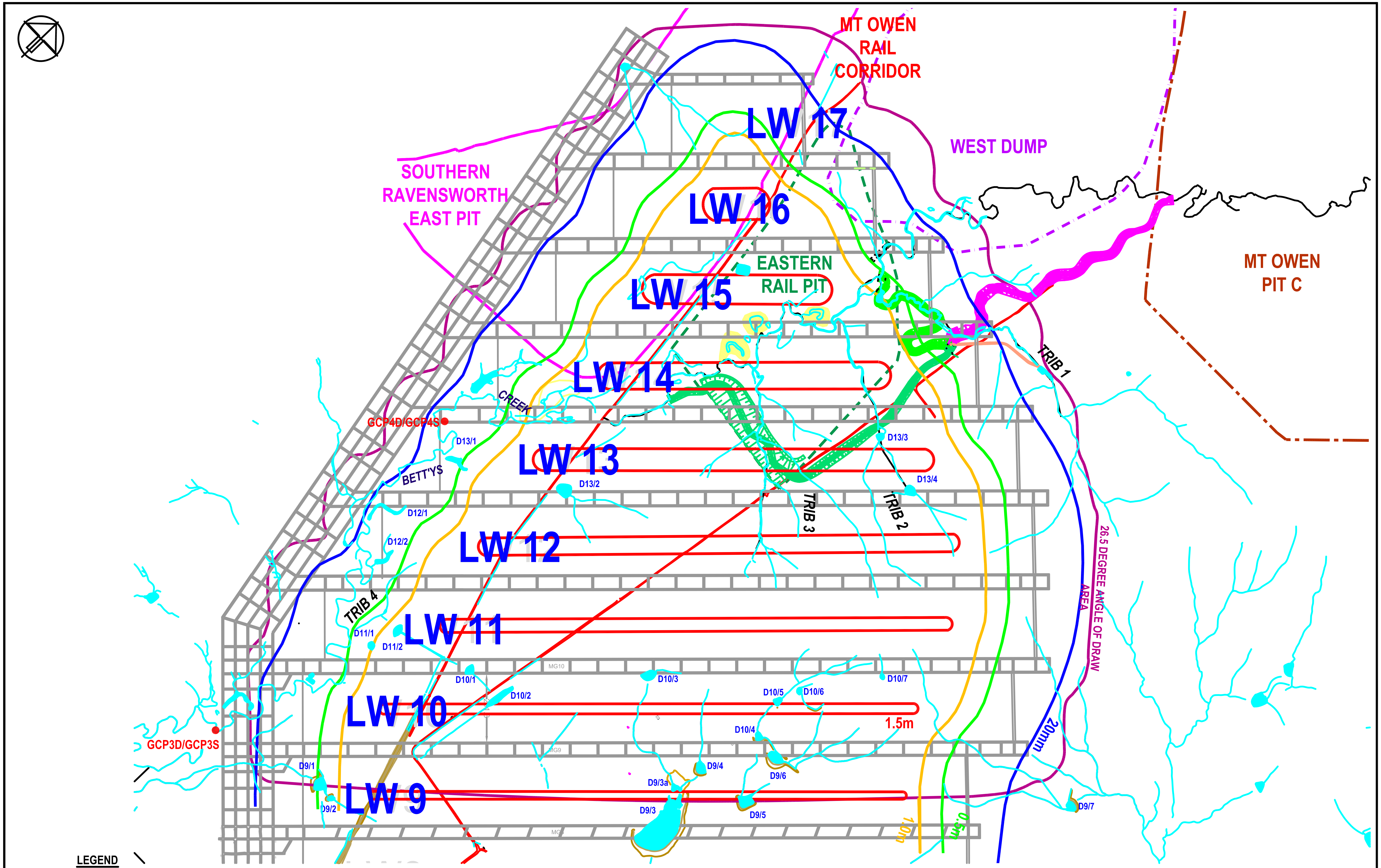
PROJECT:	GC10
DRAWN:	A. DAWKINS
DATE:	23 JULY 2007
SCALE:	1:12 500

