DONALDSONCOAL
Part of the Yancoal Australia Group

ABEL MINE

AREA 3

SUBSIDENCE MANAGEMENT PLAN APPLICATION

REPORT

March 2013

VOLUME 1

Appendix A Abel Underground Mine: SMP Area 3 – Proposed Panels 23 to 26. Subsidence Predictions and Impact Assessment for the Natural and Built Features in Support of the SMP Application (Report No MSEC596 Revision A) – December 2012 - Mine Subsidence Engineering Consultants (MSEC)

Appendix B Abel Mine Subsidence Risk Assessment (HMS Consultants Report No HMS1220 January 2013)

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1 LETTER OF APPLICATION

12 March 2013

Director Environment Sustainability
Trade & Investment, Regional Infrastructure & Services NSW – Minerals and Energy
P O Box 344
HUNTER REGION MAIL CENTRE NSW 2310

Attention: Mr Paul Langley

Dear Sir,

Subsidence Management Plan Application for Pillar Extraction from Area 3 at Abel Mine

Abel Mine is an underground coal mine located approximately 23 km north-west of Newcastle in the Newcastle Coalfield of New South Wales.

In accordance with the *Guideline for Applications for Subsidence Management Approvals* dated December 2003 (SMP Guideline 2003) application is hereby made for approval to extract coal, in an area (Area 3) held under Mining Lease ML 1618 (Act 1992), by an underground mining method in the Upper Donaldson seam, which may potentially lead to subsidence of the land surface. The SMP application area is shown on the Subsidence Management Plan Approved Plan.

Project Approval 05-0136 (Development Consent) for the mine was granted by the Department of Planning on 7 June 2007. Mining (first workings and pillar extraction, subject to an SMP approval) is presently approved under the Project Approval, Mining Operations Plan and lease conditions to take place within Mining Lease ML 1618.

SMP Approval for Area 1 was obtained on 26 May 2010 and Area 2 on 7 December 2011 with minor variations approved since that date.

The purpose of this application is to gain approval for mining of coal from the Upper Donaldson seam using pillar extraction mining methods, similar to the previously approved Areas 1 and 2. Extraction within this area is scheduled to commence in August 2013. This application area includes mining from pillar extraction panels Panel 23 to Panel 26 inclusive, plus the previously developed East Install Headings which will be extracted on retreat as shown on the attached SMP plans.

This application consists of a number of components detailed on the following pages.

If you require any further information or have any queries please do not hesitate to contact the undersigned.

Yours faithfully,

Tony Sutherland
Technical Services Manager- Underground Operations
Donaldson Coal
Abel Mine

Abel Mine Subsidence Management Plan Contents

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2 EXECUTIVE SUMMARY

This Subsidence Management Plan (SMP) application has been prepared to seek approval for the extraction of coal by pillar extraction mining methods from the Upper Donaldson coal seam in Area 3 of Abel Mine. The SMP application consists of pillar extraction panels Panel 23 to Panel 26 inclusive, plus the previously developed East Install Headings, to be extracted on retreat as shown on the attached SMP plans. The SMP application has been prepared in accordance with the NSW Department of Mineral Resources *New Approval Process for the Management of Coal Mining Subsidence* and SMP Guideline 2003.

Abel commenced coal production in May 2008 and will progressively increase production to 4.5mtpa run of mine. The SMP application area contains 170 ha, approximately 6% of the current lease area of 2755 ha.

Mining will take place in the application area under a combination of land owned by Donaldson Coal, the Catholic Diocese of Maitland - Newcastle, Telstra Corporation and seven private rural residential land holdings. The current application seeks approval to mine coal by the pillar extraction method from the Upper Donaldson Seam at depths of cover ranging generally from 50 to 200 metres.

The layout of the panels has been designed to provide management outcomes of subsidence impacts in line with the Statement of Commitments and Project Approval and to conduct the mining operations in a responsible manner, considering the existing and future environment and the community, while optimising resource recovery in the area in accordance with the principles of ecologically sustainable development. It is proposed to conduct mining in the proposed extraction panels generally bounded by existing and proposed main underground development workings to the north, the previously approved SMP Areas 1 and 2 to the east and resource thickness / quality of the Upper Donaldson seam to the south.

Maximum subsidence predicted for the pillar extraction panels in the application area is 1,450 mm, which represents 51% of the maximum extraction height of 2.8 metres, maximum predicted strains from 10 to 12 mm/m and tilts up to 70 mm/m excluding areas nominated to be protected.

The SMP application area surface is a combination of native bushland, cleared livestock grazing land (some previously used for poultry farms), rural residential, several business premises and a public road. Management measures are proposed to address any predicted environmental impacts for the surface above the application area.

Natural features are generally limited to Four Mile Creek, a Schedule 1 stream and associated tributaries, with some steep slopes above the southern ends of the proposed panels. The ecology assessment outcome was that subsidence would not result in a significant impact on any threatened flora or fauna species or any threatened or conservation significant ecological communities. Proposed management measures of natural features are listed in **Table 1**.

Table 1 - Summary of Natural Features Impact Assessment SMP Area 3

Feature/s	Summary of feature/s	Proposed Management Measures
Creeks/surface water features	Four Mile Creek – ephemeral above Panel 26	Monitoring and remediation through Property Subsidence Management Plan
Creeks/surface water features	Ephemeral tributaries	Monitoring and remediation through Property Subsidence Management Plan

Feature/s	Summary of feature/s	Proposed Management Measures
Groundwater	Sub surface aquifer	Monitoring through Groundwater Management Plan
Ecology, Threatened and Protected Species	Flora and Fauna	Monitoring through Environmental Management Plan
Steep Slopes	Above southern ends of proposed panels up to around 1 in 2 (50%)	Visual inspection and remediation of impacts (if required) through Property Management and Public Safety Management Plans
Land Prone to Flooding or Inundation	Potential for increased flooding in sections of watercourses	Monitoring through Environmental Management Plan
Water Related Ecosystems	Associated with streams	Monitoring through Environmental Management Plan

Man – made features include:

- Principal residences, Other Surface Structures and outbuildings;
- Business or commercial premises;
- Mine related infrastructure;
- Ausgrid rural 11kV and 415V domestic power lines;
- Telstra fibre optic cable;
- Telstra copper communication cables;
- State survey control marks;
- Public roads and culverts (Black Hill Road);
- Access roads and tracks;
- Cattle stockyards, holding areas and water troughs;
- Various fences, gates and cattle grids;
- A number of dams; and
- Aboriginal places and sites.

Proposed management measures of man-made features are listed in **Table 2**.

Table 2 - Summary of Man-Made Features Impact Assessment SMP Area 3

Feature/s	Summary of feature/s	Proposed Management Measures
Residences	Four Principal Residences. One above Panel 26 and one above Panel 25. Other two south of Panels 23 and 24.	Protected by Subsidence Control Zone and/or Subsidence Specific Commitment A Principal Residence (see page 17).
Other Surface Structures	Other Surface Structures and outbuildings.	Property Subsidence Management Plan to be developed for each area prior to impact of subsidence. See Subsidence Specific Commitment E Any Other Surface Structures (page 19)
Business or commercial premises	Building structures associated with Woodbury's Black Hill Quarry	Property Subsidence Management Plan to be developed
Mine related infrastructure	Various exploration boreholes and one groundwater monitoring bore.	
Electrical infrastructure	Ausgrid rural 11kV and domestic power lines	Management actions and Plan developed for Areas 1 and 2 in consultation with Ausgrid. To be reviewed for Area 3.
Telecommunication infrastructure	Telstra telecommunications enclosure	Continuing consultation with Telstra. Management Plan for Area 2 to be reviewed for Area 3.
Telecommunication cables	Telstra fibre optic cable	Continuing consultation with Telstra and MSB on options.
Telecommunication cables	Telstra copper cables	Continuing consultation with Telstra. Management Plan for Area 2 to be reviewed for Area 3.
State survey control marks	Five (5) PMs within Area 3	Notification to LPI relating to mining and reestablishment including resurvey on completion of subsidence.
General surface	Mixture of natural bushland and grazing land	Include in Property Subsidence Management Plan for each individual property
Public Roads	Black Hill Road and drainage culverts (largest 1500mm diameter)	Current Black Hill Road Management Plan for Area 2 to be reviewed and updated in consultation with Cessnock City Council and MSB prior to any subsidence impact.
Roads, tracks	Various sealed and unsealed – private	Include in Property Subsidence Management Plan for each individual property
Fences, gates and cattle grids (including cattle stockyards and holding areas)	Various types	Include in Property Subsidence Management Plan for each individual property
Dams	Various dams. Fifteen (15) dams identified in Area 3. Eleven (11) located directly above the proposed panels and one (1) located partially above the	Include in Property Subsidence Management Plan for each individual property. See Subsidence Specific Commitment F Dam Monitoring Strategy (page 20).

Feature/s	Summary of feature/s	Proposed Management Measures
	proposed panels.	NB no dams within SMP Area 3 are classed as requiring protection under the Project Approval
Aboriginal Places and sites	Six (6) archaeological sites (artefact scatters). Two (2) cultural places (areas of cultural sensitivity), the *Black Hill Locality* and the *Black Hill Pathway*, are partially located within Area 3 above the southern end of proposed Panel 25.	Management in accordance with the Abel Underground Mine : Aboriginal Heritage Management Plan.

A Subsidence Monitoring Program for the panels will be developed and implemented in consultation with the Principal Subsidence Engineer – Trade & Investment, Regional Infrastructure & Services (DTIRIS).

A Risk Assessment, in which these predicted subsidence values were used, was conducted on 12 December 2012 to identify, assess and evaluate potential subsidence impacts to surface and sub-surface as a result of mining these future panels. The potential impact arising from maximum theoretical subsidence was also considered. The risk assessment concluded that any impacts were likely to be manageable. Only one high risk issue (Telstra fibre optic cable) was identified, generally attributable to the mine design. Some agreed further actions were developed, that have either been established or are planned.

The Risk Assessment took account of matters raised during the community consultation process, which included a Stakeholder Meeting consisting of a presentation, site inspection, and question / comment opportunity conducted on 5 December 2012. In particular, matters relating to groundwater, watercourses, Threatened and Protected Species and infrastructure, particularly residences and improvements, were considered.

Community consultation during the preparation of the SMP application was undertaken in accordance with the Department of Mineral Resources Guideline for Applications for Subsidence Management Approvals and the NSW Minerals Council Community Engagement Handbook Towards Stronger Community Relationships.

A presentation followed by a site inspection was made to Trade & Investment, Regional Infrastructure & Services and identified stakeholders on 5 December 2012. An advertisement was placed in a regional newspaper on 10 November 2012 to notify the community of Abel's intent to submit a SMP application. No submissions were received following this community consultation.

Continuing consultation has been carried out with the infrastructure owners, relating to potential impacts to the infrastructure, the management of these impacts by suitable mine plan design, remediation / mitigation and development of appropriate Management Plans. Similarly, consultation with some landholders has consisted of further presentation of mine design, information on subsidence and potential impacts with discussions continuing to develop an agreed Property Subsidence Management Plan to manage / mitigate / remediate any impacts.

Updates on the SMP development have also been presented to the Abel Community Consultative Committee at meetings held on 28th May 2012, 27th August 2012 and 10th December 2012.

3 INTRODUCTION

3.1 BACKGROUND

Abel Mine is an underground coal mine operated by Donaldson Coal Pty Limited. The mine access, entries and primary surface facilities are located approximately 23 km north-west of Newcastle on John Renshaw Drive. The SMP application area is located to the south of John Renshaw Drive with the mine entries within the former mining area of Donaldson Open Cut (See **Figure 1**).

The SMP area surface naturally falls towards Four Mile Creek in the western part of the area, and into tributaries of Weakleys Flat and Viney Creeks, which drains northward into Woodberry Swamp prior to entering the Hunter River (Hunter River Catchment, in the eastern part of the area.

Abel commenced operations in May 2008. The mine currently employs approximately 280 personnel (including contractors) and currently produces approximately 2.3 million tonnes per annum (tpa), with a proposed maximum production of 4.5 million tonnes of thermal / soft coking coal from the Upper and Lower Donaldson coal seams. Abel's production is railed to Newcastle for the export market. Abel currently operates under a number of approvals relevant to this SMP, including:

- Project Approval (Development Consent) 05_0136 granted 7 June 2007;
- Mining Lease ML 1618;
- Mining Lease ML 1653;
- Abel Mine Mining Operations Plan submitted to DTIRIS in December 2009;
- Environmental Protection Licence 12856 under the Protection of the Environment Operations Act 1997.
- SMP Approvals for Area 1 dated 26 May 2010 and Area 2 dated 7 December 2011 plus approved variations, and
- Clause 88 Approvals.

The key features of the Project Approval (Development Consent) 05_0136 for the mine include:
- Construction and operation of an underground coal mine.

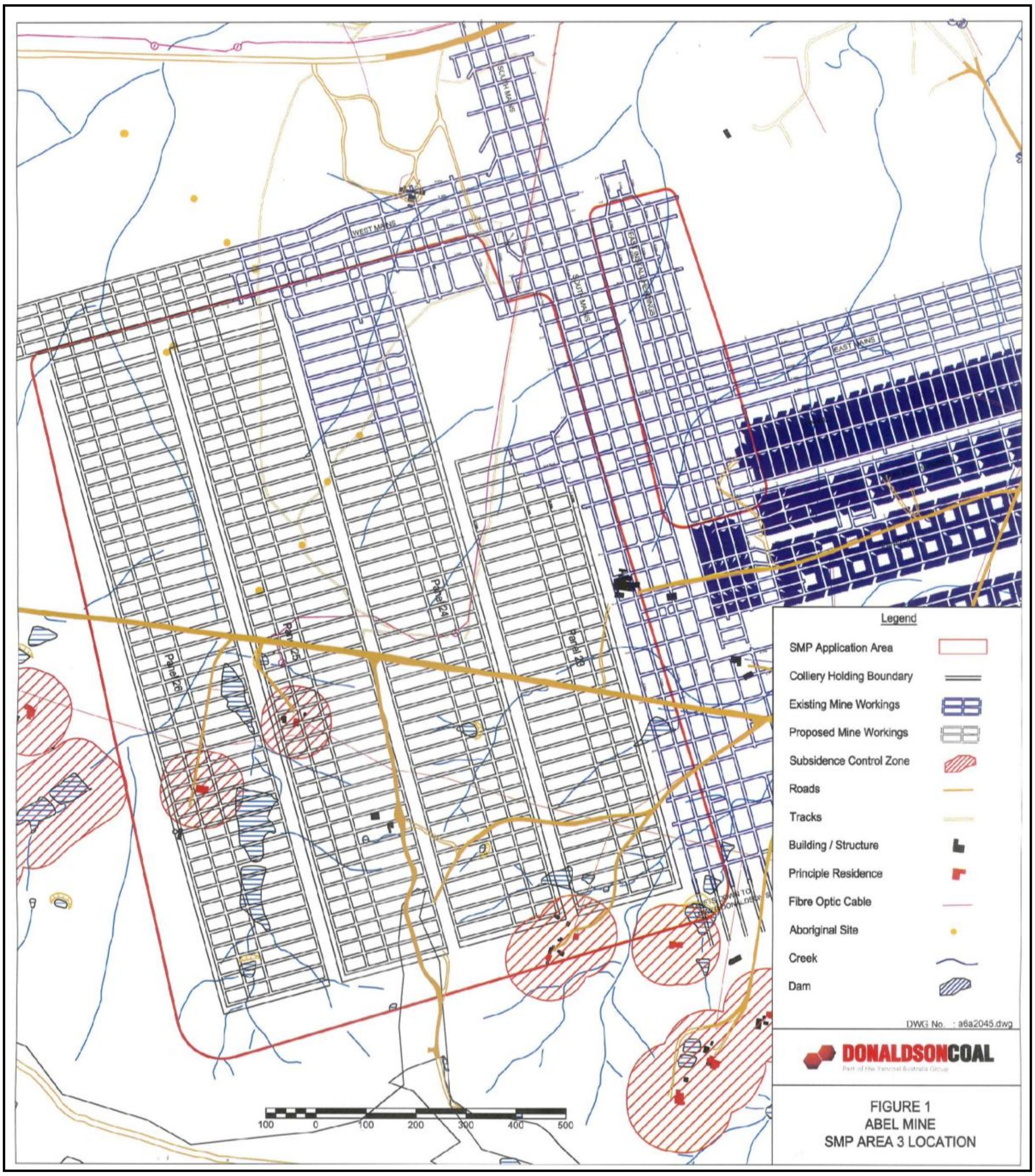
Obligations to Minimise Harm to the Environment

1. The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.

Terms of Approval

2. The Proponent shall carry out the project generally in accordance with the:
   a) EA;
   b) Statement of Commitments; and
   c) Conditions of this approval.
3. If there is any inconsistency between the above documents, the later document shall prevail to the extent of the inconsistency. However, the conditions of this approval shall prevail to the extent of any inconsistency.
4. The Proponent shall comply with any reasonable and feasible requirements of the Director-General arising from the Department's assessment of:
   (a) any reports, plans or correspondence that may be submitted in accordance with the conditions of this approval; and
   (b) the implementation of any actions or measures contained in these reports, plans or correspondence.

Figure 1 - SMP Area 3 Location



Limits of Approval

5. Mining operations may take place until 31 December 2028 on the Abel site.
6. The Proponent shall not extract more than 4.5 million tonnes of ROM coal a year from the Abel site.
7. No more than 6.5 million tonnes of ROM coal may be processed a year on the Bloomfield site.
8. All product coal produced on the Bloomfield site shall be transported by rail via the rail loading facility on the Bloomfield site, except in an emergency. In an emergency, product coal may be transported from the Bloomfield site by road with the prior written approval of the Director-General, subject to any restrictions that the Director-General may impose.

The following subsidence related and monitoring / management consent conditions and Statement of Commitments items relevant to this SMP Application are noted in **Table 3**.

Table 3 - Summary of Project Approval Conditions and Statement of Commitments Relevant to SMP Area 3

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
Schedule 4 – Specific Environmental Conditions		
Subsidence Impact Limits		
1	The Proponent shall ensure that the project does not result in any subsidence impacts on Pambalong Nature Reserve or the surface of the F3 Freeway.	Pambalong Nature Reserve and F3 Freeway outside of SMP Application Area 3
2	The Proponent shall limit mining operations to first workings beneath and ensure that mining causes no subsidence impacts requiring mitigation works on, the following features: (a) All principal residences located above the mining area; (d) all Schedule 2 streams and rainforest areas located above the mining area.	*(a)* First workings only and protected by Subsidence Control Zone *(*d) No Schedule 2 streams or rainforest areas within SMP Area 3
3	The Proponent shall ensure that the following sites are treated as "principal residences " under this approval: (a) all buildings and structures on, or proposed to be constructed on, the Catholic High School site; (b) all buildings and structures on the Boral Hotmix Asphalt Plant site	(a) Noted. (b) Not in SMP Application Area 3
5	Within 6 years of the Project Approval, the Proponent shall ensure that any subsidence caused by undermining the following land has been effectively completed: (a) The Catholic Diocese of Maitland-Newcastle owned land; and (b) Coal and Allied Operations (Now Black Hill Land Pty Limited) owned land.	(a) and (b) Noted Part of land (a) included in SMP Application Area 3.
6	With the written agreement of the relevant landowner, the Proponent may: (a) conduct additional mining operations and/or cause additional subsidence impacts beyond those permitted under conditions 2(a) or 3; and (b) increase the time within which subsidence must be effectively completed under condition 5	(a) and (b) noted. Written agreement received from Catholic Diocese, as part of property lease, to increase the time within which subsidence must be effectively completed.
Subsidence Management Plan		
7	Prior to carrying out any underground mining operations that could cause subsidence, the Proponent shall prepare a Subsidence Management Plan (SMP) to the satisfaction of the Director-General of the DPI. This plan must be prepared in accordance with the: (a) *New Approval Process for Management of Coal Mining Subsidence – Policy;* and (b) *Guideline for Applications for Subsidence Management Approvals* (or the latest versions or replacements of these documents).	(a) and (b) This SMP application prepared in accordance with these documents.
8	In preparing the Subsidence Management Plan, the Proponent shall pay particular attention to assessing and limiting the potential subsidence impacts on all areas of the proposed	

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	underground mining area where: (a) cover depths are less than 100 metres, or (b) overlying abandoned mine workings occur (e.g. Stockrington Colliery and beneath Black Hill Quarry)	(a) Considered in SMP application (b) No abandoned mine workings overlying or underlying proposed workings in this SMP application area.
First Workings Hazard Management Plan		
9	If the Proponent intends to carry out first workings under the following surface features, then it shall include a First Workings Hazard Management Plan for these workings, which describe in detail how these workings would be managed and monitored to ensure compliance with this approval and the contingency measures that would be implemented if the impact on these surface features are greater than predicted: • all buildings and structures on the Black Hill Public School, Black Hill Church and cemetery, and Boral Hotmix Plant sites; • all buildings and structures on, or proposed to be constructed on the Catholic High School site; • all Schedule 2 streams , rainforest areas and the Blue Gum Creek alluvium.	• No first workings planned under these areas as part of this SMP application. • Not within SMP Area 3 • No Schedule 2 streams, rainforest areas or the Blue Gum Creek alluvial in SMP Area 3.
Water Management Plan		
11	The Proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Director-General. To include Surface Water Monitoring Plan, and Groundwater Monitoring Program.	Submitted and approved
Surface Water Monitoring Program		
14	The Surface Water Management and Monitoring Plan must include: (a) detailed baseline data on surface water flows and quality in the creeks and other waterbodies that could be affected by the project; (b) surface water impact assessment criteria; (c) a program to monitor the impact of the project on surface water flows and quality; (d) procedures for reporting the results of this monitoring.	Submitted and approved
Groundwater Monitoring Program		
15	The Groundwater Monitoring Program must include: (a) further development of the regional and local groundwater model; (b) detailed baseline data to benchmark the natural variation in groundwater levels, yield and quality (including at any privately owned bores in the vicinity of the site); (c) groundwater impact assessment criteria; (d) monitoring of the Pambalong Nature Reserve and the rainforest areas identified; (e) a program to monitor the impact of the project on groundwater levels, yield and quality; and	Submitted and approved

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	(f) procedures for reporting the results of this monitoring.	
Aboriginal Heritage Management Plan		
28	The Proponent shall not destroy any known Aboriginal objects (as defined in the *National Parks and Wildlife Act 1974)* without the written approval of the Director-General.	Noted – subsidence impacts are predicted as unlikely for aboriginal artefacts (scatter) and Places (Blackhill Location and Pathway), identified in SMP Application Area. Management through Aboriginal Heritage Management Plan
29	The Proponent shall prepare and implement an Aboriginal Heritage Management Plan for the project to the satisfaction of the Director-General. This plan must: (a) be submitted to the Director-General within 6 months of this approval; (b) be prepared in consultation with the DEC and the Mindaribba and Awabakal Local Aboriginal Land Councils; (c) include a: • comprehensive Aboriginal heritage surveys across both the Abel site and the Bloomfield site staged so as to be complete prior to any disturbance; • salvage program for temporarily storing and then replacing retrieved material; and • protocol for ongoing consultation and involvement of aboriginal communities in the conservation and management of Aboriginal heritage on site (d) Describe the measures that would be implemented to protect Aboriginal sites on site, or if any new Aboriginal objects or skeletal remains are discovered during the project.	Submitted and approved Additional surveys have been undertaken during 2012.
Schedule 5 – Environmental Management , Monitoring, Auditing and Reporting		
Environmental Management Strategy		
1	The Proponent shall prepare and implement an Environmental Management Strategy for that project to the satisfaction of the Director-General within 6 months of this approval, and: (a) provide the strategic context for environmental management of the project; (b) identify the statutory requirements that apply to the project; (c) describe in general how the environmental performance of the project would be monitored and managed; (d) describe the procedures that would be implemented to: • keep the local community and relevant agencies informed about the operation and environmental performance of the project; • receive, handle, respond to and record complaints; • resolve any disputes that may arise during the course of activities associated with the project; • respond to any non-compliance • manage cumulative impacts; and	Submitted and approved

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	• respond to emergencies; and (e) describe the role, responsibility, authority and accountability of all key personnel involved in the environmental management of the project	
Environmental Monitoring Program		
2	The Proponent shall prepare and implement an Environmental Monitoring Program for the project to the satisfaction of the Director-General. This program must be submitted to the Director-General within 6 months of this approval, consolidate the various monitoring requirement s in Schedule 4 of this approval into a single document, and be integrated as far as practicable with the monitoring programs of the adjoining Bloomfield, Donaldson and Tasman mines.	Prepared, submitted, approved and implemented
Community Consultative Committee		
8	Within 3 months of this approval, the Proponent shall establish a Community Consultative Committee for the project. This committee shall: (a) be comprised of: • 2 representatives from the Proponent, including the person responsible for environmental management at the mine; • at least 1 representative from Council (if available); and • at least 3 representatives from the local community whose appointment has been approved by the Director-General; (b) be chaired by an independent chairperson, whose appointment has been approved by the Director-General; (c) meet at least four times per year during the construction phase and first year of mining operations, and thereafter at least twice per year; (d) review the Proponent's performance with respect to environmental management and community relations; (e) undertake regular inspections of mining operations; (f) review community concerns or complaints about the mine operations, and the Proponent's complaints handling procedures; (g) provide advice to: • the Proponent on improved environmental management and community relations, including the provision of information to the community and the identification of community initiatives to which the Proponent could contribute; • the Department regarding the conditions of this approval; • the general community on the performance of the mine with respect to environmental management and community relations; and (h) be operated generally in accordance with	Community Consultative Committee (CCC) has been established

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	any guidelines the Department may publish in regard to the operation of Community Consultative Committees for mining projects.	
9	The Proponent shall, at its own expense: (a) ensure that 2 of its representatives attend CCC meetings; (b) provide the CCC with regular information on the environmental performance of the project; (c) provide meeting facilities for the CCC; (d) arrange site inspections for the CCC, if necessary; (e) respond to any advice or recommendations the CCC may have in relation to environmental management or community relations; (f) take minutes of the CCC meetings; (g) forward a copy of these minutes to the Director-General; and (h) put a copy of these minutes on the website.	Updates on the SMP development have been presented to the Abel Community Consultative Committee at meetings held on 28th May 2012, 27th August 2012 and 10th December 2012. Copies of the CCC minutes are available on the Donaldson Coal web site www.doncoal.com.au Community newsletter issued in February 2013.
Access to Information		
10	Within 3 months of the approval of any plan/strategy/program required under this approval (or any subsequent revision of these plans/strategies/programs), or the completion of audits or AEMRs required under this approval, the Proponent shall: (a) provide a copy of these relevant document/s to the relevant agencies; (b) ensure that a copy of the relevant document/s is made publicly available at the mine; and (c) put a copy of the relevant document/s on its website.	Copy of the AEMR is available on Donaldson Coal web site www.doncoal.com.au
11	During the project, the Proponent shall: (a) make a summary of monitoring results required under this approval to be publicly available at the mine and on its website; and (b) update these results on a regular basis (at least every three months)	See Above
Statement of Commitments		
5.1 Schedule I streams	(a) Schedule 1 streams (as defined in the DIPNR 2005 guideline, "Management of stream/aquifer systems in coal mining developments") will be managed via the implementation of mitigation and remediation works where needed to ensure that: stream stability is maintained where subsidence occurs stream fractures are minimised stream channels are maintained with minimal incision from bed grade change and stream bed grade change minimised to provide stable stream length (b) Where any stream stability controls are required they will be designed in accordance with the Rehabilitation Manual for Australian Streams (Land and Water Resources Research and Development Corporation, 2000) and will be provided primarily by vegetation.	Management / remediation as required

<table>
<tr><th>Item / Condition</th><th>Description</th><th>Relevance to SMP Application Area/ Management Measure</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>5.2 Schedule 2 streams</td><td>(a) Schedule 2 streams (as defined by DIPNR, 2005) will be managed so as to ensure that:
they maintain pre-mining course, and maintain bed channel gradients which do not initiate erosion;
they maintain pool riffle sequences where they pre-existed, or have pool riffle sequences installed where appropriate;
they maintain connectivity to underground workings, and flow loss to fracture zones in similar levels to pre-mining;
they maintain geomorphic integrity of the stream;
the ecosystem habitat values of the stream are protected;
no significant alteration of the water quality occurs in the stream.
(b) The above commitments for Schedule 2 streams will be achieved by:
the provision of a minimum barrier of 40m between the 20 millimetre line of subsidence and the bank of any Schedule 2 streams; or
the carrying out of further detailed studies and the development of a Surface Water Management Plan for the Abel Underground Mine which clearly demonstrates that the above commitments can be met prior to any mining occurring which will impact on any Schedule 2 streams.</td><td>No Schedule 2 streams within SMP Area 3</td></tr>
<tr><td colspan="3">Subsidence Specific Commitments</td></tr>
<tr><td>A. Principal Residences</td><td>The Company commits to producing and implementing a plan of management for each Principal Residence existing at the date of approval of this project. A Principal Residence is defined as an existing building capable of being occupied as a separate domicile and used for such purpose. The plan of management will be produced and implemented as follows:

A1. Each Principal Residence will be individually assessed by the Mines Subsidence Board /structural engineer who will determine tolerable levels for individual subsidence parameters. Tolerable limits are those limits which will result in no mitigation works being required to the Principal Residence due to subsidence impacts from the Abel Underground Mine.

A2. Each Principal Residence will have a pre-mining survey to identify and record pre-</td><td>In progress</td></tr>
</table>

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	existing imperfections that will not be covered by the Mines Subsidence Board. A3. Such assessments will be done as and when the progression of the mining process dictates – i.e. mining may have commenced in other areas prior to the individual Principal Residence assessment being undertaken. A4. Tolerable levels will be set according to such factors as dwelling construction (e.g. brick veneer, clad), type (single, double storey), size (length and width), footings (slab, strip footings, piers), surface conditions (sand, rock, clay, steep slope) etc, with reference to the MSB Graduated Guidelines (compatible with AS 2870 and the Building Code of Australia). A5. The mine plan in proximity to each Principal Residence will be modified by the Company to maintain subsidence parameters within the tolerable levels determined above for each Principal Residence. A6. The mine plan will be reviewed by the MSB and the DPI prior to any Subsidence Management Plan being approved under the relevant lease. A7. Each Principal Residence will have a specific subsidence monitoring plan to monitor subsidence impacts before and after mining at the Principal Residence and to ensure that tolerable limits are achieved in practice. A8. The Mine Subsidence Board has the responsibility to rectify any impacts to structures that may occur as a result of mining. In cases where the owner of the Principal Residence and the Company can agree to terms which permit second workings under the Principal Residence greater than those permitted above, the Company agrees to negotiate a plan of management similar to that proposed in the section of this Statement of Commitments titled "All Other Surface Structures".	
B. Future Principal Residence	If there is no existing residence on a landholding and a residence is planned to be built, the site for this Future Principal Residence will be protected in the same way as that proposed above for Principal Residences. This commitment applies to a maximum of one Future Principal Residence per landholding. NOTE: Once the Mine Subsidence District is declared for the area all Future Principal Residences will require approval from the Mine	Noted

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	Subsidence Board and must comply with the Mine Subsidence Compensation Act 1961.	
E. All Other Surface Structures	"All Other Surface Structures" is defined as any building or structure impacted by mining-induced subsidence from the Abel Underground Mine Project which is not categorised as a Principal Residence, Future Principal Residence, Black Hill Church and Cemetery or Black Hill School. The Company shall prepare and implement plans of management for the mitigation and remediation of any damage to All Other Surface Structures prior to any mining occurring that would impact on them. The plan of management will include: (a) pre-mining audit of the structure; (b) the provision of a plan of management as part of the SMP approval process which requires the Company to mitigate/remediate any damage to improvements associated with the structure in conjunction with the Mine Subsidence Board; (c) post-mining monitoring of the improvements associated with the Structure. The mitigation/remediation measures to be undertaken will be related to the extent of damage experienced – see Schedule 1 for details.	Noted in SMP Application as Other Surface Structures and included in Property Subsidence Management Plans for each individual property within SMP Area 3.
F. Dams	A Dam Monitoring and Management Strategy (DMMS) will be formulated for all dams prior to any mining occurring which will impact on the dams. The DMMS will provide for: F1. The individual 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. F2. Photographs of each dam will be taken prior to and after undermining, when the majority of predicted subsidence has occurred.	A Dam Monitoring and Management Strategy (DMMS) will be established and included in the relevant Property Subsidence Management Plan

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	F3. 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. F4. 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. F5. 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.	
H. Powerlines	The Company shall prepare and implement a plan of management as part of the SMP process which will ensure the safety and serviceability of powerlines.	Management Plans have been developed in consultation with Ausgrid for SMP Areas 1 and 2. These will be reviewed and updated for SMP Area 3.
L. Water Supply	In the event of interruptions to water supplies due to subsidence impacts on farm dams, water tank pipelines, water mains and irrigation systems within the application area, the Company commits to providing water supplies of equivalent quality and quantity to locations convenient to those affected until such time that the affected farm dams, water tanks, pipelines, water mains and irrigation systems are restored.	Noted
M. General Surface Water Flow	The Company shall prepare and implement a plan of management to maintain the surface drainage of areas surrounding any dwellings and other structures or infrastructure, where required. This plan shall include but not be limited to monitoring, mitigation or remediation of mining-induced ponding, drainage pattern changes and any resulting serviceability difficulties and/or hazards to the public. NOTE: Also see Water Supply.	Included in individual Property Subsidence Management Plans.
N. Public Safety	The Company shall prepare and implement a surface safety management program to ensure public safety in any surface areas that may be affected by subsidence arising from the proposed underground mining. This program shall include, but not be limited to, regular monitoring of areas posing safety risks, erection	Public Safety Management Plan was approved for SMP Areas 1 and 2, has been reviewed for SMP Area 3 and is included in this SMP application.

Item / Condition	Description	Relevance to SMP Application Area/ Management Measure
	of warning signs, entry restrictions, backfilling of dangerous surface cracks and securing of unstable man-made structures or rockmass, where required and appropriate, and the provision of timely notification of mining progress to the community and any other relevant Stakeholders where management of public safety is required.	

Additionally Mining Leases include the standard Condition 8 requiring the preparation of a Subsidence Management Plan prior to commencing any underground mining operations which will potentially lead to subsidence of the land surface which includes the pillar extraction proposed by Abel for SMP Area 3.

3.2 REPORT STRUCTURE

This application has been prepared in accordance with the NSW Department of Mineral Resources *New Approval Process for the Management of Coal Mining Subsidence* and SMP Guideline 2003.

The approval requirements have been addressed within this report and the relevant guideline and report references are listed below in **Table 4.**

Table 4 - SMP Guideline Requirements

Item	Guideline reference	Report reference
• Letter of application	Section 5	Section 1
• Mining system, • Recovery, • Statutory requirements, • Expected subsidence, • Potential subsidence impacts	Section 6.1	Sections 3, 5, 10, 11 and 15
• Application area description	Section 6.2	Section 4
• Mining method, • Mining system, • Seam details, • Recovery, • Other seams	Section 6.3	Section 5
• Site conditions, • Cover, • Stratigraphy, • Lithology & Geology	Section 6.4	Section 7
• Stability of workings, • Working height, • Detail of lithology, • Geotechnical, • Geology	Section 6.5	Sections 5, 6, 7 and plans
• Surface structures, • Natural features, • Monitoring, • Identification	Section 6.6	Sections 8 and 9
• Subsidence predictions, • Individual features subsidence	Section 6.7	Sections 10 and 11
• Community consultation	Section 6.8	Section 13
• Legislation, • Approvals, • Licences	Section 6.9	Section 15
• Subsidence impacts, • Impact on increased subsidence, • Summary, • Risk Assessment	Section 6.10	Sections 11 and 12
• Proposed Subsidence Management Plan	Section 7	Separate document
• Plans	Section 9	Section 17 and attachments
• Approved Plan	Section 10	Section 17 and attachments

4 THE APPLICATION AREA

4.1 APPLICATION AREA

The SMP application area is defined as the surface area enclosed by a 26.5 degree angle of draw from the limit of proposed mining, as defined in Section 6.2 in the SMP Guideline 2003 **(Plan 1)**.

The proposed mining layout, SMP area and lease boundaries are shown on **Plan 1**.

SMP Area 3 has a total area of 170 hectares within the full ML1618 area of 2,755 hectares **(Figure 2)**.

The Upper Donaldson Seam mine workings in the SMP application area lie between 50 and 200 m below the surface **(Figure 3)**. The surface area consists of predominately native vegetation and grazing land.

4.2 LAND USES AND LAND OWNERSHIP

The surface of the SMP application area is contained within land owned by Donaldson Coal, the Catholic Diocese of Maitland - Newcastle, Telstra Corporation and seven private rural residential land holdings **(Plan 5)**.

Land use in the area is a combination of the following:

- Native bushland;
- Cleared livestock grazing land,
- Rural residential land,
- Business premises, and
- Public road

Infrastructure above the mining area consists of;

- Principal Residences and Other Surface Structures residences and outbuildings;
- Business premises;
- Mine related infrastructure;
- Ausgrid rural 11kV and 415V domestic power lines;
- Telstra fibre optic cable;
- Telstra copper communication cables;
- Permanent survey control marks;
- Public roads and culverts (Black Hill Road);
- Access roads and tracks;
- Cattle stockyards, holding areas and water troughs;
- Various fences, gates and cattle grids;
- A number of dams; and
- Areas of archaeological significance.

At this stage no potential future development, which will impact on this SMP area, has been identified and no current Development Applications are lodged with Cessnock City Council.

