GeoTerra

DONALDSON COAL PTY LTD

ABEL COAL MINE
AREA 2
SURFACE WATER ASSESSMENT

Black Hill, NSW

ABL3 – R1A

5 May, 2011

GeoTerra Pty Ltd ABN 82 117 674 941

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ABL3-R1A (5 MAY, 2011)

GeoTerra

Donaldson Coal Pty Ltd
PO Box 37
MAITLAND NSW 2320

Attention: Phil Brown

Phil,

RE: ABEL COAL MINE AREA 2 SURFACE WATER ASSESSMENT

Please find enclosed a copy of the above mentioned report.

Yours Faithfully

GeoTerra Pty Ltd

Andrew Dawkins
Managing Geoscientist (MAusIMM CP-Enviro)

Distribution:	Original	Geoterra Pty Ltd
	1 electronic copy	Donaldson Coal Pty Ltd

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

Date	Rev	Comments
28/03/2011		First Draft
05/05/2011	A	Incorporate Reviewers comments

FIGURES

TABLES

EXECUTIVE SUMMARY

This study provides a baseline, pre-mining assessment of surface water systems within the Application Area for the proposed extraction of sections (up to 2.8m) of the 4.2m thick Upper Donaldson Seam in Panels 14 to 26, South East Mains, Tailgate Headings and East Install Headings within SMP Area 2 of the Abel Underground mine.

The proposed workings are contained within a 211ha section of the 2755ha mining lease ML1618, whilst the Study Area is defined as being within the predicted extent of the 20mm subsidence zone.

The Study Area contains steep to undulating, ephemeral, first and second order, Schedule 1 tributaries and the second order, Schedule 2 channel of Viney Creek, which drains to the northeast from Black Hill into Weakleys Flat Creek and the Hunter River via Woodberry Swamp.

The Study Area has been previously mined to the east in the “Area 1” workings, whilst the Donaldson Open Cut is located to the north and the Underground Tasman Mine is located to the south of the proposed mining area.

Subsidence of up to 1.193m, along with maximum strains of 6 to 11mm/m and tilts of 17 to 49.5mm/m has been measured in Area 1, which had panels with up to 85% extraction that were up to 150m wide and 50 - 105m below surface, with up to 2.8m of mining height.

A section of Viney Creek has also been identified as being within the 1:100 ARI flood level.

Several small dams are located within the Study Area 20mm subsidence zone.

The objective of this study is to provide an assessment of the potential impact of subsidence on surface water features in the Study Area, and to provide management strategies and controls to minimise and manage subsidence impacts on the following features;

- the catchment and Schedule 1 tributaries of Viney Creek;
- the Schedule 2 main channel of Viney Creek;
- any dams located within the 20mm subsidence zone, and;
- seeps and springs that may be present that discharge into streams.

Donaldson Coal is anticipating to start bord and pillar extraction in Area 2 during October 2011 using the continuous miner method.

The Upper Donaldson Seam working height is up to 2.8m, whilst the depth of cover ranges from 100 – 150m.

The mine plan has been through a planning, review and risk assessment process to assess the implications and management measures on a range of subsidence issues, including the surface water system above the proposed mine layout.

Between 70% to 80% of the coal will be extracted depending on the subsidence management and operational issues required, with the use of Subsidence Control Zones (SCZ) to protect the Schedule 2 reach of Viney Creek and Principal Residences. The level of extraction and use of the SCZ will be determined by the degree of subsidence protection required for surface water and other significant features.

Maximum subsidence of up to 1.45m is predicted, with the final subsidence being affected by the topographic relief and stiffness of the overburden.

Maximum tilts are predicted to be less than 36mm/m along with compressive and tensile strains of up to 24mm/m.

Potential soil cracking of up to 190mm wide have been predicted over the maximum strain areas where tensile strains exceed 1.5mm/m (Ditton Geotechnical Services, 2011)

No pillar extraction will be conducted in areas with less than 50m depth of cover or within the Viney Creek Schedule 2 Subsidence Control Zone (SCZ).

Due to the low total subsidence and strains at surface and the designed disconnection between the free draining (zone A) and hydraulically disconnected (Zone B) fracture zones, direct hydraulic fracture connection from the surface to the underground workings is not anticipated where cover exceeds 80m, although the presence of an unknown, high permeability fault or dyke zone over the subsidence area could increase the potential for hydraulic inter-connection.

Indirect and discontinuous sub-surface fracturing and hydraulic connectivity may potentially occur over the workings, although no direct connection to surface is anticipated.

Although no adverse effects are anticipated, the possible worst case surface water system impacts that could potentially occur are;

- crack development in a tributary (Schedule 1) stream bed with a potential for loss of stream flow and/or increased bed and bank instability in areas with partial extraction, and / or;
- a low potential for stream flow reduction or lowering of discharge elevation for any, as yet unrecognised, groundwater seeps that may be present

Based on this study, the first and second order (Schedule 1) tributaries of Viney Creek over Panels 17, 18, 20, 22, 23 – 26 as well as the Tailgate Headings, East Install Headings and South East Mains have a low risk of subsidence effects which cannot be managed or remediated as has been the case in panels extracted in SMP Area 1. It is considered unlikely that it will be necessary to adjust the proportion of extraction in the panels to reduce subsidence effects on the streams.

In the more wooded and hilly headwaters it is anticipated that if any stream bed cracks did form, they would essentially be indiscernible in the steep alluvial / colluvial or (limited) exposed bedrock areas.

There is unlikely to be any loss of stream flow in the ephemeral channels within higher subsidence or strain areas in the steep creek beds. Due to the steeper topography, it is anticipated that if any transfer of stream flow to the shallow groundwater system does occur, it would re-emerge a short distance downstream, on the basis there is no hydraulic connection to the workings.

Cracking is not anticipated to have an observable effect on stream bed or bank stability or stream water quality in the Schedule 1 gullies, whilst bed and bank instability and downstream sediment transfer through downstream erosion is not predicted.

No reversal of flow or significant adverse effects on stream ponding are anticipated.

The 1:100 year ARI flood zone may be expanded by up to 5% of its current extent in the lower reaches of Viney Creek.

A preliminary subsidence management and monitoring strategy has been prepared to outline appropriate mitigation and remediation strategies to be used during and after mining in Area 2.

Any adverse effects that occur and require rehabilitation of the land surface, stream bed and bank stability, stream flow or water quality will be undertaken where access is possible, following preparation of a specific mining rehabilitation plan for the activity.

1. INTRODUCTION

This study provides a baseline, pre-mining assessment of surface water systems overlying the proposed Panels 14 to 26, South East Mains, Tailgate Headings, East Install Headings and 20mm subsidence zone (SMP Area 2), within the Abel Underground mine.

The proposed workings are contained within a 211ha section of the 2755ha mining lease ML1618, with the Study Area being defined as within the predicted extent of the 20mm subsidence zone.

The study's objective is to provide an assessment of the potential impact of subsidence on surface water features in the Study Area and to provide management strategies and controls to minimise and manage potential subsidence impacts on the following features;

- the catchment and Schedule 1 tributaries of Viney Creek;
- the Schedule 2 main channel of Viney Creek;
- any dams located within the 20mm subsidence zone, and;
- seeps and springs that may be present that discharge into streams.

The report is to be submitted to the NSW Department of Industry and Investment (I & I) as part of a Subsidence Management Plan (SMP) Area 2 application for approval to continue the Abel underground bord and pillar mine near Black Hill in NSW.

A prior surface water related assessment was conducted for the Abel Mine area in August 2006 for the original Environmental Assessment application (Evans and Peck, 2006) and this report updates the streams and dam component of the previous study.

Donaldson Coal Pty Ltd has previously mined Panels 1 and 2 in Area 1 within the Upper Donaldson Seam since May 2008 as shown in **Table 1**.

Table 1 Previous Abel Mine Extraction

Panel	Start	Finish	Maximum Subsidence m*	Maximum Strain mm/m *	Maximum Tilt mm/m *
1	12 July 2010	22 December 2010	1.54 / 1.19	19 / 11	53 / 49.5
2	17 September 2010	12 November 2010	1.66 / 1.017	31 / 8.5	75 / 44

NOTE: * a / b = predicted (as per SMP 2009 report) and observed

The previously extracted panels are shown in **Figure 1**.

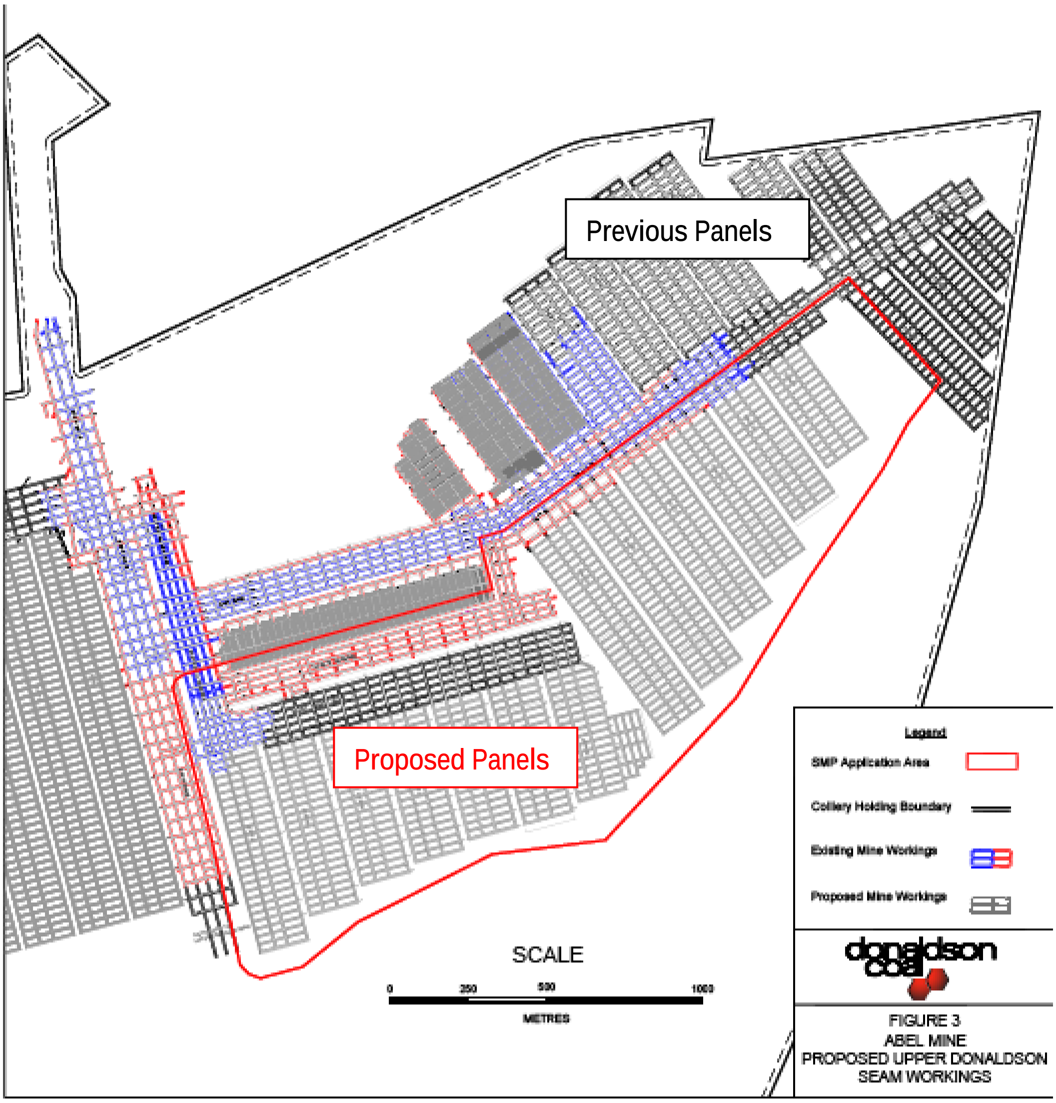

Figure 1 Previously Mined Panels and Proposed Workings

The Abel mine is located in the hilly to undulating area of Black Hill in an area comprised of native bushland, cleared livestock grazing land, and rural residential land.