GLENNIES CREEK COAL MANAGEMENT
PANELS 10 TO 17

PRE SUBSIDENCE TOPOGRAPHY

GeoTerra

DRAWING 3



LEGEND

D6/1	DAM
	PIEZOMETERS
	MINE WORKINGS
	0.2m SUBSIDENCE CONTOUR
	0.5m SUBSIDENCE CONTOUR
	1.0m SUBSIDENCE CONTOUR
	1.5m SUBSIDENCE CONTOUR
	DRAINAGE LINE
	STREAM BANK

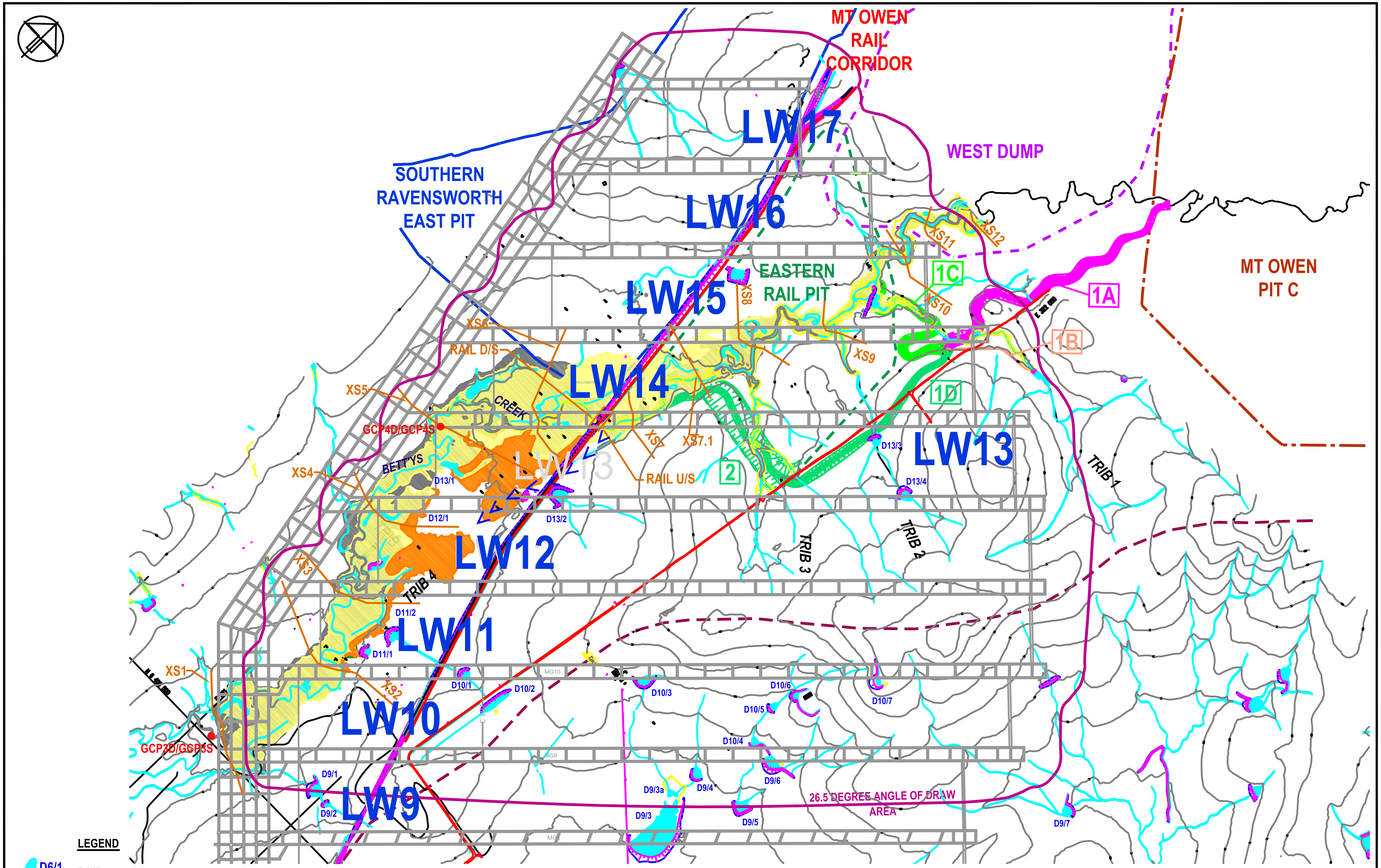
PROJECT:	GC10
DRAWN:	A. DAWKINS
DATE:	23 JULY 2007
SCALE:	1:12 500