Figure 2 - Abel Mine ML1618 / SMP Area 3

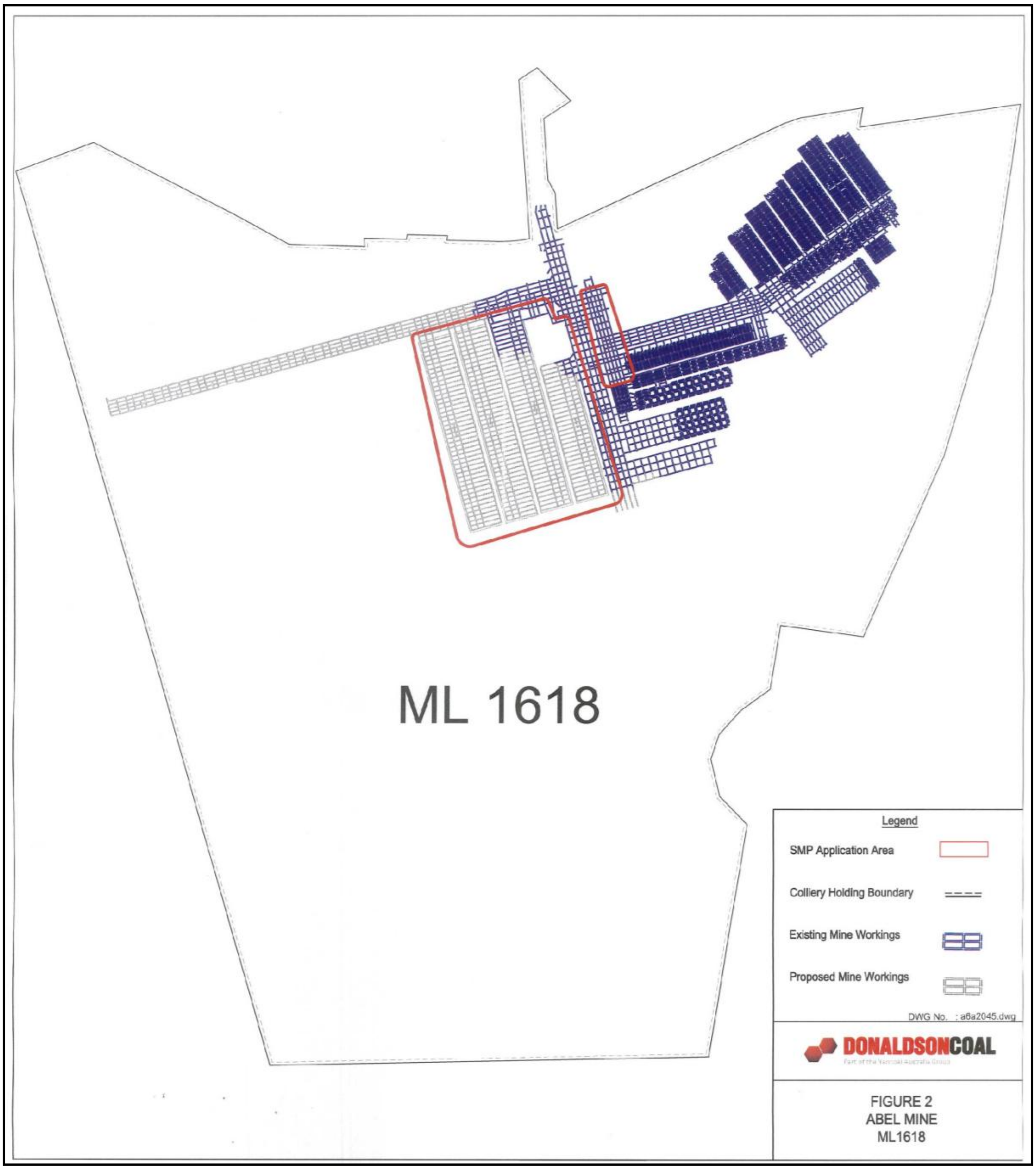
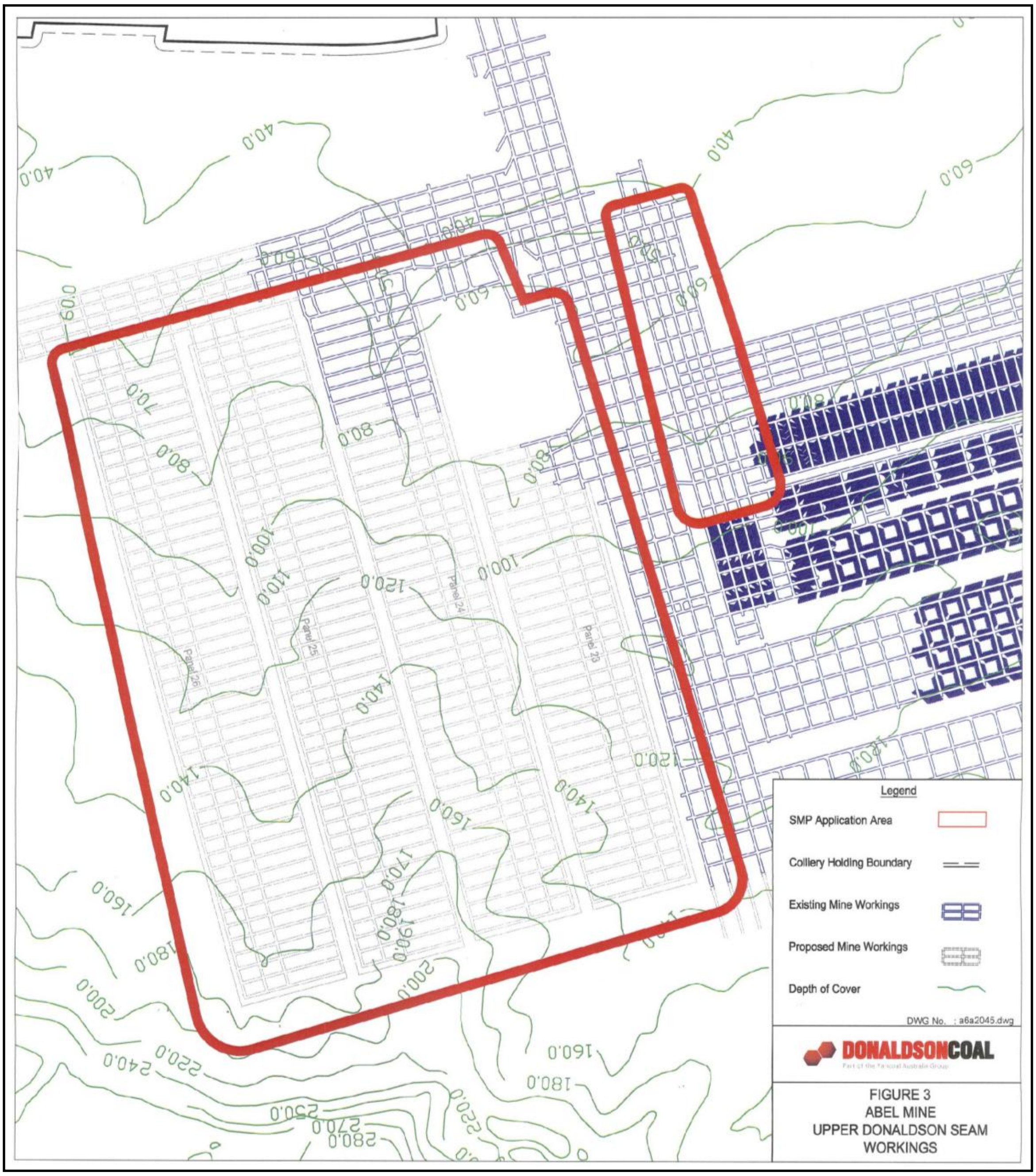


Figure 3 - Abel Mine Upper Donaldson Seam Workings



4.3 PROPERTY DESCRIPTION AND MINING TITLES

The SMP application area is located within land shown in the table below:

Lot 11	DP 11875
Lot 1	DP 123949
Lot 2	DP 123949
Lot A	DP 181350
Lot 1	DP 219167
Lot 2	DP 219167
Lot 1	DP 536570
Lot 684	DP 619758
Lot 82	DP 627799
Lot 70	DP 755260
Lot 12	DP 877937
Lot 1	DP 957782
Lot 1131	DP 1057179
Lot 1	DP 1092266
Lot 1221	DP 1098397
Lot 109	DP 1100314
Lot 110	DP 1100314

Within the Parish of Stockrington County of Northumberland and the Cessnock local government area. The relevant mining title is Mining Lease ML 1618. **(Plan 5)**.

5 MINING METHOD AND RESOURCE RECOVERY

5.1 PROPOSED MINING METHOD

Abel will use the bord and pillar method of mining with pillar extraction as the secondary working method in the Upper Donaldson seam within this application area.

The Upper Donaldson coal seam within the SMP application area of the Abel lease ranges from 1.6 to 2.8 metres in thickness. Abel currently mines up to 2.8m of the coal seam. The seam dips generally 1 in 20 towards the south within the SMP application area. Pillar extraction will take place generally in a south to north direction.

Secondary extraction panel pillars are designed to exceed one tenth the overburden depth while long term mains development pillars (located outside the current application area) are designed to be long term stable and hence not cause subsidence, thus rendering the roads serviceable for the life of the mine.

Development roads will nominally be driven at a width of up to 5.5 metres using single pass continuous miners. The secondary extraction panel pillars will typically be developed within a range of 45 to 115 metre centres and are proposed to be in the order of 25 metres wide (rib to rib).

The purpose of the development is to form pillars suitable to be extracted on the retreat.

5.2 MINE PLAN

5.2.1 Justification of the Mine Plan

The method of extraction selected allows for maximum resource recovery whilst providing enhanced safety for the workforce. The layout and method also provide an extraction layout which provides flexibility in extraction, allowing areas to be left for support of sensitive surface features thus limiting surface subsidence effects where appropriate. Subsidence effects are dependent on extraction thickness and width, depth of cover and strata conditions. There are no significant environmental impacts that preclude pillar extraction within the current SMP application area.

In the initial planning of the area an option study was conducted whereby a number of alternative mine plans were considered having regard to the lease boundaries, exploration geological data and initial environmental assessment details. The plan and layout have been continually reassessed and reviewed as additional exploration, geological, environmental and subsidence monitoring data from SMP Areas 1 and 2 have become available.

The resultant mine plan provides for optimum resource recovery within the bounds created by geological and surface constraints. It is considered to be a layout which will result in subsidence being minimised in sensitive areas while allowing total extraction and resultant subsidence to be completed in accordance with the Project Approval conditions and additional agreement relating to the Catholic Diocese land.

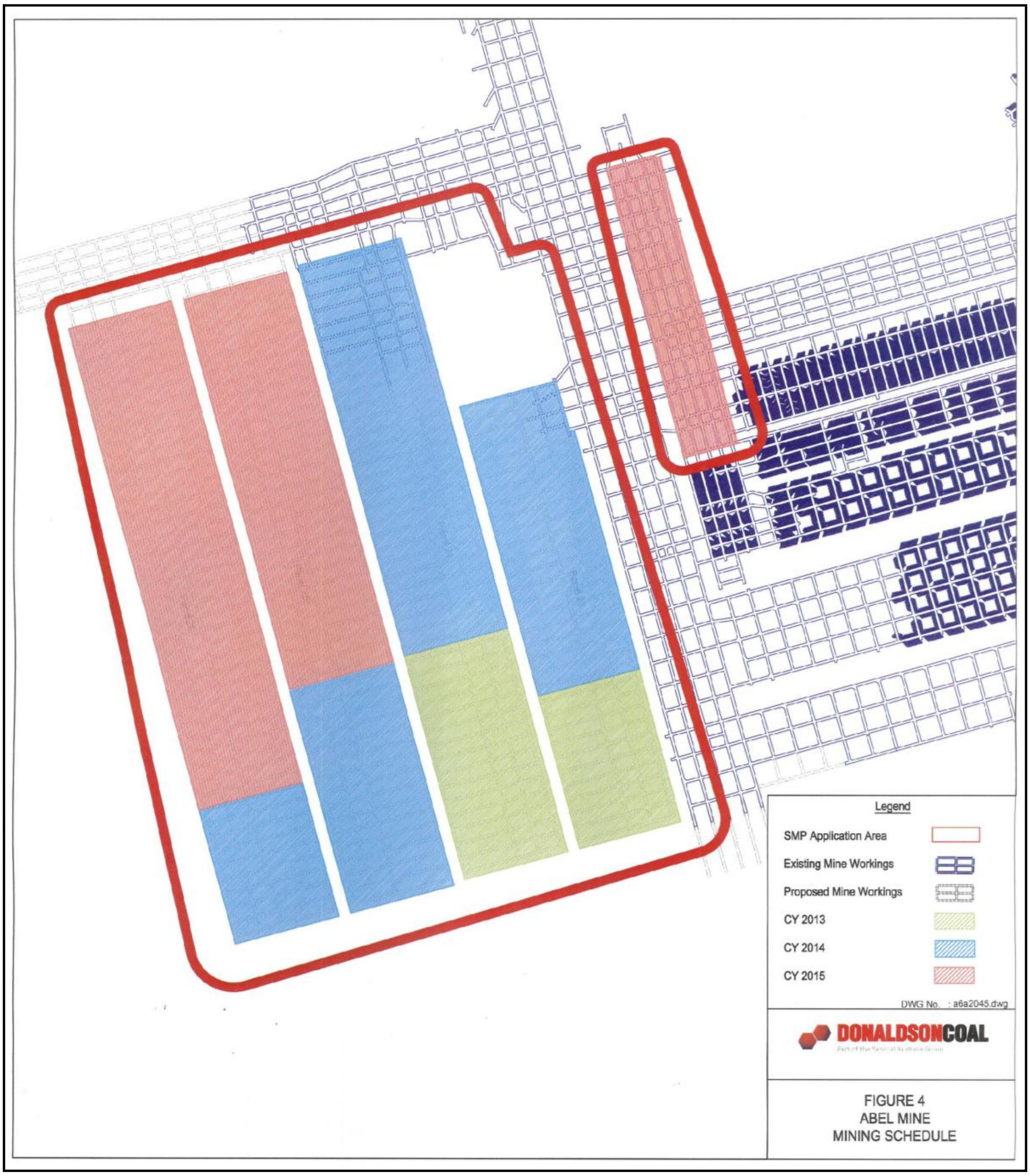
5.3 SCHEDULE OF PROPOSED MINING

The mining schedule plan for the SMP application area is shown on **Figure 4.** Pillar extraction will generally progress in a northerly direction towards the West Mains in each panel. Development rates are budgeted from 18 to 25 metres per continuous miner shift dependent on geological conditions and support regime. Pillar extraction will typically produce in the order of 1,000 tonnes per shift.

Normally operations are carried out 24 hours per day six days per week. Generally, only maintenance operations (e.g. stonedusting, roadway maintenance etc) are undertaken on Sundays.

Panel 23 extraction is scheduled to commence in August 2013. The proposed development and extraction schedule is shown in **Figure 4**.

Figure 4 - Mining Schedule



5.4 ESTIMATED RECOVERY

As noted in **Section 5.1** the Upper Donaldson coal seam within the SMP Application Area is up to 2.8 metres in thickness. Abel currently mines between 2.4 and 2.6 metres of coal in development and between 2.0 and 2.8 metres in extraction of the coal seam, the only marketable seam within the SMP application area.

The proposed panel layout for the SMP application area (as shown on **Plan 1**) will provide the following tonnages, based on an average working height of 2.4 metres development and extraction, development width of up to 5.5 metres and Relative Density of 1.5.

Table 5 - Development and Extraction Tonnages

Panel	Panel Length (m)	Development (m)	Development Tonnes	Extraction Tonnes	Total Tonnes
Panel 23	945	9,536	196,680	504,240	700,920
Panel 24	1,280	13,574	279,964	713,955	993,919
Panel 25	1,320	13,152	271,260	675,380	946,640
Panel 26	1,320	13,152	271,260	675,380	946,640
East Install	600			187,349	187,349
	TOTAL				**3,775,468**

The total insitu reserves within the SMP application area (excluding the angle of draw) in the Upper Donaldson seam is 4,947,000 tonnes.

The total recoverable tonnage from the SMP application area is 3,775,468 tonnes providing a resource recovery of 76.3%.

5.5 POSSIBLE EFFECTS ON OTHER SEAMS

Exploration drilling has encountered seams below the Upper Donaldson seam in the SMP area, including the Lower Donaldson and Ashtonfield seams. Other thin seams (0.5 to 1.0 metres) exist above the Upper Donaldson, however these seams are not considered economically mineable by underground methods.

The Lower Donaldson is positioned only a few metres below the Upper Donaldson and is effectively sterilised in this application area, while the Ashtonfield seam is non-economic in the application area.

As there are no other economically recoverable seams in the SMP application area there are no effects on potentially mineable coal seams.

5.6 FUTURE PLANS FOR MINING IN OTHER SEAMS

There are no future plans for mining these other seams in the SMP application area due to the currently non economic nature of these seams.

6 STABILITY OF UNDERGROUND WORKINGS

The proposed pillars in the application area are designed to provide stable underground workings for the period of development and subsequent extraction. Detail on predicted subsidence impacts, the associated method of prediction and relevant subsidence parameters can be found in **Appendix A**.

Long term pillar stability is of concern only in relation to the remnant "barrier" pillars between extracted panels and between the panels and the mains.

The barriers between the extracted pillar panels will generally have widths of 25m and be 925m to 1,295m long. The pillar height will range from 2.0m to 2.8m, depending on the seam thickness. The inter-panel barrier will have w/h ratios ranging from 8.9 to 12.5. These pillars are expected to yield gradually and behave elastically (strain-harden if the unlikely scenario of overloading occurs).

A solid barrier between the finishing ends of Panels 24 to 26 and the adjacent West Mains will generally be from 28.0m to 42.5m wide with pillar width/height ratios of 11.2 to 17.0 and are also expected to behave elastically in the long term.

The barrier pillar between the East Installs and the South Mains will have a width of 24.7m and pillar/height ratios of 8.8 to 9.8 and are not expected to yield after secondary extraction is completed.

7 SITE CONDITIONS OF THE APPLICATION AREA

7.1 SURFACE TOPOGRAPHY

The SMP application area is located to the south of John Renshaw Drive, generally bounded by existing and proposed main underground development workings to the north, the previously approved SMP Areas 1 and 2 to the east and resource thickness / quality of the Upper Donaldson seam to the south, with the mine entries within the former mining area of Donaldson Open Cut (See **Figure 1**).

Mining will take place in the application area under a combination of land owned by Donaldson Coal, the Catholic Diocese of Maitland - Newcastle, Telstra Corporation and seven private rural residential land holdings.

The land is a combination of native bushland, cleared livestock grazing land (some previously used for poultry farms), rural residential, several business premises and a public road.

Black Hill Road divides the SMP Area 3 basically in two with the northern half being fully vegetated and the southern half being a combination of cleared grazing land and remnant vegetation.

The privately owned land consists of a combination of natural bushland and generally cleared land used for rural residential activities.

Four vegetation communities have been mapped across SMP Area 3, being:

- Lower Hunter Spotted Gum – Ironbark Forest, approximately 62 ha, being consistent with the NSW listed Endangered Ecological Community – *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion;*
- Coastal Foothills Spotted Gum – Ironbark Forest, approximately 23 ha;
- Central Hunter Spotted Gum – Ironbark Forest, approximately 20 ha, being consistent with the NSW listed Critically Endangered Ecological Community – *Central Hunter Ironbark - Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions;* and
- Alluvial Tall Moist forest variant, approximately 4 ha.

No development applications have been lodged for any land within the SMP application area at this stage.

The surface naturally falls towards Four Mile Creek in the western part of the area, and into tributaries of Weakleys Flat and Viney Creeks in the eastern part of the area.
The surface levels directly above the proposed panels vary from a low point of approximately 40 metres AHD in the tributaries at the northern ends of the proposed panels, to a high point of approximately 125 metres AHD at the southern ends of the proposed panels. The natural surface gradients above the proposed mining area are typically less than 1 in 3 (i.e. 18º, or 33 %), with natural grades varying up to around 1 in 2 (i.e. 27º, or 50%) on the hill located above the southern ends of the proposed panels.

The prominent features are described in detail in **Section 8.4.1** to **8.4.6**.

7.2 DEPTH OF COVER

The depths of cover directly above the proposed Panels vary between a minimum of 50 metres above the north-eastern corner of the mining area, and a maximum of 200 metres above the southern end of the mining area.
Details of cover included in **Plan 3A.**

7.3 OVERBURDEN STRATIGRAPHY

The SMP application area lies in the Newcastle Coalfield within the Northern Sydney Basin. The overburden comprises part of the Dempsey Formation, which is part of the Permian Aged, Tomago Coal Measures.

The overburden for the area consists of gently, south-west dipping (i.e. 2 to 5 degrees) sedimentary strata of the Tomago Coal Measures, which generally comprise interbedded sandstone, shale, carbonaceous mudstone, tuffaceous claystone and coal. The coal seams present in the overburden (in descending order) include the Sandgate, Upper and Lower Buttai, Beresfield, Upper and Lower Donaldson, Big Ben and Ashtonfield Seams. The overlying Waratah Sandstone separates the Tomago Coal and the Newcastle Coal Measures.

A typical stratigraphic section of the Newcastle Coalfield (after Ives et al, 1999, Moelle and Dean-Jones, 1995, Loehe and Dean-Jones,1995, Loehe and Allan, 1995) is shown in **Figure 5**.

Figure 5 – Stratigraphy of the Tomago Coal Measures

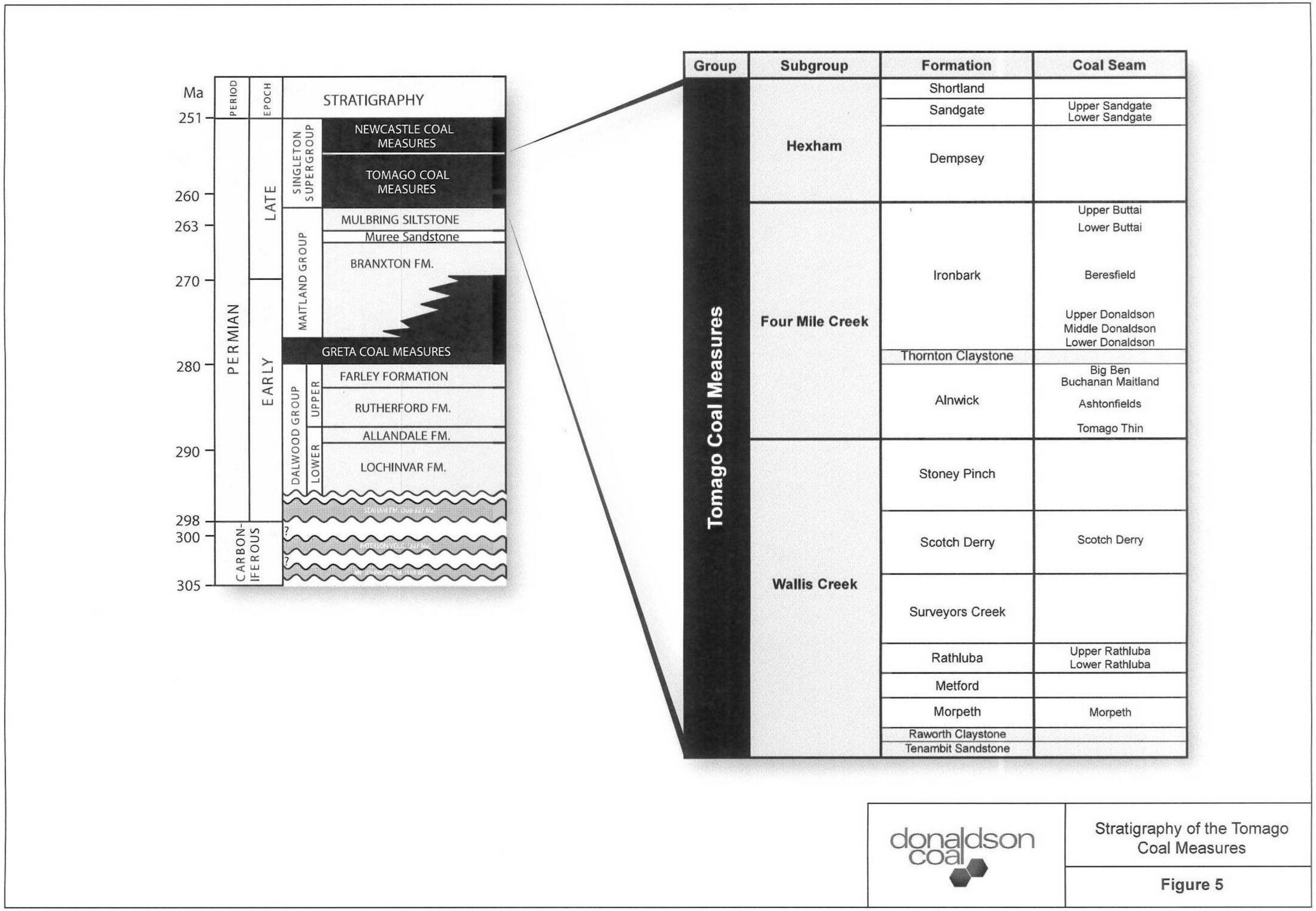


Table 6 - Stratigraphy of the Newcastle Coalfield

Stratigraphy			Lithology
Group	**Formation**	**Coal Seams**	
Narrabeen Group	Clifton		Sandstone, siltstone, mudstone, claystone
Newcastle Coal Measures	Moon Island Beach	Vales Point Wallarah Great Northern	Sandstone, shale, conglomerate, claystone, coal
	Awaba Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Boolaroo	Fassifern Upper Pilot Lower Pilot Hartley Hill	Conglomerate, sandstone, shale, claystone, coal
	Warners Bay Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone, chert
	Adamstown	Australasian Montrose Wave Hill Fern Valley Victoria Tunnel	Conglomerate, sandstone, shale, claystone, coal
	Nobbys Tuff		Tuff, tuffaceous sandstone, tuffaceous siltstone, claystone chert
	Lambton	Nobbys Dudley Yard Borehole	Sandstone, shale, minor conglomerate, claystone, coal
	Waratah Sandstone		Sandstone
Tomago Coal Measures	Dempsey		Shale, siltstone, fine sandstone, coal, and minor tuffaceous claystone
	Four Mile Creek	**Upper Donaldson** Lower Donaldson	
	Wallis Creek		
Maitland Group	Mulbring Siltstone		Siltstone
	Muree Sandstone		Sandstone
	Braxton		Sandstone, and siltstone
Greta Coal Measures	Paxton	Pelton	Sandstone, conglomerate, and coal
	Kitchener	Greta	
	Kurri Kurri	Homeville	
	Neath Sandstone		Sandstone
Dalwood Group	Farley		Shale, siltstone, lithic sandstone, conglomerate, minor marl and coal, and interbedded basalts, volcanic breccia, and tuffs
	Rutherford		
	Allandale		
	Lochinvar		
Seaham Formation			

7.4 LITHOLOGICAL AND GEOTECHNICAL CHARACTERISTICS

7.4.1 Overburden

The overburden comprises predominately sandstones and shales, interbedded with a number of coal seams.

Strength testing has been undertaken at selected horizons (**Table 7**).

Table 7 - Typical Geotechnical Properties for Abel SMP Area 3 (*Based on Boreholes C189, C238, C239, C241, C244, C254, C255, C268, C305 & C307)*

Depth to Top of Unit	Depth to Base of Unit	Strata Description	Modeled UCS Range (MPa)
0.0	13.0	Sandy unconsolidated material	
13.0	51.0	Shale with minor sandstone and claystone bands	30-45
51.0	51.4	Coal (Upper Buttai Seam)	10-15
51.4	72.4	Sandstone and shale	40-60
72.4	73.3	Coal (Lower Buttai Seam)	10-15
73.3	86.0	Sandstone and shale	45-55
86.0	107.3	Shale and sandstone	40-55
107.3	107.9	Coal (Beresfield Seam)	5-10
107.9	115.0	Shale with sandstone	30-40
115.0	118.0	Sandstone with shale	50-65
118.0	121.0	Sandstone	35-55
121.0	123.5	Coal (Upper Donaldson Seam)	10-15

7.4.2 Roof and Floor

The immediate roof and floor of the proposed mining horizon will typically consist of 5 to 10 m or more of thin to medium interbedded shale and sandstone with low to medium strength (10 to 50 MPa). The weaker materials, such as carbonaceous mudstone, mudstone and claystone are very thin (< 0.1 m thick) and exist in both the roof and floor.

The immediate roof above the Upper Donaldson Seam comprises shales and sandstones with localised variations where sandstones grade into shales, and shales grade into sandstones, with common changes in the thickness and areal extent of the bands or lenses of material. Thickly bedded or massive units are rare and have not been identified as existing in bands greater than two to three metres thickness.

Low strength immediate roof and floor materials were also generally noted in several boreholes in the north, where the cover depths are less than 50m. This is also considered to be the general depth of weathering on the Donaldson open cut mine to the north of the underground mining area. The sonic UCS results indicated thinly bedded strata with strengths ranging between 10 and 50 MPa and generally from 30 to 50 MPa for the overburden materials at depths > 50 m.

The UCS and stiffness properties of the immediate roof and floor materials have been derived from laboratory and point load strength test results from core taken from ten boreholes and in-situ geophysical testing data.

Estimates of the range of material strength and stiffness properties present in the roof and floor of the Upper Donaldson Seam are summarised in **Table 8.**

Table 8 - Strength Property Estimates for Upper Donaldson Seam, Roof and Floor Lithology

Lithology	Strata Thickness (m)	Typical UCS Range+ (MPa)	Typical Elastic Moduli Range* (GPa)	Average Moisture Sensitivity^
Interbedded sandstone/ shale beds above the UD Seam	<10	20 - 65	6 – 19.5	Non-Sensitive to Moderately Sensitive
Upper Donaldson Seam	1.9 - 3.2	5 - 15	1.5 – 4.5	Non-Sensitive to slightly sensitive stone bands
Interbedded sandstone/ shale beds below the UD Seam	<10	15 - 80	4.5 – 24	Non-Sensitive to Slightly Sensitive

Note:
+ - Unconfined Compressive Strength derived from point load testing to **ISRM, 1985** on bore core samples taken from SMP area.
* - Laboratory Young's Modulus (E) derived from laboratory and sonic UCS data, E = 300 x UCS (units are in MPa).
^ - Moisture sensitivity testing determined from the Immersion Test procedure presented in **Mark & Molinda, 1996**.

For further geotechnical details see **Table 7**.

7.5 EXISTENCE AND CHARACTERISTICS OF GEOLOGICAL STRUCTURES

The seam generally dips towards the south of the mining area at approximately 1 in 20.

The available boreholes indicate that the strata layers are frequently bedded having thickness up to around 10 metres. There were no massive sandstone or conglomerate units identified from this information.

The geological features identified at seam level comprise two north-south orientated faults through the northern ends of the proposed Panels 24 to 26, having throws up to around 0.3 metres. A north-south orientated dyke has also been identified through the northern ends of the proposed Panels 25 and 26, having a thickness of around 0.5 metres. The proposed panels are supercritical in these locations and, therefore, are predicted to achieve the maximum subsidence for single-seam mining conditions. The presence of these geological features, therefore, are unlikely to affect the subsidence predictions and, hence, impact assessments provided.

Surface joint patterns measured on the sandstone cliff lines and outcrops to the south of the SMP 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.

The Upper Donaldson Seam has low strength with sonic derived unconfined compressive strength (UCS) values ranging from 5 to 15 MPa. Some medium to high strength stone bands up to 0.5 m thick are present within the coal seam, with UCS values ranging between 30 and 90 MPa.

8 IDENTIFICATION AND CHARACTERISATION OF SURFACE AND SUB-SURFACE FEATURES

8.1 MINE SUBSIDENCE DISTRICT

The SMP application area is not located within a current Mine Subsidence District but was previously located within the Ironbark Mine Subsidence District which was revoked in October 1994. Discussions have been held with the MSB relating to the future reclassification of the area as a Mine Subsidence District.

8.2 PROPOSED DEVELOPMENTS

At this stage no potential future development, which will impact on this SMP area, has been identified and no current Development Applications are lodged with Cessnock City Council.

8.3 GENERAL DESCRIPTION

The following sections identify and describe all the significant natural features and surface improvements that lie within the SMP application area, which is shown on **Plan 2**.

Reference to the SMP Guideline 2003 was made to assist in identifying these features that may be affected by mining. In addition to this, and as part of the Risk Assessment conducted on 12 December 2012, additional sources were used to confirm the features within the SMP application area.

These sources included:

- aerial photos;
- digital cadastral information also showing surface features;
- on site surveys by mine surveyors;
- field surveys by Donaldson Coal personnel and consultants, local knowledge of the area by mine personnel and various consultants; and
- Information provided by Public Utilities and landholders.
- Information from Abel EA and subsequent modification application.

8.4 NATURAL FEATURES

Natural features contained within the SMP application area are limited to the following as listed under Appendix B of the SMP Guideline 2003.

- Catchment areas – Hunter River Catchment;
- Watercourses – Schedule 1 streams only. (**Section 8.4.1**);
- Aquifers and groundwater resources – Various aquifers (**Section 8.4.2**);
- Steep slopes – (**Section 8.4.3**)
- Land prone to flooding and inundation (**Section 8.4.4**);
- Water Related Ecosystems (**Section 8.4.5**); and
- Flora, Fauna and Natural Vegetation – Section of application area contains native vegetation, threatened and protected species (**Section 8.4.6**).

Listed in the following Table is a check list of natural features from Appendix B of the SMP Guideline 2003.

Surface and Sub-Surface features that may be affected by Underground Coal Mining.

Table 9 - Item 1 – Natural Features

No.	Description	Method of Assessment	Items in SMP Application Area
1	Catchment areas and declared Special areas	Reviewed classification of catchment areas	Hunter River Catchment
2	Rivers and creeks	Reviewed classification of catchment areas	No rivers. Schedule 1 streams only Four Mile Creek plus tributaries to Weakleys Flat and Viney Creek
3	Aquifers, known groundwater resources	Hydrogeological assessment	Aquifers
4	Springs	Ground truthing	Spring on Osborn property located to the west of SMP Area 3
5	Sea / Lake	Reviewed aerial photo and topographical plan	Nil
6	Shorelines	Reviewed aerial photo and topographical plan	Nil

No.	Description	Method of Assessment	Items in SMP Application Area
7	Natural dams	Reviewed aerial photo and topographical plan	Nil
8	Cliffs / Pagodas / Rock Formations	Reviewed aerial photo and topographical plan, targeted ground truthing	Nil
9	Steep slopes	Reviewed topographical plan, targeted ground truthing	Located along the southern ends of the proposed panels
10	Escarpments	Reviewed Aerial photo and topographical plan	Nil
11	Land prone to flooding or inundation	Reviewed Aerial photo and topographical plan. Subsidence assessment	Increased ponding potential along watercourses.
12	Swamps, wetlands, water related ecosystems	Reviewed Aerial photo and topographical plan. Ground truthing, vegetation mapping	No swamps or wetlands within Area 3. Water related ecosystems associated with the streams
13	Threatened and protected species	Surveys, literature, ground truthing, monitoring	Yes
14	National parks	Reviewed NPWS website	Nil
15	State recreation areas	Reviewed NPWS website and plans	Nil
16	State Forests particularly area zoned Forestry Management Zones 1,2 or 3	Obtained State Forest map.	Nil
17	Natural vegetation	Surveys, literature	Yes
18	Areas of significant geological interest		Nil
19	Any other feature considered significant		Nil

8.4.1 Watercourses

SMP Area 3 is located on the divide between three creek systems that drain in a northerly and north-easterly direction from the Black Hill ridge:

The Four Mile Creek catchment occupies the western half of SMP Area 3. The creek drains in a northerly direction and, after crossing under John Renshaw Drive, drains through the Donaldson and Bloomfield mine lease areas, under the New England Highway and onto the Hunter River floodplain to the north of Ashtonfield.

Weakleys Flat Creek, which occupies the north-eastern corner of Area 3, drains in a north-easterly direction and flows under John Renshaw Drive about 2 km west of the intersection with the Freeway. Weakleys Flat Creek subsequently drains through the Weakleys Flat industrial area and under the New England Highway immediately west of Beresfield where it drains into Woodberry Swamp on the Hunter River floodplain.

Viney Creek, a tributary of Weakleys Flat Creek, drains the south-east corner of Area 3. It also drains in a north-easterly direction and flows under John Renshaw Drive about 700 m west of the Freeway intersection and joins Weakleys Flat Creek about 700 m north.

There are no named rivers or Schedule 2 (i.e. third order and above) streams located the SMP Area. The nearest Schedule 2 streams are Viney Creek, Long Gully and Buttai

Creek, which are all located more than 1 kilometre outside the extents of the proposed panels. All watercourses within SMP Area 3 are ephemeral and only flow immediately after rainfall.

Four Mile Creek is the only named creek within the SMP Area, which is partially located above the proposed Panel 26. The total length of creek directly mined beneath is around 0.8 kilometres. The creek is a second order ephemeral stream. The creek has a shallow incision into the natural surface soils, derived from the Tomago Coal Measures (Pl), with some sandstone bedrock outcropping in isolated locations.

There are also a number of first and second order tributaries within SMP Area 3. The surface naturally drains into Four Mile Creek and its tributaries in the western part of the SMP Area, and into the tributaries of Weakleys Flat and Viney Creeks in the eastern part of the SMP Area.

Surface Water Catchments and Watercourses

SMP Area 3 is located to the north of the Black Hill ridge and grades from steeper slopes (up to 20% in isolated places) along the southern boundary to flatter slopes (<5%) along the northern boundary and towards north-eastern corner.

The Soil Landscapes of the Newcastle 1:100 000 Sheet (Matthei, 1995) describes the soils in the area as predominantly belonging to the Beresfield soil landscape unit with minor differences on either side of Black Hill Road. Key features of the Beresfield soil landscape unit are:

> Friable brownish-black sandy loam topsoil (50 – 150 mm deep) overlying hard setting yellowish-brown sandy-clay loam (50 – 300 mm deep) and brown clay near the ridge crests. These soils tend to be highly erodible in concentrated flows;
>
> Similar, but shallower soils on the mid slopes with some areas where the sandy loam topsoil is absent on the mid-slopes. These soils tend to hard setting and have moderate erodibility in concentrated flows.

As can be seen on **Plan 7** there are two distinct patterns of land use within Area 3:
Predominantly fully forested land to the north of Black Hill Road;
Cleared land with some remnant forest to the south of Black Hill Road.

A watercourse survey was undertaken on behalf of Donaldson Coal to collect representative data for the watercourses throughout the Abel Underground Mine area. The table below summarises the characteristics of the creek channel at locations within or immediately adjacent to SMP Area 3. The observation points are ordered along each creek from upstream to downstream.