The Study Area is contained within land owned Black Hill Land Pty Limited, the Catholic Diocese of Maitland - Newcastle, as well as a narrow strip traversing the area owned by Hunter Water Corporation and ten private rural residential land holdings.

The Study Area contains ephemeral catchments draining to the north from Black Hill, with the main Schedule 2 channel of Viney Creek draining to the north north-east as shown in **Figure 2**.

A limited number of small (<1ML) stock watering dams are located within the predicted 20mm subsidence area.

The subsidence area is defined by the cover depths and an angle of draw of 26.5^{o} from the outer periphery of the underground workings to the surface as well as the predicted 20mm vertical limit of subsidence.

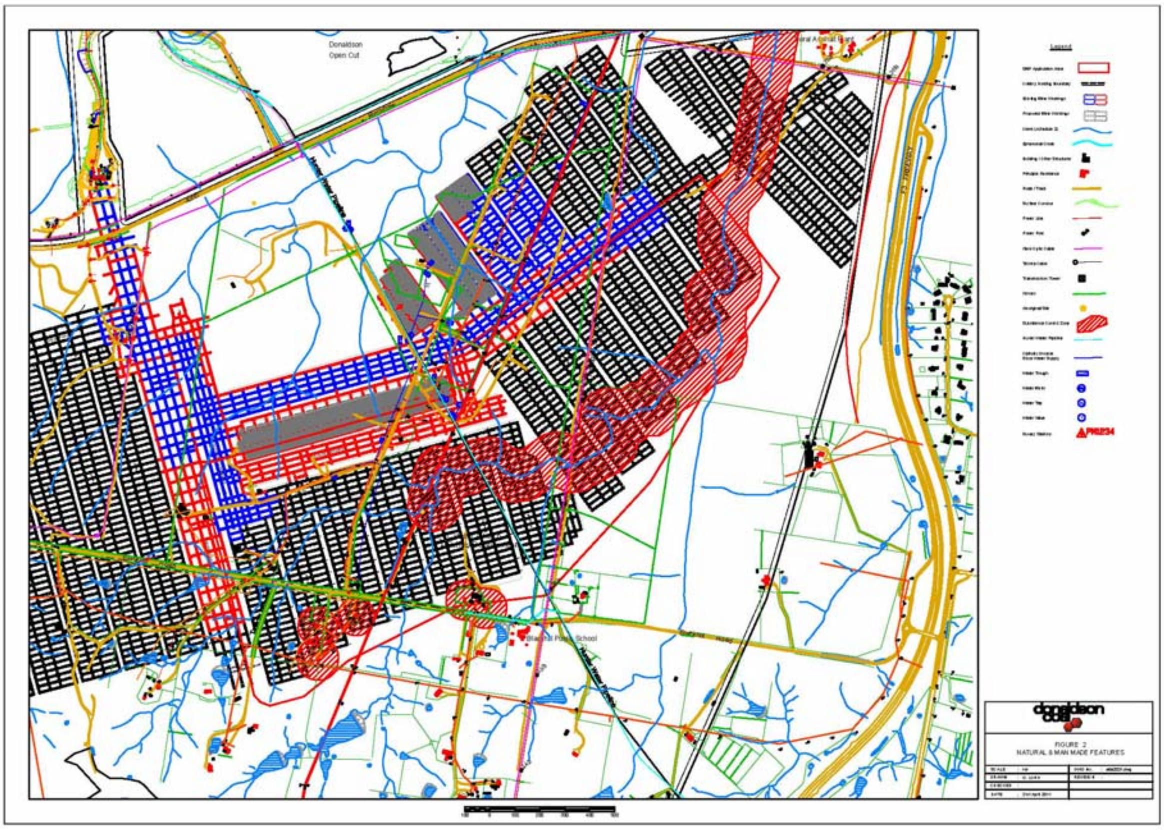

Figure 2 Site Features

2. PROPOSED MINING

The proponent intends to mine the Upper Donaldson Seam which dips to the south east from 2 - 5^{o}.

Pillar extraction is planned to commence in October 2011, with subsequent mining proceeding to the west through to Panel 26, the South East Mains, Tailgate Headings and East Install Headings as shown in **Figure 3**.

The pillar extraction panels will have cover depths ranging from 100 - 150m and average mining heights ranging from 2.0 - 2.8m. The South East Mains, Tailgate Headings and East Install Headings will also be extracted on retreat after the production panels are completed and will have panel void widths of 89 – 140m. The mining height in these panels will also range from 2.0 - 2.8m.

Panel development headings will be 5.5 m wide and range from 2.4 - 2.6m high, depending on seam thickness.

Barrier pillars between production panels will generally have widths of 24.5 and pillar width/height ratios of 9.4 - 11.1 and are expected to behave elastically in the long term (i.e. strain hardening characteristics are likely to develop if the pillars are overloaded).

A solid barrier between the finishing ends of the production panels and the adjacent East Mains and South East Mains will be 19.5 - 30.5m wide with pillar width/height ratios of 7.5

- 11.7 and are also expected to behave elastically in the long term

Barrier pillar between Panel 1 and the Tailgate Headings will have widths of 16.5m and pillar width/height ratios of 5.5 to 6.6 and are expected to yield after secondary extraction is completed.

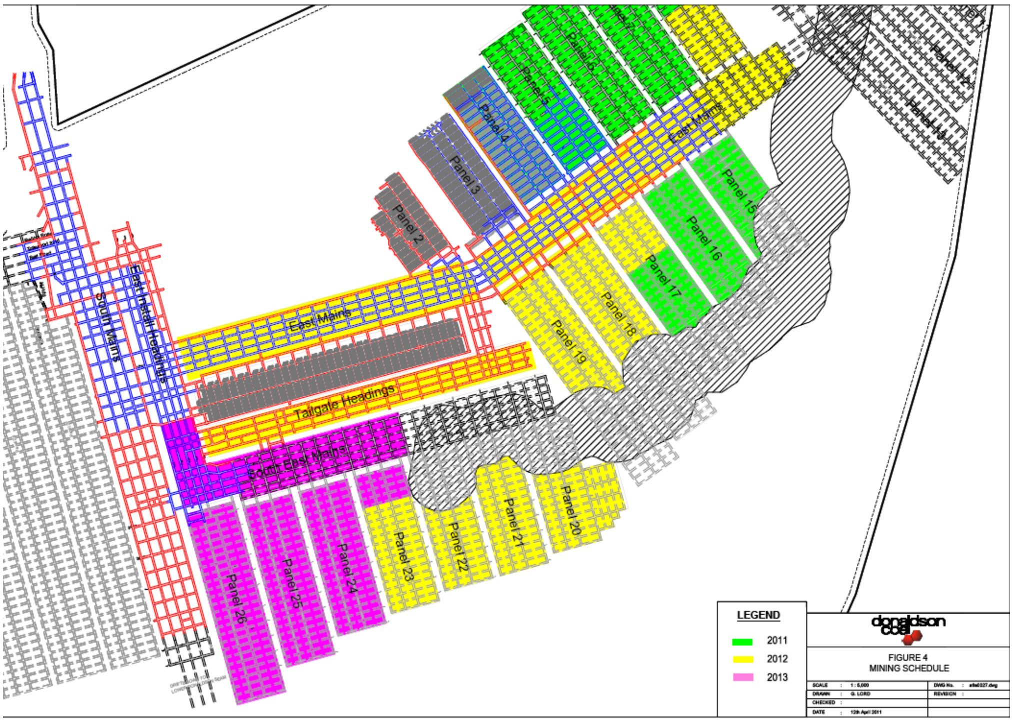

Figure 3 Proposed Panels 14 to 26

Access to the current and proposed Abel workings is via a portal and surface infrastructure located within the Donaldson Open Cut mining area in ML1618.

Donaldson Coal Pty Ltd is planning to utilise bord and pillar extraction of the Upper Donaldson Seam.

The Upper Donaldson Seam is up to 4.2m thick, however the development height is from 2.4 – 2.6m whilst the extraction height ranges from 2.0 – 2.8m, with a depth of cover from 100 – 150m as shown in **Figure 4**.

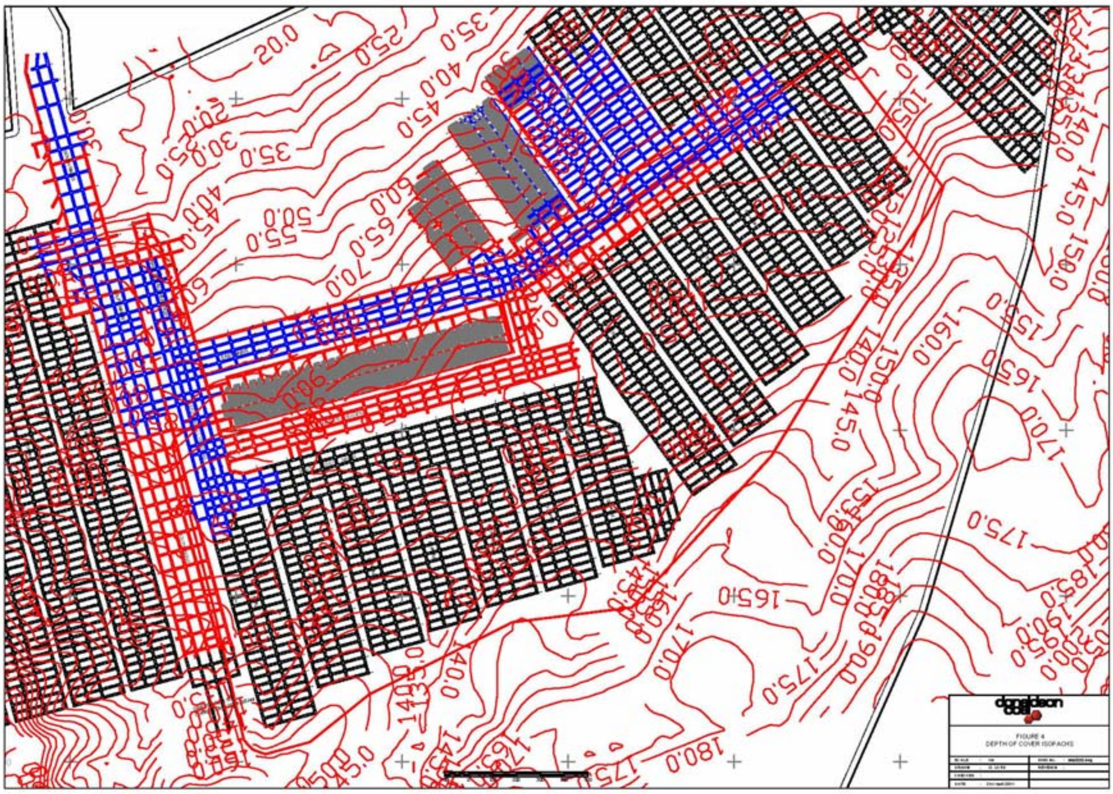

Figure 4 Existing and Proposed Mine Layout and Depth of Cover

Up to 85% of the coal will be extracted using the bord and pillar method with the degree of extraction depending on the subsidence management and operational issues required for each panel.

2.1 Mine Plan Review and Risk Assessment

The current mine plan has been through a planning and risk assessment process, with assessment of subsidence over previously mined panels being reviewed for the implications on a range of subsidence issues, such as the surface water system above the proposed mine layout.