GLENNIES CREEK COAL MANAGEMENT
PANELS 10 TO 17

PREDICTED SUBSIDENCE CONTOURS

GeoTerra

DRAWING 4



PROJECT:	GC10	GLENNIES CREEK COAL MANAGEMENT PANELS 10 TO 17	GeoTerra
DRAWN:	A. DAWKINS		
DATE:	23 JULY 2007	POST SUBSIDENCE TOPOGRAPHY	DRAWING 5
SCALE:	1:12 500		

APPENDIX A

LABORATORY ANALYSES

SYDNEY ANALYTICAL LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

GEOTERRA

77 ABERGELDIE STREET
DULWICH HILL 2203

ATTN: ANDREW DAWKINS

JOB NO: SAL17459

CLIENT ORDER: GC4

DATE RECEIVED: 11/04/06

DATE COMPLETED: 05/05/06

TYPE OF SAMPLES: WATERS

NO OF SAMPLES: 8

NATA This document is issued in accordance with NATA's accreditation requirements

Accredited for compliance with ISO/IEC 17025

Issued on 08/05/06
Lance Smith
(Chief Chemist)

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL17459
CLIENT ORDER: GC4

DATE OF COLLECTION		01/04/06	01/04/06	01/04/06	01/04/06
SAMPLES		10/2	12/2	13/2	14/1
pH		7.6	6.9	7.4	6.6
Total Dissolved Solids	mg/L	550	340	230	490
Sodium Na+	mg/L	160	75	52	140
Calcium Ca++	mg/L	8.6	16	6.6	9.3
Potassium K+	mg/L	9.4	22	14	23
Magnesium Mg++	mg/L	27	16	13	14
Chloride Cl-	mg/L	140	72	59	220
Fluoride F-	mg/L	2.2	0.76	1.1	0.93
Sulphate SO4--	mg/L	18	3	8	16
Bicarbonate HCO3-	mg/L	350	240	140	110
Conductivity	uS/cm	840	510	355	750
Total Nitrogen	mg/L	5.1	3.5	2.4	6.3
Total Phosphorus	mg/L	0.17	0.18	<0.1	0.18
Copper	mg/L	0.002	0.001	0.002	0.001
Lead	mg/L	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.001	0.003	0.004	0.004
Nickel	mg/L	<0.01	<0.01	<0.01	<0.01
Aluminium	mg/L	<0.1	<0.1	<0.1	<0.1
Iron (Dissolved)	mg/L	0.25	0.55	0.37	0.24
Manganese	mg/L	0.04	0.03	0.05	0.03
Arsenic	mg/L	<0.01	<0.01	<0.01	<0.01
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL17459
CLIENT ORDER: GC4

DATE OF COLLECTION		01/04/06	01/04/06	01/04/06	01/04/06
SAMPLES		GC3PS	GC3PD	GCP4S	GCP4D
pH		6.8	7.2	7.2	7.2
Total Dissolved Solids	mg/L	11900	7490	5800	11100
Sodium Na+	mg/L	3660	2480	1500	3200
Calcium Ca++	mg/L	215	90	140	220
Potassium K+	mg/L	13	20	15	23
Magnesium Mg++	mg/L	540	170	370	520
Chloride Cl-	mg/L	6700	3600	3160	6070
Fluoride F-	mg/L	0.53	0.29	0.75	0.53
Sulphate SO4--	mg/L	450	815	225	640
Bicarbonate HCO3-	mg/L	1220	760	710	720
Conductivity	uS/cm	18700	11400	8910	16800
Total Nitrogen	mg/L	1.1	5.3	1.4	3.5
Total Phosphorus	mg/L	0.18	0.20	0.19	<0.1
Iron (Total)	mg/L	2.3	1.0	2.9	1.5
Copper	mg/L	0.004	0.002	0.004	0.003
Lead	mg/L	0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.025	0.006	0.016	0.003
Nickel	mg/L	<0.01	<0.01	<0.01	<0.01
Aluminium	mg/L	<0.1	<0.1	<0.1	<0.1
Iron (Dissolved)	mg/L	0.04	0.07	0.02	0.18
Manganese	mg/L	0.29	0.30	0.34	0.21
Arsenic	mg/L	<0.01	<0.01	<0.01	<0.01
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL17459
CLIENT ORDER: GC4