Table 10 - Summary of Creek Channel Characteristics in the Vicinity of SMP Area 3

Creek	**Site**	**Bed Material**	**Channel Width (m)**	**Chanel Depth (m)**	**Adjoining Vegetation**	**Notes**
Four Mile	77	Sand and gravel	0.5	0.3	Dense forest	
Four Mile	76	Grass	± 2	Indistinct	Grass	Downstream of farm dam. Shallow depression with no defined bed and banks
Four Mile	52	na	na	na	na	Field data sheet missing

Creek	Site	Bed Material	Channel Width (m)	Chanel Depth (m)	Adjoining Vegetation	Notes
Four Mile	51	Sand and gravel	1.5	1	Dense forest	Pool approx 0.5 wide x 0.15 deep
Four Mile	38	Soil and gravel with small boulders	1.5	0.7	Dense forest	
Four Mile	35	Soil	1.25	3	Dense forest	
Four Mile	40	Soil and gravel with small boulders	2 - 3	0.5 - 2.0	Dense forest	Occasional Pools. Steep banks. Occasional sandstone outcrops
Four Mile	42	Soil and sand	3	1	Dense forest	Eroded bank (4 m high) downstream
Four Mile	43	Soil and sand	3	1 - 2	Dense forest	Small pool approx. 2 m x 1 m, 0.2 deep
Weakleys Flat	53	Soil - heavily grassed	-	-	Dense forest	Shallow depression with no defined bed and banks
Weakleys Flat	54	Sand and gravel	0.5 - 1.0	0.3	Dense forest	
Weakleys Flat	55	Soil and grass	0.3	0.3	Dense forest	
Weakleys Flat	72	Soil and sand	1.5	0.5	Dense forest	Sandstone outcrops
Viney	66	Sand and large boulders	1.8	2	Forest	
Viney	65	Soil and grass	1 - 4	0.7	Grass	Flat banks

Although there are some minor differences, because the creeks systems within SMP Area 3 all originate within an area of similar landform, slopes and soils, they share a range of common features:

Bed and bank material is highly variable with predominantly soil and sand with gravel and boulders in some upstream areas where the bed slope is greater. Outcropping of sandstone occurs occasionally.

The channel dimensions are highly variable with widths generally ranging from 1.5 to 3 m, and channel depth ranging from about 0.5 to 1.5 m.

In some locations where the creek lines cross cleared grass area (e.g. sites 53 and 76), the creek channel is grassed and does not have well defined bed and banks.

There was no flow in the creeks during the survey, but a number of small pools (up to 0.2 m deep) were observed. As can be seen on **Plan 2**, there are a number of significant farm dams in the headwaters of Four Mile Creek.

Creek channel gradients range from 2.5% - 3.5% in the headwaters to about 1% where the creeks flow out of SMP Area 3.

Surface Water Quality

Water quality data for the three creeks that drain from SMP Area 3 has been collected on a monthly basis at three locations:

Four Mile Creek upstream of John Renshaw Drive (about 0.5 km downstream of Area 3). Data collection for this site commenced in July 2000;

Weakleys Flat Creek upstream of John Renshaw Drive (about 2 km downstream of Area 3). Data collection for this site commenced in July 2000;

Viney Creek upstream of John Renshaw Drive (about 3.8 km downstream of Area 3). Data collection for this site commenced in June 2007.

The table below summarises the key water quality statistics for these three sites. For comparison purposes, the table also lists the default ANZECC trigger values for lowland creeks with slightly disturbed ecosystems.

Table 11 - Summary of Water Quality Statistics for Creeks Draining from SMP Area 3

	Statistic	pH (lab)	EC (lab) (µS/cm)	TSS (mg/L)	Turbidity (NTU)	Nitrate (mg/L)	Ortho-phosphate (mg/L)
	ANZECC Default Trigger	6.5 – 8.0	125 – 2,200	n.a.	6 - 50	NOx = 0.04	0.02
Four Mile Creek	Number of Samples	109	109	136	92	38	7
	Minimum	5.9	100	1	7	0.01	<0.01
	20th Percentile	6.5	215	8	36	0.03	
	Average	6.7	406	25	132	0.72	0.012
	80th Percentile	7.0	591	30	205	1.10	
	Maximum	7.9	985	269	860	3.20	0.030
Weakleys Flat Creek	Number of Samples	117	117	145	99	40	6
	Minimum	5.6	7	1	3	0.01	0.01
	20th Percentile	6.6	235	4	22	0.08	
	Average	6.9	784	26	110	0.54	0.20
	80th Percentile	7.2	1,116	31	120	0.92	
	Maximum	7.7	4,810	920	2,520	2.70	0.44
Viney Creek	Number of Samples	34	34	63	61	-	
	Minimum	6.6	520	2	1	-	
	20th Percentile	6.8	915	7	14	-	
	Average	7.0	1,323	32	73	-	
	80th Percentile[1]	7.1	1,708	28	60	-	
	Maximum	7.5	2,300	624	1,680	-	

Note 1: The apparent anomaly for 80th percentile turbidity and TSS (which are higher than the average) is attributable a few very large values which dominate the calculation of the average.

Although all three creeks drain from areas of similar landform, soils and land use within Area 3, they exhibit a number of differences in water quality that may be attributable to significant differences in the land use on the other areas of the catchments located between Area 3 and the water quality monitoring sites:

The catchment of Weakleys Flat Creek contains a large area that was formerly occupied by a poultry farm containing a large number of poultry sheds;

The catchment of Viney Creek contains a large area cleared of rural residential land located to the south of Black Hill Road.

Key aspects of the similarities and differences between the three water quality monitoring sites are:

Average pH at all three sites is neutral (pH 7) and all three also exhibit slightly alkaline conditions (pH about 8) on occasions. Both Four Mile Creek and Weakleys Flat Creek have minimum pH of less than 6.20th and 80th percentile values for all sites are within the default ANZECC trigger levels for further investigation.

There are significant differences in the salinity of the water (as indicated by electrical conductivity – EC) in the three catchments:

- Average EC increases from 406 µS/cm in Four Mile Creek to 784 µS/cm in Weakleys Flat Creek (about double) and 1,323 µS/cm in Viney Creek (more than three times the conductivity in Four Mile Creek).
- The 80th percentile EC values increase in similar proportions to the averages.
- These data indicate that there are additional sources of salts in the catchments of Weakleys Flat Creek and Viney Creek compared to Four Mile Creek. Because of the similarity of soils and land use within the headwaters of all three creeks within SMP Area 3, the sources of additional salt in Weakleys Flat and Viney Creeks are likely to be in sections of the catchments downstream of SMP Area 3.
- Apart from the maximum recordings for Weakleys Flat and Viney Creeks, all EC data are within the ANZECC default trigger range.

The turbidity data indicates that all three creeks have high turbidity levels and, on average, exceed the default ANZECC criteria of 50 NTU. The data also show very high maximum values which can be attributed to storm runoff.

Limited data has been collected for nitrogen species, with nitrate data only collected on a semi-regular basis for Four Mile and Weakleys Flat Creeks. The data for these two creeks shows average values of 0.72 mg/L and 0.54 mg/L respectively. Although this data does not include other oxides of nitrogen, the nitrate values all exceed the default ANZECC trigger values for oxides of nitrogen.

The limited data on orthophosphate suggests that there are limited sources in the Four Mile Creek catchment, leading to the average being less than the ANZECC default trigger value, with more than half of the samples being less that the laboratory detection limit. However, all the samples for Weakleys Flat Creek have concentrations above the ANZECC default trigger levels.

Overall, the water quality data indicates that at the downstream monitoring points all three catchments have water quality that is consistent with moderately disturbed catchments. Because of the level of existing disturbance on the catchments, it is unlikely that any water quality impacts attributable to mine subsidence would be detectable.

The data indicates that, for a significant proportion of the time, the water quality from the Abel mine lease does not comply with the default water quality trigger values for lowland rivers set out in the ANZECC Guidelines published in 2000 (“the Guidelines”).

The Guidelines provide **default** ‘trigger’ values for different indicators of water quality parameters as either a ‘*threshold value*’ or as a ‘*range of desirable values*’. Where an indicator is above a threshold value or outside the range of desirable values “*there may be a risk that the environmental value will not be protected”*. The purpose of these 'trigger' values is to provide a 'trigger' for action or further investigation. They are not prescribed limits.

The Guidelines also state that:

> *"Trigger values are conservative assessment levels, not 'pass/fail' compliance criteria. Local conditions vary naturally between waterways and it may be necessary to tailor trigger values to local conditions or 'local guidelines'."*

The Guidelines also state that two years of monthly sampling is regarded as sufficient to provide an indication of the local ecosystem variability and to provide a basis for derivation of 'trigger' values appropriate to conditions in a particular creek system. For physical and chemical stressors for slightly or moderately disturbed ecosystems, such as that surrounding the Abel Underground Mine, the Guidelines recommend the use of the 20^{th} and 80^{th} percentile values of the data obtained from an appropriate reference system as the basis for revised 'trigger' values.

8.4.2 Aquifers and Groundwater Resources

Previous Work

A number of groundwater studies have previously been undertaken by Donaldson Coal, and for
other surrounding mining projects, the main studies being:

- Groundwater investigations undertaken for the Donaldson Open Cut Coal Mine in 1998
  (PPK Environmental and Infrastructure, 1998; Mackie Environmental Research, 1998);
- Hydrogeological studies undertaken for the existing Tasman Underground Mine in 2002
  (PDA, 2002);
- Groundwater investigations undertaken for the Abel Underground Mine in 2006 (PDA, 2006);
- Groundwater investigations undertaken for the Bloomfield Colliery in 2008 (Aquaterra, 2008);
- Hydrogeological studies undertaken for the Tasman Extension Project in 2012 (RPS
  Aquaterra, 2012).

As part of these studies, numerous groundwater monitoring bores were installed and core samples were collected.

Study Objectives

A groundwater investigation was undertaken for the Abel Underground Mine as part of the Abel Upgrade Modification - 75W (2012) and is provided as **Appendix E**.

The groundwater investigations aimed to:

- Assess and describe the existing groundwater environment in the vicinity of the Abel Underground Mine;
- Identify potential risks to the environment from the proposal;
- Evaluate the potential impacts of the proposal on the regional and local groundwater resources, incorporating any necessary management and mitigation strategies; and

- Assess any residual post-project impacts and any ongoing management requirements.

The study was undertaken with reference to the following relevant policies:

- NSW State Rivers and Estuaries Policy;
- NSW Wetlands Management Policy;
- NSW Groundwater Policy Framework Document – General;
- NSW Groundwater Quantity Management Policy;
- NSW Groundwater Quality Protection Policy; and
- NSW Groundwater Dependent Ecosystem Policy.

The following relevant best practice guidelines have been referenced:

- *Groundwater Flow Modelling Guideline* (Middlemis, 2001);
- *Australian Groundwater Modelling Guidelines (Waterlines report 82, National Water Commission, 2012)*
- *Independent Inquiry into the Hunter River System* (Healthy Rivers Commission, 2002);
- *Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region* (DIPNR, 2005); and
- *Groundwater Monitoring Guidelines for Mine Sites within the Hunter Region (DIPNR, 2003).*

Approach to Impact Assessment

In order to assess the impacts that the Modification may have on the hydrogeological environment, the MODFLOW-SURFACT Donaldson Regional Groundwater Model was used.

Project Approval (05_0136) for the Abel Underground Mine included a requirement for the further development of the groundwater model prepared for the Abel Underground Mine Environmental Assessment. In accordance with this requirement, the Donaldson Regional Groundwater Model was developed. This model was further improved for the Tasman Extension Project and for this study.

For this study, the model was first calibrated against quasi 'steady state' pre-mining conditions, and was then subject to a transient calibration to groundwater levels, baseflows and mine inflows from 2006 to 2012. As coal mining has been undertaken in this area for over 170 years, it is not possible to represent true pre-mining conditions, so a quasi-steady state condition was adopted which is believed to represent relatively stable conditions before the start of large scale mining at the Donaldson Open Cut Mine and the Abel and Tasman Underground Mines, which has occurred since 2000.

The groundwater modelling included a number of specific approaches that were used to simulate potential impacts from the proposed mining activities, including:

- Simulation of groundwater dewatering caused by both open cut and underground mining;
  and
- Changes to the hydraulic properties of overburden material caused by the caving and
  subsidence above underground mine panels.

A further report has been prepared to support existing groundwater assessments for SMP Area 3 (**Appendix F**).

The Risk Assessment undertaken as part of the preparation of the SMP identified a range of potential impacts that are considered in this letter. These include:

- Loss of the groundwater resource as a result of:
- Connective cracking;
- Additional flow to underground workings from the intersection with structures;
- Depressurisation of aquifers due to mining activities greater than predicted;
- Elevated salinity in groundwater inflows through mine workings;
- Loss of flow from a potential spring on the “Osborn's Property” due to mining related depressurisation of aquifers being greater than that predicted.

This further report draws upon information presented in:

- information presented in the original Part 3A Environmental Assessment for the Abel Underground Mine (Donaldson Coal, 2006) with particular reference to Area 3;
- hydrogeological studies undertaken for the Tasman Extension Project in 2012 (RPS Aquaterra, 2012)
- hydrogeological studies undertaken for the Abel Underground Mine as part of the Abel Upgrade Modification - 75W (2012
- from the observed impacts associated with mining of SMP Areas 1 and 2: and
- subsidence Predictions and Impact Assessment (MSEC, 2-012).

This further report draws upon information presented in the original Part 3A Environmental Assessment for the Abel Underground Mine (Donaldson Coal, 2006) with particular reference to Area 3;
relevant information gained from the observed impacts associated with mining of SMP Areas 1 and 2: and
Subsidence Predictions and Impact Assessment (MSEC, 2012);

Overview of the Main Hydrogeological Units

Two distinct aquifer systems occur within or near the project area:
A fractured rock aquifer system in the coal measures, with groundwater flow mainly in the coal seams; and
A shallow granular aquifer system in the unconsolidated alluvium.

In the Abel Underground Mine area, permeability is generally highest in the coal seams and in areas where there is significant fracturing or faulting. However, overall the coal measures have a low inherent permeability. The interbedded sandstones and siltstones are of lower permeability and offer very limited inter-granular porosity and little secondary permeability and storage in joints.

Groundwater is also found to occur in the alluvial overburden across the footprint of the Abel underground mine. However, in Area 3 this is limited to thin cover within ephemeral streams such as:

- Four Mile Creek, plus tributaries of
- Weakleys Flat Creek
- Viney Creek
- Buttai Creek
- Bluegum Creek

There is considered to be limited hydraulic connectivity between the alluvium and the coal measures in these areas as the limited alluvium in these ephemeral streams are likely to be generally unsaturated.

Groundwater flow within the coal measures is controlled to a large degree by regional topography, with recharge occurring in areas of elevated terrain and then slow movement down-dip or along strike to areas of lower topography. There is considered to be a component of lateral flow in the coal measures out of the project area over the southern and eastern boundaries.

Groundwater levels in the near surface material, which includes alluvium/colluvium and weathered bedrock, show a much closer relationship to the local topography. While groundwater levels in the deeper coal measures are not influenced by local topography, the surficial groundwater levels are locally influenced.

Groundwater level contours for 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 Mine. The flow pattern is largely independent of the local topography. The contours are also influenced from dewatering in the Donaldson Open Cut Mine area and more recently with the mining activities within the existing underground mine in SMP Areas 1 and 2.

Groundwater flow within the deeper coal measures is therefore believed to be more regionally controlled, whereas flow within the near-surface material is subject to local topographic influences. However, groundwater within geological structures such as joint and thrust fault structures have been encountered, specifically within SMP Area 1 with elevated groundwater inflows occurring to underground workings on intersection.

Recharge and Discharge

Rainfall recharge occurs to the coal seams where they outcrop and to the alluvial aquifers.
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.

Groundwater discharge occurs through evaporation, seepage and spring flow where the water table intersects the land surface and through baseflow contributions to creeks and rivers, 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.

Groundwater and Surface Water Interaction

There is believed to be limited interaction between the surface drainage system and the deeper groundwater within the coal measures. The limited occurrences of localised surficial groundwater on the other hand are believed to be in reasonable hydraulic connection with the high level streams, and there is expected to be some interchange of water 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 should be considered to be an integral part of the surface water flow system.

Summary

Mining activities at the Donaldson Open Cut and Abel Underground Mines have to date caused a drawdown in groundwater levels in the vicinity of the open cut with a cone of depression extending a short distance into the north-eastern part of the Abel mining lease area due to excavation in SMP Areas 1 and 2. Mining activities in SMP Area 3 are expected to increase the cone of depression to an area which includes the footprint of SMP Area 3.

Groundwater modeling for the project has continued to be updated with calibration and verification including recent impacts from Area 1 and Area 2 respectively. To date, groundwater drawdowns are in line with modeled predictions and the impact on Area 3 due to mining activities is anticipated to be in line with previous observations and modeled predictions.

Monitoring of the groundwater levels within SMP Area 3 will occur using the standpipe piezometer DPZ12 which is located within the footprint of Area 3 and screened within shallow overburden and with C080, a vibrating wire piezometer located to the southwest of the SMP Area 3 footprint. C080 will monitor the lateral propagation of groundwater depressurization within the Donaldson Seam.

The salinity of groundwater inflows which will occur in SMP Area 3 is anticipated to be variable, similar to that experienced in SMP areas 1 and 2. The monitoring network at Abel Underground Mine has shown measured salinity to be variable within the Permian Coal measures.

A total of 15 farm dams have been identified within SMP Area 3 to the south of Black Hill Road, of which 11 are located within the footprint of Panels 23 – 26. The dams on the Osborn property which are located to the west of the SMP Area 3 boundary have previously been discussed as having a possible interaction with groundwater springs.

Observations made on this property revealed no perennial spring fed surface water feature although there is the possibility that subsurface flow to the dams occurs. The mechanism for any potential subsurface flow to the dams is likely to occur within shallow weathered soil profile from west to east and be driven by the significant elevation within the up gradient catchment. The potential for loss of flow springs on Osborn's property due to depressurisation of aquifers due to mining activities being greater than that predicted is assessed to be low.

8.4.3 Steep Slopes

For the purposes of this report, steep slopes have been defined as areas of land having natural gradients greater than 1 in 3 (i.e. 33 %, or an angle to the horizontal of 18°). The locations of the steep slopes within SMP Area 3 were determined using the surface level contours generated from a LiDAR survey of the area. The areas identified as having steep slopes within the SMP Area are shown in Drawing No. MSEC596-08 of **Appendix A.**

The hill located above the southern ends of the proposed panels has natural gradients varying up to around 1 in 2 (i.e. 27º, or 50 %). There are also some isolated areas along the alignments of the streams which also have natural gradients up to around 1 in 2.

Elsewhere, the natural gradients are typically less than 1 in 3, which is the threshold used to define steep slopes in this report.

The surface soils along steep slopes have developed from the Tomago Coal Measures (Pl) and the steep slopes are stabilised by natural bushland.

8.4.4 Land Prone to Flooding and Inundation

The surface within SMP Area 3 naturally drains into Four Mile Creek in the western part of the area, and into tributaries of Weakleys Flat and Viney Creeks in the eastern part of the area. The assessments of the potential for increased ponding along the streams are provided in **Section 11.2.5.**

8.4.5 Water Related Ecosystems

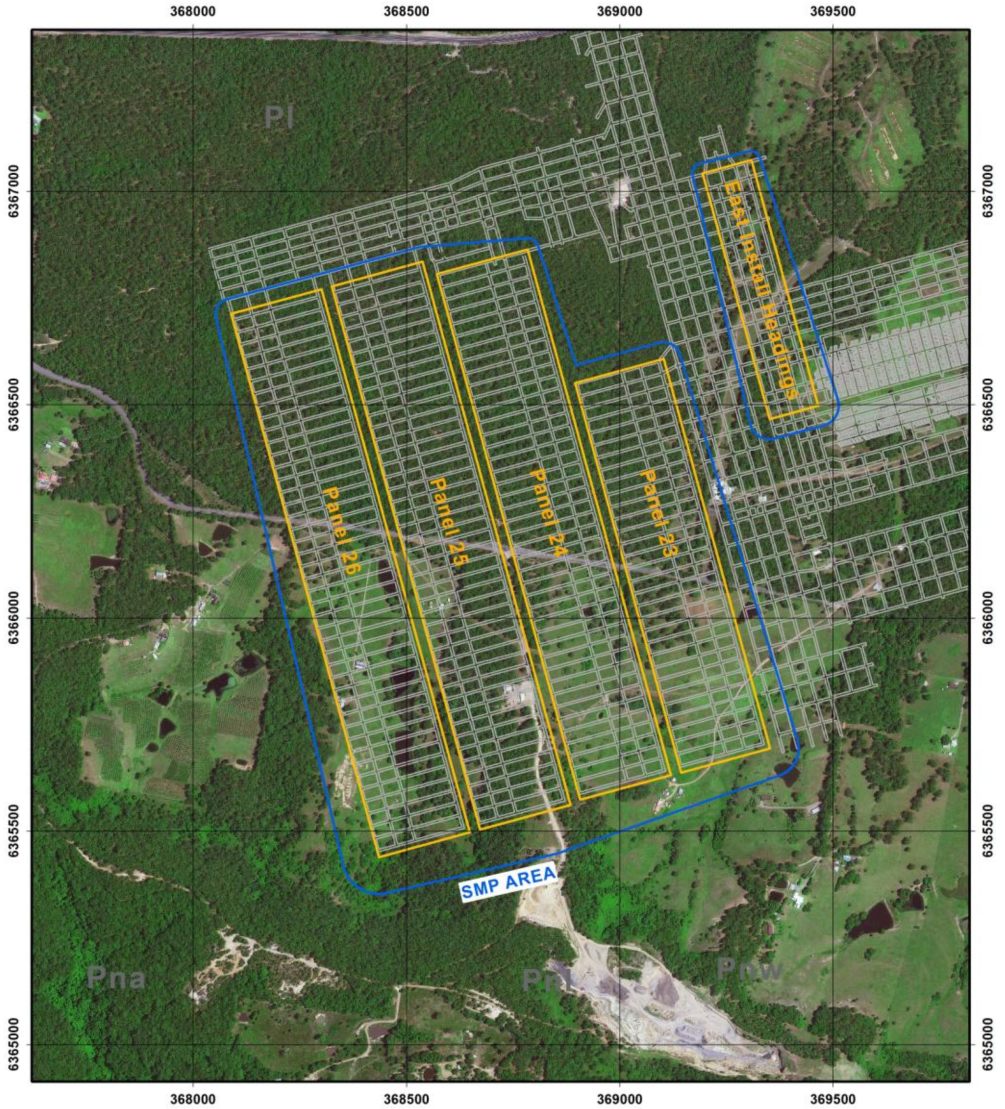
There are water related ecosystems within SMP Area 3 associated with the streams.

8.4.6 Flora, Fauna and Natural Vegetation

Rainforest communities have been identified along the upper reaches of Long Gully, which are located outside the SMP Area, at distances greater than 0.6 kilometres outside the extents of the proposed panels.

The vegetation within SMP Area 3 generally consists of undisturbed native bush. There are areas in the south-western and south-eastern corners of the area which have been cleared for residential and light agricultural purposes. The extent of natural vegetation can be seen from the aerial photograph provided in **Figure 6**

Figure 6 Aerial Photograph Showing the Extent of Natural Vegetation



SMP Area 3

This area consists of the land potentially subject to subsidence impacts over the underground mine, being approximately 85 hectares of relatively undisturbed vegetation and 85 hectares of fragmented vegetation in a farmland mosaic. The topography consists of a complex system of ridges (elevation around 300 metres) and steep gullies which drain across alluvial flats ultimately into the Hexham flood plain.

Subsidence will be varied over the mine area due to factors such as depth of workings, mining sequence, geological conditions, surface features and topography. Therefore, not all surface areas will be subject to the same degree of subsidence, with some experiencing no change.

The SMP application area encompasses only 170 hectares. A baseline survey of the proposed mining area was undertaken as part of the EA process.

Methodology

The original application for approval of the Abel Underground Mine included comprehensive flora, fauna and vegetation assessments.

- ecobiological (2011a) Annual Flora and Fauna Monitoring Report – Donaldson Open-cut Coalmine, Beresfield NSW

Starting in 2001 flora and fauna monitoring has been conducted annually in bushland surrounding Donaldson open-cut mine. Each annual report provides a compilation of all past records. SMP Area 3 includes part of, and is continuous with, the monitored bushland.

- ecobiological (2011b) Abel Underground Coalmine Dam Monitoring and Management Plan 2011 Monitoring Report.

Starting in 2008 farm dams within the Abel mine lease area have been monitored annually for fauna and flora. Each annual report provides a compilation of past records.
Refer to the above reports for methodology statements.

Results and Discussion

Vegetation Communities

Four vegetation communities have been mapped across SMP Area 3, being:

- Lower Hunter Spotted Gum – Ironbark Forest, approximately 62 ha, being consistent with the NSW listed Endangered Ecological Community – *Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion;*
- Coastal Foothills Spotted Gum – Ironbark Forest, approximately 23 ha;
- Central Hunter Spotted Gum – Ironbark Forest, approximately 20 ha, being consistent with the NSW listed Critically Endangered Ecological Community – *Central Hunter Ironbark - Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions;* and
- Alluvial Tall Moist forest variant, approximately 4 ha.

These communities are listed below in **Table 10**.

Table 12 - Vegetation Communities Mapped Across SMP Area 3

Map Unit	**Description**	**Area (ha)**
MU5	Alluvial Tall Moist Forest	4
MU15	Coastal Foothills Spotted Gum – Ironbark Forest	23
MU17	Lower Hunter Spotted Gum – Ironbark Forest	62
MU18	Central Hunter Spotted Gum – Ironbark Forest	20

A detailed description of the relevant vegetation community listed above is provided in **Appendix G.**

Groundwater Dependent Ecosystems

The Australian Bureau of Meteorology Atlas of Groundwater Dependent Ecosystems (GDE) maps the area containing the SMP Area as having moderate potential for groundwater interaction. From a local perspective, the dominant mid-canopy vegetation, *Melaleuca styphelioides* and *Backhousia myrtifolia*, in the riparian community described above as *Alluvial Tall Moist Forest variant,* is likely to be groundwater dependent. A catchment of 113 ha feeds water into the head of the mapped riparian habitat and there is likely to be alluvial base flow that provides suitable conditions for the riparian vegetation.

Flora

Threatened species obtained from a database search of the Atlas of NSW Wildlife for an area within a 5 km radius of SMP Area 3 were used as a guide to likely occurrences. These records were matched against the long term survey records for the Donaldson open cut mine. **Tables 13** and **14** show this assessment.

Table 13 - Threatened Flora Species Recorded Within 5km Radius of SMP Area 3

Family Name	Scientific Name	Common Name	NSW Status	Likelihood of Occurrence
Asteraceae	*Rutidosis heterogama*	Heath Wrinklewort	V	The nearest records for this plant are approximately 4 km west of the SMP Area 3. They have not been recorded despite targeted searches. Habitat is generally considered suitable for this species.
Elaeocarpaceae	*Tetratheca juncea*	Black-eyed Susan	V	There is abundant *Tetratheca juncea* north of John Renshaw Drive. Within the SMP Area 3s, there is no suitable habitat for this species.
Juncaginaceae	*Maundia triglochinoides*		V	This is a wetland plant and the only suitable habitat would be in farm dams. The species has not been recorded in targeted surveys of these dams (ecobiological 2011b).
Menispermaceae	*Tinospora tinosporoides*	Arrow-head Vine	V	This species is found in far north eastern NSW. It is likely that the Atlas record is the result of mis-identifying the similar looking vine *Sarcopetalum harveyanum* that has been recorded in riparian habitat in Donaldson bushland (ecobiological 2011a)
Proteaceae	*Grevillea parviflora* subsp. *parviflora*	Small-flower Grevillea	V	This species is known to occur at several locations in Donaldson bushland north of John Renshaw Drive. While the habitat appears suitable it has not been recorded in or around the SPM Area 3.
Myrtaceae	*Callistemon linearifolius*	Netted Bottle Brush	V	The similar appearing *Callistemon rigidus* has been recorded in the bushland south of John Renshaw Drive. *Callistemon linearifolius* has not been recorded. Suitable habitat for this species was present.

Fauna

Table 14 - Threatened Fauna Species Recorded Within 5km Radius of SMP Area 3

Family Name	Scientific Name	Common Name	NSW Status	Likelihood of Occurrence
BIRDS				
Acanthizidae	*Chthonicola sagittata*	Speckled Warbler	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Accipitridae	*Pandion cristatus*	Eastern Osprey	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Accipitridae	*Hieraaetus morphnoides*	Little Eagle	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Cacatuidae	*Callocephalon fimbriatum*	Gang-gang Cockatoo	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Stage 3 area (ecobiological 2011a)
Climacteridae	*Climacteris picumnus victoriae*	Brown Treecreeper (eastern subspecies)	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Columbidae	*Ptilinopus magnificus*	Wompoo Fruit-Dove	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Meliphagidae	*Melithreptus gularis gularis*	Black-chinned Honeyeater (eastern subspecies)	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Stage 3 area (ecobiological 2011a)
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Petroicidae	*Petroica boodang*	Scarlet Robin	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Pomatostomidae	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Psittacidae	*Glossopsitta pusilla*	Little Lorikeet	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
Psittacidae	*Neophema pulchella*	Turquoise Parrot	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Strigidae	*Ninox connivens*	Barking Owl	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Strigidae	*Ninox strenua*	Powerful Owl	V	This species has been recorded in long-term surveys

				and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
Tytonidae	*Tyto novaehollandiae*	Masked Owl	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Area 3
Tytonidae	*Tyto tenebricosa*	Sooty Owl	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
MARSUPIALS				
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Petauridae	*Petaurus australis*	Yellow-bellied Glider	V	No records of this species from long-term surveys of the area (ecobiological 2011a)
Petauridae	*Petaurus norfolcensis*	Squirrel Glider	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Aarea 3 (ecobiological 2011a)
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
MEGACHIROPTERAN BATS				
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	This species has been recorded in long-term surveys and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
MICROCHIROPTERAN BATS				
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V	All of these microbat species have been recorded in long-term surveys and suitable habitat exists in the SMP Area 3 (ecobiological 2011a)
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	V	
Vespertilionidae	*Miniopterus australis*	Little Bentwing-bat	V	
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	V	
Vespertilionidae	*Vespadelus troughtoni*	Eastern Cave Bat	V	
Vespertilionidae	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	V	
Vespertilionidae	*Myotis macropus*	Southern Myotis	V	
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat	V	

8.5 MAN - MADE STRUCTURES

Man - made structures contained within the SMP application area are limited to the following:

- Roads (All types) - various public (Black Hill), associated culverts and private roads plus access tracks (**Section 8.5.1**);
- Electrical infrastructure – Ausgrid 11kV and 415V rural supply to various properties (**Section 8.5.2**);
- Telecommunication infrastructure - Telstra fibre optic cable, active copper cables and telecommunications enclosure (**Section 8.5.3**);
- Rural building structures - “other structures” - (**Section 8.5.4**);
- Fences, stockyards, cattle grids, water troughs and holding areas - Various rural fences (**Section 8.5.5**);
- Farm dams - 15 in SMP area (**Section 8.5.6**);
- Business or commercial premises – Woodbury’s Quarry office and workshop (**Section 8.5.7**);
- Mining infrastructure – exploration and monitoring bores (**Section 8.5.8**);
- Aboriginal Places and Sites - Aboriginal archaeological sites and cultural places (**Section 8.5.9**);
- State survey control marks (**Section 8.5.10**); and
- Houses – Principal Residences (**Section 8.5.11**).

Listed in **Tables 15** to **20 (inclusive)** is a check list of man - made structures from Appendix B in the SMP Guideline 2003.

Man - Made Only Surface and Sub-Surface features that may be affected by Underground Coal Mining

Table 15 - Item 2 - Public Utilities

No.	Description	Method of Assessment	Items in SMP Application Area
1	Railway	Reviewed aerial photo and topographical plan	Nil
2	Roads (all types)	Reviewed aerial photo and topographical plan	Various public (Black Hill) and private roads and access tracks.
3	Bridges	Reviewed aerial photo and topographical plan	Nil
4	Tunnels	Reviewed aerial photo and topographical plan	Nil
5	Culverts	Reviewed aerial photo and topographical plan	Several (largest 1500mm diameter)
6	Water / gas / sewerage pipelines	Reviewed aerial photo. Dial Before You Dig website enquiry	Nil
7	Liquid fuel pipelines	Reviewed aerial photo. Dial Before You Dig website enquiry	Nil
8	Electricity transmission lines	Reviewed aerial photo. Dial Before You Dig	Ausgrid 11kV and 415V supply to individual

No.	Description	Method of Assessment	Items in SMP Application Area
	(overhead / underground) and associated plants	website enquiry	properties.
9	Telecommunication lines (overhead / underground) and associated plants	Reviewed aerial photo. Dial Before You Dig website enquiry	Telstra fibre optic, copper cables and telecommunications enclosure
10	Water tanks, water and sewerage treatment works	Reviewed aerial photo. Dial Before You Dig website enquiry.	Domestic water tanks only
11	Dams, reservoirs and associated works	Reviewed aerial photo and topographical plan	Nil
12	Air strips	Reviewed aerial photo and topographical plan	Nil
13	Any other infrastructure items	Reviewed aerial photo and topographical plan	Nil

Item 3 - Public Amenities

Table 16 - Item 3 – Public Amenities

No	Description	Method of Assessment	Items in SMP Application Area
1	Hospitals	Reviewed aerial photo	Nil
2	Places of worship	Reviewed aerial photo	Nil
3	Schools	Reviewed aerial photo	Nil
4	Shopping Centres	Reviewed aerial photo	Nil
5	Community centres	Reviewed aerial photo	Nil
6	Office buildings	Reviewed aerial photo	Nil public
7	Swimming pools	Reviewed aerial photo	Nil
8	Bowling greens	Aerial photos, mine plans	Nil
9	Ovals and cricket grounds	Reviewed aerial photo	Nil
10	Race courses	Reviewed aerial photo	Nil
11	Golf courses	Reviewed aerial photo	Nil
12	Tennis courts	Reviewed aerial photo	Nil
13	Any other amenities considered significant	Reviewed aerial photo	Nil

Item 4 – Farm Land and Facilities

Table 17 - Item 4 – Farm Land and Facilities

No.	Description	Method of Assessment	Items in SMP Application Area
1	Agricultural utilisation or agricultural suitability of farm land	Reviewed aerial photo	Yes
2	Farm buildings / sheds	Reviewed aerial photo	Yes
3	Gas and / or fuel storage	Reviewed aerial photo	Nil
4	Poultry sheds	Reviewed aerial photo	Nil
5	Glass houses	Reviewed aerial photo	Nil
6	Hydroponic systems	Reviewed aerial photo	Nil
7	Irrigation systems	Reviewed aerial photo	Nil
8	Fences	Aerial photos, mine plans	Yes, various plus stockyards, holding areas, cattle grids gates
9	Farm dams	Reviewed aerial photo	Yes. Fifteen (15) dams identified in Area 3. Eleven (11) located directly above the proposed panels and one (1) located partially above the proposed panels.
10	Wells / bores	Consultant report	Nil
11	Any other feature considered significant		Nil

Table 18 - Item 5 – Industrial, Commercial and Business Premises

No.	Description	Method of Assessment	Items in SMP Application Area
1	Factories	Reviewed aerial photo	Nil
2	Workshops	Reviewed aerial photo	Workshop for Woodbury's Quarry
3	Business or commercial premises	Reviewed aerial photo	Offices (demountable) for Woodbury's Quarry
4	Gas and / or fuel storage and associated plants	Reviewed aerial photo	Nil
5	Waste storages and associated plants	Reviewed aerial photo	Nil
6	Buildings, equipment and operations that are sensitive to surface movements	Reviewed aerial photo	See telecommunications lines and associated plant
7	Surface mining (open cut) voids and rehabilitated areas	Reviewed aerial photo	Nil
8	Mine infrastructure including tailings dams and emplacement areas	Aerial photos, mine plans	Various exploration boreholes and one groundwater monitoring bore.
9	Any other feature considered significant	Reviewed aerial photo	Nil

Table 19 - Items 6, 7 and 8 - Archaeological, Heritage, Architectural Significance

Item	Description	Method of Assessment	Items in SMP Application Area
1	Areas of archaeological and / or heritage significance (including aboriginal)	Reviewed Aerial photo. Inspections of area conducted during various EA studies	Yes. Six (6) archaeological sites (artefact scatters). Two (2) cultural places (areas of cultural sensitivity), the *Black Hill Locality* and the *Black Hill Pathway*, are partially located within Area 3 above the southern end of proposed Panel 25.
2	Items of Architectural significance	Reviewed Aerial photo. Inspections of area conducted during various EA studies.	Nil
3	Permanent survey control marks	Inquiry to Department of Lands Survey. Search of department of Lands website	Five (5) PMs within Area 3

Item 9 – Residential Establishments

Table 20 - Item 9 – Residential Establishments

No.	Description	Method of Assessment	Items in SMP Application Area
1	Houses	Reviewed aerial photo	Yes, Principal residences and Other Surface Structures. Four Principal Residences. One above Panel 26 and one above Panel 25. Other two south of Panels 23 and 24.
2	Flats / Units	Reviewed aerial photo	Nil
3	Caravan Parks	Reviewed aerial photo	Nil
4	Retirement / aged care villages	Reviewed aerial photo	Nil
5	Associated structures such as workshops, garages, on-site waste water systems, water or gas tanks, swimming pools and tennis courts	Reviewed aerial photo	Yes
6	Any other feature considered significant	Reviewed aerial photo	Nil

8.5.1 Roads (All Types)

Public Roads

The local roads within SMP Area 3 are shown on **Plan 2**.

Black Hill Road is the only public road within SMP Area 3. The road crosses directly above the proposed Panels 23 to 26, with a total length of approximately 1.0 kilometre located directly above the proposed mining area. Black Hill Road has a bitumen seal and is maintained by the Cessnock Council.

Drainage culverts have been constructed where the road crosses various streams. The largest drainage culvert within SMP Area 3 is a 1500 mm diameter circular culvert which is located where Black Hill Road crosses Four Mile Creek.

Photographs of Black Hill Road and the drainage culvert at Four Mile Creek are provided in **Plate 1**.

Plate 1 Black Hill Road and the Drainage Culvert at Four Mile Creek

There are also other unsealed roads and tracks within the SMP Area which provide access to the private properties.

8.5.2 Electrical Infrastructure

The locations of the electrical infrastructure are shown on **Plan 2**. The infrastructure within SMP Area 3 comprises 11 kV and low voltage aerial powerlines, supported on timber poles, which service the residential properties. The powerlines are owned by Ausgrid.