3. ASSOCIATED STUDIES

In order to complete this assessment, the following report has been reviewed;

- Subsidence Predictions and Impact Assessment For the Proposed SMP Area 2 Pillar Extraction Panels at Abel Mine, Black Hill (Ditton Geotechnical Services Pty Ltd Report ABL-002/1 2011).

4. GENERAL DESCRIPTION

4.1 Previous Mining

The Area 1 workings at Abel are located to the north of the proposed Area 2 mining area and comprise both first workings and pillar extraction areas.

Subsidence has affected the surface where cover depths range between 50 – 105m over areas of “full” extraction where subsidence troughs range up to 1.19m, with tilts up to 49.5mm/m and strains up to approximately 20mm/m.

Additional stooks were left to support the mine roof where sub-vertical faults intersected the Panel 1 and 2 workings, with the stooks estimated to have decreased maximum subsidence.

As shown in **Table 2,** the outcome of the subsidence review indicates that in general, the measured maximum subsidence values plot below the predicted upper 95% confidence limits for a given panel geometry.

Table 3 indicates the outcome of the review indicates that 88% of the measured maximum tilts plot within the upper and lower 95% confidence limits for the predicted values. Predicted tilts were exceeded by 1.27 times the measured values at two locations.

The prediction exceedances for tilt above Panels 1, 3 and 4 may have been due to 'discontinuous' subsidence behaviour exacerbated by sloping surface topography near water courses and/or secondary subsidence profile development due to irregular stook geometry or face extraction height variation in the workings. Further data is required to determine if the model is actually under-predicting tilt and curvature significantly and therefore require re-calibration.

Table 2 Area 1 Panels 1 to 4 Predicted Vs Monitored Subsidence

Panel No.	Line/ Chain from start	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	Panel# e%	Predicted (mean -U95%CL)		Measured	
							Subsidence S_{max} (m)	S_{max}/Te (m/m)	Subsidence S_{max} (m)	S_{max}/Te (m/m)
1	CL 60	120	105	1.14	2.8	98	1.03 - 1.17	0.38 - 0.43	1.193	0.42
	CL 137	120	100	1.20	2.8	93	0.85 - 0.96	0.33 - 0.37	0.788*	0.30*
	CL 626	120	90	1.33	2.35	98	0.97 - 1.08	0.42 - 0.47	1.027	0.45
	XL 275	120	98	1.22	2.35	98	0.91 - 1.00	0.40 - 0.45	0.99	0.43
2	CL 75	150	67	2.24	2.5	92	1.29 - 1.33	0.56 - 0.58	1.004	0.44
	XL 124	150	75	2.00	2.5	83	1.14 - 1.20	0.52 - 0.58	0.900	0.43
3	CL 73	160.5	60	2.68	2.5	95	1.33 - 1.38	0.56 - 0.58	0.835	0.35
	CL 260	160.5	78	1.89	2.5	95	1.33 - 1.38	0.56 - 0.58	0.933	0.39
	XL 170	160.5	70	2.29	2.5	95	1.33 - 1.38	0.56 - 0.58	0.817	0.34
4	CL 45	160.5	55	2.92	2.5	95	1.22 - 1.27	0.56 - 0.58	0.900	0.41

Notes:

- e% = panel extraction ratio. Panel 1 had only one central row of 3 m wide (average) x 19 m long stooks. Panels 2 to 4 had 2 stook rows with additional stooks left adjacent to the fault through Panel 2.

* - subsidence in Panel 1 reduced by additional coal stooks left beneath a fault and where the Breaker Line supports were buried by a goaf fall.

Bold - Measured value exceeded predictions by > 10%.

Table 3 Area 1 Panels 1 to 4 Predicted Vs Monitored Tilt

Panel No.	Line/ Chain from start	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	Panel# e%	Predicted Tilts (mean - U95%CL) (mm/m)	Measured (mm/m)
1	CL 60	120	105	1.14	2.8	98	26 - 39	49.5
	CL 137	120	100	1.20	2.8	93	20 - 30	27
	CL 626	120	90	1.33	2.35	98	24 - 36	22
	XL 275	120	98	1.22	2.35	98	22 - 33	34 - 42
2	CL 75	150	67	2.24	2.5	92	47 - 70	44
	XL 124	150	75	2.00	2.5	83	36 - 54	19 - 27
3	CL 73	160.5	60	2.68	2.5	95	49 - 73	41
	CL 260	160.5	78	1.89	2.5	95	43 - 64	29
	XL 170	160.5	70	2.29	2.5	95	49 - 73	14 - 45
4	CL 45	160.5	55	2.92	2.5	95	43 - 65	58

- e% = panel extraction ratio. Panel 1 had only one central row of 3 m wide (average) x 19 m long stooks. Panels 2 to 4 had 2 stook rows with additional stooks left adjacent to the fault through Panel 2.

Bold - Measured value exceeded predictions by > 10%.

As shown in **Table 4**, to-date, maximum measured tensile and compressive strains above Panels 1 to 2 have ranged between +/- 11 mm/m, with local strains of up to 30 mm/m indicated by observed maximum crack widths of 180 mm (Panel 1), 50 mm (Panel 2) 260 mm (Panel 3), 300 mm (Panel 4).

Some compressive shear failures with associated uplift of 100 mm to 150 mm have also been observed above Panel 3.

Table 4 Area 1 Panels 1 to 4 Predicted v. Measured Horizontal Strain

Panel No.	Line	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	Panel# e%	Predicted Strains^ (mean - U95%CL)		Measured Strains	
							Tensile $+E_{min}$ (mm/m)	Compressive $-E_{max}$ (mm/m)	Tensile $+E_{min}$ (mm/m)	Compressive $-E_{max}$ (mm/m)
1	CL 60	120	105	1.14	2.8	98	11 - 17	14 - 22	11	11
	CL 137	120	100	1.20	2.8	93	9 - 14	12 - 18	4	5
	CL 626	120	90	1.33	2.35	98	11 - 16	14 - 20	4	9
	XL 275	120	98	1.22	2.35	98	10 - 15	13 - 19	8	11
2	CL 75	150	67	2.24	2.5	92	20 - 30	25 - 38	6	9
	XL 124	150	75	2.00	2.5	83	16 - 24	21 - 31	5	7
3	CL 73	160.5	60	2.68	2.5	95	21 - 31	27 - 40	7	2
	CL 260	160.5	78	1.89	2.5	95	21 - 31	24 - 36	8	6
	XL 170	160.5	70	2.29	2.5	95	19 - 28	27 - 40	n.a.	n.a.
4	CL 45	160.5	55	2.92	2.5	95	19 - 29	24 - 37	n.a.	n.a.

- e% = panel extraction ratio. Panel 1 had only one central row of 3 m wide (average) x 19 m long stooks. Panels 2 to 4 had 2 stook rows with additional stooks left adjacent to the fault through Panel 2.

Bold - Measured value exceeded predictions by > 10%.

^ - Strains calculated by multiplying predicted curvatures by 10.

4.2 Local Catchments

The Abel Underground Mine area is located within the lower section of the Hunter River catchment and consists of low undulating forested hills with patches of cleared land for rural/residential properties.

A ridgeline associated with Black Hill runs east-west through the proposed underground mine area, with the ephemeral tributaries of Buttai Creek, Viney Creek, Weakleys Flat Creek and Four Mile Creek draining to the north and Long Gully as well as Blue Gum Creek draining to the south and east of the ridgeline toward Pambalong Nature Reserve.

Surface topography in Area 2 is varies from the steeper to lower slope foothills of Black Hill, with a range of approximately 16m to 68m AHD.

The proposed mining area is predominantly above the 1:100 year ARI flood extent, although the lower reaches can be prone to flooding.

Stream flow is generated from surface runoff along with small, ephemeral, shallow groundwater seeps with runoff occurring for short periods following rainfall events.

4.2.1 Viney Creek

The ephemeral Viney Creek sub-catchment overlies the proposed Area 2 workings and drains to the north into Weakleys Flat Creek then Woodberry Swamp prior to entering the Hunter River.

The sub-catchment is approximately 935 hectares, which represents about 34 percent of the total underground mine area.

A large portion is cleared land that previously supported chicken production.

Viney Creek contains bed and bank material predominantly consisting of soil and gravel, with occasional outcropping sandstone. The channel width ranges from 1.5 - 3m, and channel height ranges from 0.5 - 1.5m. There was no flow in the creeks during the 2006 survey, but small ponds were observed (GSS, 2006). The creek is heavily vegetated and in places is almost fully choked with weeds and reeds. Outside of these areas, it has a high cover of natural forest / riparian shrub vegetation, with lesser, although prevalent weeds.

The creek banks are predominantly composed of dark brown silty clay, which is eroded in places with vertical banks of up to 1.5 - 2.0m high, and the stream bed is composed of a sandy/small gravel alluvium resting on top of the incised silty clay stream bed (Geoterra, 2009).

Viney Creek is classified as a Schedule 2, 2^{nd} Order stream to the south of Panels 14 – 19 and north of Panels 21 – 26. as shown in **Figure 2**.

4.2.2 Viney Creek Water Quality

The available data indicates that Viney Creek is derived from mostly surface runoff, with some proportion of groundwater baseflow, whilst Weakleys Flat Creek has been sustained by groundwater baseflows over recent dry years. The groundwater is probably from the near surface zone (i.e.: alluvium/colluvium and/or weathered bed rock) and is not connected with deeper regional groundwater.

As shown in **Figure 5,** water quality is highly variable with lower salinities and circum-neutral pH during periods of high runoff, with higher salinities during extended dry periods when groundwater seepage dominates in the upper catchment.

The overall contribution to stream flows from groundwater seepage is less than 2% of total runoff, with a large proportion of the seeps lost through evaporation (PJ Dundon & Assoc, 2002).

A plot of salinity and pH from upstream to downstream over the proposed Area 2 and existing Area 1 workings in late March 2009 is shown in **Figure 6** from locations shown in **Figure 7.**

Figure 5 indicates that salinity of the creek always exceeds the ANZECC 2000 criteria, whilst pH generally does not, whilst **Table 5** indicates nitrogen and phosphorous nutrients in the creek as well as copper, and occasionally zinc, exceed the ANZECC 2000 criteria.

