YANCOAL
兖煤澳大利亚有限公司

DONALDSONCOAL
Part of the Yancoal Australia Group

Abel Mine

Area 4

Extraction Plan

May 2014

DOCUMENT CONTROL

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30/5/2014	0	Daniel Lee	Tony Sutherland Phillip Brown Matthew Wright John Krick	Tony Sutherland

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1 EXECUTIVE SUMMARY

This Extraction Plan (EP) / Subsidence Management Pan (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 4 of Abel Mine. The EP application consists of pillar extraction of Panel 27 to Panel 35 inclusive to be extracted on retreat as shown on the attached SMP plans. The EP application has been prepared in accordance with the NSW Planning and Environment draft *Guidelines for the Preparation of Extraction Plans* and the NSW Department of Mineral Resources *Guideline for Applications for Subsidence Management Approvals* 2003.

Abel commenced coal production in May 2008 with secondary extraction commencing in July 2010. The EP / SMP application area contains 209 ha, approximately 7.5% of the current ML 1618 area (2755 ha).

Mining will take place in the application area under a combination of land owned by Donaldson Coal, and a number of 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 280 metres.

Abel Mine operates under Project Approval 05_0136 (Development Consent) approved by the Department of Planning on 7 June 2007. Project Approval 05-0136 was modified (MOD 3) under delegated authority of the Minister for Planning and Infrastructure on 4 December 2013 to allow the method of extraction to include shortwall and longwall as well as bord and pillar extraction methods in the Upper and Lower Donaldson Seams and an increase in ROM coal extraction at Abel Mine.

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 the depth of cover and the lease to the north, the previously approved SMP Area 3 to the east and by 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 >30mm/m and tilts up to 70 mm/m excluding areas nominated to be protected.

The EP / SMP application area surface is a combination of native bushland, rural residential properties, and public and private roads. Management measures are proposed to manage and mitigate 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 unless there was a significant long term loss of available water. Proposed management measures of natural features are listed in **Table 1.1**.

Table 1.1 - Summary of Natural Features Impact Assessment EP / SMP Area 4

Feature/s	Summary of feature/s	Proposed Management Measures
Creeks/surface water features	Four Mile Creek – ephemeral above Panel 27	Monitoring and remediation through Water and Property Subsidence Management Plan
Creeks/surface water features	Ephemeral tributaries	Monitoring and remediation through Water and Property Subsidence Management Plan
Groundwater	Sub surface aquifer	Monitoring through Water Management Plan
Ecology, Threatened and Protected Species	Flora and Fauna	Monitoring through Biodiversity Management Plan
Steep Slopes	Above southern ends of proposed panels up to around 1 in 2 (50%) with some isolated areas up to 1 in 1.5 (67%)	Visual inspection and remediation of impacts (if required) through Land and Public Safety Management Plans
Land Prone to Flooding or Inundation	Potential for increased flooding in sections of watercourses	Monitoring through Water and Land Management Plans

Man – made features include:

- Principal residences, Other surface structures and outbuildings;
- Business or commercial premises;
- Ausgrid rural 11kV and 415V domestic power lines;
- Telstra copper communication cables;
- Private communication tower;
- State survey control marks;
- Public roads and culverts (Black Hill Road, Meredith Road and Browns 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 1.2.**

Table 1.2 - Summary of Man-Made Features Impact Assessment EP Area 4

Feature/s	Summary of feature/s	Proposed Management Measures
Principal Residences	16 Principal Residences.	Protected by Subsidence Control Zone and/or Subsidence Specific Commitment
Other Surface Structures	Other Surface Structures and outbuildings.	Built Features Management Plan - Property subsidence Management Plans to be developed for each area prior to impact of subsidence
Business or commercial premises	Orchards and Fuel Storage structures	Built Features Management Plan - Property Subsidence Management Plan to be developed
Mine related infrastructure	Various exploration boreholes	Mine related infrastructure is a matter Abel manages internally.
Electrical infrastructure	Ausgrid rural 11kV and domestic power lines	Built Features Management Plan – Ausgrid developed for Areas 1, 2 and 3 in consultation with Ausgrid. To be reviewed for Area 4.
Telecommunication cables	Telstra copper cables	Current Built Features Management Plan (Telstra Management Plan) for Area 2 and 3 to be reviewed and updated in consultation with Telstra.
Permanent Marks (PM's) and State Survey Marks (SSM's)	Ten (10) PMs & SSM's within Area 4	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 Land Management Plan and Property Subsidence Management Plan for each individual property
Public Roads	Blackhill Road, Meredith Road, Browns Road and drainage culverts	Current Built Features Management Plan (Black Hill Road Management Plan) for Area 3 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 Built Features Management Plan - Property Subsidence Management Plan for each individual property
Fences, gates and cattle grids (including cattle stockyards and holding areas)	Various types	Include in Built Features Management Plan - Property Subsidence Management Plan for each individual property
Dams	Various dams. Thirty-eight (38) dams identified in Area 4. Thirty-two (32) located fully or partially above the proposed panels.	Include in Built Features Management Plan - Property Subsidence Management Plan and Dam Monitoring Management Strategy for each individual property. NB Four (4) dams within SMP Area 4 are classed as requiring protection under the Abel Project Approval 05_0136 (MOD3)
Aboriginal Places and sites	Four (4) archaeological sites, (3	Management in accordance with the