8.5.3 Telecommunication Infrastructure

The locations of the telecommunications infrastructure within the SMP Area are shown on **Plan 2.** The enclosure comprises a small metal shed on concrete piers and a photograph is provided in **Plate 2**

Plate 2 Telecommunications Enclosure on Black Hill Road

There are also direct buried copper telecommunications cables located above the proposed panels. A main copper cable follows the alignment of Black Hill Road, and consumer cables cross the southern ends of the proposed panels which service the residential properties.

The telecommunications infrastructure within SMP Area 3 are owned by Telstra.

8.5.4 Rural Buildings / Structures

The locations of the rural building structures within SMP Area 3 are shown on **Plan 2**. These structures include sheds, garages and other non-residential building structures. The structure Ref. B01r01 is a disused commercial building which is now owned by the Trustees of the Roman Catholic Diocese of Maitland Newcastle.

There are ten rural building structures which have been identified within SMP Area 3, of which, three structures (Refs. A01r01, A02r01 and A02r02) are located directly above the proposed panels. It is noted, however, that the two rural building structures on Property A02 are located within the subsidence control zone for the principal residence and, therefore, secondary extraction will not occur beneath them.

8.5.5 Fences

Various rural type fences throughout SMP Area 3 including boundary fences between the neighbouring landholders, internal fences for stock control and boundary fences between the landholders and public roads.

8.5.6 Farm Dams

There are 15 farm dams which have been identified within SMP Area 3, of which, 11 dams are located directly above the Panels 23 to 26, and one is partially located above the proposed panels. The farm dams are typically of earthen construction and have been established by localised cut and fill operations within the natural drainage lines.
NB no dams within SMP Area 3 are classed as requiring protection under the Project Approval. A photograph of typical farm dams in the area is provided in **Plate 3**.

Plate 3 Typical Farm Dams

The three largest dams are located on Property A02 (i.e. A02d02, A02d03 and A02d04), directly above the proposed Panel 26, and have surface areas between 4,100 m^2 and 8,200 m^2 and maximum plan dimensions between around 140 metres and 160 metres.

The dams A05d01 and A07d01 have surface areas of 1,700 m^2 and 1,900 m^2, respectively, and maximum plan dimensions of 60 metres and 90 metres, respectively. The remaining dams within SMP Area 3 have surface areas between 90 m^2 and 800 m^2 and the maximum plan dimensions vary between 12 metres and 40 metres.

8.5.7 Business and Commercial Premises

The administration buildings structures associated with Woodbury's Black Hill Quarry are located above the proposed Panel 25. The operating quarry face itself is located outside the SMP Area, to the south of the proposed panels. The administration building structures are all of light-weight construction.

8.5.8 Mining Infrastructure

The mining infrastructure consists of various exploration and two monitoring bores. The exploration bores are located directly above the proposed panels.

Groundwater monitoring bores on land owned by Donaldson Coal within SMP Area 3, are shown in **Figure 5**.

8.5.9 Aboriginal Places and Sites

There are six archaeological sites which have been identified within SMP Area 3, which are shown on **Plan 2**. A summary of these sites is provided in **Table 21**.

Table 21 Archaeological Sites Within the SMP Area

Site Name	Site ID	Type	Location
AMA2/A	*Pending*	Artefact Scatter	Directly above Panel 25
AMA2/B	*Pending*	Artefact Scatter	Directly above Panel 24
AMA2/C	*Pending*	Artefact Scatter	Above pillar between Panels 24 and 25
CA6	*Pending*	Artefact Scatter	Immediately north of Panel 25
F1/B	38-4-0980	Artefact Scatter	Immediately north of Panel 25
FMC6 Donaldson Mine	38-4-0668	Artefact Scatter	Directly above Panel 25

There are also cultural places (i.e. areas of cultural sensitivity) identified within SMP Area 3, which are shown in Drawing No. MSEC596-13 of **Appendix A**. The *Black Hill Locality* and the *Black Hill Pathway* are partially located within SMP Area 3 and above the southern end of the proposed Panel 25.

Further descriptions of the archaeological sites and cultural places are provided in the report prepared by South East Archaeology. **Appendix H**

8.5.10 State Survey Control Marks

Five (5) Permanent Marks (PMs) are located within SMP Area 3. Notification will be provided to LPI prior to the commencement of mining followed by further notification of completion of subsidence.

8.5.11 Houses – Principal Residences

There are four principal residences (i.e. houses) which have been identified within the SMP Area. The locations of the principal residences are shown on **Plan 2** and details are provided in **Table 22**.

Table 22 Details of the Principal Residences within the SMP Area

Structure Reference	Description	Location
A01h01	Single-storey brick-veneer structure with a tiled roof. The concrete floor slab is part on ground and part suspended and supported by brick piers and perimeter brick walls	Above the proposed Panel 26, but outside the extents of secondary extraction
A02h02	Single-storey timber framed structure on concrete piers, with weatherboard cladding and metal roof sheeting	Above the proposed Panel 25, but outside the extents of secondary extraction
A05h01	Single-storey timber framed	30 metres south of the

Structure Reference	Description	Location
	structure on concrete piers, with weatherboard cladding and metal roof sheeting	proposed Panel 23
A05h02	Single-storey steel framed structure on a concrete slab on ground, with hardiplank wall cladding and metal roof sheeting	45 metres south of the proposed Panel 24

8.6 AREAS OF ENVIRONMENTAL SENSITIVITY

Section 6.6.3 of the **SMP Guideline 2003** sets out a list of potentially environmentally sensitive areas that must be assessed as part of the SMP application. In **Table 23** below each item has been assessed with respect to the Abel SMP application area.

Table 23 - Assessment of Environmental Sensitivity

Item	Description	Method of Assessment	Items in SMP Application Area
1	Land reserved as State Conservation Area under National Parks and Wildlife Act 1974 (NPWA74)	Reviewed National Parks database. Also Industry & Investment	Nil
2	Land reserved as an Aboriginal Place under NPW Act 74	Review of Archaeological reports	Nil
3	Land identified as wilderness by the Director NPWS under the Wilderness Act 1987	Reviewed National Parks database	Nil
4	Land subject to a conservation agreement under NPWA74	Historic Knowledge, title search	Nil
5	Land acquired by Minister for the Environment under Part 11 NPWA74	Reviewed National Parks website.	Nil
6	Land within State Forests mapped as Forestry Management Zones 1, 2 or 3	No State Forests in SMP Area 2	Nil
7	Wetlands mapped under SEPP14 – Coastal Wetlands	Internet search	Nil
8	Wetlands listed under the Ramsar Wetlands Convention	Website, internet search	Nil
9	Lands mapped under SEPP 26 – Coastal Rainforests	Website, internet search	Nil
10	Areas listed on the Register of National Estate	Reviewed by internet search	Nil
11	Areas listed under the Heritage Act 1977 for which a plan of management has been prepared	Reviewed Australian Heritage Register	Nil
12	Land declared as critical habitat under the Threatened Species Conservation Act 1995	Reviewed NSW NPWS website	Nil
13	Land within a restricted area prescribed by a controlling	Enquiry to Hunter Water Corporation	Nil

Item	**Description**	**Method of Assessment**	**Items in SMP Application Area**
	water authority		
14	Land reserved or dedicated under the Crowns Land Act 1989 for the preservation of flora, fauna, geological formations or other environmental protection purposes	Government Gazette searches	Nil
15	Significant surface watercourses and groundwater resources identified through consultation with relevant government agencies	Aerial photos, topo maps, some ground truthing.	Viney Creek (Schedule 2)
16	Lake foreshores and flood prone areas	Cessnock City Council LEP	Nil identified flood prone areas
17	Cliffs, escarpments and other significant natural features	Aerial photographs, topographical maps, ground truthing	Nil
18	Areas containing significant ecological values	Internet searches, review of websites. Also as part of other reviews within this section	Nil
19	Major surface infrastructure	Aerial photographs, topographical maps, ground truthing	None that were not previously identified
20	Surface features of community significance (including cultural, heritage or archaeological significance)	Reviewed by archaeological survey. Aerial photos, ground truthing	Nil
21	Any other land identified by the Department to the titleholder		Nil

9 BASELINE DATA AND MONITORING

Various monitoring programs have been conducted since Abel commenced production. Refer to **Figure 7** for location of current monitoring sites within and adjacent to the SMP application area. Monitoring programs currently in place are described in **Sections 9.1** to **9.5**.

9.1 SUBSIDENCE

No subsidence monitoring has been conducted within SMP Area 3. A subsidence Monitoring Program will be developed in consultation with the Principal Subsidence Engineer. Subsidence Monitoring Programs have been developed, approved, installed and are currently being monitored for various panels in SMP Areas 1 and 2. Information obtained from this monitoring is reviewed and the available information has been summarized in the subsidence predictions for SMP Area 3. The subsidence model is continually updated and reviewed as additional monitoring information becomes available.

9.2 WATER

The location of the water quality sampling locations is shown on **Figure 7**.

Analytes measured in the laboratory include pH, Electrical Conductivity (EC), Total Dissolved Solids, Total Suspended Solids (TSS), Chloride, Sulfates, Alkalinity (Bicarbonate), Alkalinity (Carbonate), Calcium, Magnesium, Sodium and Potassium. Data for the main watercourses within Abel SMP Area 3 is presented in **Table 11**. This data has been sourced from sampling undertaken as part of the surface water assessment.

9.3 GROUNDWATER

Ongoing groundwater quality and level monitoring is undertaken as part of the integrated network of monitoring bores for the Abel, Donaldson, Tasman and Bloomfield mines. Measurement of the quality and volume of inflow water to the underground workings is also undertaken. Results of the groundwater monitoring are shown in **Table 24.**

Table 24 - Groundwater Sampling Results

Sample Site	ECµS/cm			pH		
	Max	**Min**	**Mean**	**Max**	**Min**	**Mean**
DPZ 6	4,140	1,090	2,615	7.69	4.76	6.22
DPZ 12	14,200	2,390	8,295	7.46	6.31	6.88
JRD 1	4,990	3,520	4,255	8.38	6.65	7.52
JRD 2	2,520	315	1,418	7.77	7.02	7.40

Groundwater Levels

Groundwater levels are monitored monthly in all piezometers on the Abel project area. Overall, there are almost 16 years of relevant groundwater level monitoring records extending from July 1997 to the present time. The earliest records were collected during the pre-project investigations for the adjacent Donaldson mine in 1997. Routine monthly monitoring at Donaldson commenced in 2000, prior to the commencement of mining in the Donaldson open cut in January 2001.

Impacts on groundwater levels to date are limited to areas at close proximity to mining. No impact from mining activities at Abel Underground Mine has been seen at other monitoring locations within the local and regional monitoring network.

Groundwater Quality

Groundwater quality across the area is variable, both in terms of key field parameters such as salinity and pH, and also in terms of major and minor hydrochemical constituents.

The quality of groundwater sampled from within the Abel Underground Mine area is variable, with total dissolved solids (TDS) ranging from less than 500 mg/L to 16,000 mg/L. The highest salinities are reported from the surficial groundwater (i.e. the weathered Permian/alluvium-colluvium). The lowest reported salinity of 518 mg/L was from the Donaldson Seam.

Because salinity is often high in the colluvium, salinity in the creeks is highly variable. During periods of high runoff, salinity can be very low (<300mg/l TDS). However, during dry periods, shallow groundwater seepages (often from temporary, perched regolith aquifers) can increase creek salinities to higher levels, with values of between 1,000 and 15,000mg/L TDS (recorded in Four Mile Creek). Because of this high variability in surface water flow rates and quality, and the presence of high salinity in the shallow colluvium, salinity is not generally a good indicator of the degree of connectivity between surface water systems and deeper regional groundwater in this case.

9.4 FLORA

A program of vegetation monitoring has been introduced to assist in determination of any impacts (if any) on mining induced subsidence on vegetation.

9.5 FAUNA

Long term fauna monitoring sites have been established to identify impacts (if any) of mining induced subsidence on native fauna.

9.6 MINE WATER MAKE

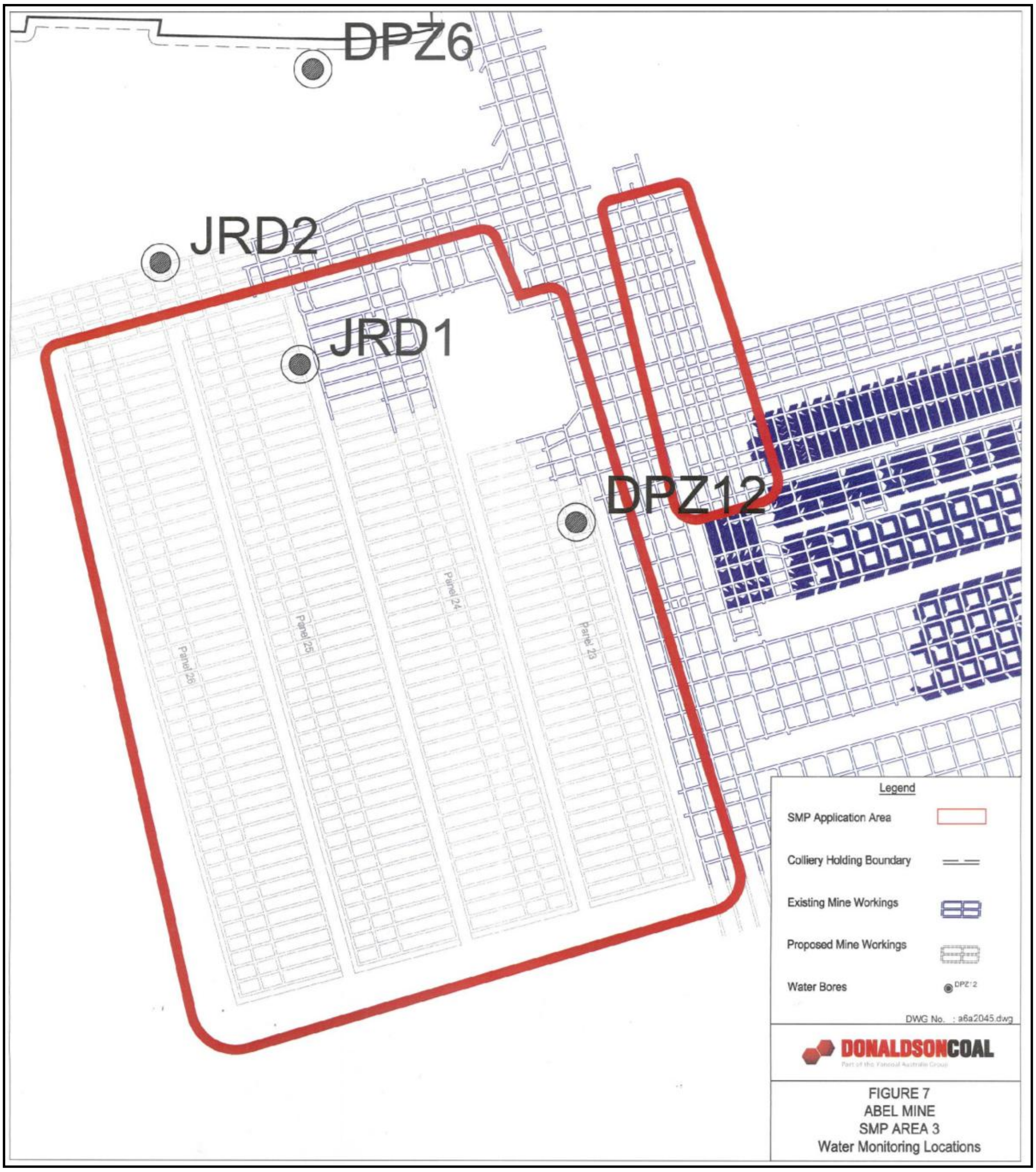
Pumping quantities from various mine pump lines are currently monitored with some water recycled for use within both the mine surface and underground in accordance with the approved Water Management Plan.

All underground water is pumped to a sump in the Abel Mine box cut. Excess water from here is pumped to the Big Kahuna Dam (surface water dam located within ML 1461 for the Donaldson Open Cut mine) for re use.

Although the current mine water make at the Abel mine shows a minor variation compared to that predicted at the time of the preparation of the Water Management Plan, the analysis contained in the Plan indicates that the overall system is capable of accommodating such variation without detracting from the objectives of providing a reliable supply for mining and CHPP operations as well as the discharge to the environment.

Groundwater is currently pumped from the mine at a rate of about 1.5ML/day.

Figure 7 - Environmental Monitoring Locations.



10 SUBSIDENCE PARAMETERS, METHODS AND PREDICTIONS

10.1 GENERAL DESCRIPTION OF SUBSIDENCE FEATURES

Following is a general description of the type of subsidence effects associated with both development and pillar extraction mining within the SMP application area.

Development headings are first workings, involving the formation of a series of headings (tunnels) driven up to 5.5 metres wide and up to 2.6m in height. Development headings are designed to remain stable for extended periods of time. Consequently, no collapse of overlying rock strata into the area from which coal is extracted is anticipated. Subsequently, there are no subsidence impacts from first workings.

Pillar extraction mining within the SMP application area involves the progressive removal of substantial portions of the coal seam (the pillars formed during development), creating a void up to 220 metres wide. The extraction of this coal, and subsequent collapse of the immediate overlying strata, results in surface subsidence. Subsidence of the ground surface normally occurs to an extent less than the extracted seam thickness. The extent of the subsidence depends on a number of factors including the height and width of the coal seam extracted, mining sequence, surface topography, characteristics of the overlying strata and the depth of mining.

In pillar extraction mining situations the roof is unable to support itself with the strata above subsequently fracturing and caving into the resultant void. The caved material fills the void (goaf) to a height dependent upon the bulking factor of the fractured / broken material, with the strata above lowering and settling onto the goaf. The settlement and bending of the strata to the surface is such that a subsidence trough develops that is wider than the area of coal that has been extracted.

The angle at which subsidence tapers out to the limit of subsidence at the surface is referred to as the angle of draw. The angle of draw is defined in the Department of Mineral Resources SMP Guideline 2003 as being 26.5 degrees from the vertical to the subsidence limit, which is taken to be a point where subsidence is equal to 20mm. This is also dependent on the strength of the strata, the lithology and other parameters.

10.1.1 Overview of Conventional Subsidence Parameters

The normal ground movements resulting from the extraction of panels or longwalls are referred to as conventional or systematic subsidence movements. These movements are described by the following parameters:-

- ***Subsidence*** usually refers to vertical displacement of a point, but subsidence of the ground actually includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small beyond the panel goaf edges, can be greater than the vertical subsidence. Subsidence is usually expressed in units of *millimetres (mm)*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.

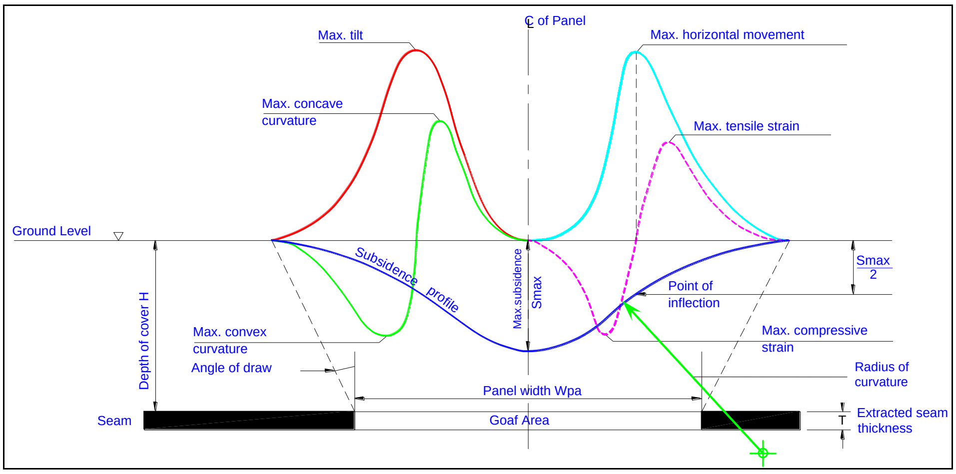
- **Curvature** is the second derivative of subsidence, or the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres* (km^{-1}), but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.

- **Strain** is the relative differential horizontal movements of the ground. **Normal strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile Strains** occur where the distances between two points increases and **Compressive Strains** occur when the distances between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20.
  Whilst mining induced normal strains are measured along monitoring lines, ground shearing can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using 3D survey monitoring techniques.

- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. It is not possible, however, to determine the horizontal shear strain across a monitoring line using 2D or 3D monitoring techniques. High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations), and vice versa.

A cross-section through a typical single extraction panel, for a horizontal seam in level terrain, showing typical profiles of conventional subsidence, tilt, curvature and strain is provided in **Figure 8**.

Figure 8 Typical Profiles of Conventional Subsidence Parameters for a Single Extraction Panel



The **incremental** subsidence, tilts, curvatures and strains are the additional parameters which result from the extraction of each panel. The **total** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of panels. The **travelling** tilts, curvatures and strains are the transient movements as mining occurs directly beneath a given point.

10.1.2 Far Field Movements

The measured horizontal movements at survey marks which are located beyond the panel goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. An empirical database of observed horizontal movements has been developed which confirms this.

The strata mechanisms that are believed to have caused the horizontal movements to be higher than the vertical movements, at locations beyond the panel edges and over solid unmined coal, are associated with the redistribution of the in-situ horizontal compressive stresses in the strata around the panels. Before mining these in-situ stresses, which are generally compressive in all directions, are in a state of equilibrium or balance. When mining occurs, this equilibrium is disturbed and the stresses achieve a new balance by shearing through the weaker strata units allowing the strata to move or expand towards the goaf areas, where the confining stresses have been redistributed.

Far-field horizontal movements have been observed at considerable distances from extracted panels. Such movements are predictable and occur whenever significant excavations occur at the surface or underground. When large horizontal movements are measured outside the goaf area, they are likely to be the result of a combination of mechanisms, including far-field and valley related movements, in addition to the conventional mine subsidence movements.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural or built features, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

In some cases, higher levels of far-field horizontal movements have been observed where steep slopes or surface incisions exist nearby, as these features influence both the magnitude and the direction of ground movement patterns. Similarly, increased observed horizontal movements are often observed around sudden changes in geology or where blocks of coal are left between panels or near other previously extracted series of panels.

In these cases, the levels of observed subsidence can be slightly higher than normally predicted, but these increased movements are generally accompanied by very low levels of tilt and strain.

Far-field horizontal movements and the method used to predict such movements are described further in **Sections 10** and **11.**

10.1.3 Overview of Non Conventional Subsidence Movements

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void. Normal conventional subsidence movements due to mining are easy to identify where panels are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is higher, such as the case in the southern part of the mining area, the observed subsidence profiles would be expected to be generally smooth. Where the depth of cover is less than 100 metres, such as the case in the northern part of the mining area, the observed subsidence profiles are expected to be irregular. Very irregular subsidence movements are observed with much higher tilts, curvatures and strains at very shallow depths of cover where the collapsed zone above the extracted panel extends up to or near to the surface.

Irregular subsidence movements are occasionally observed in single-seam mining conditions at the higher depths of cover along an otherwise smooth subsidence profile.

The cause of these irregular subsidence movements can be associated with:-

- sudden or abrupt changes in geological conditions,
- steep topography, and
- valley related movements.

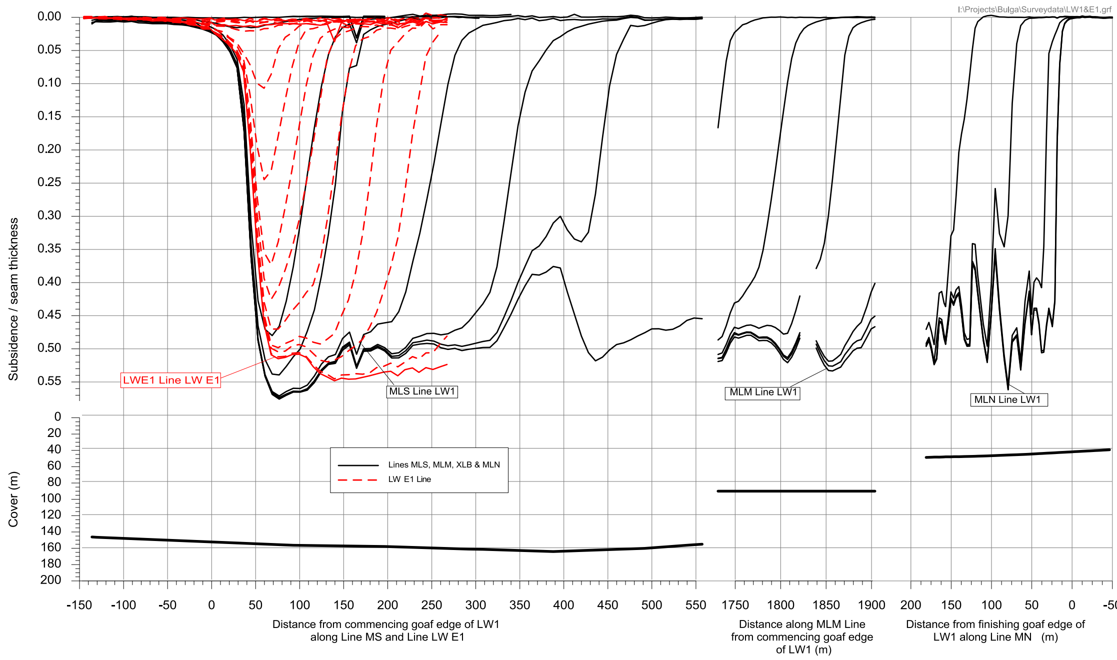
Non-conventional movements due to shallow depths of cover, changes in geological conditions, steep topography and valley related movements are discussed in the following sections.

10.1.3.1 Non Conventional Subsidence Movements Due To Shallow Depth of Cover

Irregular ground movements are commonly observed in shallow mining situations, where the collapsed zone, which develops above the extracted panels, extends near to the surface. This type of irregularity is generally only seen where panel widths are super-critical and where the depths of cover are less than 100 metres, such as the case in the northern part of the mining area. These irregular movements appear as localised bumps and steps in the observed subsidence profiles, which are accompanied by elevated tilts, curvatures and ground strains.

The levels of irregular subsidence movement at varying depths of cover can be seen in the observed subsidence profiles over the previously extracted Whybrow Seam longwalls at South Bulga Colliery, which are shown in **Figure 9**.

Figure 9 Observed Subsidence Profiles at South Bulga Colliery



The observed subsidence profiles along the MLS and LWE1 monitoring lines above the southern ends of Whybrow Seam Longwalls 1 and E1, respectively, having average depths of cover of 160 metres, are shown in the left of this figure. The observed subsidence profile along the MLM monitoring line above the northern end of Longwall 1, having an average depth of cover of 90 metres, is shown near the middle of the figure. The observed subsidence profile along the MLN monitoring line above the northern end of Longwall 1, having an average depth of cover of 45 metres, is shown in the right of this figure.

The observed subsidence profiles are relatively smooth (i.e. normal or conventional) along the MLS and LWE1 monitoring lines, where the depths of cover are much greater than 100 metres. The observed subsidence profile is still relatively smooth along the MLM monitoring line, where the depth of cover is just less than 100 metres. The observed subsidence profile along the MLN line is very irregular (i.e. irregular or non-conventional), where the depth of cover is less than 50 metres.

10.1.3.2 Non Conventional Subsidence Movements Due To Changes in Geological Conditions

It is believed that most non-conventional ground movements are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in a bump in an otherwise smooth subsidence profile and these bumps are usually accompanied by locally increased tilts, curvatures and ground strains. Buckling of near surface bedrock can also occur.

Even though it may be possible to attribute a reason behind most observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term “anomaly” is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, non-conventional ground movements are being included statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements. The impact assessments for the natural and built features include historical impacts resulting from previous mining which have occurred as the result of both conventional and non-conventional subsidence movements.

10.1.3.3 Non Conventional Subsidence Movements Due To Steep Topography

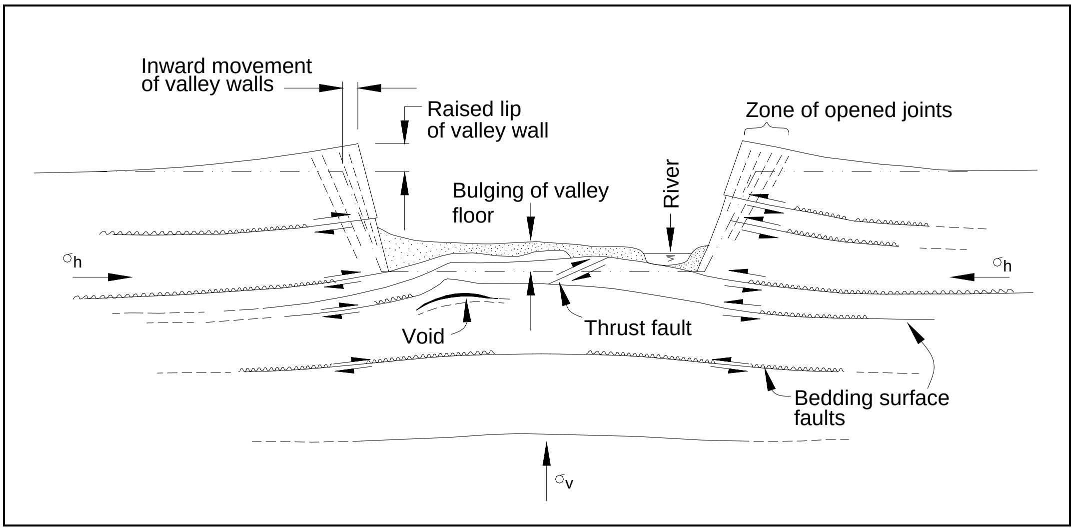
Non-conventional movements can also result from down slope movements where panels are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from down slope movements include tension cracks at the tops and along the sides of the steep slopes and compression ridges at the bottoms of the steep slopes.

10.1.3.4 Valley Related Movements

The watercourses within the SMP Area may be subjected to valley related movements, which are commonly observed along stream alignments in the Southern Coalfield, but less commonly observed in the Newcastle and Hunter Coalfields. The reason why valley related movements are less commonly observed in the northern coalfields could be that the conventional subsidence movements are typically much larger than those observed in the Southern Coalfield and, therefore, these movements tend to mask any smaller valley related movements which may occur.

Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing development of the valley, as illustrated in **Figure 10**. The potential for these natural movements are influenced by the geomorphology of the valley.

Figure 10 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)



Valley related movements can also be caused by or accelerated by mine subsidence as the result of a number of factors, including the redistribution of horizontal in-situ stresses and down slope movements. Mining induced valley related movements are normally described by the following parameters:-

- **Upsidence** is the reduced subsidence within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The term uplift is used for the cases where the ground level is raised above the pre-mining level, i.e. when the upsidence is greater than the subsidence. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.
- **Closure** is the reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides.
- **Compressive Strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile Strains** also occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

- **Scarp Development -** Scarps refer to small steps in the surface that are the result of sub-vertical shear failure above the limits of total extraction and solid or partial extraction boundaries.

10.2 SUBSIDENCE PREDICTION METHOD AND ASSESSMENT CRITERIA

Due to the variability in rock strata composition, strength and behaviour, all subsidence assessments / predictions involve estimations based on historical data (empirical method) and may involve computer based mathematical modeling. Empirical subsidence estimation methods have been extensively documented and the accuracy of this method has been demonstrated, by monitoring to be in the order of +/-10%.

The subsidence predictions models used in this study is summarized below.

10.2.1 The Incremental Profile Method

The Incremental Profile Method (IPM) was initially developed by Waddington Kay and Associates, now known as MSEC, as part of a study in 1994 to assess the potential impacts of subsidence on surface infrastructure. The method has been continually refined using the extensive monitoring data which has been gathered from the Southern, Newcastle, Hunter and Western Coalfields of New South Wales and from the Bowen Basin in Queensland.

The empirical database comprises monitoring data from numerous collieries including: Angus Place, Appin, Awaba, Baal Bone, Bellambi, Beltana, Blakefield South, Bulga, Bulli, Burwood, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Cumnock, Dartbrook, Delta, Dendrobium, Donaldson, Eastern Main, Ellalong, Elouera, Fernbrook, Glennies Creek, Grasstree, Gretley, Invincible, John Darling, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Moranbah North, Mt. Kembla, Munmorah, Nardell, Newpac, Newstan, Newvale, Newvale 2, NRE Wongawilli, Oaky Creek, Ravensworth, South Bulga, South Bulli, Springvale, Stockton Borehole, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

A detailed review of the monitoring data showed that, whilst the final subsidence profiles measured over a series of panels are irregular, the observed incremental subsidence profiles due to the extraction of individual panels are consistent in both magnitude and shape and vary according to local geology, depth of cover, panel width, seam thickness, the extent of adjacent previous mining, the widths and stabilities of the pillars and a time-related subsidence component.

MSEC has developed standard subsidence prediction curves for the Southern, Newcastle and Hunter Coalfields of New South Wales using the empirical database. The predictions curves can then be further refined, for the local geology and local conditions, based on the available monitoring data from the area. Discussions on the calibration of the Incremental Profile Method for the proposed Panels 23 to 26 at the Abel Underground Mine are provided in **Section 10.2.2**.

The prediction of subsidence is a three stage process where, first, the magnitude of each increment is calculated, then, the shape of each incremental profile is determined and, finally, the total subsidence profile is derived by adding the incremental profiles from each panel in the series. In this way, subsidence predictions can be made anywhere above or outside the extracted panels, based on the local surface and seam information.

For panels in the Newcastle and Hunter Coalfields, the maximum predicted incremental subsidence is initially determined, using the IPM subsidence prediction curves for a single isolated panel, based on the void width (W) and the depth of cover (H). The incremental subsidence is then increased, using the IPM subsidence prediction curves for multiple panels, based on the panel series, panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H). In this way, the influence of the panel width (W), depth of cover (H), as well as panel width-to-depth ratio (W/H) and pillar width-to-depth ratio (W_{pi}/H) are each taken into account.

The shapes of the incremental subsidence profiles are then determined using the large empirical database of observed incremental subsidence profiles. The profile shapes are derived from the normalised subsidence profiles for monitoring lines where the mining geometry and overburden geology are similar to that for the proposed panels. The profile shapes can be further refined, based on local monitoring data.

Finally, the total subsidence profiles resulting from the series of panels are derived by adding the predicted incremental profiles from each of the panels. Comparisons of the predicted total subsidence profiles, obtained using the Incremental Profile Method, with observed profiles indicates that the method provides reasonable, if not, slightly conservative predictions where the mining geometry and overburden geology are within the range of the empirical database. The method can also be further tailored to local conditions where observed monitoring data is available close to the mining area.

10.2.2 Calibration of the Incremental Profile Method

The available boreholes indicate that the strata layers within the mining area are frequently bedded having thickness up to around 10 metres. There were no massive sandstone or conglomerate units identified from the available information and, therefore, the standard Incremental Profile Method for the Newcastle Coalfield was used for the subsidence predictions.

The Incremental Profile Method was then refined for local conditions using the available ground monitoring data from the existing bord and pillar mining operations at the mine. Donaldson Coal is using bord and pillar total extraction methods, where the majority of the coal pillars are extracted, leaving only small remnant pillars (i.e. stooks) to support the roof during mining.

The maximum achievable subsidence in the Newcastle Coalfield, for single-seam super-critical conditions, is generally 55 % to 60 % of the effective extracted thickness. The total extraction mining method can extract around 85 % of the available coal (including the coal extracted as part of the first workings) and, therefore, the maximum achievable subsidence for this type of mining is typically around 47 % to 51 %, for single-seam mining conditions.

The locations of the available ground monitoring lines for the previous mining at the Abel Underground Mine are shown in Drawing No. MSEC596-01 in **Appendix A**. The monitoring lines located above Panels 1 to 6 in the Upper Donaldson Seam have been used to refine the Incremental Profile Method for local conditions.

Panel 1 has an overall void width of 110 metres at a depth of cover around 100 metres and, therefore, the width-to-depth ratio is around 1.1 (i.e. critical in width). Panels 2 to 6 have overall void widths of 160 metres at depths of cover between 50 metres and 100 meters and, therefore, the width-to-depth ratios vary between 1.6 and 3.2 (i.e. supercritical in width).

The subsidence movements along the monitoring lines were back-predicted using the standard Incremental Profile Method for the Newcastle Coalfield. The comparisons between the observed and the back-predicted subsidence, tilt and curvature for

Centreline and Crossline monitoring lines above Panels 1 to 6 are shown in Figures. C.01 to C.12, in **Appendix A.**

It can be seen from these figures, that the maximum observed subsidence along these monitoring lines were less than the maximum predicted. The maximum observed subsidence of approximately 1300 mm represents around 46 % of the maximum extraction height of 2.8 metres. The maximum predicted subsidence, based on supercritical mining conditions, is 51 % of the extraction height.

The profiles of observed subsidence reasonably match those predicted. In some cases, the observed subsidence exceeds those predicted just inside the panel edges, however, in these cases the steepness of the observed profiles (i.e. tilt) were less than those predicted.

The magnitudes of the maximum observed tilts and curvatures along the monitoring lines were also reasonably similar to or less than those predicted. In some cases, there were small lateral shifts between the observed and predicted maxima, however, the offsets were generally less than 30 metres.

In most cases, the profiles of observed tilts and curvatures reasonably match those predicted. There were some localised irregularities in the observed profiles (i.e. non-conventional movements) which are expected at these very shallow depths of cover. It is then noted, that the Incremental Profile Method provides predictions of conventional movements and that non-conventional movements are assessed using the statistical analysis of strain.

It has also been found, in the NSW Coalfields, that the shapes of the subsidence profiles resulting from bord and pillar total extraction are similar to those resulting from longwall mining, where the mining geometry and overburden geology are reasonably similar. The magnitudes of subsidence resulting from bord and pillar total extraction, however, are slightly less than those resulting from the equivalent longwall mining, due to the remnant pillars (i.e. stooks) which are used to provide temporary roof support during mining.

The observed subsidence movements along monitoring lines located above longwall mining in the region should, therefore, also provide a reasonable indication to the accuracy of the subsidence prediction model for bord and pillar total extraction. The comparisons between the observed and predicted profiles of subsidence, tilt and curvature for monitoring lines located above previously extracted longwalls in the Newcastle and Hunter Coalfields, where the width-to-depth ratios were around 1.0, 2.0 and 3.0, are shown in C.13, C.14 and C.15, respectively, in **Appendix A**.