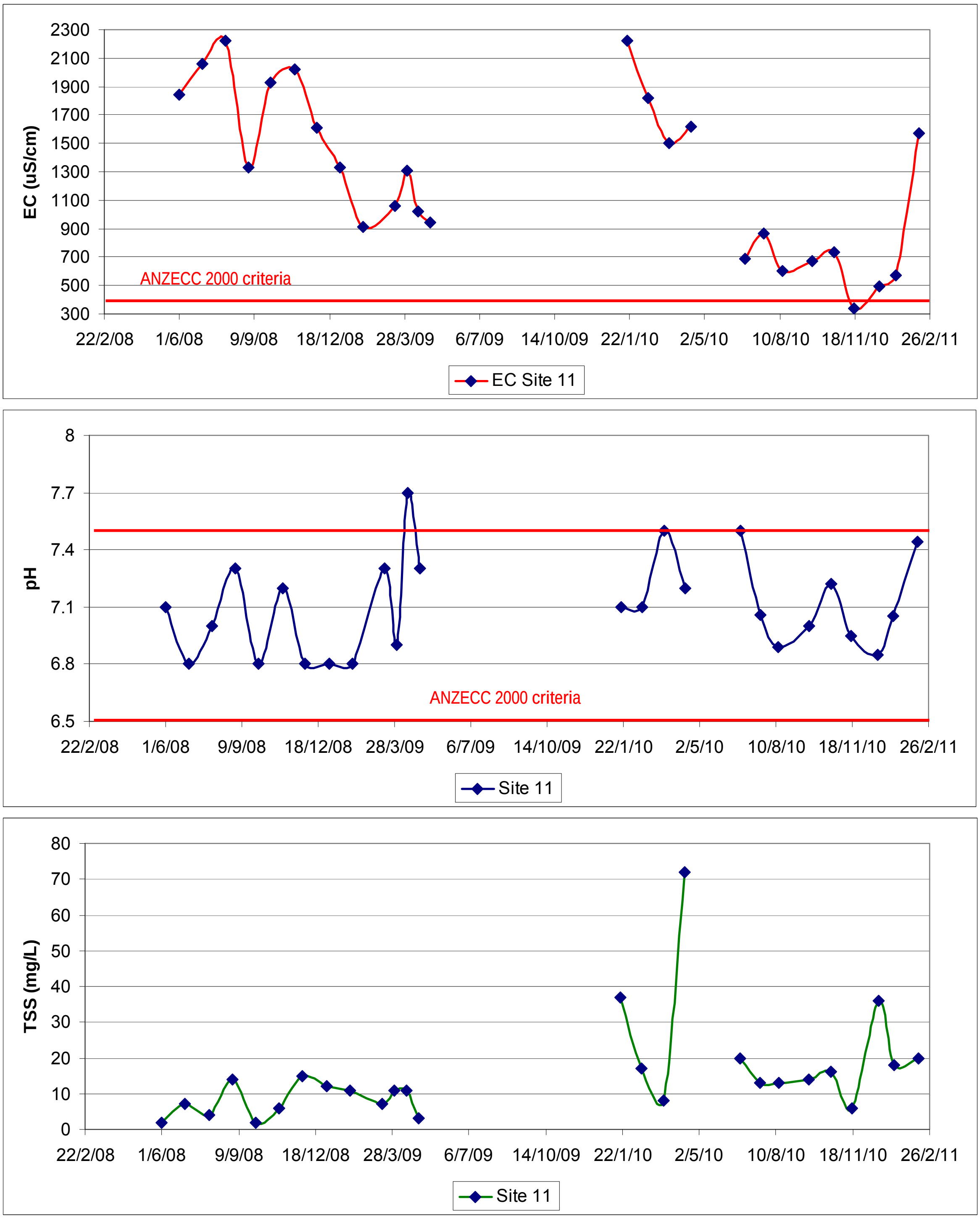

Figure 5 Viney Creek Salinity, pH and Total Suspended Solids

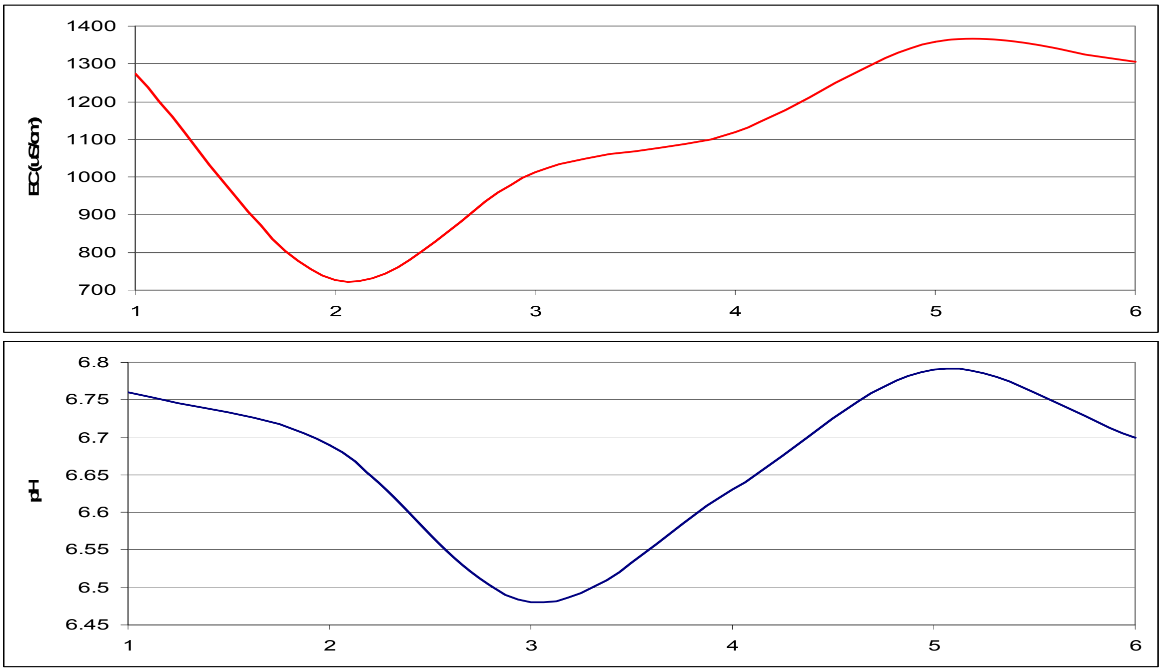

Figure 6 Viney Creek Salinity and pH (31/3/209)

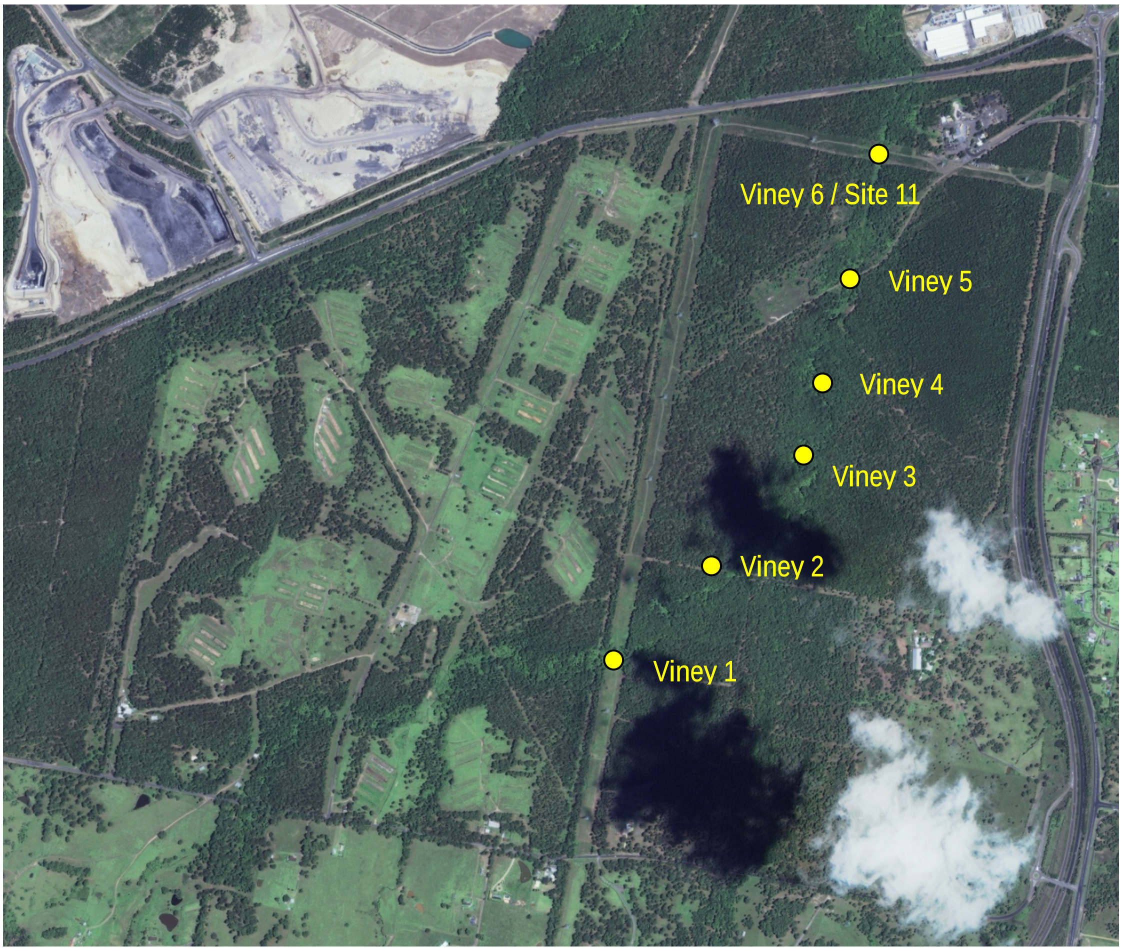

Figure 7 Viney Creek Sampling Sites

Table 5 Viney Creek Chemistry

SITE	DATE	TDS	Na	Ca	K	Mg	Cl	F	HCO_3	SO_4	TN	TP	DOC
1	3/7/09	570	160	14	8.7	28	265	0.34	110	47	**1.8**	**0.38**	19
2	31/3/09	440	115	11	12	23	200	0.3	85	22	**1.7**	**0.38**	25
3	3/7/09	550	140	21	8.8	26	255	0.27	78	45	**1.6**	**0.30**	20
6	31/3/09	760	215	18	18	35	360	0.42	140	36	**2.2**	**0.18**	30
6	3/7/09	470	115	24	8.1	23	190	0.29	120	37	**1.5**	**0.37**	22
ANZECC		-	-	-	-	-	-	-	-	-	0.25	0.02	-

SITE	DATE	Fe_T	Fe_F	Mn_T	Mn_F	Cu_F	Pb_F	Zn_F	Ni_F	Al_F	As_F	Li_F	Ba_F	Sr_F
1	3/7/09	2.1	0.47	0.03	0.07	**0.003**	<0.001	0.002	<0.01	<0.01	<0.01	0.009	0.04	0.21
2	31/3/09	3.6	0.90	0.04	0.01	<0.001	<0.001	0.004	<0.01	0.04	<0.01	0.013	0.03	0.29
3	3/7/09	3.1	0.85	0.06	0.02	**0.003**	<0.001	**0.009**	<0.01	0.04	<0.01	0.006	0.04	0.19
6	31/3/09	1.7	0.91	<0.01	<0.01	**0.003**	<0.001	0.002	<0.01	0.05	<0.01	0.018	0.04	0.28
6	3/7/09	2.7	1.0	0.03	0.01	**0.002**	<0.001	0.016	<0.01	0.04	<0.01	0.008	0.05	0.3
ANZECC		-	-	1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.024	-	-	-

NOTE: all units in mg/L except as shown T = total F = 0.45uM filtered

ANZECC 2000 default trigger values for risk of adverse effects from physical and chemical stressors in SE Aust. Upland Rivers or Upland Freshwaters SE Aust streams

(highlighting indicates values outside ANZECC 2000 criteria)

4.3 Geology

The Upper Donaldson Seam outcrops in the Donaldson Open Cut area as shown in **Figure 8**. In the proposed mining area, the Upper Donaldson Seam lies within a shallow basinal structure with a gentle plunge to the south.

Limited coal extraction has been conducted from the Upper Donaldson Seam in Area 1 of the Abel Underground and within the Donaldson Open Cut.

The Study Area lies in the Newcastle Coalfield within the Sydney Basin, with the overburden comprising part of the Dempsey Formation, which is part of the Permian, Tomago Coal Measures.

The overburden consists of gently, south-west dipping (2 – 5^{o}) strata of the Tomago Coal Measures, which generally comprise interbedded sandstone, shale, carbonaceous mudstone, tuffaceous claystone and coal. The coal seams present (in descending order) include the Sandgate, Upper and Lower Buttai, Beresfield, Upper and Lower Donaldson, Big Ben and Ashtonfield Seams.

The generalised stratigraphy of the Tomago Coal measures (after Robinson 1969) is shown in **Figure 8**.