DATE OF COLLECTION		01/04/06	01/04/06
SAMPLES		GCP4D DUP	BLANK
pH		7.1	7.2
Total Dissolved Solids	mg/L	11300	<1
Sodium Na+	mg/L	3250	<0.1
Calcium Ca++	mg/L	225	<0.1
Potassium K+	mg/L	24	<0.1
Magnesium Mg++	mg/L	500	<0.1
Chloride Cl-	mg/L	6120	<1
Fluoride F-	mg/L	0.55	<0.1
Sulphate SO4--	mg/L	630	<2
Bicarbonate HCO3-	mg/L	720	<1
Conductivity	uS/cm	17100	1.6
Total Nitrogen	mg/L	3.4	<0.1
Total Phosphorus	mg/L	<0.1	<0.1
Iron (Total)	mg/L	1.4	<0.01
Copper	mg/L	0.002	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.004	<0.001
Nickel	mg/L	<0.01	<0.01
Aluminium	mg/L	<0.1	<0.1
Iron (Dissolved)	mg/L	0.16	<0.01
Manganese	mg/L	0.19	<0.01
Arsenic	mg/L	<0.01	<0.01
Selenium	mg/L	<0.01	<0.01

SYDNEY ANALYTICAL LABORATORIES

LABORATORY DUPLICATE REPORT

JOB NO: SAL17459
CLIENT ORDER: GC4

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPD
GCP4D	pH			7.2	7.1	1
GCP4D	TDS	mg/L	1	11100	11300	2
GCP4D	Sodium	mg/L	0.1	3200	3250	2
GCP4D	Calcium	mg/L	0.1	220	225	2
GCP4D	Potassium	mg/L	0.1	23	24	4
GCP4D	Magnesium	mg/L	0.1	520	500	4
GCP4D	Chloride	mg/L	1	6070	6120	1
GCP4D	Fluoride	mg/L	0.1	0.53	0.55	4
GCP4D	Sulphate	mg/L	2	640	630	2
GCP4D	Bicarbonate	mg/L	1	720	720	0
GCP4D	Conductivity	uS/cm	0.1	16800	17100	2
GCP4D	Total Nitrogen	mg/L	0.1	3.5	3.4	3
GCP4D	Total P	mg/L	0.1	<0.1	<0.1	0
GCP4D	Iron (Total)	mg/L	0.01	1.5	1.4	7
GCP4D	Copper	mg/L	0.001	0.003	0.002	33
GCP4D	Lead	mg/L	0.001	<0.001	<0.001	0
GCP4D	Zinc	mg/L	0.001	0.003	0.004	25
GCP4D	Nickel	mg/L	0.01	<0.01	<0.01	0
GCP4D	Aluminium	mg/L	0.1	<0.1	<0.1	0
GCP4D	Iron	mg/L	0.01	0.18	0.16	12
GCP4D	Manganese	mg/L	0.01	0.21	0.19	10
GCP4D	Arsenic	mg/L	0.01	<0.01	<0.01	0
GCP4D	Selenium	mg/L	0.01	<0.01	<0.01	0

Acceptance criteria:

RPD <50% for low level (<10xMDL)
RPD <20% for medium level (10-50xMDL)
RPD <10% for high level (>50xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL17459
CLIENT ORDER: GC4

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 20th Edition, or other approved methods listed below:

4500B	pH
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
2320B	Bicarbonate HCO3-
2510B	Conductivity
4500B	Total Nitrogen
4500BF	Total Phosphorus
3111B	Iron (Total)
3111C	Copper
3111C	Lead
3111C	Zinc
3111B	Nickel
3111D	Aluminium
3111B	Iron (Dissolved)
3111B	Manganese
3114B	Arsenic
3114B	Selenium

Sulphate: Dept Mineral Resources - BaCrO4 Method

A preliminary report was faxed on 05/05/06

APPENDIX B

GROUNDWATER MODELLING