It can be seen from these figures, that the profiles of observed subsidence and tilt reasonably match those predicted. The magnitudes of the maximum observed subsidence are less than the maxima predicted, as the Incremental Profile Method has been designed to generally provide conservative predictions. In some cases, there is a lateral shift between the observed and predicted profiles, which could be the result of surface dip, seam dip, or variations in the overburden geology.

The magnitudes of the maximum observed tilts and curvatures along the monitoring lines were also reasonably similar to those predicted using the standard Incremental Profile Method. It can be seen, however, that the observed tilts and curvatures were less than those predicted, in some locations, whilst the observed tilts and curvatures exceed those predicted in other locations. This demonstrates the difficultly in predicting tilts and curvatures at a point, especially at shallow depths of cover. It is important then to recognise, that there is greater potential for variation between observed and predicted movements at a point as the depth of cover decreases.

The observed zones of hogging and sagging curvature reasonably match those predicted. The observed curvatures exceed those predicted, in some locations, which were localised and possibly the result of irregular movements or, possibly, disturbed ground marks. It is then noted, that the Incremental Profile Method provides predictions of conventional curvature and that non-conventional movements are assessed using the statistical analysis of strain.

Based on these comparisons along the selected monitoring lines at the Abel Underground Mine, and elsewhere in the Newcastle and Hunter Coalfields, it would appear that the standard Incremental Profile Method provides reasonable predictions of conventional subsidence, tilt and curvature. It has not been considered necessary, therefore, to provide any site specific calibration of the standard IPM subsidence prediction curves for the proposed extraction of the East Install Headings and Panels 23 to 26 within the Upper Donaldson Seam.

10.3 RELIABILITY OF THE PREDICTED CONVENTIONAL SUBSIDENCE PARAMETERS

The Incremental Profile Method is based upon a large database of observed subsidence movements in the NSW and Queensland Coalfields and has been found, in most cases, to give reasonable, if not, slightly conservative predictions of maximum subsidence, tilt and curvature. The predicted profiles obtained using this method also reflect the way in which each parameter varies over the mined area and indicate the movements that are likely to occur at any point on the surface.

The prediction of the conventional subsidence parameters at a specific point is more difficult. Variations between predicted and observed parameters at a point can occur where there is a lateral shift between the predicted and observed subsidence profiles, which can result from seam dip or variations in topography. In these situations, the lateral shift can result in the observed parameters being greater than those predicted in some locations, whilst the observed parameters being less than those predicted in other locations.

The prediction of strain at a point is even more difficult as there tends to be a large scatter in observed strain profiles. It has been found that measured strains can vary considerably from those predicted at a point, not only in magnitude, but also in sign, that is, the tensile strains have been observed where compressive strains were predicted, and vice versa. The following reasons contribute to why strain predictions cannot be provided with the same degree of confidence as subsidence and tilt predictions:-

- Variations in local geology can affect the way in which the near surface rocks are displaced as subsidence occurs. In the compression zone, the surface strata can buckle upwards or can fail by shearing and sliding over their neighbours. If the surface strata layers are thinly bedded or if localised cross bedding exists within the top strata layer, then shearing can occur at relatively low values of stress. These variations in the local geology can result in fluctuations in the local strains, which can range from tensile to compressive. In the tensile zones around mined voids, existing joints can be opened up at relatively low strain values and new fractures can be formed at random, leading to localised concentrations of tensile strain.
- Where a thick surface layer of soil, clay or rock exists, the underlying movements in the bedrock are often transferred to the surface at reduced levels and the measured strains are, therefore, more evenly distributed and hence more conventional in nature than they would be if they were measured at rockhead.
- Strain measurements can sometimes give a false impression of the state of stress in the ground. For example:-
    - buckling of the near-surface strata can result in localised cracking and apparent tensile strain in areas where overall, the ground is in fact being compressed, because the actual values of the measured strains are dependent on the locations of the survey pegs.

  - where existing natural joints open up or new cracks develop in the tensile phase, it may be difficult for these joints to close up during the compressive phase, if the joints fill with soil or if shearing occurs during the movements. In these cases, the ground can appear to be in tension when, in reality, it is actually in compression.
- Sometimes, survey limitations or errors can also affect the measured strain values and these can result from movement in the benchmarks, inaccurate instrument readings, or disturbed survey pegs. In these circumstances it is not surprising that the predicted conventional strain at a point does not match the measured strain.
- In sandstone dominated environments, much of the earlier tensile ground movements can be concentrated at existing natural joints. These concentrations of strain at these pre-existing joints results in higher strain values being observed at the natural joints accompanied by lower values between the joints.
- Current conventional horizontal movement prediction methods are principally based on factors being applied to the predicted ground curvature movements and do not account for the release of in situ horizontal stress, the far-field movement mechanisms or valley related movements.
- It is also recognised that the ground movements above a panel can be affected by the gradient of the coal seam, the direction of mining and the presence of faults and dykes above the panel, which can result in a lateral shift in the subsidence profile.

It is also likely that some localised irregularities will occur in the subsidence profiles due to near surface geological features. The irregular movements are accompanied by elevated tilts, curvatures and strains, which often exceed the conventional predictions. In most cases, it is not possible to predict the locations or magnitudes of these irregular movements. For this reason, the strain predictions provided in this report are based on a statistic analysis of measured strains at the mine, including both conventional and non-conventional anomalous strains. Further discussions on irregular movements are provided later in the document.

The Incremental Profile Method approach allows site specific predictions for each natural and built feature and, hence, provides a more realistic assessment of the subsidence impacts than by applying the maximum predicted parameters at every point, which would be overly conservative and would yield an excessively overstated assessment of the potential subsidence impacts.

10.4 RELIABILITY OF THE PREDICTED UPSIDENCE AND CLOSURE MOVEMENTS

The predicted valley related movements resulting from the proposed mining were made using the empirical method outlined in ACARP Research Project No. C9067 (Waddington and Kay, 2002).

The development of the predictive methods for upsidence and closure are the result of recent and ongoing research and the methods do not, at this stage, have the same confidence level as conventional subsidence prediction techniques. As further case histories are studied, the method will be improved, but it can be used in the meantime, so long as suitable factors of safety are applied. This is particularly important where the predicted levels of movement are small, and the potential errors, expressed as percentages, can be higher.

Whilst the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor that is thought to influence the upsidence and closure movements is the level of in-situ horizontal stress that exists within the strata. In-situ stresses are difficult to obtain and not regularly measured and the limited availability of data makes it impossible to be definitive about the influence of the in-situ stress on the upsidence and closure values. The methods are, however, based predominantly upon the measured data from Tower Colliery in the Southern Coalfield, where the in-situ stresses are high. The methods should, therefore, tend to over-predict the movements in areas of lower stress.

10.5 PREDICTED SUBSIDENCE PARAMETERS

Introduction

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of the proposed Panels 23 to 26 in the Upper Donaldson Seam. The predicted subsidence parameters and the impact assessments for the natural and built features are provided in **Section 11**.

The predicted subsidence, tilt and curvature have been obtained using the standard Incremental Profile Method for the Newcastle Coalfield, as described in **Sections 10.2.1** and **10.2.2**. The predicted strains have been determined by analysing the strains measured during the previous extraction of the bord and pillar total extraction panels in SMP Areas 1 and 2 at the mine.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this report describe and show the conventional movements and do not include the valley related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in **Section 11**.

10.6 MAXIMUM PREDICTED CONVENTIONAL SUBSIDENCE, TILT AND CURVATURE

The locations of the proposed Panels in the Upper Donaldson Seam are shown on **Plan 1**. A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of each of the proposed panels, is provided in **Table 25**.

Table 25 Maximum Predicted Incremental Conventional Subsidence, Tilt and Curvature Resulting from the Extraction of Each of the Proposed Panels

Panel	Maximum Predicted Incremental Conventional Subsidence (mm)	Maximum Predicted Incremental Conventional Tilt (mm/m)	Maximum Predicted Incremental Conventional Hogging Curvature (km^{-1})	Maximum Predicted Incremental Conventional Sagging Curvature (km^{-1})
Due to East Install Headings	1,250	40	2.5	2.5
Due to Panel 23	1,300	50	> 3.0	> 3.0
Due to Panel 24	1,300	70	> 3.0	> 3.0
Due to Panel 25	1,300	60	> 3.0	> 3.0
Due to Panel 26	1,450	70	> 3.0	> 3.0

The predicted total conventional subsidence contours, resulting from the extraction of the proposed Panels, are shown in Drawing Nos. MSEC596-14 to MSEC596-17 of **Appendix A** . A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of the proposed panels, is provided in **Table 26**.

Table 26 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature after the Extraction of Each of the Proposed Panels

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	1,300	50	> 3.0	> 3.0
After Panel 24	1,350	70	> 3.0	> 3.0
After Panel 25	1,350	70	> 3.0	> 3.0
After Panel 26	1,450	70	> 3.0	> 3.0

The maximum predicted total subsidence after the completion of the proposed panels, is 1450 mm, which represents around 51 % of the maximum extraction height of 2.8 metres. The maximum predicted total conventional tilt is 70 mm/m (i.e. 7 %), which represents a change in grade of 1 in 14. The maximum predicted total conventional hogging and sagging curvatures are both greater than 3.0 km^{-1}, which represents a minimum radius of curvature of less than 0.3 kilometres.

It is noted, that the maximum predicted tilt and curvatures occur in the northern part of the mining area, where the minimum depth of cover is around 50 metres. Elsewhere, the depths of cover above the proposed panels typically range between 100 metres and 160 metres. The typical tilts and curvatures in the mining area, therefore, are generally less than the maxima provided in **Tables 25** and **26**.

The predicted conventional subsidence parameters vary across the SMP Area as the result of, amongst other factors, variations in the depths of cover and extraction heights. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been determined along Prediction Lines 1 and 2, the locations of which are shown in Drawing Nos. MSEC596-14 to MSEC596-17 of **Appendix A**.

The predicted profiles of conventional subsidence, tilt and curvature along Prediction Lines 1 and 2, resulting from the extraction of the proposed panels, are shown in Figs. E.01 and E.02, respectively, in **Appendix A**. The predicted total profiles along the alignment of these prediction lines, after the extraction of each of the proposed panels, are shown as solid blue lines.

10.7 PREDICTED STRAINS

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock.

Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

It has been found that applying a constant factor to the predicted maximum curvatures provides a reasonable prediction for the normal or conventional strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones.

In the Newcastle Coalfield, it has been found that a factor of 10 provides a reasonable relationship between the predicted maximum curvatures and the predicted maximum conventional strains. The maximum predicted conventional strains resulting from the extraction of the proposed Panels, based on applying a factor of 10 to the maximum predicted conventional curvatures, are greater than 30 mm/m tensile and compressive. It is noted, that these maxima occur in the north-eastern corner of the mining area, where the minimum depth of cover is the shallowest and, elsewhere, the predicted conventional strains are less.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of potential strains above the proposed Panels has been determined using the monitoring data from the previously extracted bord and pillar total extraction panels in SMP Areas 1 and 2 at the mine. The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

The width-to-depth ratios of the proposed Panels vary between 1.1 (at a maximum depth of cover of 200 metres) and 4.4 (at a minimum depth of cover of 50 metres). The ground strains will vary considerably across the mining area, with the greatest strains occurring in the locations of shallowest depths of cover and lower strains occurring in the locations of higher depths of cover.

There are no built features identified towards the northern ends of the proposed panels, where the depths of cover are the shallowest, with the surface comprising natural bushland. The majority of the surface infrastructure is located where the depths of cover typically vary between 100 metres (i.e. width-to depth ratio of 2.2) to 160 metres (i.e. width-to-depth ratio of 1.4). The range of potential strains above the proposed Panels, therefore, has been determined above the middle and southern ends of the proposed panels (i.e. where the width-to-depth ratios are between 1.4 and 2.2). Donaldson Coal has previously extracted bord and pillar total extraction panels in SMP Areas 1 and 2 at the Abel Underground Mine. Comparisons of the overall void widths, depths of cover, width-to-depth ratios and extraction heights for the proposed Panels 23 to 26 with the previously extracted Panels 1 to 6 in SMP Areas 1 and 2 are provided in **Table 27**.

Table 27 Comparison of the Mine Geometry for the Proposed Panels 23 to 26 with the Previously Extracted Panels 1 to 6 in SMP Areas 1 and 2 at the Mine

Parameter	Proposed Panels 23 to 26		Existing Panels 1 to 6 in Areas 1 and 2	
	Range	Average	Range	Average
Width	210	210	110 (Panel 1) 160 (Panels 2 to 6)	150
Depth of Cover	50 ~ 200	120	50 ~ 100	80
Overall W/H Ratio	1.4 ~ 2.2*	1.7	1.2 ~ 3.2	1.9
Extraction Height	1.6 ~ 2.8	2.5	2.2 ~ 2.8	2.6

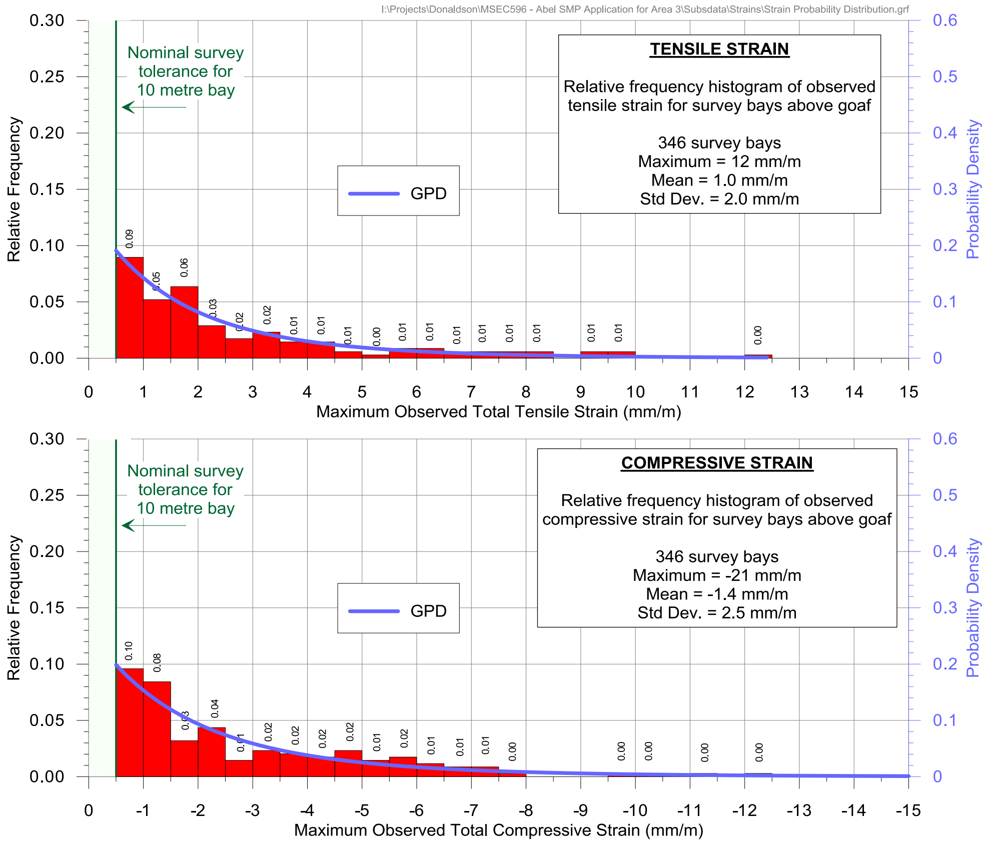
Note: * denotes panel width-to-depth ratios for the proposed Panels 23 to 26 based on the depths of cover above the middle and southern ends of the proposed panels only (i.e. in the locations of the built features).

It can be seen from the above table, that the overall width-to-depth ratios and extraction heights for the proposed Panels 23 to 26 are similar to or slightly less than those for the existing Panels 1 to 6 in Areas 1 and 2 at the mine. The observed strains for the existing Panels 1 to 6 should, therefore, provide a reasonable indication of the range of potential strains above the middle and southern ends of the proposed panels. The range of strains above the northern ends of the proposed panels is expected to be greater, however, there are no built features identified in this location

The locations of the available ground monitoring lines for the previous mining at the Abel Underground Mine are shown in Drawing No. MSEC596-01 of **Appendix A**. The strain analysis utilised the Centreline and Crossline monitoring lines above Panels 1 to 6.

The frequency distribution of the maximum observed tensile and compressive strains measured in survey bays located directly above Panels 1 to 6 is provided in **Figure 11**. The probability distribution functions, based on the fitted GPDs, are also shown in this figure.

Figure 11 Distributions of the Measured Maximum Tensile and Compressive Strains for Panels 1 to 6 in Areas 1 and 2 at the Abel Underground Mine



Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a panel extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

The 95 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 5 mm/m tensile and 6 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 10 mm/m tensile and 12 mm/m compressive.

10.8 PREDICTED CONVENTIONAL HORIZONTAL MOVEMENTS

The predicted conventional horizontal movements over the proposed panels are calculated by applying a factor to the predicted conventional tilt values. In the Newcastle Coalfield a factor of 10 is generally adopted, being the same factor as that used to determine the maximum conventional strains from the maximum curvatures, and this has been found to give a reasonable correlation with measured data. This factor will in fact vary and will be higher at low tilt values and lower at high tilt values. The application of this factor will therefore lead to over-prediction of horizontal movements where the tilts are high and under-prediction of the movements where the tilts are low.

The maximum predicted conventional tilt within the SMP Area is 70 mm/m, which occurs at the northern ends of the mining area. The maximum predicted conventional horizontal movement is, therefore, approximately 700 mm, i.e. 70 mm/m multiplied by a factor of 10.

Horizontal movements do not directly impact on natural and built features, rather impacts occur as the result of differential horizontal movements. Strain is the rate of change of horizontal movement. The impacts of ground strain on the natural and built features are addressed in the impact assessments for each feature in **Section 11**.

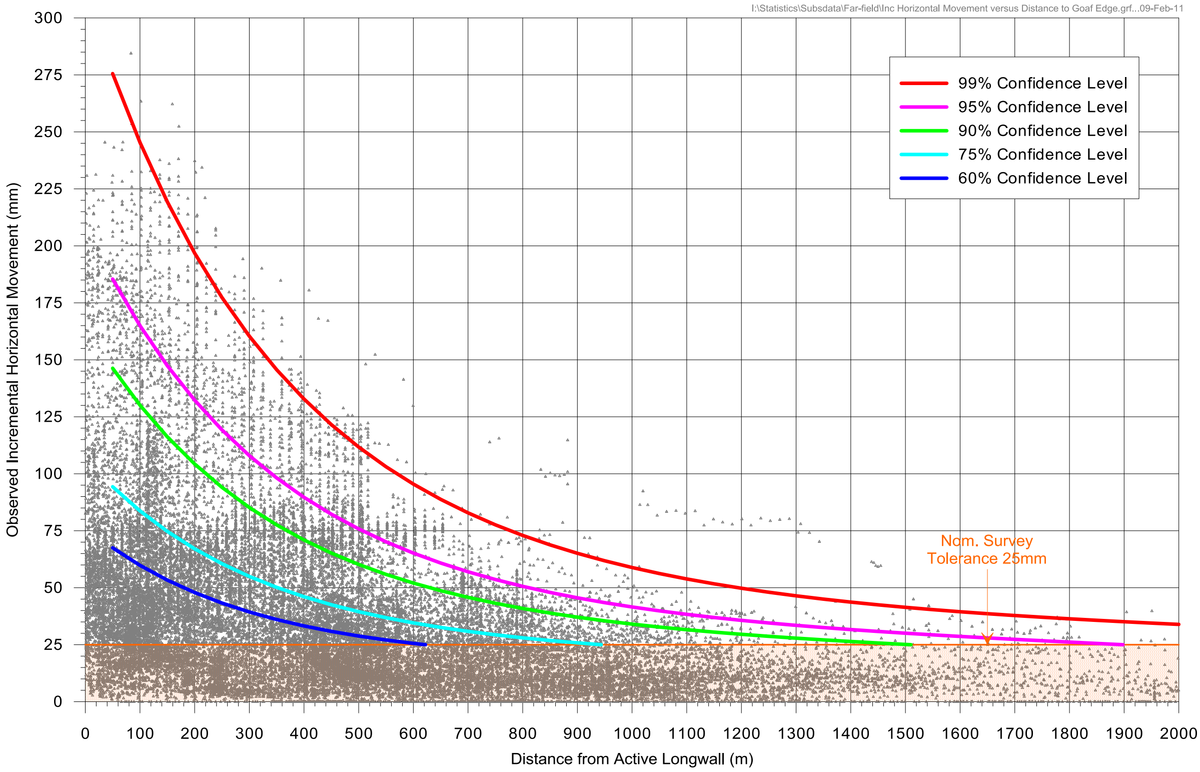
10.9 PREDICTED FAR FIELD HORIZONTAL MOVEMENTS

In addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed panels, and the predicted valley related movements along the creeks, it is also likely that far-field horizontal movements will be experienced during the proposed mining.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominantly from the Southern Coalfield. The far-field horizontal movements resulting from mining were generally observed to be orientated towards the extracted panels. At very low levels of far-field horizontal movements, however, there was a high scatter in the orientation of the observed movements.

The observed incremental far-field horizontal movements, resulting from the extraction of a single panel, is provided in **Figure 12**. The confidence levels, based on fitted GPDs, have also been shown in this figure to illustrate the spread of the data.

Figure 12 Observed Incremental Far-Field Horizontal Movements



As successive panels within a series are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in-situ stresses within the strata has been redistributed around the collapsed zones above the first few extracted panels, the potential for further movement is reduced. The total far-field horizontal movement is not, therefore, the sum of the incremental far-field horizontal movements for the individual panels.

The predicted far-field horizontal movements resulting from the extraction of the proposed panels are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally in the order of survey tolerance. The impacts of far-field horizontal movements on the natural and built features in the vicinity of the proposed panels are not expected to be significant.

10.10 NON CONVENTIONAL GROUND MOVEMENTS

It is likely non-conventional ground movements will occur within the SMP Area, due to near surface geological conditions and, to lesser extents, steep topography and valley related movements. These non-conventional movements are often accompanied by elevated tilts, curvatures and strains which are likely to exceed the conventional predictions.

In most cases, it is not possible to predict the exact locations or magnitudes of the non-conventional anomalous movements due to near surface geological conditions. For this reason, the strain predictions provided in this report are based on a statistic analysis of measured strains at the mine.

Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the streams. The impact assessments for the streams are based on both the conventional and valley related movements. The potential for non-conventional movements associated with steep topography is discussed in the impact assessments for the steep slopes.

10.11 GENERAL DISCUSSION ON MINING INDUCED GROUND DEFORMATIONS – SURFACE CRACKING

Bord and pillar total extraction mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural jointing in the bedrock and the presence of near surface geological structures.

Fractures and joints in bedrock occur naturally during the formation of the strata and from subsequent erosion and weathering processes. Bord and pillar total extracted mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones.

The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the bedrock.

The incidence of surface cracking is dependent on the location relative to the extracted panel edges, the depth of cover, the extracted seam thickness and the thickness and inherent plasticity of the soils that overlie the bedrock. The widths and frequencies of the cracks are also dependent upon the pre-existing jointing patterns in the bedrock. Large joint spacing can lead to concentrations of strain and possibly the development of fissures at rockhead, which are not necessarily coincident with the joints.

The surface cracks will generally be parallel to the longitudinal edges of the panels. It is also likely that some cracking would occur across the panels as the subsidence trough develops. This cracking tends to be transient, since the tensile phase which causes the cracks to open up, is generally followed by a compressive phase that closes them. In some cases, however, the transient cracks do not fully close up or they form compression heaving.

As subsidence occurs, surface cracks will generally appear in the tensile zone, i.e. within 0.1 to 0.4 times the depth of cover from the extents of the extracted panel perimeters.

Most of the cracks will occur within a radius of approximately 0.1 times the depth of cover from the perimeters. At shallow depths of cover, such as the case above the northern ends of the proposed panels, surface cracking and heaving can potentially occur in any location above the extracted panels. The larger and more permanent cracks, however, are usually located in the final tensile zones around the perimeters of the panels.

Open fractures and heaving, however, can also occur due to the buckling of surface beds that are subject to compressive strains.

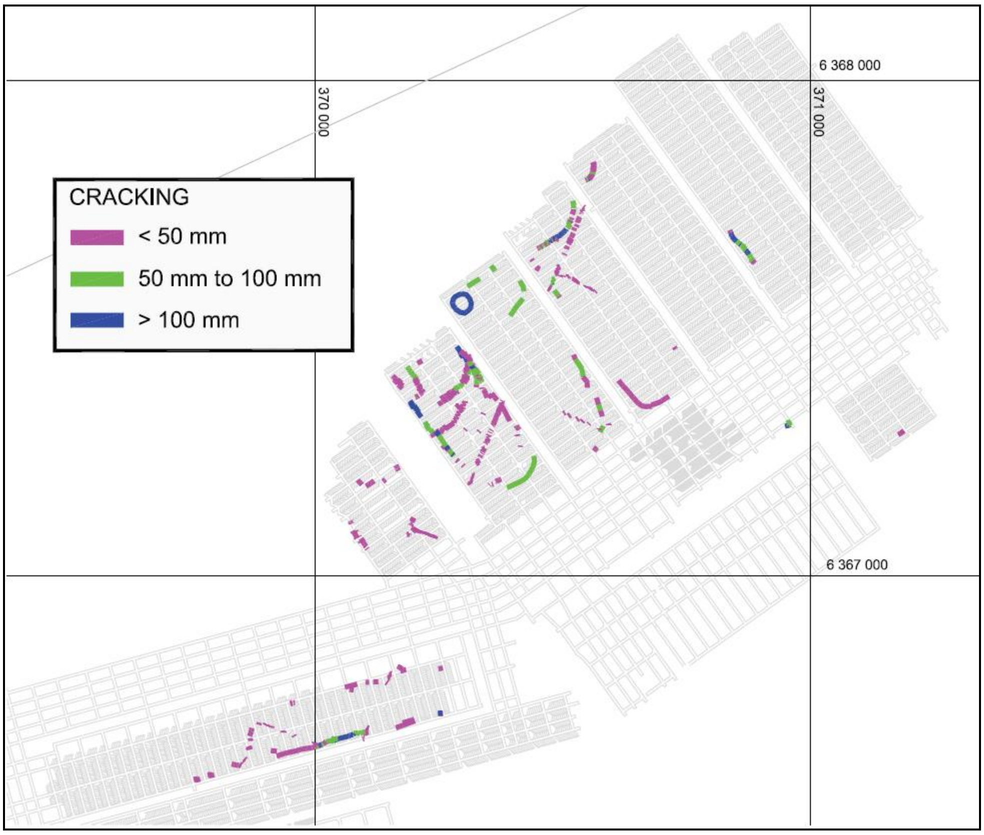
The size and extent of surface cracking above the northern ends of the proposed Panels 23 to 26 are expected to be similar to those observed above the previously extracted panels in SMP Areas 1 and 2. The range of surface crack widths measured above these panels is illustrated in **Figure 13**.

It can be seen from this figure that the surface crack widths in SMP Areas 1 and 2 were typically between 25 mm and 100 mm, with localised surface crack widths greater than 100 mm. The largest surface crack width measured above these panels was around

375 mm. However on a small number of occasions, the predicted crack widths were exceeded.
This was generally found to be related to the presence of adverse or anomalous geological or topographical conditions. Strain concentrations in near surface rock can also result in increased crack widths. The depth of cover above the panels in SMP Areas 1 and 2 varies between 50 metres and 100 metres.

It has also been found, from past mining experience in the NSW Coalfields that the surface crack widths reduce as the depth of cover increases. Crack widths in the order of 30 mm to 50 mm are typically observed where the depths of cover are around 200 metres, such as the case above the southern ends of the proposed panels.

Figure 13 Surface Cracking Observed above the Panels in SMP Areas 1 and 2



Photographs of typical surface cracking observed from previous mining at the Abel Underground Mine and elsewhere in the NSW Coalfields, at shallow depths of cover, are provided in **Plates 4** and **5**, respectively.

Plate 4 Typical Surface Cracking at the Abel Underground Mine (50 metres to 100 metres Depth of Cover)

Plate 5 Typical Surface Cracking in the Hunter Coalfield (Less than 100 metres Depth of Cover)

It is possible, that large surface cracking will also occur along the steep slopes due to down slope movements resulting from the extraction of the proposed panels. The potential for surface cracking from down slope movements is discussed elsewhere in the document.

10.11.1 Surface Cracking Remediation

As a result of cracking of soil on the land surface experienced in SMP Areas 1 and 2, Donaldson Coal has well developed procedures for the identification and rehabilitation of permanent surface cracks which are most likely in areas of maximum curvature along the edges of the panels. This consists of:

- Excavation to the base of the crack;
- Compaction and refilling of area;
- Reseeding.

In the event of significant cracking of exposed bedrock, cement based grout and crushed rock may be employed.

10.12 ESTIMATED HEIGHT OF THE FRACTURED ZONE

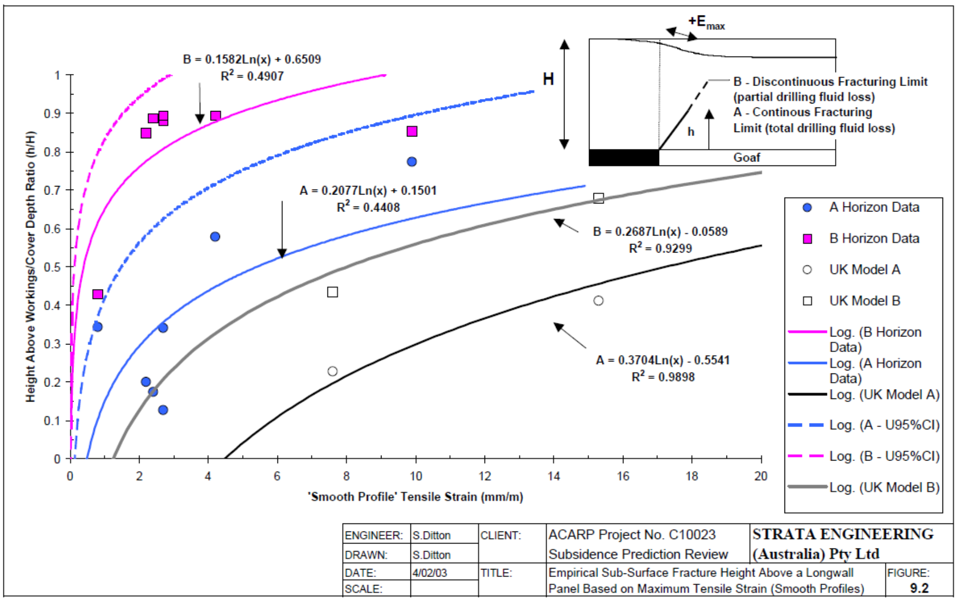
The estimated heights of fracturing in the overburden for the proposed panels have been determined using the method described in the ACARP Research Project C10023 (ACARP, 2003). This method was previously used to estimate the heights of fracturing in the Part 3A Environmental Assessment (SE, 2006).

As described in the Part 3A Environmental Assessment, "*Continuous sub-surface cracking refers to the extent of fracturing above a total extraction panel that would provide a direct flow-path or hydraulic connection to the workings, if a sub-surface aquifer or coal seam were intersected*" (SE, 2006). The height of continuous cracking is referred to as the "*A Horizon*".

Also, as described in the Part 3A Environmental Assessment, "*Discontinuous fracturing refers to the extent above a total extraction panel that could experience a general increase in horizontal and vertical permeability with the rock mass, due to bending or curvature deformation of the overburden. This type of fracturing does not provide a direct flow path or connection to the workings and is more likely to interact with surface cracks or joints*" (SE, 2006). The height of discontinuous cracking is referred to as the "*B Horizon*".

The estimated heights of continuous and discontinuous fracturing are based on the depth of cover and either the maximum 'smooth profile' (i.e. conventional) tensile strain or the '*overburden curvature index*'. The relationship between the estimated heights of the *A Horizon* and the *B Horizon*, based on the maximum conventional tensile strain, are illustrated in **Figure 14**.

Figure 14 Estimated Heights of the A and B Horizons (ACARP, 2003)



The estimated heights of continuous and discontinuous fracturing as proportions of the depths of cover, based on the maximum conventional tensile strain, are provided by the following equations (ACARP, 2003):-

Equation 1 $A = 0.2077 Ln(+E_{max}) + 0.150$ ***Height of continuous fracturing divided by cover***

$B = 0.1582 Ln(+E_{max}) + 0.651$ *Height of discontinuous fracturing divided by cover*

where $+E_{max}$ = the maximum conventional tensile strain (mm/m)

The estimated heights of continuous and discontinuous fracturing as proportions of the depths of cover, based on the '*overburden curvature index*', are provided by the following equations (ACARP, 2003):-

Equation 2 $A = 0.2295 Ln(S_{max} / W^2) + 1.132$ ***Height of continuous fracturing divided by cover***

$B = 0.1694 Ln(S_{max} / W^2) + 1.381$ *Height of discontinuous fracturing divided by cover*

where S_{max} = maximum subsidence (mm)
W = width of panel (m)

A summary of the estimated heights of continuous and discontinuous fracturing for the proposed panels, based on the ACARP 2003 method, is provided in **Table 28**. The heights of fracturing have been based on the greater of those determined using the maximum conventional tensile strain and the maximum subsidence.

Table 28 Estimated Heights of Continuous and Discontinuous Cracking Based on ACARP 2003

Location	Depth of Cover (m)	Maximum Predicted Conventional Tensile Strain (mm/m)	Maximum Predicted Subsidence (mm)	Estimated Height of the A Horizon (m)	Estimated Height of the B Horizon (m)
Panels 23 to 26	50	> 30	1450	50 ~ 140	100 ~ 200
	200	15	1350		

It can be seen from the above table, that continuous cracking is predicted to extend up to the surface where the depths of cover are shallowest above the northern and central parts of the proposed Panels 23 to 26. It is also possible, that discontinuous cracking could extend up to the surface above the southern ends of the proposed panels.

11 SUBSIDENCE IMPACTS ASSESSMENT AND MANAGEMENT STRATEGIES

11.1 DESIGN OF SUBSIDENCE CONTROL ZONES

11.1.1 General

The design of a reliable Subsidence Control Zone (SCZ) requires consideration of the following issues:

- The 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.

- The long-term stability of the pillars in the SCZ under abutment loading conditions from adjacent high extraction areas.

- The 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.

- Whether the performance of the SCZ needs to be trialled in non-sensitive panels.

Further design criteria, specific to the feature being protected, are provided in the following sections.

11.1.2 Minimum Design Set-Back Distances for SCZs

Minimum set back distances required for SCZs will depend upon the type of feature and the consequences of excessive damage, if it occurs. Based on the Statement of Commitments in the Project Approval, it will be necessary to protect all Principal Residences from mining related impacts.

<u>Principal Residences</u>

Principal residences will require adequate set-back distances from full extraction mining panels to protect the structures from differential displacements (pending confirmation of tolerable limits from MSB).

The general advice given by the MSB is to ensure that any damage to the structures due to mining is 'safe, serviceable and reparable'.

The above design criteria for the SCZs is indicative of 'negligible' to 'slight' (i.e. Category 0 to 2 damage), as defined in **AS2870, 1996**. These damage categories are defined as 'minor' and would be considered normal in regards to footing performance over the life of similar types of buildings with moderately reactive clay (Class M) or controlled fill beneath shallow footings.

Another consideration is that the houses within the Abel Mining Lease are not within a proclaimed mine subsidence district, and as a result, the MSB have been unable to impose any development restrictions on the houses built within the lease. As a result, some of the houses may not have been built with a level of articulation that would be considered appropriate for a limited amount of mine subsidence movement, or similar to that for a Class M reactive clay site.

*Note: A Class M site is defined by **AS2870, 1996** as having 20 to 40 mm of vertical surface movement due to natural soil moisture content changes over seasonal cycles of 'wet' and 'dry' conditions*.

It is therefore recommended that the design set-back distances should consider a combination of mining and non-mining related factors (i.e. structure and footing type, the level of articulation, topography, performance history of the structure, and moisture changes in foundation materials beneath footings).

The following set-back distances from Principal Residences presented in **Table 29** have been adopted at this stage to control subsidence, tilt, curvature and strain to the limits recommended in **Appleyard, 2001** for a given residential structure type.

Table 29 - Summary of Recommended Design Angles of Draw to Various Principal Residence Structure Types for a Given Topography

Principal Residence Structure Type+	Tolerable Subsidence Impact Parameters (i.e. 'Negligible' to 'Slight' Damage Category in AS2870 - 1996)				Minimum Design Angle of Draw (degrees) [setback distance in terms of cover depth, H]	
	Subsidence# (m)	Tilt (mm/m)	Curvature (1/km)	Strain (mm/m)	Flat-Moderate Topography*	Steep Topography^
Clad Frame on Strip/Pad Footings	<0.05	<4	<0.25	<3	17 [0.3H]	26.5 [0.5H]
Articulated Masonry Veneer on Strip/Pad/Slab Footings	<0.03	<3	<0.2	<2	20 [0.35H]	30 [0.6H]
Non-articulated Masonry Veneer on Strip/Pad/Slab Footings	<0.02	<2	<0.1	<1.0	26.5 [0.5H]	35 [0.7H]
Articulated Full Masonry Strip/Pad/Slab Footings	<0.02	<2	<0.1	<1.0	26.5 [0.5H]	35 [0.7H]
Non-articulated Full Masonry on Strip/Slab Footings	<0.01	<1	<0.05	<0.5	35 [0.7H]	45 [1H]

Notes:
+ - Buildings are single or double storey and have wall lengths ranging between 10 m and 30 m.
# - subsidence limits applied to limit associated tilts, strains and curvatures.
* - ground slopes < 15^o between mining limits and structure.
^ - ground slopes > 15^o between mining limits and structure.

11.2 ASSESSMENT FOR SUBSIDENCE IMPACTS

11.2.1 Watercourses

11.2.1.1 Predictions for the Watercourses

The Schedule 2 streams are all located outside the SMP Area, at distances greater than 1 kilometre outside the extents of the proposed panels. It is unlikely, therefore, that these streams would experience any measurable conventional or valley related movements.

The predicted profiles of subsidence, tilt and curvature along Four Mile Creek are shown in Fig. E.03, in **Appendix A**. The predicted total profiles along the alignment of the creek, after the extraction of each of the proposed panels, are shown as solid blue lines.