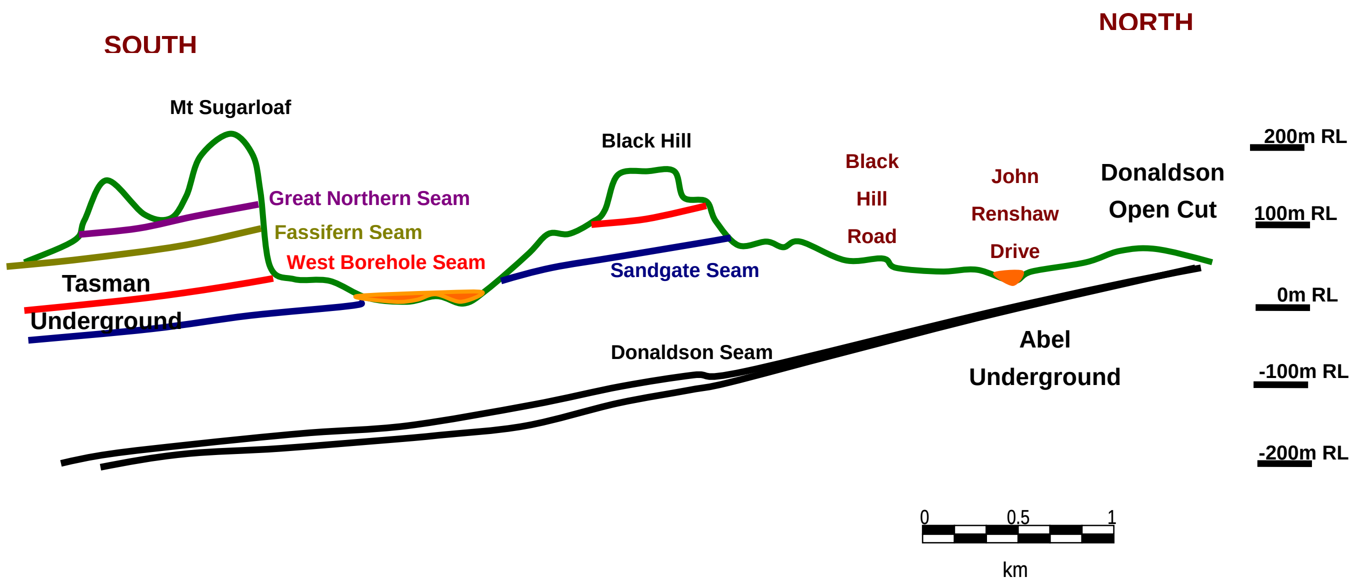

Figure 8 Schematic Geological Cross Section

Several significant NW:SE striking faults and dykes occur along Buttai Creek and Long Gully Creek to the west, whilst an 8m throw reverse fault is present in the north-east corner of the Study Area with a north westerly strike. The south-eastern bedding dip is associated with the southern arm of the Four Mile Creek Anticline, which is located to the west of the site.

Surface joint patterns measured on the sandstone cliff lines and outcrops to the south of the Study Area consist of a sub-vertical, widely spaced, planar to wavy, persistent joint sets striking between 025º and 035º (NNE to NE). A sub-vertical joint set striking at approximately 135º (NW:SE) is also present. The trends of the cliff faces are similar to the above joint sets.

4.4 Hydrogeology

In the Abel Underground Mine area, permeability is generally highest in the coal seams and areas of significant fracturing or faulting. However, overall the coal measures have low permeability. The interbedded sandstones and siltstones have very limited intergranular porosity and little secondary permeability and storage in joints.

Groundwater occurs in the alluvial overburden, which comprises mainly swamp, floodplain and estuarine sediments, with limited hydraulic connectivity between the alluvium and coal measures.

Groundwater flow in the coal measures is controlled by the regional topography, with recharge occurring in areas of elevated terrain and then slow movement down-dip or along strike to areas of lower topography, with a lateral flow component through the southern and eastern boundaries. This flow is believed to be limited due to the substantial overburden cover (up to several hundred metres).

Groundwater levels in the Donaldson Seam show an overall pattern of flow to the east, south and west from a central ridge which extends southwards from the Donaldson Open Cut which is largely independent of the local topography. The contours also show the influence of dewatering in the Donaldson Open Cut with a prominent cone of depression located to the north of John Renshaw Drive.

A similar flow pattern is apparent for the overburden, with groundwater levels about 5 - 10m higher above the Donaldson Seam, with a consistent pattern of lower pressure heads with depth.

Groundwater levels in the alluvium/colluvium and weathered bedrock, show a much closer relationship to the local topography whilst flow in the deeper coal measures is assessed to be more regionally controlled.

The alluvium around Hexham Swamp and the wetlands of Pambalong Nature Reserve is believed to be in hydraulic continuity with the swamp, but there is believed to be negligible hydraulic connection between the swamps and the deeper groundwater.

Rainfall recharge occurs to the coal seams where they outcrop and into the alluvial aquifers. The alluvial aquifers are likely to be in hydraulic continuity with Hexham Swamp in the east and Wallis Creek to the west of the Abel Underground Mine area. During periods of high stream flow, surface water courses are likely to contribute to this alluvial aquifer recharge. However, stream flows from rainfall runoff are reported to be short-lived after rainfall events.

The coal seams, where covered by overburden, are recharged mainly by flow along the bedding from elevated areas where the beds are exposed in outcrop, with minimal downward percolation through the overburden. After reaching the water table, flow is predominantly down-gradient along the more permeable horizons, but also with a component of continuing downward flow to recharge underlying coal seam aquifers.

Rainfall recharge rates within the hard rock outcrop area are believed to be relatively low (below 10 mm/yr). However, where alluvial deposits occur, recharge rates may be as high as 100mm/yr.

Groundwater discharge occurs through evaporation, seepage and spring flow where the water table intersects the land surface, and through baseflow contributions to creeks, rivers and Hexham Swamp, including discharge to the alluvium where it occurs. There is almost no existing groundwater abstraction in the Abel Underground Mine area other than for coal mine dewatering at Donaldson Open Cut Mine and Bloomfield Colliery.

4.4.1 Groundwater and Surface Water Interaction

Limited interaction is assessed between the surface drainage system and the coal measures.

Limited occurrences of localised surficial groundwater are also assessed to be in hydraulic connection with high level streams, along with interchange between the creek beds and the shallow weathered bedrock beneath. These localised occurrences of surficial groundwater do not represent a significant or regionally extensive aquifer system, and are considered to be an integral part of the surface water flow system.

4.4.2 Groundwater Quality

The quality of groundwater sampled from within the Abel Underground Mine area is variable, with total dissolved solids (TDS) ranging from 518 - 13,000 mg/L, with the highest salinities observed in the weathered Permian and alluvium-colluvium, and the lowest from the Donaldson Seam.

The salinities reported from the Donaldson Open Cut Mine area are also variable and represent a broad spectrum of lithologies, including the coal seams (Donaldson Seam and others above and below) and various levels within the coal measures overburden. Salinities ranged from 770 - 16,000mg/L TDS with pH being close to neutral.

4.5 Climate

Daily rainfall data since 1902 from East Maitland indicates that annual rainfall exhibits a moderate seasonal pattern with the highest mean rainfall between December to June and lower rainfall between July and November.

Average annual potential evapo-transpiration is around 1470 mm, with an on average excess evaporative capacity over rainfall, although the rainfall is variable and can exceed evapo-transpiration during the winter months.

5. PREDICTED SUBSIDENCE, TILT, STRAIN AND CRACKING

The panel width to cover depth (W/H) ratios for the proposed 160.5 m wide pillar extraction panels 14 to 26 will range from 0.90 to 1.97, indicating 'critical' to 'supercritical' subsidence behaviour, which are assumed to occur when panel W/H ratios are > 0.6 and >1.4 respectively.

The panel width to cover depth (W/H) ratios for the 89m and 125m wide Tailgate and South East Mains panels will range from 0.90 to 1.46, indicating critical subsidence behaviour.

Predictions of subsidence development curves for 10, 30 & 50m/week have been derived using the dynamic subsidence analysis module provided in the SDPS program. The predicted curves are consistent with the measured curves for SMP Area 1 panels in regards to subsidence development, and indicate that 90 - 95% of first maximum panel subsidence will occur within 4 - 6 weeks after undermining, depending on the inevitable variation in retreat rates that will occur during second workings (Ditton Geotechnical Services, 2011)

The following subsidence impact parameters for all of the proposed pillar extraction panels are predicted as shown in **Tables 6 and 7.**

- First and Final maximum panel subsidence ranging from 0.75 - 1.45 m (27.5% to 54% of the average mining height);
- First and Final barrier pillar subsidence ranges from 0.03 - 0.17 m due to total pillar stresses after mining;
- Final maximum panel tilt ranges from 14 - 36mm/m;

- Final maximum panel hogging curvature ranges from 0.51 - 1.89 km^{-1};
- Final maximum panel sagging curvature will range from 0.65 - 2.39 km^{-1};
- Final tensile strains associated with the hogging curvatures will range from 5 - 19mm/m;
- Compressive strains associated with the sagging curvatures will range from 7 - 24mm/m.
- Final maximum panel horizontal displacement from 140 - 360mm.

Table 6 Predicted General Subsidence

PARAMETER	RANGE
Depth of Cover	100 - 150m
Panel Width	89 - 160.5m
Panel W/H Ratio	0.90 - 1.97
Maximum Subsidence	750 - 1,450mm
Barrier Pillar Subsidence	30 – 170mm
Horizontal Movements	140 – 360mm
Tensile Strain	5 – 19mm/m
Compressive Strain	7 – 24mm/m
Tilt	14 – 36mm/m

Table 7 Predicted Stream Subsidence

	Maximum Predicted Subsidence (mm)	**Maximum Predicted Tilt (mm / m)**	**Maximum Predicted Tensile Strain (mm / m)**	**Maximum Predicted Compressive Strain (mm / m)**
Ephemeral Tributaries	750 - 1,450	14 - 36	5 - 19	7 - 24
Schedule 2 Viney Creek Channel	Nil	Nil	Nil	Nil
Land Prone to Flooding	Up to 1,000	-	-	-
Farm Dams	Up to 1,450	14 - 36	5 - 19	7 - 24

The predicted subsidence, tilt and strains are illustrated in **Figures 9** to **11.**

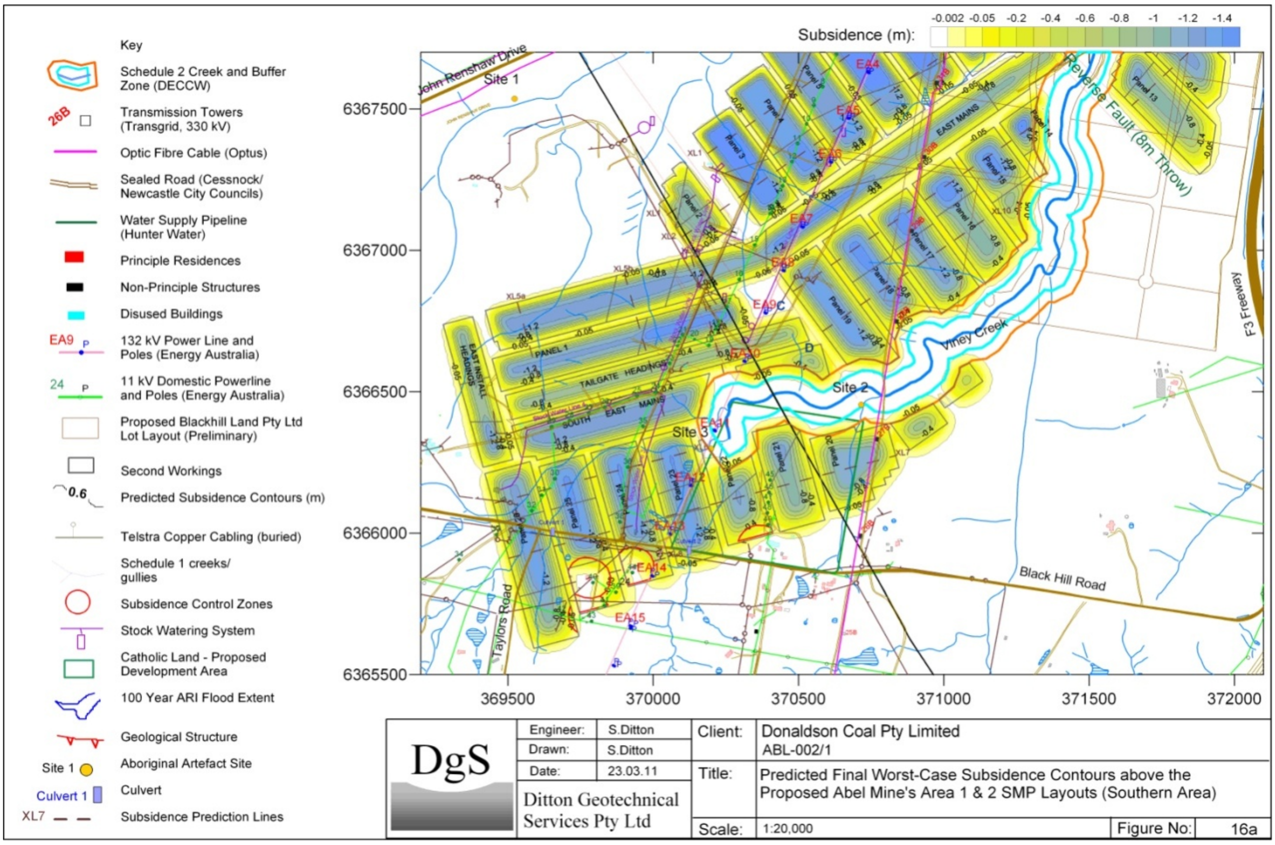

Figure 9 Predicted Subsidence

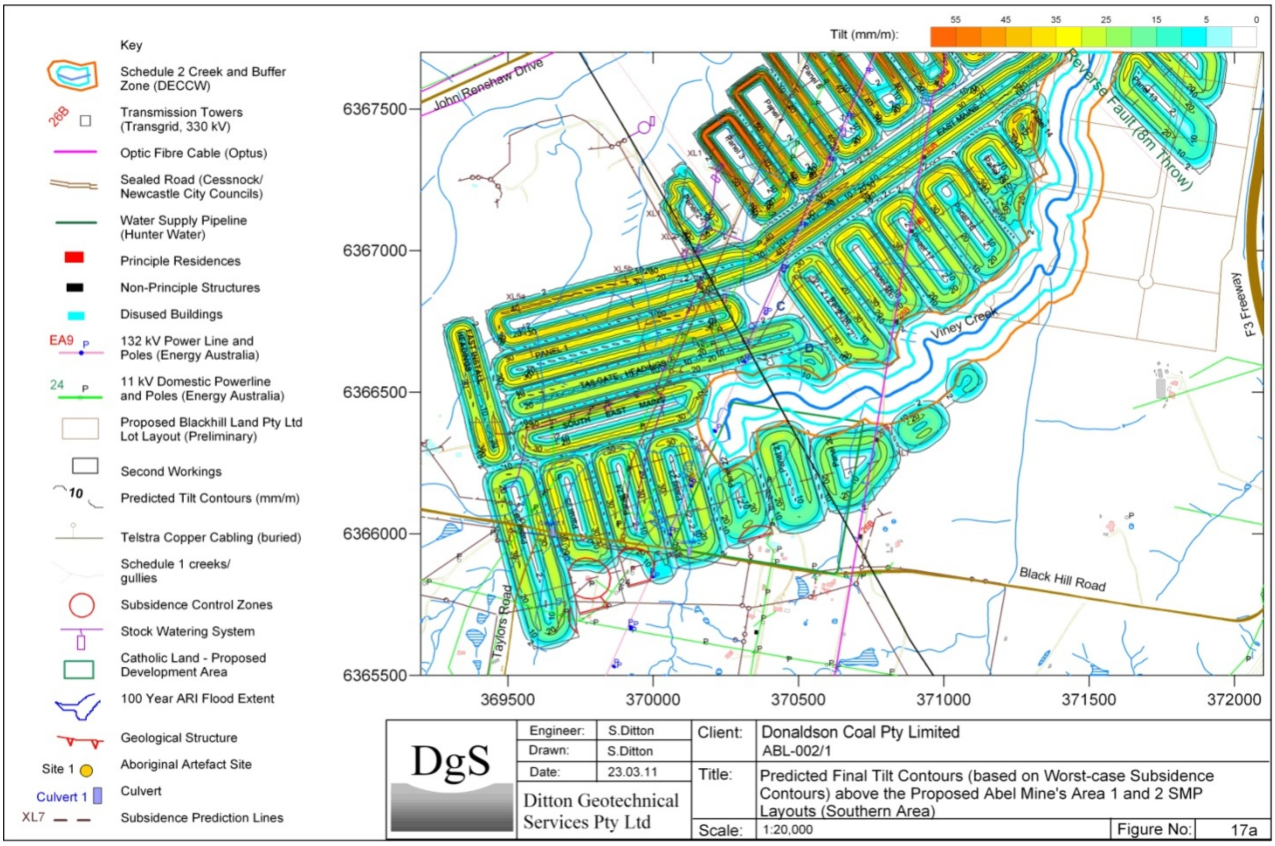

Figure 10 Predicted Tilt

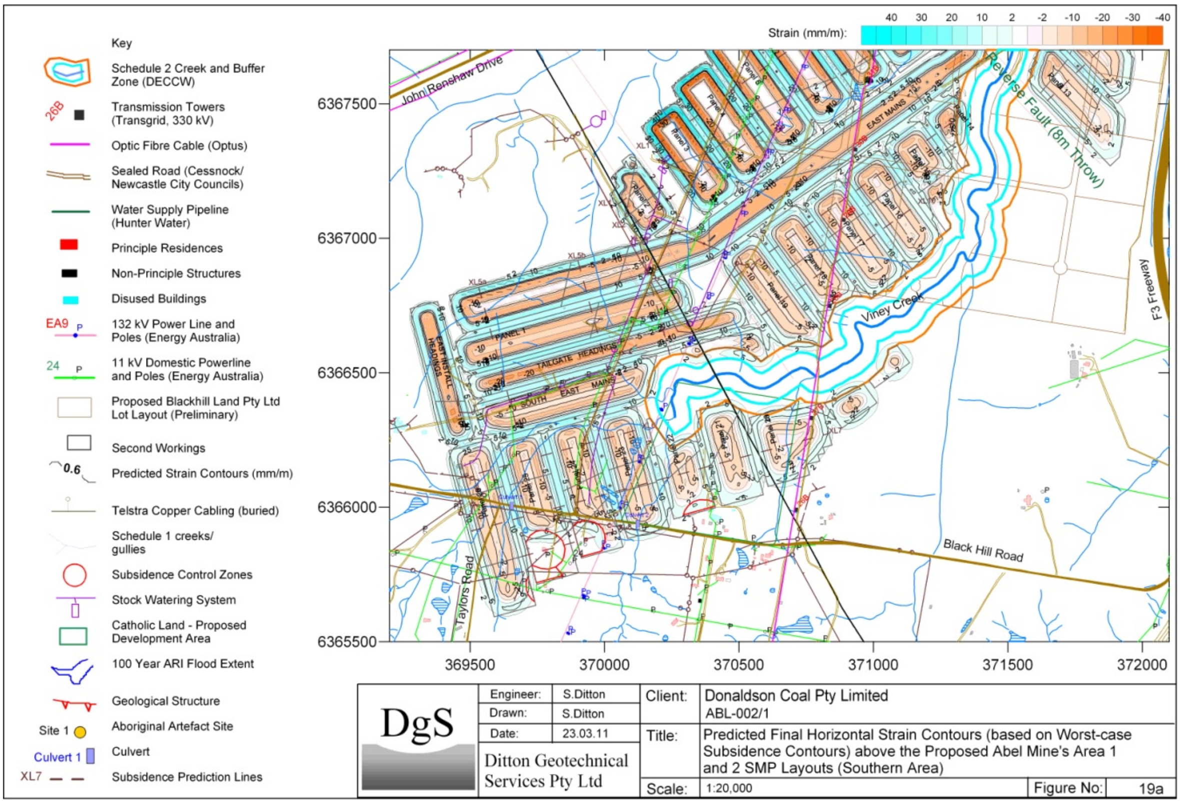

Figure 11 Predicted Strain

5.1 Potential Surface Crack Development

The predicted panel subsidence range of 750 - 1450mm is likely to cause surface cracks within the limits of the extracted panels, although it is very unlikely that surface cracks will develop above first workings pillars, where subsidence magnitudes of <20mm are predicted.

Cracks are likely to develop in the tensile strain zones that will occur from 18 - 44m inside the ribs of a total extraction panel. Crack widths of up to 10mm may develop where tensile strains exceed 1mm/m over a distance of 10m. The maximum crack widths generally develop where maximum tensile strains occur.

Compressive strains >2 - 3mm/m can also cause cracking and upward ‘buckling’ of near surface rock beds due to low-angle shear failures, with the compressive strains peak at one or two locations in the middle third of the panels.

Based on the predicted range (5 - 19 mm/m) of maximum transverse tensile strains, maximum surface cracking widths of between 50 - 190mm could occur above Panels 14 to 26, within the limits of extraction over Area 2. Strain concentration in near surface rock could also double the above cracks widths locally to 100 mm and 380 mm respectively.

The predicted tensile strains above the extracted South East Mains, Tailgate Headings and East Install Headings are estimated to range between 9 - 16mm/m, indicating maximum crack widths from 90 - 160mm. Strain concentrations in near surface rock could also double the above crack widths locally to 180 mm and 320 mm respectively.

The tensile cracks will probably be tapered and extend to depths ranging from 5 - 10m, and possibly deeper if near surface bedrock exposures are present.

The predicted (7 - 24mm/m) range of maximum transverse compressive strains may result in shear displacements or 'shoving' from 70 - 210mm within the central limits of proposed production and extracted main headings panels.

In addition, tensile cracks will probably develop up to 30m behind the advancing goaf edge of the total pillar extraction panels. The majority of these cracks are transient however, and are likely to close in the central areas of the panels where permanent compressive strains develop after mining is completed.