Table 30 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for Four Mile Creek

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 25	< 20	< 0.5	< 0.01	< 0.01
After Panel 26	1400	70	> 3.0	> 3.0

A summary of the maximum predicted conventional subsidence, tilt and curvatures for Four Mile Creek is provided in **Table 30**. The predicted tilts provided in this table are the maxima after the completion of each of the proposed panels. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed panels.

The maximum predicted conventional hogging and sagging curvatures for Four Mile Creek are both greater than 3.0 km^{-1}, which represents a minimum radius of curvature less than 0.3 kilometres. The maximum predicted curvatures occur adjacent to the northern end of Panel 26, where the depth of cover is the shallowest. Elsewhere, the predicted curvatures are less than 2.0 km^{-1} hogging and 1.5 km^{-1} sagging, which represent minimum radii of curvature of 0.5 kilometres and 0.7 kilometres, respectively.

The maximum predicted conventional strains for Four Mile Creek, based on applying a factor of 10 to the maximum predicted conventional curvatures, are greater than 30 mm/m tensile and compressive. Away from the northern end of Panel 26, the predicted conventional curvatures are less than 20 mm/m tensile and less than 15 mm/m compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

The tributaries are located across the SMP Area and, therefore, are expected to experience the full range of predicted subsidence movements.

The streams within the SMP Area have shallow incisions into the surface soils and, therefore, the valley related upsidence and closure movements are expected to be insignificant when compared to the conventional subsidence movements.

11.2.1.2 Impact Assessments for the Watercourses

The Schedule 2 streams are all located well outside the mining area and, therefore, are not expected to experience any measurable conventional or valley related movements. It is not anticipated that these streams would experience any adverse impacts, resulting from the extraction of the proposed Panels 23 to 26, even if the predictions were exceeded by a factor of 2 times.

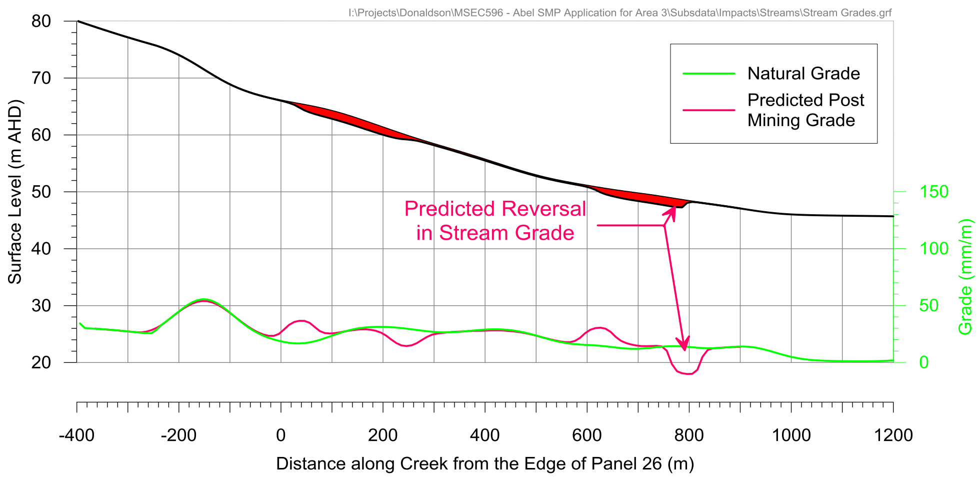
The impact assessments for Four Mile Creek and the tributaries located within the SMP Area are provided in the following sections.

Potential for Increased Levels of Ponding, Flooding and Scouring

Mining can potentially result in increased levels of ponding in locations where the mining induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining induced tilts considerably increase the natural stream gradients that exist before mining.

The maximum predicted tilt along Four Mile Creek is 70 mm/m (i.e. 7.0 %), which represents a change in grade of 1 in 14. The maximum predicted tilt is similar to the natural grades along this creek. The natural surface level and grade and the predicted post mining surface level and grade along Four Mile Creek are illustrated in **Figure 15**.

Figure 15 Natural and Predicted Post-Mining Levels and Grades along Four Mile Creek



It can be seen from **Figure 15**, that there is a predicted reversal of grade along Four Mile Creek immediately upstream of the northern end of the proposed Panel 26. It is possible that locally increased ponding could occur in this location, having a depth less than 0.5 metres and a length around 100 metres. Elsewhere, the predicted post-mining grades are similar to the natural grades along this creek.

Similarly, increased levels of ponding could also occur along the tributaries which are located directly above the proposed mining area. The ponding will develop where the tributaries exit the extents of the proposed panels, having depths up to approximately 0.5 metres and lengths up to approximately 100 metres.

The levels and extents of ponding are similar to or less than those assessed in the Part 3A Environmental Assessment, which states that "*potential ponding depths of 0.1 to 0.5 m estimated for the majority of these [Schedule 1] creeks*" with "*ponding depths ranging between 0.4 and 1.0 m*" for two tributaries (SE, 2006).

Based on the predicted subsidence effects and the ephemeral nature of the creeks over the proposed panels, it is envisaged that some pools may develop within the creek channels near the northern end of the panels. As noted in the baseline creek survey pools are an existing feature of the creeks and it is unlikely that remedial works would be required. In addition, any increased ponding along the creeks is likely to be 'in-channel' and therefore the potential effects on existing flora and fauna are likely to be minimal.

Potential for Cracking in the Creek Beds and Fracturing of Bedrock

Fracturing of the uppermost bedrock has been observed in the past, as a result of mining, where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m. It is likely, therefore, that fracturing would occur in the uppermost bedrock based on the predicted maximum strains.

Four Mile Creek and the tributaries within the SMP Area have shallow incisions into the surface soils, with some sandstone bedrock outcropping in isolated locations. Cracking in the beds of the streams would only be visible at the surface where the depths of the surface soils are shallow, or where the bedrock is exposed.

The streams are ephemeral and so water typically flows during and for short periods of time after rain events. In times of heavy rainfall, the majority of the runoff would flow over the beds and would not be diverted into the fractured and dilated strata below. In times of low flow, however, some of the water could be diverted into the fractures and dilated strata below the beds.

It is likely that the fractured zone above the northern ends of the proposed panels could extend from the seam up to the surface. It is possible, therefore, that there could be some loss of the surface water flows into the mine, where the depths of cover are the shallowest. It may be necessary, at the completion of mining, to remediate the bed of Four Mile Creek.

The previous bord and pillar total and partial extraction panels in SMP Areas 1 and 2 at the mine were extracted beneath the first and second order ephemeral tributaries to Weakleys Flat and Viney Creeks. The total length of streams directly mined beneath is approximately 2 kilometres at depths of cover varying between 50 metres and 100 metres.

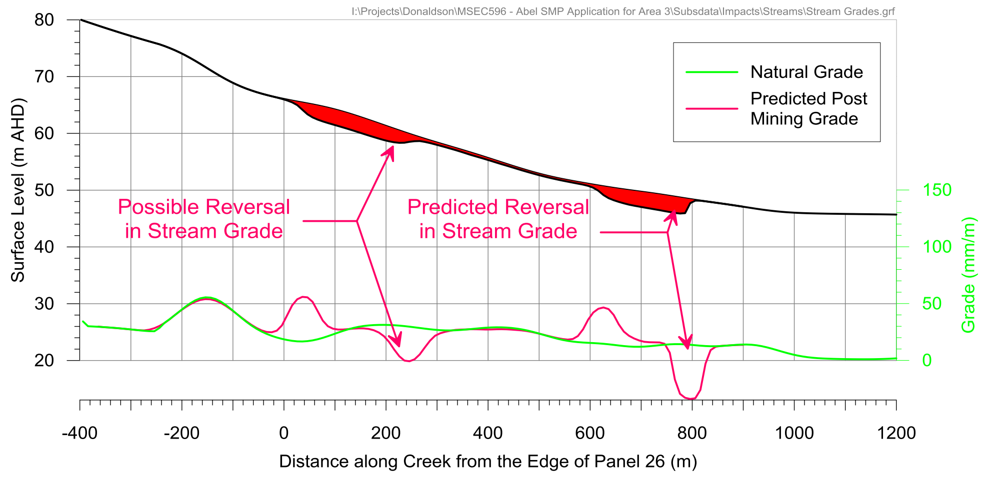
To date, there has been no reported loss of surface water flows into the mine.

Also, the longwalls in the Whybrow Seam at South Bulga and the Beltana No. 1 Underground Mine were previously extracted beneath a number of ephemeral drainage lines, where the depths of cover varied between 40 metres and 200 metres. Although surface cracking was observed across the mining areas, there were no observable surface water flow diversions in the drainage lines, after the remediation of the larger surface cracks had been completed.

11.2.1.3 Impact Assessments for the Watercourses Based on Increased Predictions

If the actual conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilt within the SMP Area would be greater than 100 mm/m (i.e. > 10 %), which represents a change in grade greater than 1 in 10. In this case, increased levels of ponding are likely to occur along the streams immediately upstream of the panel edges. This is illustrated in **Figure 16**, which shows the natural and predicted post mining surface levels and grade along Four Mile Creek, based on the subsidence exceeding the predictions by a factor of 2 times.

Figure 16 Natural and Predicted Post-Mining Levels and Grades along Four Mile Creek Based on Subsidence Exceeding Predictions by a Factor of 2 Times



It is estimated that locally increased ponding could occur upstream of the northern end of Panel 26, having a depth around 1.0 metre and a length around 200 metres, if the predictions were exceeded by a factor of 2 times. It is also possible that locally increased ponding could occur further upstream, having a depth less than 0.1 metres and a length less than 50 metres.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, it would be expected that the extent of fracturing in the uppermost bedrock would increase along the sections of the streams located directly above the proposed panels. In this case, the extent of remediation would also be expected to increase, however, the methods of remediation would not be expected to change significantly.

11.2.1.4 Impact Management Strategies

Four Mile Creek will be visually monitored as part of the Environmental Management Plan as the proposed panels are extracted directly beneath it as part of an approved monitoring program. Remediation measures have been developed to repair surface cracks and, if required, grout the underlying bedrock where the depths of cover are the shallowest, subject to any required approvals.

If subsidence creates a pool that is significantly larger than predicted, remedial actions would include:

Assessment of the ecological significance of the pool and its impact on the aquatic and riparian habitat by an appropriately qualified ecologist;

Consultation with regulatory agencies to determine whether action is warranted to reduce or eliminate the pool;

If required, channels excavation and stabilisation works to re-grade a section of channel in order to eliminate or reduce the length of the pond.

Notwithstanding, the option of undertaking works to re-grade a section of channel, as noted above previous consultation with the relevant department has suggested that extensive in channel disturbance is not favoured.

11.2.2 Groundwater Resources

11.2.2.1 Impact on Groundwater Supply

There are no registered groundwater bores within SMP Area which are used for potable water or for stock. The alluvium associated with Blue Gum Creek and Long Gully provides groundwater resource in the area, however, the alluvial is located around 1.6 kilometres south of the proposed panels and, therefore, is unlikely to be adversely impacted by the proposed mining.

With the absence of any groundwater users in the SMP application area the development will not impact on groundwater users.

As part of the SMP groundwater impact assessment it is necessary to assess the potential for future usage of the groundwater resources in the SMP application area.

It is unlikely that the aquifers identified contain significant groundwater resources that could be used in the future.

11.2.2.2 Impact on Groundwater Resource

Groundwater inflows to the mine have been predicted and during operations will be managed using the existing processing and mine water management system. Because of the shallow depths of cover over the Area 3 workings, there is a risk that connective cracking could provide a direct link between the underground mine and surface. Subsidence may also cause a connection with sub-surface geological structures which contain stored groundwater in volumes which could cause short term elevated inflow rates. This has previously occurred in Area 1 with elevated inflows arising due to fracturing and lasting for short periods until storage is depleted. This occurred in Panel 3 and Panel 7 within Area 1. The structure intersected in Panel 3 was interpreted as a thrust fault which did not propagate into the Donaldson Seam. The Panel 7 inflow event being more persistent and assessed to be the result of interconnection of storage associated with an inferred thrust fault to the east of Panel 7 which is the most significant geological structure associated with Abel Underground Mine. In each case the elevated inflow rate peaks were short and inflow water quality having elevated salinity levels indicating that the groundwater entering the mine were not sourced from surface water features.

The Subsidence Predictions and Impact Assessment (MSEC, 2012) indicates that with the shallow depth of cover at the northern end of the panels, it is likely that the fractured zone above the proposed panels could extend from the seam up to the surface. However, experience in SMP Areas 1 and 2 beneath the first and second order ephemeral tributaries to Weakleys Flat and Viney Creeks suggest there has been no reported loss of surface water flows into the mine.

The main effect of the underground mining upon the groundwater regime comes from changes in bulk rock mass permeability caused by fracturing associated with subsidence and the pumping out of groundwater that enters the mine as a consequence. This caving and associated extraction of groundwater has a number of effects on the hydrogeological system during mining operations.

These include :

- Inflow of water to the underground mine and the management of that mine water;
- Impacts on groundwater levels during operational mining within the Permian hard rock strata.

Incremental impacts on a regional level are considered to be minimal.

Once mining is completed, and pumping from the mine ceases, the strata will re-pressurise as the mine fills with water. Previous experience indicates that the pre-mining hydrogeological conditions will eventually re-establish following mining.

11.2.2.3 Depressurisation of Aquifers Due To Mining Activities Greater Than Predicted

Groundwater levels have been predicted to be lowered to extraction levels during mining activities. To date, mining activities within Area 1 and Area 2 have caused a drawdown cone in line with expectations with observation data confirming predictive modelling results and confirming that the low permeabilities of coal measure stratigraphy limits the lateral propagation of drawdown impacts.
Mining activities in Area 1 and 2 have partially caused depressurisation in Area 3 and the progression of panel development and extraction within Area 3 will extend to drawdown to mining levels across the footprint of SMP Area 3.
Given the experience of mining activities to date and results of ongoing monitoring, it is unlikely that lateral propagation of depressurisation, greater than that predicted will occur.

11.2.2.4 Elevated Salinity in Groundwater Inflows Through Mine Workings

The monitoring network at Abel Underground Mine has shown measured salinity to be variable within the Permian Coal measures. Recent monitoring of groundwater inflow from within Area 1 and 2 indicated that groundwater entering the underground mine ranges from 2225 – 11000 µS/cm. The cover depth, mining levels and overburden stratigraphy encountered in Area 3 are very similar to that which occurred in Areas 1 and 2. Therefore, groundwater salinities in Area 3 are anticipated to be similar.

11.2.2.5 Potential Loss of Flow from Spring

A potential issue raised during the risk assessment process included dams on the Osborne Property located on the western boundary of the SMP3 area. The MSEC report identifies a total of 15 farm dams within SMP Area 3 to the south of Black Hill Road, of which 11 are located within the footprint of Panels 23 – 26. However, the dams on the Osborn property which are located to the west of the SMP Area 23 boundary, are the only example with suggestion of direct spring interaction.

A number of terraced dams occupy the more elevated western areas of the Osborn property which are recharged primarily by surface water run-off. However, there is the perception that a component of stored water is spring fed. Observations made on this property revealed no perennial spring fed surface water feature although there is the possibility that subsurface flow to the dams occurs. It is understood that salinity levels within the dams vary with changes to dam levels with lower salinities being experienced at high dam levels.

The mechanism for any potential subsurface flow to the dams is likely to occur within shallow weathered soil profile from west to east and be driven by the significant elevation within the up gradient catchment.

Therefore the potential for loss of flow springs on Osborn's property due to depressurisation of aquifers due to mining activities being greater than that predicted is assessed to be low as the depressurisation is not expected to be propagated into the higher terrain in this location on the southern margins of the SMP area where greater depths of cover occur.

11.2.2.6 Mine Water Make

Groundwater inflow rates at the Abel mine workings are measured using a flow meter on the mine water extraction pipeline. Comparison with the 2006 Water Management Studies conducted as part of the project environmental assessment is not straightforward, as the mine scheduling and plan utilised in the 2006 study vary slightly to the actual mining carried out. This means that actual mine flows have a slightly different "phasing" than those predicted in the 2006 report. However, in terms of quantity, mine inflow rates to date have been relatively stable, with an average inflow rate of approximately less than 1.5 Ml / day and these rates are in line with the predicted rates from groundwater modeling undertaken during the Environmental Assessment. The impact of mining is expected to lead to a minor increase in water make in the mine.

This increased water make will not impact on the surface environment of the SMP application area as mine water is pumped to the surface but not within the SMP application area.

Based on discussions with the specialist surface and groundwater consultants for the project, the absence of significant surface alluvium and ephemeral nature of the creeks/gullies 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 more likely that any redirected surface flows will be manageable underground and cracks able to be repaired at the surface.

11.2.3 Steep Slopes

11.2.3.1 Predictions for the Steep Slopes

A summary of the maximum predicted conventional subsidence, tilt and curvatures for steep slopes located above the southern ends of the proposed panels is provided in **Table 30**. The predicted tilts provided in this table are the maxima after the completion of each of the proposed panels. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed panels.

Table 31 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Steeps Slopes Located above the Southern Ends of the Proposed Panels

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	< 20	< 0.5	< 0.01	< 0.01
After Panel 24	950	25	0.9	0.7
After Panel 25	1,300	25	1.0	0.7
After Panel 26	1,350	25	1.0	0.7

The maximum predicted conventional curvatures for the steep slopes are 1.0 km^{-1} hogging and 0.7 km^{-1} sagging, which represent minimum radii of curvature of 1 kilometre and 1.4 kilometres, respectively. The maximum predicted conventional strains, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 10 mm/m tensile and 7 mm/m compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements and downslope movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

The isolated steep slopes along the alignments of the streams are located across the SMP Area and, therefore, are expected to experience the full range of predicted subsidence movements.

11.2.3.2 Impact Assessments for the Steep Slopes

The maximum predicted tilt for the steep slopes located above the southern ends of the proposed panels is 25 mm/m (i.e. 2.5 %, or 1 in 40). The maximum predicted tilt for the isolated steep slopes along the alignments of the streams is 70 mm/m (i.e. 7 %, or 1 in 140). The predicted tilts are small when compared to the natural grades of the steep slopes, which are greater than 1 in 3 and, therefore, the tilts are unlikely to result in any adverse impact on the stability of the steep slopes.

The steep slopes are more likely to be affected by curvatures and strains. The potential impacts would generally result from the downslope movement of the surface soils, causing tension cracks to appear at the tops and sides of the slopes and compression ridges could possibly form at the bottoms of the slopes.

It is expected, that the sizes and extents of surface cracking for the steep slopes located above the southern ends of the proposed panels would be similar to those observed during the extraction of Longwalls 1 and 2 at Dendrobium Mine. These longwalls were extracted beneath steep slopes greater than 1 in 2, at similar depths of cover, similar void width-to-depth ratios, and also included some multi-seam mining.

Dendrobium Longwalls 1 and 2 had void widths of 245 metres and a solid chain pillar width of 50 metres and were extracted from the Wongawilli Seam at depths of cover ranging between 170 metres and 320 metres. These longwalls partially mined beneath previous bord and pillar workings in the overlying Bulli Seam, having an interburden thickness of approximately 20 metres to 30 metres.

The larger surface cracks observed in Area 1 at Dendrobium Mine were associated with the slippage of soils adjacent to the ridgeline and down the steep slopes, resulting in large tension cracks at the tops of the slopes and compressive ridges at the bottom of slopes. The widths of the observed surface cracks at the tops of the ridgeline and steep slopes varied up to 400 mm wide. Additional surface cracks, typically in the order of 100 mm to 150 mm in width, were also observed further down the ridgeline and steep slopes.

If tension cracks were to develop, as a result of the extraction of the proposed Panels 23 to 26, it is possible that soil erosion could occur if these cracks were left untreated. It is possible, therefore, that some remediation might be required, including infilling of surface cracks with soil or other suitable materials, or by locally regrading and recompacting the surface. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.

The requirement and methodology for any erosion and sediment control and remediation techniques would be determined in consideration of:- potential impacts when unmitigated, including potential risks to public safety and the potential for self-healing or long-term degradation; potential impacts of the control/remediation technique, including site accessibility; and consultation with relevant stakeholders.

11.2.3.3 Impact Assessments for the Steep Slopes Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be 50 mm/m (i.e. 5 %, or 1 in 20) for the steep slopes located above the southern ends of the proposed panels, and greater than 100 mm/m (i.e. > 10 %, or 1 in 10) for the isolated steep slopes along the alignments of the streams. In this case, the tilts at the steep slopes would still be small in comparison with the existing natural grades, which exceed 1 in 3.
If the actual curvatures exceeded those predicted by a factor of 2 times, the maximum curvatures at the steep slopes would be 2 km^{-1} hogging and 1.4 km^{-1} sagging for the steep slopes located above the southern ends of the proposed panels, and greater than 3.0 km^{-1} for the isolated steep slopes along the alignments of the streams. Whilst the sizes and extents of the surface cracking would increase, it would still be unlikely that any large scale slope instabilities would occur. This is based on the extensive experience of mining beneath similar steep slopes in the NSW Coalfields.

11.2.3.4 Impact Management Strategies

It is recommended that the steep slopes are visually monitored throughout the mining period and until any necessary rehabilitation measures are completed. In addition to this, it is recommended that any significant surface cracking which could result in increased erosion or restrict access to areas be remediated by infilling with soil or other suitable materials, or by locally regrading and compacting the surface.

11.2.4 Land Prone to Flooding or Inundation

The surface within the SMP Area naturally drains into Four Mile Creek in the western part of the area, and into tributaries of Weakleys Flat and Viney Creeks in the eastern part of the area. The assessments of the potential for increased ponding along the streams are provided in **Section 11.2.1.2**. Further information is provided in **Appendix D**.

11.2.5 Water Related Ecosystems

There are water related ecosystems within the SMP Area associated with the streams. The assessments of the potential impacts on the streams are provided in **Section 11.2.1**. Further discussions are provided in the report by the specialist ecology consultant on the project.

11.2.6 Flora, Fauna and Natural Vegetation

No threatened species were identified within the SMP Area, however threatened flora and fauna are recorded within a 5km radius of the SMP area.

Rainforest communities have been identified along the upper reaches of Long Gully, which are located outside the SMP Area, at distances greater than 0.6 kilometres outside the extents of the proposed panels. At these distances, it is unlikely that the rainforest communities would experience any measurable conventional or valley related movements resulting from the extraction of the proposed Panels 23 to 26. It is not anticipated, therefore, that the rainforest communities would experience any adverse impacts, due to the proposed mining, even if the predictions were exceeded by a factor of 2 times.

11.2.6.1 Impact on Flora and Fauna Habitat

Some surface disturbance may occur within the SMP application area, but this would have a minor impact upon any flora or fauna.

Subsidence due to underground mining, may result in lowering of the surface. This can result in cracking of valley floors and creek lines and with subsequent effects on surface hydrology.

Subsidence may result in some changes to these formations, but the changes are those that occur naturally although there may be some small loss of existing habitat for some species, the new habitats created will allow animals dependent upon rock formations to continue to use the area.

There are no permanent watercourses or swamps within SMP Area 3 that will be subject to pillar extraction and the ephemeral nature of these watercourses would not significantly change as a consequence of subsidence. Any cracks within a watercourse bed will be remediated.

The flora and fauna associated with the watercourses within SMP Area 3 are already adapted to intermittent dry conditions, so any changes to surface water flows should not affect plants and animals.

11.2.6.2 Impact on Threatened Flora and Fauna Species

Impacts on any threatened species are not likely, as habitat areas will not be significantly affected from mining induced subsidence. The predicted subsidence levels will not be sufficient to significantly alter potentially sensitive habitat.

Seven Part Tests of significance (Section 94 of the NSW *Threatened Species Conservation Act 1995)* were undertaken for each of the species listed under the TSC Act to determine whether the species or their habitat would be significantly impacted by the secondary mining. It was determined that none of the species would be significantly affected.

The ongoing effects of subsidence on any threatened flora and fauna will be monitored using systematic monitoring surveys in the SMP application area to detect any changes in species diversity and abundance.

11.2.6.3 Impact on Endangered Ecological Communities

The only Threatened or Endangered Ecological Communities (EEC) within the SMP application area is the Lower Hunter Spotted Gum-Ironbark Forest. No significant impact is predicted.

11.2.6.4 Impact on Groundwater Dependent Ecosystems

In order to have an impact on a Groundwater Dependent Ecosystem, sub surface cracking associated with subsidence would need to result in drainage of water from aquifers that supply the water dependent vegetation. The layout of the SMP Area 3 panels shows that the section of riparian habitat on the upper end of Four Mile Creek lies directly above the pillars between Panels 25 and 26.

11.2.7 Roads (All types) and Culverts

11.2.7.1 Predictions for the Roads

The predicted profiles of conventional subsidence, tilt and curvature along Black Hill Road are shown in Fig. E.04, in **Appendix A.** The predicted total profiles along the alignment of the road, after the extraction of each of the proposed panels, are shown as solid blue lines.
A summary of the maximum predicted conventional subsidence, tilt and curvatures for Black Hill Road is provided in **Table 32**. The predicted tilts provided in this table are the maxima after the completion of each of the proposed panels. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed panels.

Table 32 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for Black Hill Road

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	1,300	35	2.0	2.0
After Panel 24	1,350	35	2.0	2.0
After Panel 25	1,350	35	2.0	2.0
After Panel 26	1,400	40	2.0	2.0

The maximum predicted conventional hogging and sagging curvatures for Black Hill Road are both 2.0 km^{-1}, which represents a minimum radius of curvature of 0.5 kilometres. The maximum predicted conventional strains for the road, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 20 mm/m tensile and compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

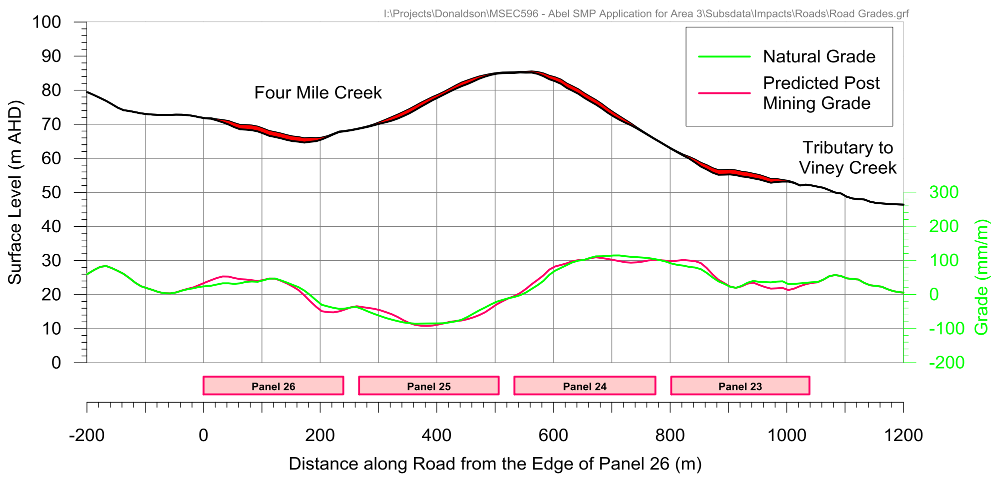
The maximum predicted conventional movements for the drainage culvert where Black Hill Road crosses Four Mile Creek are 1200 mm subsidence, 40 mm/m tilt, and 2.0 km^{-1} hogging and sagging curvatures. The maximum predicted conventional strains for the culvert, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 20 mm/m tensile and compressive.

The other roads and tracks within the SMP Area are located across the mining area and, therefore, are expected to experience the full range of predicted subsidence movements.

11.2.7.2 Impact Assessments for the Roads

The predicted vertical subsidence and tilts along Black Hill Road could potentially affect the surface water drainage along this road. The existing and predicted post-mining levels and grades along Black Hill Road are provided in **Figure 17**.

Figure 17 Existing and Predicted Post-Mining Levels and Grades along Black Hill Road



It can be seen from the above figure, that the predicted post-mining grades are similar to the existing grades along Black Hill Road. The potential changes in the surface water drainage for this road, therefore, are not expected to be significant. Whilst it is possible that localised increased ponding could occur at the stream crossings, directly above the proposed panels, it would be expected that this could be remediated using normal road maintenance techniques.

It is expected, at the magnitudes of predicted curvatures and strains, that cracking and heaving of the road surface would occur as each of the proposed panels are extracted beneath Black Hill Road. The depths of cover along the road vary between 110 metres and 140 metres, which equate to panel width-to-depth ratios between 1.6 and 2.0.

The minimum depth of cover along Black Hill Road is similar to that for Longwalls 1 to 10 at the Beltana No. 1 Underground Mine, which were extracted directly beneath Charlton Road. The impacts observed along Charlton Road should, therefore, provide a reasonable guide to the potential impact along Black Hill Road resulting from the extraction of the proposed Panels 23 to 26.

Beltana Longwalls 1 to 10 had void widths of 275 metres and a solid chain pillar width of 25 metres and were extracted from the Whybrow Seam at depths of cover ranging between 80 metres and 115 metres. The impacts to Black Hill Road are expected to be less than those observed along Charlton Road, as the width-to-depth ratio of the proposed Panels 23 to 26, of 1.6 to 2.0, are less than those for Longwalls 1 to 10 at Beltana, which were greater than 2.0.

The crack widths observed along Charlton Road, due to the extraction of Beltana Longwalls 1 to 10, typically varied between 50 mm and 100 mm, with a maximum observed crack width around 380 mm. The heave and step heights observed along the road were typically in the order of 25 mm. Examples of the impacts observed along Charlton Road at Beltana are provided in **Plate 6**.

Plate 6 Impacts Observed Along Charlton Road at the Beltana No. 1 Underground Mine

It is expected, that Black Hill Road could be maintained in a safe and serviceable condition throughout the mining period using visual monitoring and normal road maintenance techniques. It is expected, that the impacts would develop gradually as the panels are extracted directly beneath the road.

The maximum predicted tilt at the drainage culvert, where Black Hill Road crosses Four Mile Creek, is 40 mm/m (i.e. 4 %, or 1 in 25), which is orientated obliquely to the axis of the culvert. The predicted change in grade along the alignment of the culvert is a reduction of approximately 10 mm/m (i.e. 1 %, or 1 in 100), which could potentially affect the serviceability of the culvert. If the flow of water through the culvert were to be adversely affected, as a result of the proposed mining, this could be remediated by relevelling the culvert.

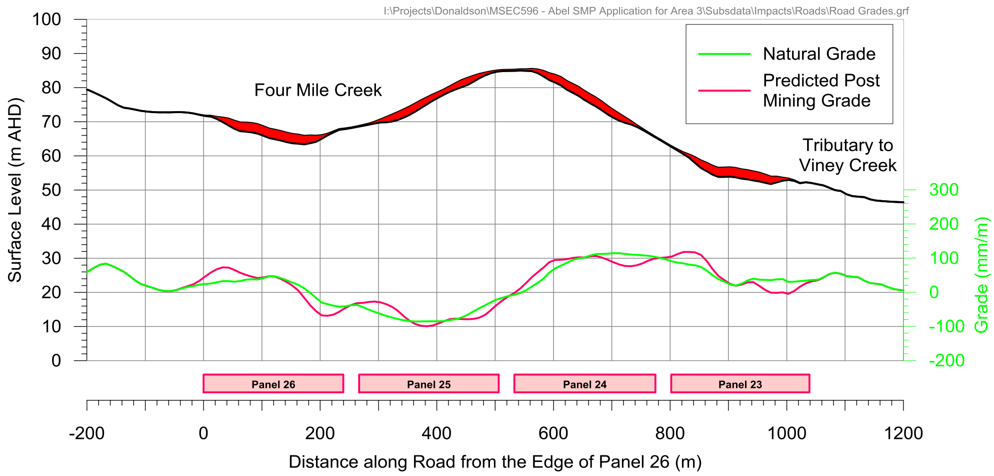
The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the culvert or the headwalls. It is unlikely, however, that these movements would adversely impact on the stability or structural integrity of the culvert. The potential impacts on the drainage culvert could be managed by visual inspection and, if required, any affected sections of the culvert repaired or replaced.

Previous experience of mining beneath culverts in the NSW Coalfields, at similar depths of cover, indicates that the incidence of impacts is low. Impacts have generally been limited to cracking in the concrete headwalls which can be readily remediated. In some cases, however, cracking in the culvert pipes occurred which required the culverts to be replaced.

11.2.7.3 Impact Assessments for the Roads Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt along Black Hill Road would be 80 mm/m (i.e. 8.0 %, or 1 in 13). In this case, the tilts would still be small when compared with the natural grades along the road and, therefore, would still be unlikely to adversely impact on the serviceability of the road. This is illustrated in **Figure 18**, which shows the existing and predicted post-mining levels and grades along Black Hill Road, based on the subsidence exceeding the predictions by a factor of 2 times.

Figure 18 Existing and Predicted Post-Mining Levels and Grades along Black Hill Road Based on Subsidence Exceeding Predictions by a Factor of 2 Times



It can be seen from the above figure, that the predicted post-mining grades are similar to the existing grades along Black Hill Road, even if the predictions were exceeded by a factor of 2 times.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the incidence of cracking, stepping and heaving along Black Hill Road would increase directly above the proposed panels. It would still be expected that the road could be maintained in safe and serviceable conditions, throughout the mining period, using normal road maintenance techniques.

11.2.7.4 Impact Management Strategies

Black Hill Road will be visually monitored as the proposed panels are extracted beneath it, such that any impacts can be identified and remediated accordingly during active subsidence. A ground monitoring line will be established along the road, which will assist in the early detection of any irregular or non-conventional ground movements.

The existing Black Hill Road Management Plan developed for SMP Area 2, in consultation with Cessnock Council and the Mine Subsidence Board, so that the road can be maintained in safe and serviceable conditions throughout the mining period will be reviewed and updated for SMP Area 3 prior to the commencement of pillar extraction.

11.2.8 Electrical Infrastructure

11.2.8.1 Predictions for the Electrical Infrastructure

The predicted profiles of conventional subsidence, tilt along and tilt across the alignment of the 11 kV powerline are shown in Fig. E.05, in **Appendix A**. The predicted total profiles along and across the alignment of the powerline, after the extraction of each of the proposed panels, are shown as solid blue lines.

A summary of the maximum predicted subsidence parameters for the powerlines is provided in **Table 33**. The parameters provided in this table are the maximum anywhere along the alignments of the powerline (i.e. not just at the powerpole locations).

Table 33 Maximum Predicted Total Conventional Subsidence and Tilts for the Powerlines

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt Along Alignment (mm/m)	Maximum Predicted Total Conventional Tilt Across Alignment (mm/m)
After Panel 23	1,300	30	15
After Panel 24	1,350	30	15
After Panel 25	1,350	30	20
After Panel 26	1,400	30	20

The maximum predicted tilts for the powerline are 30 mm/m (i.e. 3 %, or 1 in 33) along its alignment, and 20 mm/m (i.e. 2 %, or 1 in 50) across its alignment.

11.2.8.2 Impact Assessments for the Electrical Infrastructure

A rule of thumb used by some electrical engineers is that the tops of the poles may displace up to 2 pole diameters horizontally before remediation works are considered necessary. Based on pole heights of 15 metres and pole diameters of 250 mm, the maximum tolerable tilt at the pole locations is in the order of 33 mm/m.

It is possible, therefore, that the powerlines could experience some adverse impacts resulting from the proposed mining. It may be necessary that preventive measures are implemented, which could include the installation of cable rollers, guy wires or additional poles, or the adjustment of cable catenaries.

Extensive experience of mining beneath powerlines in the NSW Coalfields, where the mine subsidence movements were similar to those predicted for the proposed mining, indicates that incidences of impacts is very low and of a minor nature.

11.2.8.3 Impact Assessments for the Electrical Infrastructure Based on Increased Predictions

If the actual tilts at the powerlines exceeded those predicted by a factor of 2 times, the likelihoods of impacts would also increase. It would be expected, however, that the types of preventive measures would not change, although these would be more extensive.

11.2.8.4 Impact Management Strategies

The predicted movements will be provided to Ausgrid so that any necessary preventive measures can be developed, which may include the installation of cable rollers, guy wires or additional poles, or the adjustment of cable catenaries. The powerlines will also be visually monitored during active subsidence, so that they can be maintained in safe and serviceable conditions at all times.

The existing Ausgrid Management Plan for SMP Area 2 developed in consultation with Ausgrid to ensure the predicted subsidence effects on the poles and powerlines do not result in unsafe conditions or loss of serviceability, as a result of subsidence, during and after mining will be reviewed and updated, if required for SMP Area 3.

11.2.9 Telecommunication Infrastructure

11.2.9.1 Predictions for the Telecommunication Infrastructure

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of the optical fibre cable are shown in Fig. E.06, in **Appendix A**. The predicted total profiles along the alignment of the cable, after the extraction of each of the proposed panels, are shown as solid blue lines.

A summary of the maximum predicted conventional subsidence parameters for this cable is provided in **Table 34**. The predicted tilts provided in this table are the maxima after the completion of each of the proposed panels. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed panels.

Table 34 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Optical Fibre Cable

Location	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	1,050	70	> 3.0	> 3.0
After Panel 24	1,350	70	> 3.0	> 3.0
After Panel 25	1,350	70	> 3.0	> 3.0
After Panel 26	1,350	70	> 3.0	> 3.0

The maximum predicted conventional hogging and sagging curvatures for the optical fibre cable are both greater than 3.0 km^{-1}, which represents a minimum radius of curvature less than 0.3 kilometres. The maximum predicted conventional strains for the optical fibre cable, based on applying a factor of 10 to the maximum predicted conventional curvatures, are greater than 30 mm/m tensile and compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

The main copper telecommunications cable follows the alignment of Black Hill Road. The predicted profiles of conventional subsidence, tilt and curvature for this cable, therefore, are similar to those along the road, which are shown in Fig. E.04 of **Appendix A**. The consumer copper cables are located south of Black Hill Road, where the depths of cover are greater and, therefore, are predicted to experience mine subsidence movements less than the main copper cable.

A summary of the maximum predicted subsidence, tilt and curvatures for copper telecommunications cables is provided in **Table 35**. The predicted tilts provided in this table are the maxima after the completion of each of the proposed panels. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed panels.

Table 35 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for Copper Telecommunications Cables

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	1,300	40	2.0	2.0
After Panel 24	1,350	40	2.0	2.0
After Panel 25	1,350	40	2.0	2.0
After Panel 26	1,350	40	2.0	2.0

The maximum predicted conventional hogging and sagging curvatures for the copper telecommunications cables are both 2.0 km^{-1}, which represents a minimum radius of curvature of 0.5 kilometres. The maximum predicted conventional strains for the cables, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 20 mm/m tensile and compressive.