5.2 Potential Sub-Surface Fracturing

Estimates for development of hydraulically connected sub-surface fracturing (A-Zone) and hydraulically disconnected (B-Zone) fracturing are shown in **Table 8.**

Table 8 Predicted Sub-Surface Fracturing Heights

Panel No.	Cover Depth (m)	Panel Width (m)	Effective Mining Height (m)	First Panel S_{max} (mean) (m)	Panel S_{max}/W'^2 (mean) (mm/m^2 or km^{-1})	Predicted Fracture Heights (m)					
						Continuous Fracture Zone (A Horizon)				Discontinuous Fracture Zone (B Horizon)	
						ACARP, 2003 (mean - U95%CL)		Forster, (1995)		ACARP, 2003 (mean - U95%CL)	
Pillar Extraction Panels 14 to 26											
14	110	96	2.66	0.75	0.075	59	89	56	88	*104*	*123*
15	110	160.5	2.66	1.19	0.050	49	79	56	88	96	*115*
15	120	160.5	2.66	1.12	0.044	50	82	56	88	102	*123*
16	105	160.5	2.66	1.23	0.057	50	78	56	88	94	*112*
16	115	160.5	2.66	1.16	0.045	48	79	56	88	98	*119*
17	107	160.5	2.66	1.21	0.054	49	78	56	88	95	*114*
17	120	160.5	2.66	1.12	0.044	50	82	56	88	102	*123*
18	110	160.5	2.66	1.19	0.050	49	79	56	88	96	*115*
18	120	160.5	2.66	1.12	0.044	50	82	56	88	102	*123*
19	110	160.5	2.66	1.19	0.050	49	79	56	88	96	*115*
19	120	160.5	2.66	1.12	0.044	50	82	56	88	102	*123*
20	137	270.5	2.09	1.16	0.031	46	83	44	69	109	*133*
21	137	160.5	2.19	0.89	0.035	49	86	46	72	111	*135*

Panel No.	Cover Depth (m)	Panel Width (m)	Effective Mining Height (m)	First Panel S_{max} (mean) (m)	Panel S_{max}/W'^2 (mean) (mm/m^2 or km^{-1})	Predicted Fracture Heights (m)					
						Continuous Fracture Zone (A Horizon)				Discontinuous Fracture Zone (B Horizon)	
						ACARP, 2003 (mean - U95%CL)		Forster, (1995)		ACARP, 2003 (mean - U95%CL)	
22	133	160.5	2.38	0.97	0.038	51	86	50	78	110	*133*
23	112	160.5	2.66	1.18	0.048	49	79	56	88	97	*117*
23	127	160.5	2.66	1.09	0.042	52	86	56	88	107	*130*
24	112	160.5	2.66	1.18	0.048	49	79	56	88	97	*117*
24	124	160.5	2.66	1.10	0.043	51	84	56	88	105	*127*
24	130	160.5	2.66	1.09	0.042	53	88	56	88	110	*133*
25	111	160.5	2.66	1.18	0.049	49	79	56	88	97	*116*
25	120	160.5	2.66	1.12	0.044	50	82	56	88	102	*123*
25	125	160.5	2.66	1.09	0.042	51	84	56	88	106	*127*
26	112	160.5	2.57	1.14	0.046	48	78	54	85	96	*116*
26	117	160.5	2.66	1.14	0.044	49	80	56	88	100	*120*
26	130	160.5	2.66	1.09	0.042	53	88	56	88	110	*133*
23	110	160.5	2.66	1.19	0.050	49	79	56	88	96	*115*
25	110	160.5	2.66	1.19	0.050	37	79	56	88	96	*115*
Tailgate and South East Mains Headings											
SE	105	125	2.66	1.03	0.066	53	82	56	88	97	*115*
SE	103	125	2.66	1.04	0.067	53	80	56	88	95	*113*
TG	97	99	2.66	0.89	0.089	56	82	56	**88**	94	*111*
TG	100	99	2.38	0.77	0.077	54	81	50	79	95	*112*
TG	100	99	2.66	0.77	0.077	60	89	56	88	104	*123*

Notes: *Single panel S_{max} = f(effective mining height, W/H, H, W/t, y/H) (**ACARP, 2003**).*

Heights of fracturing based on effective mining heights T'= 0.95T.

Effective Panel Width = lesser of actual width and 1.4H (i.e. the super-critical width).

Bold - Mean or U95%CL A-Horizon prediction is within 10 m of the surface.

Italics - Mean or U95%CL B-Horizon prediction is within 10 m of surface.

Connective cracking to the surface is considered 'unlikely' for depths of cover between 80 - 100m, as the A-Zone Horizon is predicted to be between 10 - 20m below the surface, whilst connective cracking is considered 'very unlikely' for depths of cover > 100 m, as the A-Zone Horizon is predicted to be > 20 m below the surface (range is 19 - 89m below the surface for cover depths from 100 - 140m)

Disconnected (B-Zone) cracking is predicted to occur within 10m of the surface for cover depths <100m above the pillar extraction panels for the proposed mining geometries and is considered 'likely' to interact with surface cracks.

In areas of shallow or exposed surface rock, creek flows may be re-routed to below-surface pathways and re-surfacing down-stream of the mining extraction limits in these areas.

The predicted U95%CL B-Horizon values are all within 10m of the surface for cover depths <140 m. It is therefore assessed that surface water impacts from the discontinuous sub-surface fracturing interaction will be ‘possible’ where cover depths range between 100 - 140m.

The height of continuous and discontinuous fracturing is influenced by the panel width and overburden spanning capability.

What is clear from the above exercise is that there a high degree of uncertainty in predicting the A and B-Zone horizons using any of the available models. The measurement of sub-surface fracturing and their impact on groundwater has therefore been undertaken over the first two panels at the Abel mine for the purpose of validating the prediction models applied in this study.

Overall, it is considered that the measured and predicted fracture zones are in good agreement for Panels 1 and 2 at this stage and indicates the predicted fracture zones for the Area 2 panels are likely to be within the mean and U95%CLs presented.

5.3 Valley Uplift and Closure

Valley uplift and closure movements may occur along the drainage gullies present above the proposed mining area.

Due to the suspected and observed low horizontal stress regime in the Abel mine workings roof to-date (i.e. the Upper Donaldson Seam at this location is in relatively flat area with shallow cover), it is considered unlikely that large magnitude movements will occur in the gullies / broad crested valleys above the proposed panels.

The lack of thick, massive beds of conglomerate and sandstone units along the creeks / valleys at the surface may also mean uplift development is likely to be limited to <100mm. Minor cracking in creek beds may cause some shallow sub-surface re-routing of surface flows due to the valley closure mechanism.

Uplift movements of between 10 - 30mm have occurred just outside the limits of mining above the Stage 1 panels to-date. However, these movements are due to overburden cantilevering affects caused by systematic subsidence development and unrelated to valley closure phenomena.

6. SCHEDULE 2 VINEY CREEK SUBSIDENCE CONTROL ZONE

Where required, Subsidence Control Zones (SCZ's) will be used for surface water features in an adaptive management mine planning method for the Schedule 2 reach of Viney Creek.

The design of a reliable Subsidence Control Zone (SCZ) for Viney Creek will require consideration of the following issues:

- minimum set-back distance from high pillar extraction panels (i.e. panels with > 85% of coal extracted) to control subsidence deformation to below tolerable design limits for the feature;
- long-term stability of the pillars in the SCZ under abutment loading conditions from adjacent high extraction areas;
- use of narrower total extraction panels that are sub-critical (i.e. W/H < 0.6) or partial extraction panels with long term stable remnant pillars left beneath sensitive surface features to control subsidence impacts to within tolerable limits, and;
- trialling the performance of a SCZ in a non-sensitive area of the workings

The Schedule 2 reach of Viney Creek will be managed to ensure that:

- the pre-mining course is maintained,
- the bed channel gradient will not initiate additional erosion;
- the pool riffle sequences are maintained where they currently existed, or pool riffle sequences will be installed where appropriate;
- the current hydraulic connectivity to the underground workings is maintained,
- current stream flow loss to fracture zones will be maintained at a similar level to before mining in Area 2;
- the geomorphic integrity of the stream is maintained;
- the ecosystem habitat values of the stream are protected, and;
- no significant alteration of the water quality occurs in the stream.

The above mentioned commitments will be achieved by:

- provision of a minimum barrier of 40m between the 20 mm line of subsidence and the bank of any Schedule 2 streams; or
- conducting further studies and development of a Surface Water Management Plan which demonstrates the above commitments can be met prior to mining which could impact on the Schedule 2 reach of Viney Creek.

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The Subsidence Control Zone is proposed to limit impacts to within tolerable levels from the proposed mining layout. Whilst the proposed setback distances are considered conservative, they will need to be confirmed as adequate through subsidence monitoring in less sensitive areas during earlier mining.

The subsidence control levels will require a subsidence management plan to define appropriate mitigation and remediation strategies before, during and after mining.

Monitoring programs will also be included in the management plans to provide the appropriate amount of information required to effectively manage the process.

7. POTENTIAL SURFACE WATER SYSTEM IMPACTS

7.1 Potential Impact on Streams

7.1.1 Stream Flow

It is anticipated there could be soil or bedrock crack development with a low potential for sub-surface transfer of stream flow in the Viney Creek tributaries, upstream of the Schedule 2 stream reach. However, as connective cracking between the surface cracks and the "Zone A" cracked overburden are not predicted to inter connect, it is not predicted that surface water flows will enter the underground mine workings.

However, as the extent of the surface cracking, as well as the disconnected (Zone B) and connected (Zone A) fracturing is not definitive, it is possible that re-activation of or focussing of fracturing on an unknown structural feature, such as a fault or dyke, could, although is considered unlikely, enable limited hydraulic connection between a subsided stream bed and the workings.

If any short reach sub-surface transfer of stream flow occurs, it is anticipated that the transfers to the shallow groundwater system, if they occur, will re-emerge a short distance downstream, on the basis there is no hydraulic connection to the workings.

Based on the combination of the mining method with the potential to vary the amount of extraction and use of the Viney Creek Subsidence Control Zone, creek stretches which may have a low potential to be affected by cracking and sub surface transfer of surface flow or bed and / or bank instability are shown in **Table 9**.

Creek beds with the shallowest depth of cover are rated with the highest risk, which reduces as the depth of cover increases and with the relative location of maximum subsidence over a panel.

Table 9 Potential Adverse Stream Effects

PANEL	RISK OF ADVERSE EFFECTS	COMMENTS
17 , 18	LOW	Subsidence in ephemeral 1st order gully of Viney Ck
20	LOW	Subsidence in ephemeral 2nd order gully of Viney Ck
22 , 23	LOW	Subsidence in ephemeral 2nd order gully of Viney Ck
24	LOW	Subsidence in ephemeral 2nd order gully of Viney Ck
25, 26	LOW	Subsidence in ephemeral 2nd order gully of Viney Ck
26	LOW	Subsidence in ephemeral 1st order gully of Viney Ck
Tailgate Headings	LOW	Subsidence in ephemeral 1st order gully of Viney Ck
South East Mains	LOW	Subsidence in ephemeral 1st order gully of Viney Ck

The prediction and assessment of subsidence effects under streams and management of its effect on stream flow can be attained through observing the effects of subsidence in previously mined panels which do not underlie stream beds.

Based on the lack of observed adverse effects on the ephemeral streams over the previously mined panels in Area 1, it is anticipated that adverse effects may be observed in the ephemeral streams overlying the proposed Area 2 workings, however they are not anticipated to be at a significant scale.

If future observations change the current assessment and if adverse effects are observed, the adaptive management measures available using the proposed variable extraction mining method will enable, if required, the amount of seam extraction to be reduced to limit the development of cracking and loss of stream flows in greater risk streams.

No known regionally significant structural features are present over the proposed workings that could act as an enhanced conduit after subsidence to connect the stream system to the underground workings.

Close observation of subsidence effects in similar depths of cover, similar stream systems and similar geology in prior panels will be needed to determine whether the degree of extraction needs to be modified for the gullies outlined in **Table 9**.

7.1.2 Stream Bed or Bank Instability

Cracking is not anticipated to have a significant observable effect on stream bed or bank stability or stream water quality in the Schedule 1 gullies.

Bed and bank instability and downstream sediment transfer through downstream erosion is possible, although unlikely.

7.1.3 Stream Flow Reversal

As the stream gradients generally exceed the predicted tilts over the proposed panels, no reversal of flow is anticipated.

7.1.4 Groundwater Dependent Ecosystems

No discernible adverse effects are anticipated on groundwater dependent ecosystems in the potential subsidence affected zone due to the significant depth of the water table below the potential cracking zone.

7.1.5 Inundation or Flooding

Due to the hilly terrain with limited exposed bedrock in the upper channels along with moderately dense vegetative cover along the creek banks over the proposed subsidence area, it is anticipated that the development of subsidence “bowls” will not be particularly obvious.

The final depth and width of the bowls will depend on the response of the seam and overburden to panel extraction.

The potential development of ponding depends upon several factors, such as rain duration, extent of surface cracking and effective percolation and evapo-transpiration rates.

The potential ponding depths and volumes for the proposed mining layout has been estimated as shown in **Table 10**.