The telecommunications enclosure is predicted to experience 900 mm subsidence, 40 mm/m tilt and 2.0 km^{-1} hogging and sagging curvatures. The maximum predicted conventional strains for the enclosure, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 20 mm/m tensile and compressive.

11.2.9.2 Impact Assessments for the Fibre Optic Cable

Optical fibre cables can typically tolerate tensile strains up to 4 mm/m without adverse impacts. It is likely, therefore, that the optical fibre cable would be adversely impacted as a result of the proposed mining.

The optical fibre cable could also potentially be affected by elevated strains, resulting from non-conventional ground movements or where the cables connect to the support structures, which may act as anchor points, preventing any differential movements that may have been allowed to occur in the ground. Tree roots have also been known to anchor cables to the ground. The extent to which the anchor points affect the ability of the cables to tolerate the mine subsidence movements depends on the cable size, type, age, installation method and ground conditions.

In addition to this, optical fibre cables contain additional fibre lengths over the sheath lengths, where the individual fibres are loosely contained within tubes. Compression of the sheaths can transfer to the loose tubes and fibres and result in "micro-bending" of the fibres constrained within the tubes, leading to higher attenuation of the transmitted signal.

If the maximum predicted compressive strains were to be fully transferred into the optical fibre cable, they could be of sufficient magnitude to result in the reduction in capacities of the cable or transmission loss.

It is expected, therefore, that preventive measures would be required for the optical fibre cable, which could include duplicating the cable in flexible PVC conduits and by leaving sufficient slack in the draw pits to accommodate the predicted ground movements or relocation.

Similar preventive measures have been successfully undertaken at South Bulga Colliery and the Beltana No. 1 Underground Mine.

The strains transferred into the optical fibre cable can be monitored using Optical Time Domain Reflectometer (OTDR), which can be used to detect elevated strains resulting from non-conventional ground movements. If elevated strains are detected along the cable, they can be relieved by exposing and then reburying the affected section of cable. The alternative is to relocate the cable. Ongoing consultation is being conducted with Telstra to assess these options.

11.2.9.3 Impact Assessments for the Copper Cables

Copper telecommunications cables can typically tolerate tensile strains of up to 20 mm/m without adverse impacts. It is possible, therefore, that the copper cables could be impacted as a result of the proposed mining.

Extensive experience of mining beneath copper telecommunications cables in the NSW Coalfields, where the mine subsidence movements were similar to those predicted for the proposed mining, indicates that incidences of impacts is extremely low and of a minor nature.

Copper telecommunications cables were previously mined beneath by the Whybrow Seam longwalls at South Bulga Colliery and the Beltana No. 1 Underground Mine and there were no reported impacts. The maximum observed strains, where the Beltana Longwalls 1 to 10 mined directly beneath the copper cables, were 26 mm/m tensile and 24 mm/m compressive.

Based on this experience, it is unlikely that the proposed mining would result in any significant impacts on the copper telecommunications cables within the SMP Area. Any impacts on these cables would be expected to be relatively infrequent and readily repairable.

11.2.9.4 Impact Assessments for the Telecommunications Enclosure

The maximum predicted tilt for the telecommunications enclosure is 40 mm/m (i.e. 4 %, or 1 in 25), which could result in the structure being out of level by around 100 mm. If any equipment in the enclosure were to be sensitive to tilt, this could be remediated by relevelling the structure.

The enclosure is elevated above the ground on concrete piers and, therefore, is unlikely to be adversely impacted by curvature or strain. It is possible, that the optical fibre or copper cables leading into the structure could be adversely impacted, if there is differential movement between the cables and structure. It is also possible, that the aerial powerlines to the structure could be adversely impacted due to the short span to the adjacent powerpole.

The cables leading into the enclosure are to be inspected and any necessary preventive measures are developed in consultation with Telstra for this infrastructure prior to mining beneath the enclosure.

11.2.9.5 Impact Assessments for the Telecommunication Infrastructure Based on Increased Predictions

If the actual curvatures or strains at the optical fibre cable exceeded those predicted by a factor of 2 times, the likelihoods of impacts would increase, primarily near the northern end of Panel 23 where the depth of cover is the shallowest. It would be expected, however, that the management strategies for this cable would not change. The strains in the optical fibre cable can be monitored using OTDR and, if required, preventive measures can be implemented when the strains approach the allowable tolerances.

If the actual curvatures or strains at the copper telecommunications cables exceeded those predicted by a factor of 2 times, the likelihoods of impacts would also increase. Any impacts on these cables would still be expected to be relatively infrequent and readily repairable.

If the actual mine subsidence movements at the telecommunications enclosure exceeded those predicted by a factor of 2 times, it would still be unlikely to adversely affect the stability or structural integrity of the shed. It may be necessary, however, to relevel the shed at the completion of mining.

11.2.9.6 Impact Management Strategies

The predicted movements for the optical fibre cable and enclosure will be provided to Telstra so that the necessary management strategies can be developed.

The strategies could include duplicating the cable in flexible PVC conduits and by leaving sufficient slack in the draw pits to accommodate the predicted ground movements or relocation of the cable. A Management Plan, including Trigger Action Response Plan (TARP) will be developed, in conjunction with ground and OTDR monitoring, and consultation with Telstra, so that preventive measures can be undertaken if the strains in the cable approach the allowable tolerances.

The management Plan will also include strategies for the copper telecommunications cables, which could include methods to repair or replace cables which are adversely impacted by mining.

Consultation with Telstra as to the design tolerances, location and Management Plan has already commenced.

11.2.10 Rural Buildings / Structures

11.2.10.1 Predictions for the Rural Buildings / Structures

The predicted conventional subsidence, tilt and curvatures for each of the building structures within the SMP Area are provided in Table D.01, in **Appendix A**. A summary of the maximum predicted subsidence parameters for the rural building structures is provided in **Table 36**.

Table 36 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Rural Building Structures

Structure Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
A01r01	< 20	1	0.05	< 0.01
A02r01	25	1	0.02	< 0.01
A02r02	< 20	< 0.5	0.1	< 0.01
A05r01	25	1	0.04	< 0.01
A05r02	< 20	< 0.5	0.02	< 0.01
A05r03	< 20	< 0.5	< 0.01	< 0.01
A05r04	< 20	< 0.5	0.1	< 0.01
A05r05	< 20	< 0.5	0.1	< 0.01
A05r06	< 20	< 0.5	0.04	< 0.01
B01r01	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional curvatures for the rural building structures are 0.10 km^{-1} hogging and less than 0.01 km^{-1} sagging, which represent minimum radii of curvature of 10 kilometres and greater than 100 kilometres, respectively.

11.2.10.2 Impact Assessments for the Rural Buildings / Structures

The maximum predicted tilt for the rural building structures is 1 mm/m (i.e. 0.1 %, or 1 in 1000), at Structures Refs. A01r01, A02r02 and A05r01. The remaining rural building structures within the SMP Area are predicted to experience tilts less than 0.5 mm/m (i.e. < 0.1 %, or less than 1 in 1000). The maximum predicted conventional strains for the rural building structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 1 mm/m tensile and less than 0.5 mm/m compressive (i.e. in the order of survey tolerance).

Experience of mining in the NSW Coalfields indicates that tilts and strains of these magnitudes are unlikely to have adverse impacts on the rural building structures, due to their smaller sizes and flexible types of construction. It is possible, that the rural building structures located above the edges of the proposed panels (i.e. Refs. A01r01 and A05r01) could experience some minor impacts, however, it would be expected that these could be remediated using normal building maintenance techniques.

11.2.10.3 Impact Assessments for the Rural Buildings / Structures Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the rural building structures would be 2 mm/m (i.e. 0.2 %, or 1 in 500). In this case, the likelihood of serviceability impacts, such as door swings and issues with gutter and pavement drainage would only slightly increase. It would still be unlikely that stabilities of these rural building structures would be affected by tilts of these magnitudes.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihood of impacts would only slightly increase for the rural building structures located above the edges of the proposed panels (i.e. Refs. A01r01 and A05r01). It would still be expected that these structures would remain safe, serviceable and repairable using normal building maintenance techniques. With the implementation of any necessary remediation measures, it is unlikely that there would be any significant long term impacts on the rural building structures.

11.2.10.4 Impact Management Strategies

The rural building structures which are located above the proposed panels are inspected, as per the Abel Project Approval Statement of Commitments, to confirm the existing conditions and to determine whether any preventive measures are required, prior to mining beneath these structures. With the implementation of these management measures, it would be expected that the rural building structures could be maintained in safe and serviceable conditions during and after the proposed mining.

The properties within the SMP Area have water storage tanks which collect rainwater from the roofs of the principal residences (i.e. houses) and the sheds (i.e. rural building structures).

The tanks adjacent to the rural structures could experience subsidence movements similar to these structures. The tanks are typically resting on the natural ground and, therefore, are unlikely to experience adverse impacts from the curvatures and ground strains resulting from the proposed panels.

It is possible, that any buried water pipelines associated with the tanks within the SMP Area could be impacted by the ground strains, if they are anchored by the tanks, or by other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be readily repaired.

Property Subsidence Management Plans will be developed for the properties within the SMP Area, to manage any potential impacts on these tanks or associated infrastructure.

11.2.11 Fences

Wire fences can be affected by tilting of the fence posts and by changes of tension in the fence wires due to strain as mining occurs. These types of fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without significant impacts.

It is likely, therefore, that some of the wire fences within the SMP Area would be impacted as the result of the extraction of the proposed panels. Any impacts on the wire fences could be remediated by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

Impact Management Strategies

The above impacts may be managed with the rapid repair of any surface cracking and fences and associated items. The Property Subsidence Management Plans (PMP) for each property will be reviewed in consultation with the landowner to address these potential issues.

11.2.12 Farm Dams

11.2.12.1 Predictions for the Farm Dams

The predicted conventional subsidence, tilt and curvatures for each of the farm dams within the SMP Area are provided in Table D.02, in **Appendix A**. A summary of the maximum predicted subsidence parameters for these dams is provided in **Table 37**. The parameters provide in this table are the maximum values within 20 metres of the perimeters of the dams, at any time during or after the extraction of the proposed panels.

Table 37 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Farm Dams

Location	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
After Panel 23	1,150	35	2.0	2.0
After Panel 24	1,350	40	2.0	2.0
After Panel 25	1,400	40	2.0	2.0
After Panel 26	1,400	40	3.0	2.5

The maximum predicted conventional curvatures for the farm dams are 3.0 km^{-1} hogging and 2.5 km^{-1} sagging, which represent minimum radii of curvature of 0.3 kilometres and 0.4 kilometres, respectively. The maximum predicted conventional strains for these dams, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 30 mm/m tensile and 25 mm/m compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

11.2.12.2 Impact Assessments for the Farm Dams

The predicted tilts for the farm dams located directly above the proposed panels vary between 10 mm/m (i.e. 1 %, or 1 in 100) and 40 mm/m (i.e. 4.0 %, or 1 in 25). Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side and decreasing on the other. Tilt can potentially reduce the storage capacity of farm dams by causing them to overflow.

The predicted changes in freeboard for the farm dams have been determined by taking the difference between the maximum predicted subsidence and the minimum predicted subsidence anywhere around the perimeter of each farm dam. A summary of the maximum predicted changes in freeboard for the farm dams within the SMP Area is provided in **Table 38.**

Table 38 Maximum Predicted Changes in Freeboard for the Farm Dams

Ref.	Maximum Predicted Change in Freeboard (mm)			
	After Panel 23	After Panel 24	After Panel 25	After Panel 26
A02d01	< 50	< 50	100	100
A02d02	< 50	< 50	< 50	1,000
A02d03	< 50	< 50	< 50	1,000
A02d04	< 50	< 50	< 50	250
A02d05	< 50	< 50	< 50	550
A03d01	< 50	< 50	< 50	< 50
A04d01	< 50	50	100	100
A04d02	< 50	< 50	< 50	< 50
A04d03	< 50	< 50	< 50	< 50
A05d01	150	200	200	200
A05d02	600	600	600	600
A05d03	150	150	150	150
A06d01	< 50	< 50	< 50	< 50
A06d02	< 50	< 50	< 50	< 50
A07d01	< 50	< 50	< 50	< 50

Of the 15 identified farm dams, eight are predicted to be subject to 100 mm or less differential settlement. The differential settlement on the other seven dams ranges from 150 mm to 1 m. The potential impact of this differential settlement on these dams is a function of the orientation of the differential with respect to the orientation of the dam. The summary below lists the dams with 150 mm or more differential settlement in ascending order:

Dam A05d03 is a very small dam located towards the southern end of Panel 23 on a tributary of Viney Creek that flows in a westerly direction. From the aerial photography, the dam appears to be heavily overgrown and to have limited storage capacity. Differential settlement of 150 mm is predicted to occur in a northerly direction (ie towards the land that rises away from the creek line). It is unlikely that differential settlement would have any significant impact on this dam.

Dam A05d01 is located upstream of Dam A05d03 and lies across the boundary between Panels 23 and 24. The embankment of this dam is orientated north-south with the spillway at the southern end of the embankment. Differential subsidence of about 200 mm is predicted at the northern end of the embankment. Minor earthworks may be required to maintain the embankment freeboard and continued functioning of the existing spillway.

Dam A02d04 is located on a tributary of Four Mile Creek towards the southern end on Panel 26. The embankment is orientated approximately east-west with the spillway on the eastern end. Differential subsidence of 250 mm is predicted at the western end of the embankment. This has the potential to cause water to spill from the dam at the western end of the embankment. Potential remedial works would involve raising the western end of the embankment which, in combination with the subsidence, would lead to an increase in the capacity of the dam.

Dam A02d05 is a small dam located upstream of Dam A02d04 at the southern end of Panel 26. From the aerial photography the dam appears to have limited capacity and be overgrown with vegetation. The embankment for this dam appears to be a semi-circle on the northern side of the dam. Differential subsidence of 550 mm is predicted to lower the embankment side of the dam and is likely to cause a loss of storage capacity. However, given the apparent growth of vegetation within the dam, the value of any restoration works would require further assessment.

Dam A05d02 is a small dam located towards the southern end of Panel 23 immediately downstream of Dam A05d01 on a tributary of Viney Creek. The dam appears to have a small embankment orientated approximately north-south with a spillway on the southern end. Differential subsidence of 600 mm is predicted to lower the northern side of the embankment and storage area relative to the southern side. If warranted, remedial actions for this dam could include raising the embankment at the northern end to retain functioning of the existing spillway.

Dam A02d02 is a relatively large dam located on a tributary of Four Mile Creek towards the eastern edge of Panel 26 immediately south of Black Hill Road. The embankment of this dam is orientated approximately north-south with a spillway at the northern end. Relative to the southern-eastern (inflow) end of the water storage area, the northern end of the embankment is predicted to subside by about 500 mm and the southern end by about 1,000 mm. Options for remedial works to maintain the storage capacity of this dam would need to be assessed in detail at the time.

Dam A02d03 is a relatively large dam (surface area about 8,200 m^2) located on a tributary of Four Mile Creek towards the eastern edge of Panel 26. The embankment of this dam is orientated approximately north-west to south-east with the spillway at the south-east end. Differential settlement for this dam is predicted to be 1,000 mm, with the greatest subsidence at the southern end of the storage where water enters the dam. Differential subsidence is predicted to lower the south-eastern end by about 300 mm. Although subsidence at the southern end of the storage area would tend to cause an increase in water storage volume, rehabilitation work may be required to raise the spillway level and the south-eastern end of the embankment in order to maintain the storage capacity of the dam.

It can be seen from the above table, that Dams Refs. A02d02 and A02d03 are predicted to experience changes in freeboard of 1,000 mm. The directions of the final tilts are orientated across these dams and, therefore, do not result in a reduction of freeboard at the dam walls. The predicted changes in freeboard at the remaining dams are 600 mm, or less. It is unlikely, at the magnitudes of the predicted changes in freeboards that there would be any adverse impacts on the stability of the dam walls.

It is possible that the storage capacities of some of the farm dams which are located directly above the proposed panels could be reduced. If the storage capacities of any farm dams were adversely affected, they could be re-established by raising the earthen walls, if required.

The predicted conventional strains for the farm dams located directly above the proposed panels vary between 10 mm/m and 30 mm/m tensile, and between 2 mm/m and 25 mm/m compressive. It is likely, at these magnitudes of strain, that these farm dams could be affected by cracking, heaving or stepping in the bases or dam walls. It is also likely that fracturing and buckling uppermost bedrock would occur beneath these farm dams.

There is also a possibility that high concentrations of strain could occur at faults, fissures and other geological features, or points of weaknesses in the strata, and such occurrences could be coupled with localised stepping in the surface. If this type of phenomenon coincided with a farm dam wall, then, there is a possibility that cracking in the dam wall or base could occur resulting in loss of the stored water.

Any surface cracking or leakages in the farm dams could be identified by visual inspections and remediated by re-instating the bases and walls of the dams with cohesive materials. Any loss of water from the farm dams would flow into the drainage line in which the dam was formed. There are no principal residences or other building structures located within the alignments of the drainage lines downstream of the farm dams.

11.2.12.3 Impact Assessments for the Farm Dams Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum final tilt at the farm dams would be 80 mm/m (i.e. 8 %, or 1 in 13). In this case, the maximum changes in freeboard would be 1,000 mm, or greater, at Dams Refs. A02d02, A02d03, A02d05 and A05d02. It would still be unlikely to affect the stability of the dam walls and, if required, the storage capacities could be restored by raising the dam walls.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihood and extents of cracking in the bases and dam walls would increase for the dams located directly above the proposed panels. It would still be expected, that any adverse impacts could be repaired, as required, by re-instating the bases and walls of the dams with cohesive materials.

11.2.12.4 Impact Management Strategies

Dam Monitoring Management Strategies will be developed for the larger farm dams which are located directly above the proposed panels, which could include lowering the stored water levels prior to mining directly beneath them. The farm dams will be visually monitored, during active subsidence, such that any impacts can be identified and remediated accordingly.

As part of Donaldson Coal's commitments for the Abel Underground Mine, Donaldson Coal will develop a Dam Monitoring and Management Strategy (DMMS) for dams prior to any mining which will potentially impact on the dams.

The DMMS will provide for:

1. The individual 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.

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

3. 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.

4. 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.

5. 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.

For additional information on possible remediation measures see **Section 12.2.12.2**.

11.2.13 Business or Commercial Premises

11.2.13.1 Predictions for the Business or Commercial Premises

The predicted conventional subsidence, tilt and curvatures for the building structures within the SMP Area are provided in Table D.01, in **Appendix A**. A summary of the maximum predicted subsidence parameters for the Woodbury's Quarry building structures (Refs. A03c01 to A03c04) is provided in **Table 39**.

Table 39 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Administration Building Structures

Structure Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
A03c01	1,300	20	0.7	0.8
A03c02	650	25	0.8	0.3
A03c03	800	25	0.4	0.4
A03c04	800	25	0.4	0.4

The maximum predicted conventional curvature for the administration building structures are 0.8 km^{-1} both hogging and sagging, which represents a minimum radius of curvature of 1.3 kilometres. The maximum predicted conventional strains for these structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are 8 mm/m tensile and compressive.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

11.2.13.2 Impact Assessments for the Business or Commercial Premises

The maximum predicted tilt for the administration building structures is 25 mm/m (i.e. 2.5 %, or 1 in 40). The administration building structures are of light-weight construction and, therefore, it is unlikely that these structures would become unstable as the result of mining induced tilt. It is likely, however, that serviceability impacts would occur for these structures, including door swings and issues with roof and pavement drainage, which could be remediated by relevelling the light-weight structures.

The predicted conventional strains for the administration building structures vary between 4 mm/m and 8 mm/m tensile, and between 3 mm/m and 8 mm/m compressive. It is possible, at these magnitudes of strain, that impacts could occur to the administration building structures, including cracking or differential movement of the wall claddings and flexing or distortion of the structural frames. It is unlikely that any of these structures would become unstable due to the more flexible types of constructions. It has been found, from past mining experience, that the incidence of impacts on these types of structures is low and that any impacts can generally be remediated using normal building maintenance techniques.

11.2.13.3 Impact Assessments for the Business or Commercial Premises Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the administration building structures would be 50 mm/m (i.e. 5 %, or 1 in 20). In this case, the incidence of serviceability impacts would increase, such as door swings and issues with gutter and pavement drainage. It would still be unlikely that stabilities of these structures would be affected by tilts of these magnitudes.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the incidence of impacts would increase for the administration building structures. Since these structures are small in size and of light-weight construction, they would still be expected to remain safe, serviceable and repairable using normal building maintenance techniques. With the implementation of any necessary remediation measures, it is unlikely that there would be any significant long term impacts on the administration building structures.

11.2.13.4 Impact Management Strategies

The administration building structures on Property A03 will be inspected, as per the Abel Project Approval Statement of Commitments, to confirm the existing conditions and to determine whether any preventive measures are required, prior to mining beneath these structures. With the implementation of these management measures, it would be expected that the administration building structures could be maintained in safe and serviceable conditions during and after the proposed mining.

11.2.14 Mining Infrastructure

The exploration bores are located directly above the proposed panels and, therefore, could experience the full range of predicted subsidence movements. It is likely, therefore, that fracturing and shearing would occur in the boreholes as the result of mining.

There are also two groundwater monitoring bores owned by Donaldson Coal within the SMP Area. The bores are located directly above the proposed Panels and therefore, are likely to experience some impacts as the result of the proposed mining.

Impacts could include temporary lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements at different horizons within the strata.

11.2.15 Aboriginal Places and Sites

11.2.15.1 Predictions for the Aboriginal Places and Sites

The predicted conventional subsidence, tilt and curvatures for each of the archaeological sites within the SMP Area are provided in Table D.03, in **Appendix A**. Summaries of the maximum predicted subsidence, tilt and curvatures for the archaeological sites and cultural places provided in **Table 40** and **Table 41**, respectively. The parameters provide in these tables are the maximum values within a 20 metre radius of the sites. The tilt and curvatures are the maxima at any time during or after the completion of mining.

Table 40 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Archaeological Sites within the SMP Area

Site Name	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
AMA2/A	1,350	20	2.5	2.5
AMA2/B	1,400	5	> 3.0	> 3.0
AMA2/C	150	10	2.0	0.3
CA6	50	7	0.9	0.1
F1/B	< 20	3	0.4	0.03
FMC6 Donaldson Mine	1,300	40	2.5	2.5

Table 41 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Cultural Places within the SMP Area

Site Name	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Black Hill Locality and Black Hill Pathway	1,150	20	0.5	0.5

The maximum predicted conventional hogging and sagging curvatures for the archaeological sites are both greater than 3.0 km^{-1}, which represents minimum a radius of curvature of 0.3 kilometres. The maximum predicted conventional hogging and sagging curvatures for the cultural places are both 0.5 km^{-1}, which represents a minimum radius of curvature of 2 kilometres.

The maximum predicted conventional strains, based on applying a factor of 10 to the maximum predicted conventional curvatures, are greater than 30 mm/m tensile and compressive for the archaeological sites, and are 5 mm/m tensile and compressive for the cultural places.

The analysis of strains measured above the previously extracted bord and pillar total extraction panels at the Abel Underground Mine is provided in **Section 10.6**. Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, amongst other things, anomalous movements. The analysis of strains provided includes those resulting from both conventional and non-conventional anomalous movements.

11.2.15.2 Impact Assessments for the Aboriginal Sites

The archaeological sites within the SMP Area all comprise artefact scatters. These types of sites can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. Discussions on the potential for surface deformations resulting from the proposed mining are provided in **Section 10.6**. It is unlikely, that these scattered artefacts or isolated finds themselves would be impacted by surface cracking.

Further discussions on the potential impacts on the artefact scatter sites, resulting from the proposed mining, are provided in the report by the specialist archaeological consultant on the project (**Appendix H**), which notes that any potential impacts, though unlikely, would probably result in no loss of value and further notes no management action required.

11.2.15.3 Impact Assessments for the Aboriginal Places

The cultural places identified within the SMP Area are the Black Hill Locality and Black Hill Pathway. The potential impacts on the cultural places include surface cracking and deformations and changes in surface water drainage.

Further discussions on the potential impacts on the artefact scatter sites, resulting from the proposed mining, are provided in the report by the specialist archaeological consultant on the project (**Appendix H**), which notes that any potential impacts, though unlikely, would probably result in no loss of value and further notes no management action required.

11.2.15.4 Impact Assessments for the Aboriginal Places and Sites Based on Increased Predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be 80 mm/m (i.e. 8 %, or 1 in 13) for the archaeological sites and 40 mm/m (i.e. 4 %, or 1 in 25) for the cultural places. These types of sites are not adversely affected by tilt and, therefore, the likelihoods of impact would not be expected to increase.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihoods and extents of cracking in the surface soils would also increase. It would still be unlikely that the artefact scatters or isolated finds themselves would be impacted by the surface cracking and the methods of remediation, if required, would not be expected to change.

11.2.15.5 Impact Management Strategies

In accordance with the approved Aboriginal Heritage management Plan, the area has been surveyed prior to secondary extraction being undertaken. The additional sites identified will be treated in accordance with the approved Aboriginal Heritage Management Plan (AHMP).

The Aboriginal Heritage Management Plan (AHMP) will be revised to clarify that any direct surface impacts proposed in the Abel Underground Mine Area south of John Renshaw Drive will be assessed and any identified Aboriginal Heritage managed in accordance with the AHMP procedures.

The Department of Environment and Heritage (OEH) require that an archaeological record of the artefact scatters be developed before recommending that mining activities be approved. The record for the SMP Area is understood to have now been completed.

As the archaeological surveys to-date have not identified any sites that are likely to be affected by mine subsidence, formal management plans will not need to be established prior to extraction of SMP Area 3.

11.2.16 State Survey Control Marks

The survey control mark located directly above the proposed panels could experience the full range of predicted subsidence movements. The survey control marks located in the immediate area could be affected by far-field horizontal movements, outside the extents of the proposed mining area. Far-field horizontal movements and the methods used to predict such movements are described earlier in this document.

It will be necessary on the completion of the proposed panels, when the ground has stabilised, to re-establish any survey control marks that are required for future use. Consultation between Donaldson Coal and the Department of Lands will be required to ensure that these survey control marks are reinstated at the appropriate time, as required.

Impact Management Strategies

A protocol exists where mining may impact on Permanent Survey Control Marks. This consists of notification of both commencement of mining and completion of subsidence impact to LPI survey. The Control Marks are then removed from the register until completion of subsidence when reestablishment (if required) and resurvey are conducted.

11.2.17 Houses

11.2.17.1 Predictions for the Principal Residences

The Project Approval 05-0136 requires Donaldson Coal to *"limit mining operations to first workings beneath, and ensure mining causes no subsidence requiring mitigation works"* for principal residences (i.e. houses). Subsidence control zones have been established around each of the principal residences, based on 26.5 degree angle of draw lines.

A summary of the maximum predicted subsidence, tilt and curvatures for the principal residences within the SMP Area is provided in **Table 42**. The predicted movements are the maxima within a distance of 20 metres of each structure, at any time during or after the extraction of the proposed panels

Table 42 Maximum Predicted Total Conventional Subsidence, Tilt and Curvatures for the Principal Residences

Structure Reference	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
A01h01	< 20	< 0.5	< 0.01	< 0.01
A02h02	< 20	< 0.5	< 0.01	< 0.01
A05h01	< 20	< 0.5	< 0.01	< 0.01
A05h02	< 20	< 0.5	< 0.01	< 0.01

The maximum predicted conventional hogging and sagging curvatures for the principal residences are both less than 0.01 km^{-1}, which represents a minimum radius of curvature greater than 100 kilometres. The maximum predicted conventional strains for these structures, based on applying a factor of 10 to the maximum predicted conventional curvatures, are less than 0.3 mm/m tensile and compressive (i.e. less than the order of survey tolerance).

11.2.17.2 Impact Assessments for the Principal Residences

The principal residences are predicted to experience less than 20 mm of vertical subsidence. Whilst these structures could experience some low level subsidence, they would not be expected to experience any significant tilts, curvatures or strains. It is unlikely, therefore, that the principal residences would be adversely impacted, even if the predictions were exceeded by a factor of 2 times. That is, it is not anticipated that impacts would occur to the principal residences which would require mitigation or remedial works.

11.2.17.3 Infrastructure Associated With the Principal Residences

The properties within the SMP Area have water storage tanks which collect rainwater from the roofs of the principal residences (i.e. houses) and the sheds (i.e. rural building structures).

The tanks adjacent to the principal residences are located within the subsidence control zones, which limits mining to first workings beneath the principal residence. It is unlikely, therefore, that these water tanks would experience any adverse impacts as a result of the proposed mining.

The properties within the SMP Area also have other non-residential buildings and infrastructure. The descriptions, predictions and impact assessments for the rural building structures, tanks, fences and farm dams are provided earlier in this Section. There were no private swimming pools or tennis courts identified within the SMP Area.

Other infrastructure on the private properties include septic tanks and driveways. The potential impacts on this infrastructure can be managed with the implementation of Built Features Management Plans.

11.2.17.4 Impact Management Strategies

As previously discussed, as a result of the subsidence control zone (SCZ) around the Principal Residences, any associated outbuildings, in-ground tanks and pipes will be afforded some level of protection from significant damage.

The maximum subsidence is estimated to be < 20mm for minimum set back distances of 26.5 degrees for the proposed SCZ beneath the Principal Residences. Any damage to Principal residences should not be greater than Category 0 to 2 Damage Classification categories (i.e. "Negligible" to "Slight") in accordance with **AS2870, 1996**.

The proposed management strategies required to minimise impact to the Principal Residences due to subsidence, and to be included in the Property Subsidence Management Plan, are:

- Each Principal Residence will be individually assessed, pre-mining by the Mine Subsidence Board / structural engineer who will determine tolerable levels for individual subsidence parameters. Tolerable limits are those limits which will result in no mitigation works being required to the Principal Residence due to subsidence impacts from the Abel Underground Mine, and will also identify and record pre-existing imperfections that will not be covered by the Mine Subsidence Board.

- Installation of monitoring pins or pegs around each structure and conduct base line subsidence, peg location and strain measurements prior to undermining.

- Pre-mining inspections of the properties will be conducted by representatives of Abel Mine as well as the MSB before second workings in the vicinity of the site are undertaken.

- Post mining structure surveys and visual inspections should be conducted no earlier than one month after second workings of a panel has been completed.

- Each Principal Residence will be specifically monitored before and after mining to measure any subsidence impacts at the Principal Residence and to ensure that tolerable limits are achieved in practice.

- The Mines Subsidence Board has the responsibility to rectify any impacts to structures that may occur as a result of mining.

- Any minor repair works to internal / external cracking or re-levelling of Other Surface Structures should be implemented as soon as mining related movements have ceased.

- If impacts to Principal Residences exceed a Category 2 damage classification in accordance with AS2870, 1996 or "Moderate" damage, then it will be necessary to review the SCZ set back distance in regards to applying them to other Principal Residences.

11.2.17.5 Other Surface Structures

“Other Surface Structures” are addressed in the Project Approval under “All Other Surface Structures” which is defined as any building or structure impacted by mining-induced subsidence from the Abel Underground Mine Project which is not categorised as a Principal Residence, Future Principal Residence, Black Hill Church and Cemetery or Black Hill School.

The Company shall prepare and implement plans of management for the mitigation and remediation of any damage to All Other Surface Structures prior to any mining occurring that would impact on them.

The plan of management will include:

(a) pre-mining audit of the structure;
(b) the provision of a plan of management as part of the SMP approval process which requires the Company to mitigate/remediate any damage to improvements associated with the structure in conjunction with the Mines Subsidence Board;

(c) post-mining monitoring of the improvements associated with the Structure.

The mitigation/remediation measures to be undertaken will be related to the extent of damage experienced.

11.2.18 Far Field Displacement F3 Freeway and John Renshaw Drive

The Sydney-Newcastle (F3) Freeway is located well outside the SMP Area. The freeway is located more than 2 kilometres east of the proposed Panel 23, at its closest point to the proposed panels. The Hunter Expressway is currently being constructed to the south-west of the SMP Area. The expressway is located more than 4 kilometres from the proposed Panel 26, at its closest point to the proposed panels.

At these distances, the Sydney-Newcastle (F3) Freeway and the Hunter Expressway are not predicted to experience any measurable conventional subsidence movements. It is unlikely, therefore, that the pavements, bridges, or other associated infrastructure would be adversely impacted as a result of the extraction of the proposed Panels 23 to 26, even if the predictions were exceeded by a factor of 2 times.

John Renshaw Drive is located in excess of 350 metres from Area 3, substantially more than the distance from the previously mined Area 1. No impacts were recorded following mining in Area 1 and no impacts are predicted from the mining of Area 3.

It is not considered necessary to monitor far-field movements along these roads as any movements that occur will probably be less than survey accuracy limits for horizontal displacement (i.e. <10 to 20 mm).

11.3 SUMMARY

Comparison of Subsidence Profile Predictions to the Environmental Assessment

For completeness the proposed SMP mining layout and impact predictions have been compared to the Environmental Assessment.

The predicted subsidence parameters were previously provided in the report by Strata Engineering (SE, 2006) which supported the Part 3A Environmental Assessment for the Abel Underground Mine. A comparison of the maximum predicted subsidence parameters described in the Part 3A Application, with those predicted for the proposed Panels 23 to 26 in this report, is provided in **Table 43**.

Table 43 Comparison of the Maximum Predicted Subsidence Parameters

Case	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Part 3A Application (SE, 2006) Panels D and H	1,330	48	3.24	4.12
SMP Application (MSEC596) Panels 23 to 26	1,450	70	> 3.0	> 3.0

It can be seen from the above table, that the maximum predicted subsidence and tilt for the proposed Panels 23 to 26 (MSEC596) are greater than those previously provided in the Part 3A Environmental Assessment (SE, 2006). The reason for this is that the proposed Panels 23 to 26 have overall void widths of 220 metres, whereas the panels adopted in the Part 3A Environmental Assessment had nominal void widths of 150 metres. The maximum predicted curvatures for the proposed panels provided in this report are similar orders of magnitude as those previously provided in the Part 3A Environmental Assessment.

It is considered that the predicted subsidence and associated impacts to the natural and man-made features will be similar in magnitude and location to the EA study outcomes.

Conclusion

It is concluded that the assessed range of potential subsidence and far-field displacement impacts after the mining of the proposed pillar extraction panels will be manageable for the majority of the site features, based on the analysis outcomes and discussions with the stakeholders' to-date.

No practically measureable mine subsidence or far-field displacement movements or impacts are expected along John Renshaw Drive or the F3 Freeway due to the proposed mining layout.

Subsidence Control Zones (SCZ) have been proposed to limit impacts to within tolerable levels from the proposed mining layout at Abel for the Principal Residences. The proposed setback distances are considered conservative, however, they will still need to be confirmed as adequate through subsidence monitoring in less sensitive areas during mining.

The above subsidence impact limit criteria will be achieved in the SCZ with first workings only proposed at this stage. The potential exists however to implement a partial pillar extraction layout provided the long-term stability of remnant pillars and tolerable impacts to surface features can be demonstrated.

All matters relating to subsidence management of the Principal Residences and Other Structures will be addressed in individual Property Subsidence Management Plans (PSMP's).

The extent of any mining layout adjustment will also require further discussions (and review of monitoring data) after the completion of a given panel with the stakeholder and government agencies.

12 RISK ASSESSMENT

12.1 RISK ASSESSMENT AND SUMMARY

A risk assessment was conducted on 12 December 2012 to identify, assess and review any potential subsidence impacts to the surface and sub-surface as a result from the mining of the proposed SMP application area at Abel. A copy of the risk assessment is included in **Appendix B**.

The risk assessment was facilitated by HMS Consultants and involved a team with wide ranging experience. The team consisted of members of Abel staff, specialist consultants in subsidence, surface and groundwater.

A key step in the process was the gathering of the data related to the application to present to the team. Once the scope and mandate of the team was determined a number of tools were used to identify issues relating to the application and identify risks as a result of the mining process. Whilst worst case scenarios were discussed by the risk assessment team, the worst case scenario as not necessarily the consequence severity chosen for risk ranking. The risk assessment team used their industry and site experience, as well as their knowledge of the effectiveness of the actual Abel controls, to choose the most appropriate consequence severity for risk ranking. The losses were ranked according to their likelihood and consequences with quantification where possible. Once this had been completed current and additional controls were identified, followed by nominated further actions in order to eliminate or control the identified risk issue to an acceptable level.

In total twenty seven risk issues were identified. Of those risks assessed, there was one (1) “High” risk and six (6) “Significant” risks identified by the risk assessment team. There were nil “Catastrophic” consequences identified with one (1) potential “Major” consequence identified by the risk assessment team. The “High” risk relates to the Telstra fibre optic cable (2.03.01), “Major” consequence relates to Black Hill Road (2.01.01) and these are listed in risk rank order in **Table 44**.

Table 44 - Summary of Further Actions Relating to High, Significant Risk and Major Consequence Issues

Process	Risk Issue	Existing Controls	Further Actions
2.03.01	Damage to Telstra Optical Fibre Cables		1. Consider options with Telstra of protection (conduit sheathing etc.) or relocation 2. Consult with MSB re installation parameters (if any) and responsibilities
2.01.01	Injury to road user on Black Hill Rd due to impact of mine subsidence	1. Road management plan with Cessnock City Council 2. Public Safety Management Plan 3. Ongoing consultation 4. Industry experience mining under roads at similar depth	1. Review and update Road MP and PSMP 2. Research Blakefield Road MP
2.04.01	Use of disturbed State Survey Marks	1. Location of marks known 2. Notify Department of Lands 3. Requirement to re-establish marks following subsidence	1. Conduct further searches to identify State Survey Marks
2.03.02	Damage to Telstra Local Copper Cables		1. Undertake an audit of copper cable locations within SMP Area 3 and develop a MP to mitigate risk 2. Consider provision of mobile phones in PSMP in the event of damage to Telstra cables
2.03.03	Damage to Telstra exchange building	1. Free standing structure on piers	1. Develop a Built Features MP 2. Consider provision of mobile phones in PSMP in the event of damage to Telstra exchange
3.04.01	Damage to dams and water reticulation systems resulting in loss of service-ability and integrity of dam wall	1. Statement of commitments to provide water in the event of interruption of supply of water from dam	1. Develop Dam Monitoring and Management Strategy (DMMS) for all dams prior to any mining occurring which will impact on the dams 2. Develop PSMP for individual properties
6.01.01	Damage to quarry office and workshop		1. Mine Subsidence Board inspections to determine tolerable levels 2. Develop PSMP

The risk assessment identified existing controls but also highlighted a number of additional controls or further actions that the team thought necessary to manage subsidence.

The further action items for High, Significant Risk Issues and Major Consequences listed in **Table 44** and Summary of Further Actions for Remaining Risk Issues listed in **Table 45** were generated from the risk assessment in order to control the associated risks. These actions are either proposed actions or actions in progress. The implementation of the further actions is to be reviewed and updated on a regular basis documenting the status of the implementation process.

The limiting of potential high risk issues is mostly attributable to the proposed mine design layout which includes Subsidence Control Zones.

This approach provides a high level of confidence that the subsidence impacts to these features from pillar extraction, once further actions are considered, will be minimal.

Table 45 - Summary of Further Actions for Remaining Risk Issues

H# **Process** **Subprocess**	**Risk Issue**	**Further Actions**
5.02.01 **Areas of Archaeological and/or Cultural Significance** Aboriginal heritage	**Damage to Aboriginal artefacts e.g. isolated scatters**	Review methods of surface remediation with stakeholders to ensure artefacts are not damaged whilst any subsidence remediation works are undertaken
1.01.01 **Natural Features** First or second order tributaries	**Loss of runoff to existing farm dams**	Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP)
1.03.01 **Natural Features** Springs	**Loss of flow from spring on Osborn's property**	Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP) Further investigations by Hydrogeologist Determine location of spring
1.04.01 **Natural Features** Land prone to flooding or inundation	**Increased area of ponding or flooding as a result of subsidence and rainfall event**	Conduct additional modelling to determine post mining contours
1.08.01 **Natural Features** Steep slopes	**Increased surface cracking**	To be included in PSMP Review existing methods of remediation for larger cracks
2.02.01 **Public Utilities** Electricity transmission lines (overhead/underground) and associated plants	**Damage and / or loss of clearance to 11kV Ausgrid Power line**	Review and update existing Ausgrid Power line MP Ausgrid clearance surveys to be conducted prior to completion of MP review Ausgrid to review need for pulleys and guy lines
3.01.01 **Farm Land and Facilities** Agricultural utilisation or agricultural suitability of farm land	**Temporary loss of access to sections of property**	Develop PSMP's
3.02.01 **Farm Land and Facilities** Internal Access tracks	**Damage to internal property access tracks**	Develop PSMP's
3.03.01 **Farm Land and Facilities** Fences, gates and cattle grids	**Damage to fences and / or gates including resulting loss of livestock**	Develop PSMP's
3.05.01 **Farm Land and Facilities** Farm structures	**Damage to farm structures due to subsidence**	Develop PSMP for individual properties
4.02.01 **Residential Establishments** "Other surface structures"	**Damage to other structures**	Develop PSMP for individual properties including TARPs and remediation / mitigation strategies
4.01.01 **Residential Establishments** Principal Residences and proposed Principal Residences	**Damage to Principal Residences requiring repair**	Mine Subsidence Board inspections to determine tolerable levels Develop Monitoring arrangements (Subsidence)

H# **Process** **Subprocess**	**Risk Issue**	**Further Actions**
1.01.02 **Natural Features** First or second order tributaries	**Increased erosion**	Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP)
1.02.02 **Natural Features** Aquifers, known groundwater resources	**Additional flow to underground workings resulting in business interruption**	Consider installation of additional piezometers and surface extensometers
		Investigate options for managing additional water make
1.02.03 **Natural Features** Aquifers, known groundwater resources	**Elevated salinity in groundwater inflows through mine workings**	Investigate options for managing additional water make
1.07.01 **Natural Features** Natural Vegetation	**Change in habitat / fauna**	Inspections and remediation as per EMP
5.02.02 Areas of Archaeological and/or Cultural Significance Aboriginal heritage	**Damage to Black Hill Pathway**	Review methods of surface remediation with stakeholders to ensure no loss of value of Black Hill Pathway occurs whilst subsidence remediation works are undertaken
		Record location of Black Hill Pathway on SMP Application Plan 2
		TS and PB to discuss with RS

Table 46 - Risk Table – Risk Rank Order

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
2	Public Utilities	2.03	Telecommunication lines (overhead/ underground) and associated plants	2.03.01	Damage to Telstra Optical Fibre Cables	1. Strains		F	3	A	6	H	1. Consider options with Telstra of protection (conduit sheathing etc.) or relocation 2. Consult with MSB re installation parameters (if any) and responsibilities
2	Public Utilities	2.01	Roads (all types, including culverts)	2.01.01	Injury to road user on Black Hill Rd due to impact of mine subsidence	1. Cracking 2. Steps (Scarps) 3. Change in road profile 4. Reduction in sight distance on road 5. Change in drainage / damage to culverts 6. Tree falling	1. Road management plan with Cessnock City Council 2. Public Safety Management Plan 3. Ongoing consultation 4. Industry experience mining under roads at similar depth	P	2	C	8	S	1. Review and update Road MP and PSMP 2. Research Blakefield Road MP
2	Public Utilities	2.04	State Survey marks	2.04.01	Use of disturbed State Survey Marks	1. Disturbance of State Survey Marks due to subsidence	1. Location of marks known 2. Notify Department of Lands 3. Requirement to re-establish marks following subsidence	F	4	A	10	S	1. Conduct further searches to identify State Survey Marks

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
2	Public Utilities	2.03	Telecommunication lines (overhead/ underground) and associated plants	2.03.02	Damage to Telstra Local Copper Cables	1. Strains		F	3	C	13	S	1. Undertake an audit of copper cable locations within SMP Area 3 and develop a MP to mitigate risk 2. Consider provision of mobile phones in PSMP in the event of damage to Telstra cables
2	Public Utilities	2.03	Telecommunication lines (overhead/ underground) and associated plants	2.03.03	Damage to Telstra exchange building	1. Strains 2. Tilt	1. Free standing structure on piers	F	3	C	13	S	1. Develop a Built Features MP 2. Consider provision of mobile phones in PSMP in the event of damage to Telstra exchange
3	Farm Land and Facilities	3.04	Farm dams and water reticulation system	3.04.01	Damage to dams and water reticulation systems resulting in loss of service-ability and integrity of dam wall	1. Cracking 2. Strains	1. Statement of commitments to provide water in the event of interruption of supply of water from dam	F	3	C	13	S	1. Develop Dam Monitoring and Management Strategy (DMMS) for all dams prior to any mining occurring which will impact on the dams 2. Develop PSMP for individual properties
6	Commercial Establishments	6.01	Black Hill Quarry Structures	6.01.01	Damage to quarry office and workshop	1. Subsidence		F	4	B	14	S	1. Mine Subsidence Board inspections to determine tolerable levels 2. Develop PSMP

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
5	Areas of Archaeological and/or Cultural Significance	5.02	Aboriginal heritage	5.02.01	Damage to Aboriginal artefacts e.g. isolated scatters	1. Subsidence	1. Artefact locations have been identified 2. Heritage surveys have been completed 3. Aboriginal Heritage Assessment report has been finalised 4. Subsidence assessment indicates artefact scatters are unlikely to be impacted 5. Consultation with Aboriginal community	R	3	D	17	M	1. Review methods of surface remediation with stakeholders to ensure artefacts are not damaged whilst any subsidence remediation works are undertaken
1	Natural Features	1.01	First or second order tributaries	1.01.01	Loss of runoff to existing farm dams	1. Surface cracking 2. Cracking in creek 3. Ponding in creek	1. >140m depth of cover 2. Surface grades minimise ponding 3. Experience from SMP Area 1 and 2 show location, intensity and depth of cracking is relatively minor 4. Provide supplementary supply in the event of water loss from dams 5. Dam monitoring program	F	4	C	18	M	1. Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP)

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
1	Natural Features	1.03	Springs	1.03.01	Loss of flow from spring on Osborn's property	1. Depressurisation of aquifers due to mining activities greater than predicted		R	4	C	18	M	1. Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP) 2. Further investigations by Hydrogeologist 3. Determine location of spring
1	Natural Features	1.04	Land prone to flooding or inundation	1.04.01	Increased area of ponding or flooding as a result of subsidence and rainfall event	1. Differential Subsidence associated with flat gradients 2. Significant Rainfall Event	1. Ephemeral streams 2. Existing natural gradients	F	4	C	18	M	1. Conduct additional modelling to determine post mining contours
1	Natural Features	1.08	Steep slopes	1.08.01	Increased surface cracking	1. Strain 2. Topography	1. Surface gradients less than 1 in 2 2. Naturally vegetated slopes 3. Higher depth of cover (>140m)	E	4	C	18	M	1. To be included in PSMP 2. Review existing methods of remediation for larger cracks
2	Public Utilities	2.02	Electricity transmission lines (overhead/underground) and associated plants	2.02.01	Damage and / or loss of clearance to 11kV Ausgrid Power line	1. Subsidence 2. Tilt	1. Timber poles more resilient to subsidence impacts 2. Power line Management Plan 3. Industry and Donaldson experience mining under power lines at similar depth	F	4	C	18	M	1. Review and update existing Ausgrid Power line MP 2. Ausgrid clearance surveys to be conducted prior to completion of MP review 3. Ausgrid to review need for pulleys and guy lines

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
3	Farm Land and Facilities	3.01	Agricultural utilisation or agricultural suitability of farm land	3.01.01	Temporary loss of access to sections of property	1. Surface cracking	1. Previous Donaldson experience 2. Ongoing consultation with property owners 3. Established methods of remediation	F	4	C	18	M	1. Develop PSMP's
3	Farm Land and Facilities	3.02	Internal Access tracks	3.02.01	Damage to internal property access tracks	1. Cracking 2. Steps (Scarps) 3. Change in road profile 4. Change in drainage 5. Tree falling	1. Previous Donaldson experience 2. Ongoing consultation with property owners 3. Established methods of remediation	F	4	C	18	M	1. Develop PSMP's
3	Farm Land and Facilities	3.03	Fences, gates and cattle grids	3.03.01	Damage to fences and / or gates including resulting loss of livestock	1. Strain 2. Subsidence 3. Falling tree 4. Cracking	1. Previous Donaldson experience 2. Ongoing consultation with property owners 3. Established methods of remediation	F	4	C	18	M	1. Develop PSMP's
3	Farm Land and Facilities	3.05	Farm structures	3.05.01	Damage to farm structures due to subsidence	1. Strains 2. Tilt	1. Previous industry and Donaldson experience with mining under similar structures 2. Ongoing consultation with property owners 3. Established methods of remediation 4. Farm structures inherently more flexible than brick structures	F	4	C	18	M	1. Develop PSMP for individual properties

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
4	Residential Establishments	4.02	"Other surface structures"	4.02.01	Damage to other structures	1. Strains 2. Tilt	1. Previous industry and Donaldson experience with mining under similar structures 2. Ongoing consultation with property owners 3. Established methods of remediation	F	4	C	18	M	1. Develop PSMP for individual properties including TARPs and remediation / mitigation strategies
4	Residential Establishments	4.01	Principal Residences and proposed Principal Residences	4.01.01	Damage to Principal Residences requiring repair	1. Subsidence impacts	1. Statement of Commitments 2. Subsidence control zones (SCZ) to limit subsidence to 20mm at Principal Residences (assumed 26.5 degrees for design purposes) 3. Pillar Extraction Management Plan (PEMP) including Authority to Mine (ATM) 4. Mine schedule provides for substantial amount of subsidence data prior to setting out SCZ underneath Principal Residences 5. Periodic review and recalibration if required of subsidence model 6. Mine design and layout 7. SMP mine design compliance audit	F	3	E	20	L	1. Mine Subsidence Board inspections to determine tolerable levels 2. Develop Monitoring arrangements (Subsidence)

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
1	Natural Features	1.01	First or second order tributaries	1.01.02	Increased erosion	1. Step / scarp subsidence developing a head cut scouring erosion	1. Has not happened in previous subsidence results 2. Previous visual monitoring	E	4	D	21	L	1. Inspections, remediation as per the Property Subsidence MP (PSMP) and Environmental MP (EMP)
1	Natural Features	1.02	Aquifers, known groundwater resources	1.02.01	Loss of groundwater resource	1. Connective cracking 2. Depressurisation of aquifers due to mining activities greater than predicted 3. Intersection with structures	1. Water Management Plan 2. Limited resource not currently utilised 3. Past experience mining in area	E	4	D	21	L	
1	Natural Features	1.02	Aquifers, known groundwater resources	1.02.02	Additional flow to underground workings resulting in business interruption	1. Connective cracking 2. Depressurisation of aquifers due to mining activities greater than predicted 3. Intersection with structures	1. Water Management Plan 2. Pumping capacity is approximately 3 times current flows 3. Mapping of geological structures 4. Additional surface storage (Square pit) available prior to commencement of extraction in SMP Area 3	BI	4	D	21	L	1. Consider installation of additional piezometers and surface extensometers 2. Investigate options for managing additional water make
1	Natural Features	1.02	Aquifers, known groundwater resources	1.02.03	Elevated salinity in groundwater inflows through mine workings	1. Connection with overlying aquifers with elevated salinity	1. Water Management Plan 2. Monitoring flow and salinity 3. Additional surface storage (Square pit) available prior to commencement of extraction in SMP Area 3	BI	4	D	21	L	1. Investigate options for managing additional water make

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
1	Natural Features	1.07	Natural Vegetation	1.07.01	Change in habitat / fauna	1. Falling tree 2. Dieback	1. Mine design 2. Monitoring arrangements 3. Visual inspections 4. TARPs - remediation works 5. Previous experience 6. Flora and Fauna MP	E	4	D	21	L	1. Inspections and remediation as per EMP
5	Areas of Archaeological and/or Cultural Significance	5.02	Aboriginal heritage	5.02.02	Damage to Black Hill Pathway	1. Subsidence	1. Location of Black Hill Pathway is known 2. Cultural Heritage Assessment Report for Abel Upgrade Modification has determined that partial or no loss of value will occur in the event of subsidence impacting Black Hill Pathway and that no management action is required	R	5	C	22	L	1. Review methods of surface remediation with stakeholders to ensure no loss of value of Black Hill Pathway occurs whilst subsidence remediation works are undertaken 2. Record location of Black Hill Pathway on SMP Application Plan 2 3. TS and PB to discuss with RS
1	Natural Features	1.07	Natural Vegetation	1.07.02	Visual impact	1. Falling tree 2. Dieback	1. Mine design 2. Monitoring arrangements 3. Visual inspections 4. TARPs - remediation works 5. Previous experience 6. Flora and Fauna MP 7. Ongoing consultation	R	5	D	24	L	

P#	Process	S#	Subprocess	H#	Risk Issue	Causes	Existing Controls	Loss Type	Consequence	Likelihood	Risk Rank	Risk Level	Further Actions
2	Public Utilities	2.05	Any other infrastructure items	2.05.01	Damage to derelict Chicken Farm Structures (Lab on Catholic land))	1. Strains 2. Tilt	1. Less than 20mm subsidence	F	5	D	24	L	
1	Natural Features	1.05	Swamps, wetlands, water related ecosystems	1.05.01	Change in groundwater regime for possible Groundwater Dependent Ecosystem (GDE)	1. Depressurisation of shallow aquifers due to mining activities greater than predicted 2. Connective cracking	1. No GDE identified in the area.				n/a	n/a	
1	Natural Features	1.06	Threatened and protected species	1.06.01	No threatened and protected species identified in the area.						n/a	n/a	
5	Areas of Archaeological and/or Cultural Significance	5.01	Areas of Archaeological and/or Heritage Significance	5.01.01	Nil identified						n/a	n/a	
6	Commercial Establishments	6.02	Mine Infrastructure	6.02.01	Nil identified						n/a	n/a	

13 COMMUNITY CONSULTATION

Community consultation during the preparation of the SMP was undertaken in accordance with the Department of Primary Industries – Mineral Resources *Guideline for Applications for Subsidence Management Approvals* dated December 2003 (SMP Guideline 2003) and the New South Wales Minerals Council *Community Engagement Handbook Towards Stronger Community Relationships*. The definition of "Community" adopted for the purpose of developing the SMP community consultation strategy is anyone with an interest in subsidence issues for the proposed SMP application.

Consultation Process

The SMP Guideline (DPI-MR, 2003) outlines a process for community consultation with persons or organisations that may be impacted by predicted subsidence following secondary extraction mining in the SMP area. The following describes the consultation undertaken in accordance with these guidelines.

Consultation undertaken has involved:

- Regular meetings with the Community Consultative Committee
- Identification of relevant stakeholders;
- Letters to the relevant stakeholders, including landholders and Community Consultative Committee, advising of the SMP process and inviting attendance at a meeting including a presentation and inspection;
- Stakeholder presentation;
- Advertising of the SMP process in Local and newspaper, with a request to provide comment;
- Meetings with landowners within and adjacent to the SMP area and with local community groups;
- Specific meetings with the owners of infrastructure located on or near the SMP area; and

Relevant Stakeholder Identification

Stakeholders who were identified as having an interest in or concern about subsidence issues relating to the SMP include:

- SMP Inter-agency committee (comprising members included in the list below);
- Department of Trade & Investment, Regional Infrastructure & Services – Division of Resources and Energy (DTIRIS);
- Private Landowners within and adjacent to the SMP area, including Catholic Diocese of Maitland – Newcastle;
- Mindaribba Local Aboriginal Land Council;
- Environmental Protection Agency;
- NSW Office of Water;
- Department of Planning and Infrastructure;
- Dams Safety Committee;
- Department of Primary Industries - NSW Fisheries;

- Ausgrid;
- Telstra;
- Hunter Water Corporation;
- Cessnock City Council (CCC);
- Mine Subsidence Board;
- Abel Mine Community Consultative Committee; and
- Woodbury's Quarry.

13.1 CONSULTATION DURING THE PREPARATION OF THE SMP APPLICATION

Stakeholder / Community Consultation

Stakeholder / Community consultation conducted to date has consisted of:

1. Community Consultative Committee Meetings
2. SMP Stakeholders presentation meeting, site inspection and submission process detail on 5 December 2012.
3. SMP Advertisement 10 November 2012

A presentation followed by a site inspection was made to DTIRIS and identified stakeholders on 5 December 2012 *to* outline the SMP process and progress to date, relating to mine design, environmental considerations, results of mining SMP Areas 1 and 2 to date, subsidence predictions and potential impacts.

The day was structured as follows;

1 Introduction and Meeting Objectives

2 Donaldson Coal Background

3 The Subsidence Management Plan (SMP) Process

4 Abel Mine
- Mine Planning
- Mining Methods
- SMP Areas 1 and 2
- SMP Area 3

5 SMP Areas 1 and 2 Approvals and Conditions, Management Plans, Monitoring Programs.

6 SMPs Area 1 and 2 progress to date.

7 Subsidence Results Panel 1, impacts and remediation.

8 SMP Area 3 Key surface features,
Man made and natural features potentially impacted by subsidence including,
Properties;
Roads;
Powerlines;
Telephone lines;
Dams; and
Other infrastructure.

9 Abel SMP Area 3 Subsidence Assessment and Predictions.

10 Abel SMP Area 3 Subsidence Impacts.

11 Abel SMP Area 3 Proposed Monitoring.

12 Abel SMP Area 3 Mining Schedule.

13 Field Visit SMP Areas 1 and 3.

The objective of the meeting was to provide an introduction and review of the approval procedure, update the results of mining SMP Areas 1 and 2 to date, outline the planning and baseline studies conducted in relation to SMP Area 3 and consult with interested parties (relevant stakeholders) to identify potential issues and relevant concerns to be considered and addressed in the preparation of the Subsidence Management Plan.

Following this meeting a copy of the presentation was forwarded to all relevant stakeholders and placed on the company web site. Copy of presentation and minutes is included in Appendix F.

A list of relevant stakeholders and relevant details is provided in **Table 47.**

Table 47 - Stakeholder / Community Consultation Information

Stakeholder	Invitation to Consultation Meeting	Attendance
Dr Gang Li - DTIRIS	Yes	No
Ray Ramage – DTIRIS	Yes	Yes
Paul Langley – DTIRIS	Yes	No
Steve Barry - DTIRIS	Yes	No
Rod Sandell – Cessnock City Council	Yes	No
Boyd McCallum -Catholic Diocese	Yes	Yes
Grahame Clark – Environmental Protection Authority	Yes	No
Scott Carter – DPI Fisheries	Yes	No
Bill Ziegler – Dam Safety Committee	Yes	No
Phil Alexander – Mine Subsidence Board	Yes	Yes
Howard Reed – Department of Planning and Infrastructure	Yes	No
Mark Mignanelli – NSW Office of Water	Yes	No
Fergus Hancock – NSW Office of Water	Yes	No
Patrick Boyle – Ausgrid	Yes	No
Colin Dove – Telstra Consultant	Yes	Yes
Mark Schneider -Telstra	Yes	No
Nathan Hays - Hunter Water Corporation	Yes	No
Brad Ure – Community Consultative Committee	Yes	Yes

Stakeholder	**Invitation to Consultation Meeting**	**Attendance**
Alan Jennings – Community Consultative Committee	Yes	Yes
Alan Brown – Community Consultative Committee	Yes	Yes
Terry Lewin – Community Consultative Committee	Yes	No
Anthony and Rosalie Seton – Residents	Yes	No
Clifford Harding – Resident	Yes	No
Hayden Osborn - Resident	Yes	Yes
Carol Fraser	Yes	Yes
John Allan – Resident	Yes	No
Peter Allan – Resident	Yes	No
Mark Woodbury – Woodbury's Quarry	Yes	No
Ken Riddiford - Mindaribba Local Aboriginal Land Council	Yes	No

SMP Advertisement

As per the SMP Guideline 2003, Abel prepared an advertisement to notify the community of the intention to submit an SMP application for approval. The advertisement stated :

"Donaldson Coal is developing a Subsidence Management Plan to accompany an application to the Department of Trade and Investment, Regional Infrastructure and Services for Pillar Extraction mining at Abel Mine in the Application Area 3 outlined below. Once prepared the draft plan will be advertised and displayed for comment. Any person wishing to provide input to the preparation of the plan can contact the mine on (02) 40151100."

The advertisement included a map of the SMP Area, existing workings and regional locality. Donaldson Coal placed the advertisement in the Newcastle Morning Herald on 10 November 2012. A copy of this advertisement is provided in **Appendix C**.

14 ECONOMIC AND SOCIAL IMPACTS AND BENEFITS

Abel currently has approximately 20 years of coal reserves within the current mining lease.

The majority of Abel's production is railed to Newcastle for the export market with a small amount to various local markets.

Abel provides valuable training and industry experience to apprentices and work experience to both local youth and university students (local and intrastate).

In the Abel Project Approval Statement of Commitments Donaldson Coal Pty Ltd committed to providing monetary contributions towards environmental and community enhancements. These Company Contribution Initiatives are listed in **Table 48**.

Table 48 - Company Contribution Initiatives

No.	Proposed Activities	Monetary Value
1.	**Conservation** The company will contribute $1,000,000 to be distributed over ten years by a community trust to be established for the purpose. These monies will be able to be expended by the trust on environmental education or research or environmental management works or activities in State Conservation Area lands or other environmentally valuable lands that lie within or above Donaldson's mining leases and exploration licences or other land owned by the company	$1,000,000
2.	**Community Welfare** The company will contribute $250,000 over 5 years to be spent as decided by a community trust on educational needs, community works or other works or activities of benefit to the community within the Abel underground mine area.	$250,000
3.	**Road Safety** The company contributed $250,000 towards the cost of upgrading the intersection of Black Hill Rd and John Renshaw Drive, provided that construction of the upgrade is initiated by June 2009	$250,000
4.	**Employment Generation** The Company also operates the **Donaldson Job Creation Trust,** a charitable trust already in operation set up to distribute $1,000,000 over ten years. Monies are expended on job training, job creation and Youth at Risk programs in the Lower Hunter. $500,000 of these monies remain to be spent	$500,000
		$2,000,000

Abel currently employs 280 personnel, including contractors, and this will increase to 375 once full production level is reached. Town planning calculations anticipate that for each mine employee there are approximately 2.5 indirect employees retained in the community. Consequently the operation of Abel provides approximately 1,300 additional jobs within the local area.

Substantial industry expenditure occurs locally and both federal and state governments will continue to receive income by way of royalty, excise and various taxes.

15 STATUTORY REQUIREMENTS

15.1 PROJECT APPROVAL

The construction and operation of Abel mine was approved by The Minister for Planning on 7 June 2007, being Project Approval (Development Consent) 05_0136 and allowing mining operations to take place until 31 December 2028.

Abel commenced operations in May 2008. The mine currently employs 280 personnel, including contractors, and currently produces approximately 1.8 million tonnes per annum (tpa), with a proposed maximum production for CY2013 of 2.34 million tonnes of thermal / soft coking coal from the Upper Donaldson coal seam. Abel's production is railed to Newcastle for the export market.

The key features of the Project Approval (Development Consent) 05_0136 for the mine include:

- Construction and operation of an underground coal mine.

Obligations to Minimise Harm to the Environment

1. The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.

Terms of Approval

2. The Proponent shall carry out the project generally in accordance with the:
    d) EA;
    e) Statement of Commitments; and
    f) Conditions of this approval.

3. If there is any inconsistency between the above documents, the later document shall prevail to the extent of the inconsistency. However, the conditions of this approval shall prevail to the extent of any inconsistency.

4. The Proponent shall comply with any reasonable and feasible requirements of the Director-General arising from the Department's assessment of:
    (c) any reports, plans or correspondence that may be submitted in accordance with the conditions of this approval; and\
    (d) the implementation of any actions or measures contained in these reports, plans or correspondence.

Limits of Approval

5. Mining operations may take place until 31 December 2028 on the Abel site.

6. The Proponent shall not extract more than 4.5 million tonnes of ROM coal a year from the Abel site.

7. No more than 6.5 million tonnes of ROM coal may be processed a year on the Bloomfield site.
8. All product coal produced on the Bloomfield site shall be transported by rail via the rail loading facility on the Bloomfield site, except in an emergency. In an emergency, product coal may be transported from the Bloomfield site by road with the prior written approval of the Director-General, subject to any restrictions that the Director-General may impose.

Subsidence related and monitoring / management consent conditions and Statement of Commitments items relevant to this SMP Application are noted in **Table 3** located earlier in this application.

Information regarding all Project Approval conditions is included in each Annual Environmental Management Report (AEMR) lodged with the DII – Minerals and Energy. An annual presentation on the previous year's results and AEMR is made to the DII – Minerals and Energy and other agencies.

15.2 MINING LEASE CONDITIONS

The Abel underground mine is accessed through ML 1618. Underground mining is currently undertaken only within this lease. An additional lease, ML 1653 is held for mining purposes.

Table 49 - Abel Mine Mining Lease ML1618 and ML 1653

Primary Facility (underground)	Expiry Date	Area (ha)
Mining Lease 1618 (Act 1992)	15 May 2029	2,755
Mining Lease 1653 (Act 1992)	21 January 2032	0.25

The relevant lease contains one condition relating to subsidence, being that relating to Subsidence Management, which is listed below.

Subsidence Management

(a) The lease holder shall prepare a Subsidence Management Plan prior to commencing any underground mining operations which will potentially lead to subsidence of the land surface.

(b) Underground mining operations which will potentially lead to subsidence include secondary extraction panels such as longwalls or miniwalls, associated first workings (gateroads, installation roads and associated main headings, etc), and pillar extractions, and are otherwise defined by the *Applications for Subsidence Management Approvals guidelines (EDG17).*

(c) The lease holder must not commence or undertake underground mining operations that will potentially lead to subsidence other than in accordance with a Subsidence Management Plan approved by the Director-General, an approval under the *Coal Mine Health and Safety Act 2002*, or the document *New Subsidence Management Plan Approval Process – Transitional Provisions (EDP09).*

(d) Subsidence Management Plans are to be prepared in accordance with the *Guideline for Applications for Subsidence Management Approvals*.

(e) Subsidence Management Plans as approved shall form part of the Mining Operations Plan required under Condition 2 and will be subject to the Annual Environmental Management Report process as set out under Condition 3. The SMP is also subject to the requirements for subsidence monitoring and reporting set out in the document *New Approval Process for Management of Coal Mining Subsidence - Policy*.

15.3 RELEVANT LEGISLATION

15.3.1 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires the approval of the Commonwealth Minister of the Environment, Water, Heritage and the Arts for actions that may have a significant impact on matters of National Environmental Significance (NES). Approval from the Commonwealth is in addition to approvals under the NSW legislation. However a bilateral agreement has been concluded between the NSW and Commonwealth government which provides for the accreditation of the NSW assessment and approvals process such that one approval may be granted covering both State and Commonwealth requirements.

The EPBC Act also provides for the identification, conservation and protection of places of National Heritage significance and provides for the management of Commonwealth Heritage places.

The EPBC Act lists seven matters of NES that must be addressed when assessing the impacts of a proposal which are:

- World Heritage Places;
- National Heritage places;
- RAMSAR wetlands (wetlands of international significance);
- Listed threatened species, critical habitats and ecological communities;
- Listed migratory species;
- Commonwealth land and marine areas or reserves; and
- nuclear actions (including uranium mining).

The flora and fauna study undertaken for the Abel Environmental Assessment considered RAMSAR wetlands, listed migratory species and listed threatened species and populations in accordance with the Commonwealth EPBC Act 1999. The flora and fauna study concluded that there would be no significant impact on these matters resulting from works associated the proposed development and mining. An assessment undertaken in accordance with the requirements of the EPBC Act concluded that the proposed mining will not result in a significant impact on the species' habitat. The proposed mining is therefore not a controlled action and approval from the Commonwealth Minister for the Environment and Heritage is not required.

15.3.2 State Legislation and Planning Policies

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP & A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP & A Regulation) provide the framework for environmental planning in NSW and include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment, and also provide opportunity for public involvement. is administered by the Department of Planning (DoP). It institutes a system of environmental planning and assessment for the State of New South Wales.

The objectives of the EP & A Act that are relevant to the proposed pillar extraction mining of SMP Area 1 are:

- the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment;
- the promotion and co-ordination of the orderly and economic use and development of land;
- public involvement;
- the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats; and
- ecologically sustainable development.

Abel has Project Approval 05_0136 granted 7 June 2007.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is the principal NSW legislation relating to environmental regulation and in particular contains strict provisions regulating water, air, noise and land pollution. A key feature of the POEO Act is the requirement for certain '*Scheduled activities',* which are listed in Schedule 1 of the POEO Act to have an Environmental Protection Licence (EPL).

Clause 28 of Schedule 1 of the POEO Act relates to mining for coal and provides that coal mines with a capacity to produce more than 500 t of coal per day are classified as '*scheduled activities'*

Abel Mine has this capacity and currently holds EPL No.12856 under the POEO Act. No variation to this licence is required for the proposed extraction of the SMP Area 2.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) provides protection for threatened plants and animals native to NSW (excluding fish and marine vegetation which are protected under the *Fisheries Management Act 1994*). The Act integrates the conservation of threatened species into development approval processes under the EP & A Act. Under the EP & A Act, impacts on threatened species listed under the TSC Act are assessed by a seven-part test. Where a development is likely to have a significant impact on a threatened species, population or ecological community, the preparation of a Species Impact Statement (SIS) is required.

The results of the seven part tests conducted for threatened fauna species identified in the SMP application area conclude that the proposed pillar extraction mining operation is not likely to have a significant effect on these species based on predicted levels of subsidence. Similarly the effects on identified threatened flora species are considered to be minimal, if any.

Mining Act 1992

The *Mining Act 1992* (Mining Act) makes provision for a variety of mining authorities, including mining leases and exploration licences which are required for the prospecting and mining of minerals and coal. The Mining Act also makes provision for the protection of the environment in relation to mining activities, including rehabilitation of areas affected by mining activities.

Abel Mine currently holds a mining lease (ML 1618) over the SMP application area. A condition of this lease requires a Subsidence Management Plan to be prepared prior to the commencement of any mining operations which may potentially lead to subsidence.

Part 11 of the Mining Act deals with the protection of the environment and provides that conditions may be imposed upon a mining authority or mineral claim requiring that land affected by mining activities be rehabilitated. Standard conditions generally imposed upon a mining lease include requirements to submit a MOP prior to the commencement of mining operations as well as Annual Environmental Management Reports (AEMR). These documents form the Mining Rehabilitation and Environmental Management Process (MREMP)

The Mining Operations Plan (MOP) is systematically updated to cover the mining operations. The current MOP was accepted in December 2008 and will be modified to include the SMP application area. Environmental performance of the operation will be reported in the Annual Environmental Management Report (AEMR).

Coal Mines Health and Safety Act 2002 and Coal Mine Health and Safety Regulation 2006

The *Coal Mines Health and Safety Act 2002* (CMHS Act) operates in conjunction with the *Occupational Health and Safety Act 2000* (OH & S Act) and *Coal Mine Health and Safety Regulation 2006* (CMHS Regulation) with the key objects being:

- to assist in securing the objects of the *Occupational Health and Safety Act 2000* in relation to coal operations;
- to put in place special provisions necessary for the control of particular risks arising from the mining of or exploration for coal;
- to ensure that the effective provisions for emergencies are developed and maintained at coal operations or related places.

Part 5 of the CMHS Act sets out the duties of the mine operator in relation to health, safety and welfare at coal operations. The Act requires that the mine operator have a health and safety management system providing :

- the basis for the identification of hazards, and of the assessment of risks arising from these hazards, by the operator;
- for the development of controls for those risks; and
- for the reliable implementation of those controls.

The Act may also require the operator to have in place:

- Major hazard plan;
- Management structure;
- Contractor management plan; and
- Emergency management system.

These documents form part of the existing general health and safety system in place at Abel.

- Under Clause 88 of the *Coal Mine Health and Safety Regulation 2006* under the CHMSA, Abel must also submit an application for approval to I & I NSW – Mineral Resources prior to the commencement of secondary extraction.

Mine Subsidence Compensation Act 1961

The *Mine Subsidence Compensation Act 1961* (MSC Act) establishes a scheme for the payment of compensation for damage sustained to surface improvements by subsidence resulting from the mining of coal or shale.

Section 10 of the Act establishes the Mine Subsidence Compensation Fund. Colliery proprietors are required to make an annual contribution to this fund based upon the land value of the colliery. Under the Act, claims can be made against this fund for damage arising out of subsidence. Abel makes contributions, as appropriate and required under this Act.

Section 15 of the Act makes provision for the establishment of Mine Subsidence Districts (MSD) and requires that an application be lodged with the Mine Subsidence Board (MSB) for the erection or alteration of improvements or the subdivision of land within a mine subsidence district.

The SMP application area is not located within a current Mine Subsidence District but was previously located within the Ironbark Mine Subsidence District. Discussions have been held with the MSB relating to the reclassification of the area as a Mine Subsidence District.

Water Management Act 2000

The *Water Management Act 2000* (WM Act) is administered by the NSW Office of Water and provides for the regulation of access to water. The Act, as amended, came into force in July 2004.

The object of the Act is to ensure sustainable and integrated management of water in NSW for present and future generations and it is based on the concept of ecologically sustainable development.

Licensing and approval systems are in place over those areas of NSW subject to an operational water sharing plan. These plans have been compiled for most of the regulated river systems in NSW. The licensing system applies to both surface and groundwaters.

Water Act 1912

Licences under the *Water Act 1912* authorise the taking of water and the use of water. Abel currently holds a licence (**20BL171935 valid until 4 August 2013)** issued under the *Water Act 1912* for the purpose of mine dewatering.

The area of proposed extraction does not have any major rivers or streams running through it and the extraction should not require any additional water for processing. It is not anticipated that large volumes of groundwater will be encountered, however, if dewatering beyond licence requirements is required, an amendment to the existing water license would be pursued. It is therefore not anticipated that any new licenses would be required under the WMA 2000.

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP)

State Environmental Planning Policy (Mining, Petroleum Production and extractive Industries) 2007 (Mining SEPP) recognises the importance of mining, petroleum production and extractive industries and sets out activities which are permissible both with and without development consent, and also specifies prohibited development.

The proposed mining within the SMP application area is permissible with the existing Project Approval.

Dams Safety Act 1978

The SMP application area does not contain any dams (including stored waters and reservoirs) and / or structures referred to by the *Dams Safety Act 1978.*

National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NP & W Act) provides for the establishment, care, control and management of national parks, historic sites, nature reserves, State Conservation Areas, Aboriginal areas and state game reserves.

The Act also provides for the protection of Aboriginal objects and the protection of native flora and fauna. A consent to destroy permit is required under Section 90 of the Act prior to the destruction of any known Aboriginal Archaeological sites. Aboriginal heritage assessments of the SMP application area have been conducted. Potential impacts to Aboriginal places and objects, native flora and native fauna have been considered in this SMP application with no significant impacts predicted.

Heritage Act 1977

The purpose of *Heritage Act 1977* (Heritage Act) is to protect and conserve on-aboriginal cultural heritage, including scheduled heritage items, sites and relics. The Heritage Act is administered by the NSW Heritage Office, which maintains the State Heritage Register, listing heritage items of State significance. The Act also requires that a permit be obtained prior to disturbance of any known heritage items (greater than 50 years old).

An assessment of European heritage has been conducted over SMP application area with no items located.

15.3.3 Local Planning

The Abel Underground Mine lease area is within Newcastle and Cessnock local government areas (LGAs). The SMP application area is within Cessnock LGA.

The area within Cessnock LGA is zoned 1(a) Rural A by the Cessnock Local Environment Plan 1989, which permits underground mining and associated surface activities with consent.

The Abel pillar extraction within the SMP application area is permissible in all applicable local government area zonings.

16 REFERENCES

Department of Infrastructure, Planning and Natural Resources 2002 – *Draft Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region*

NSW Department of Mineral Resources (2003) – *Guideline for Applications for Subsidence Management Approvals.*

NSW Department of Mineral Resources (2003) – *New Approval Process for the Management of Coal Mining Subsidence.*

NSW Minerals Council – *Community Engagement Handbook Towards Stronger Community Relationships*

17 PLANS

SMP guideline reference	**Plan Name - Number**
Plan 1	Existing & Proposed Workings
Plan 2	Natural & Man-made Features
Plan 3A	Depth of Cover Isopachs and Seam thickness
Plan 3B	Seam floor contours and geological structures
Plan 4	Other Seams
Plan 5	Mining Titles & Land Ownership
Plan 6	Geological Sections/Strata Profile
Plan 7	Aerial Photograph
Approved Plan	SMP Approved Plan

18 APPENDICES