Table 10 Potential Worst-Case Ponding

Location	Pre-Mining Ponds				Post-Mining Ponds				Ponded Area Increase After Mining#
	Max Pond RL	Max. Depth (m)	Size L x B	Area (ha) [Vol] (ML)	Max Pond RL	Max. Depth (m)	Size (m)	Area (ha) [Vol] (ML)	Area (ha) [Vol] (ML)
Panel 23 (south)	-	-	-	**-**	35.35	0.8	80x40	**0.25 [1.01]**	**0.25 [1.01]**
Panel 23 (north)	-	-	-	**-**	31.60	0.8	95x23	**0.17 [0.69]**	**0.17 [0.69]**
Panel 24 (north)	35.0	0.9	75x29	**0.17 [0.77]**	34.1	1.0	64x25	**0.13 [0.63]**	**-0.04 [-0.14]**
Panel 25 (north1)	38.1	0.3	50x28	**0.11 [0.55]**	37.50	0.9	84x39	**0.26 [1.16]**	**0.15 [0.61]**
Panel 25 (north2)	-	-	-	**-**	38.0	1.0	35x26	**0.07 [0.36]**	**0.07 [0.36]**
Panel 26 (north)	-	-	-	**-**	40.0	1.0	69x26	**0.14 [0.70]**	**0.14 [0.70]**

Pond Area = π x pond width x pond length/4;

Pond Volume = Area x Maximum Pond Depth/2.

- Net increase = Post-mining pond - pre-mining pond.

It is possible that six closed form depressions with volumes ranging from 0.36 - 1ML could develop along the Viney Creek tributaries above Panels 23 to 26 with maximum potential depths of 0.8 - 1.0m.

Two of the pond locations exist above Panels 24 and 25 and are already depressions, with one above Panel 24 expected to be decrease after mining from 0.77 - 0.63 ML.

7.2 Groundwater Seep / Spring Flow to Streams

No known groundwater seeps have been observed over the proposed workings. As a result, subsidence is not anticipated to have an observable effect on the contribution to stream flows.

It is possible that a low volume springs that seeps into a creek bed after significant rain can discharge into the catchment at a lower elevation determined by the depth below surface and connectivity of cracking. Cracking may occur in exposed bedrock sections of the stream bed, which could enable transfer of stream flow into the stream sub-surface, and for the transferred water to re-emerge further downstream in the catchment.

Development of surface subsidence cracking, with breaching or interconnection of unconfined to semi-confined shallow aquifers, as well lowering of hillslope springs or seeps downslope may occur. However, due to their generally low gradient, the tributaries over the proposed workings may have a LOW risk of overburden groundwater loss.

If adverse effects occur on the shallow groundwater system and associated stream flow, reduced baseflow or spring seepage may result where higher streams could have a reduced groundwater recharge, however as the springs / seeps discharge into the catchment at a lower elevation after subsidence, this would mean that lower elevation sections of the creek bed could obtain an increased groundwater recharge.

7.3 Flooding

Viney Creek and its tributaries have potential areas of flooding.

The pre-mining 1 in 100 Year ARI flood levels for the Black Hill Pty Ltd property were provided by the stakeholder to assess potential flooding impacts due to the proposed mining layout.

The post-mining 1 in 100 Year ARI flood levels will require a hydrological assessment based on the predicted surface levels prepared in this study.

It is estimated that the areal extent of flooding due to the 1 in 100 year may increase by up to 5% for the subsided reaches of two Viney Creek tributaries above Panels 15, 17 and 18.

7.4 Dams

Several abandoned earth embankment dams with < 1ML capacity are present in the Black Hill Land Pty Ltd and Catholic Diocese Land, although they are backfilled and dry.

Several earth embankment dams with <1ML capacity are present in private property and are generally full of water, except for one dam with numerous piping failures tat are used for stock watering.

Although adverse effects are possible, it is not anticipated that any of the small (<1ML) stock watering farm dams over the proposed workings will be observably affected in terms of water holding capacity or dam wall stability.

8. PROPOSED MONITORING

8.1 Streams

A water level depth transducer and logger assembly should be installed in the Schedule 2 reach of Viney Creek where the culvert passes under the power transmission line, downstream of Panel 20 (Viney 1 Site – See Figure 7) as well as at Site 11 to enable stream flow depths, and if the sites are suitable, stream flow volumes to be monitored.

Regular monthly monitoring of stream pH, salinity (EC), as well as total suspended solids, sulfate, total iron and total acidity should also be conducted at the Viney 1 **(Figure 7)** and Site 11 locations.

Inspection and photographic recording of stream bed / bank stability and stream erosion should be conducted over each stream before and after it is undermined to assess if any stream bed cracking or bed / bank instability has been caused by subsidence, or if any ameliorative actions are required.

The monitoring of streams will be carried out by the proponent or its appointed representatives with the monitoring program satisfying conditions of approval to be provided by the DII.

8.2 Dams

In accordance with the Project Approval and Statement of Commitments a Dam Monitoring and Management Strategy (DMMS) will be formulated for each dam prior to any mining which could impact on the dams. The DMMS will provide for the inspection of each dam by a qualified engineer for:

- current water storage level;
- current water quality (EC and pH);
- wall orientation relative to the potential cracking;
- wall size (length, width and thickness);
- construction method and soil / fill materials;
- wall status (presence of rilling / piping / erosion / vegetation cover);
- potential for safety risk to people or animals;
- downstream receptors, such as minor or major streams, roads, tracks or other farm infrastructure; and
- potential outwash effects.

Photographs of each dam will be taken prior to and after undermining, when the majority of predicted subsidence has occurred.

Dam water levels, pH and EC will be monitored prior to and after undermining to assess the baseline and post mining dam water level and water quality in order to determine whether rehabilitation is required.

8.3 Rainfall and Evaporation

Daily rainfall and evaporation data will be obtained from the nearest private or Bureau of Meteorology station.

9. POTENTIAL REMEDIATION

Any adverse effects that require rehabilitation of the land surface, stream bed and bank stability or stream flow and water quality will be undertaken, where access is possible, following preparation of a post mining rehabilitation plan that addresses the relevant issues.

The following sections outline in a generic manner what actions may occur, if required.

It should be noted that access in the very steep terrain is limited, with very few tracks apart from along ridge lines.

9.1 Stream Bed or Catchment Surface Cracking and Injury to People, Stock or Native Animals

Soil or bedrock crack repairs may need to be implemented in adversely affected areas which may involve ripping, backfilling and top dressing works or the placement of cement-based grout, crushed rock into wider, deeper cracks.

If sufficient adverse effects due to stream bed cracking occurs, the following remediation strategies may be adopted:

- Undertake pre-mining and post-mining inspections along the creek, with the results of these inspections communicated to the respective stakeholders. Should a significant impact be identified during these inspections, an appropriate remediation strategy will be developed.
- Consultation with DECCW has suggested that natural regeneration may be the favoured management strategy in most scenarios, due to the likely level of disturbance caused by other remediation strategies such as back filling with imported materials from haulage trucks.

Regular inspections with a trigger for the assessment of remediation requirements will occur when a crack is observed to develop that could pose an adverse threat to stream flow or bed / bank stability.

Deep ripping is not recommended in wooded country due to the potential adverse effects on the vegetation, the difficulty of access and potential safety hazards to personnel.

Any impacts identified that may require remediation in the wooded hills will be conducted only after consultation with relevant departmental officers.

9.2 Sub Surface Cracking

SCZ options may be required if connective cracking to the surface becomes apparent through increased inflow to the underground workings or unusual loss of stream flow.

Subsurface measurement of the A-Zone horizon may be required for cover depths >80m.

However, the absence of significant surface alluvium and the ephemeral nature of the tributaries is unlikely to result in significant degradation of the creeks or inrush event into the underground workings should connective cracking to the surface occur.

It is considered likely that any re-directed surface flows will be manageable underground and cracks able to be repaired at the surface.

The above assessment is dependent on our limited understanding of the continuous fracture heights in this area of the mine until monitoring/measurement data becomes available.

9.3 Valley Uplift

The impact of valley uplift closure effects due to mine subsidence may be managed as follows:

(i) Install and monitor survey lines along representative drainage gullies where considered appropriate and along gully crests during and after undermining. Combine with visual inspections to locate damage (cracking, uplift).

(ii) Review predictions of upsidence and valley crest movements after each panel is extracted.

(iii) Assess whether repairs to cracking, as a result of upsidence or gully slope stabilisation works are required to minimise the likelihood of long-term degradation to the environment or risk to personnel and the general public.

9.4 Overland Surface Drainage and Ponding

Based on the predicted subsidence effects and the ephemeral nature of the catchments over the proposed panels, it is not envisaged that significant adverse effects on surface pondage will occur.

If required, a potential management strategy could include:

(i) development of a suitable monitoring and mitigation response plan, based on consultation with the regulatory government authorities to ensure ponding impacts on existing vegetation do not result in long-term environmental degradation, and;

(ii) review and appraisal of changes to drainage paths and surface vegetation in areas of ponding development (if they occur), after each panel is extracted.

The impact of the increased ponding along the creek beds is likely to be 'in-channel' and therefore the potential effects on existing flora and fauna is likely to be minimal.

Further assessment on the ponding impacts may be needed by specialist ecological consultants to confirm this assessment however, local experience to-date suggests that this is not a negative consequence.

9.5 Flooding

A post-mining hydrological assessment of the Black Hill Land Pty Ltd site should be completed by the stakeholder for both the current site and re-developed site conditions.

The assessment should determine if any additional drainage system measures may be required as a result of mine subsidence.

9.6 Stream Bed and Bank Stability / Erosion

No significant adverse destabilisation of the creek lines over the propose panels is predicted.

If adverse subsidence effects do occur, some of the following actions could be used to remediate the effects, based on the limitation of access to remote locations.

9.6.1 Alluvial Bank Stabilisation

Where subsidence monitoring indicates instability in unconsolidated banks, where access is possible and safety hazards are manageable, the bank may be graded back to its angle of repose and revegetated.

9.6.2 Rilling and Piping of Subsidence Cracks

Erosion of subsidence cracks in the soil can be protected by ripping the exposed surface and placing topsoil in less vegetated areas. Loose soil will be protected by establishing ground cover and installing contour banks above the area to divert surface runoff away from subsidence impacted areas, along with silt fences placed downstream of the works area in the stream channel.

Contour banks may be installed on the up-gradient side of cracked areas to slow water runoff from the slopes and to minimise further erosion as access permits.

9.6.3 Vegetation Stabilisation of Denuded Areas

If required, disturbed areas will be protected from erosion by grass seeding followed by tree planting as establishing sustainable vegetation growth is critical in attaining successful riparian zone rehabilitation.

Revegetation of the creek banks and the (limited) alluvial terraces would mimic the current vegetated sections of the creek by using grasses, indigenous trees and shrubs.

9.7 Injury to People or Stock near Unstable Banks

If unstable banks develop, then the bank rehabilitation actions outlined above will be used to manage the potential for injury to stock and people.

9.8 Farm Dams

In the event that subsidence / crack development monitoring indicates a significant potential for dam wall failure, dam water will be managed in one of the following manners:

- pumped to an adjacent dam to lower the water level to a manageable height that reduces the risk of dam wall failure,

- discharged to a lower dam via existing channels if the water cannot be transferred, or
- not transferred if the dam water level is sufficiently low to pose a minor risk.

An alternate water supply will be provided to the dam owner until the dam can be reinstated.

In the event of subsidence damage to any dams the Company shall remediate the damage and reinstate the dam in conjunction with the Mine Subsidence Board.

10. REFERENCES

ACARP, 2006 Techniques to Predict and Measure Subsidence and its Impact on the Groundwater Regime Above Shallow Longwalls – Project No. C23020

Ditton Geotechnical Services, Report No. ABL-002/1 2011 Subsidence Predictions and Impact Assessment for the Proposed SMP Area 2 Pillar Extraction Panels at Abel Mine

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

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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.

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