Feature/s	Summary of feature/s	Proposed Management Measures
	artefact scatters and 1 scarred tree) are located over or adjacent to proposed panels. One (1) cultural place (areas of cultural sensitivity), the *Black Hill Pathway*, is partially located within Area 4 above the southern end of proposed Panel 32.	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 3 April 2014 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. Four (4) high risk issues were identified with one (1) risk being assessed as having a potentially "Catastrophic" consequence (Failure of 3ha dam in the North West portion of Area 4). Some agreed further actions were developed that have either been established or are planned such as a separate risk assessment.

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 27 March 2014. In particular, matters relating to groundwater, watercourses, threatened and protected species, infrastructure, dams, historic mine workings, particularly residences and improvements were considered.

Community consultation during the preparation of the EP / 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 27 March 2014. An advertisement was placed in a regional newspaper on 1 March 2014 to notify the community of Abel's intent to submit an EP / 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 a Property Subsidence Management Plan to manage / mitigate / remediate any impacts. Updates on the EP / SMP development have also been presented to the Abel Community Consultative Committee at meetings held on 9th December 2013 and 19th March 2014.

This EP/ SMP considers the impacts of mining on surface and built features within proposed Area 4. The conclusion is that mining will have minimal impact within the area. This report details methods and actions to be implemented during mining to manage the impacts.

2 INTRODUCTION

Donaldson Coal Pty Ltd (Donaldson) a subsidiary of Yancoal Australia Pty Limited (Yancoal), operates Abel Mine, an underground coal mine located approximately 23 kilometres north-west of Newcastle in the Newcastle Coalfield of New South Wales (see **Figure 2.1**). Abel Mine has successfully undertaken pillar extraction mining using the Bord and Pillar system within the Upper Donaldson seam between 2010 and 2014 in Abel's SMP Areas 1, 2 and 3. The EP / 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 2.2**).

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. Project Approval 05-0136 was modified (MOD 3) under delegated authority of the Minister for Planning and Infrastructure on 4 December 2013 to allow the method of extraction to include shortwall and longwall as well as bord and pillar extraction methods in the Upper and Lower Donaldson Seams and an increase in ROM coal extraction at Abel Mine.

Abel Mine commenced coal production in May 2008. The Mine currently employs approximately 360 personnel (including contractors) and currently produces approximately 2.5 million ROM tonnes per annum (tpa), with a proposed maximum production of 6.1 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 EP / SMP, including:

- Project Approval (Development Consent) 05_0136 granted 7 June 2007;
- Modification application 05_0136 MOD 1 Approval granted June 2010;
- Modification application 05_0136 MOD 2 Approval granted May 2011;
- Modification application 05_0136 MOD 3 Approval granted 4 December 2013;
- Mining Lease 1618;
- Mining Lease 1653;
- Abel Mine Mining Operations Plan approved by DTIRIS on 6 April 2011;
- Environmental Protection Licence 12856 under the Protection of the Environment Operations Act 1997;
- SMP Approvals for Area 1 dated 26 May 2010, Area 2 dated 7 December 2011 and Area 3 dated 16 July 2013 plus approved variations, and
- Clause 88 Approvals.

The key feature of the Mod 3 Approval 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 reasonable and feasible 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) EA (MOD 1);
   (c) EA (MOD 2);
   (d) EA (MOD 3);
   (e) statement of commitments; and
   (f) conditions of this approval.

3. If there is any inconsistency between the above documents, the more recent 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 requirement/s of the Director-General arising from the Department's assessment of:
   (a) any strategies, plans, programs, reviews, audits, reports or correspondence that are submitted in accordance with this approval; and
   (b) the implementation of any actions or measures contained in these documents.

Limits on Approval

5. The Proponent may carry out mining operations on site until the end of December 2030.

6. The Proponent shall not extract more than 6.1 million tonnes of ROM coal from the site per calendar year.

7. The Proponent shall not process more than 8.5 million tonnes of ROM coal at the Bloomfield site per calendar year.

8. The Proponent shall transport all ROM coal from the Abel pit-top area to the Bloomfield site via the private haul road, or by coal conveyor, or by a combination of both methods.

The EP has been prepared in accordance with the requirements of Schedule 3, Condition 4 of the modification application 05_0136 MOD 3 and has also been prepared to meet the requirements for a SMP which is required by condition 8 of Mining Lease 1618.

2.1 SCOPE & OBJECTIVE

The objective of this EP / SMP is to identify the management strategies for subsidence induced impacts on natural and built features from secondary extraction of Panels 27 to 35 within the Upper Donaldson Seam at Abel Mine using Bord and Pillar technique (the **EP / SMP Area** shown as **Figure 2.2**).

The objective of the EP / SMP will be achieved by:

- Providing an overview of the planned coal resource recovery methods;

- Identifying the predicted subsidence impacts and/or environmental consequences within the EP area associated with the planned coal recovery;

- Identifying the management activities (including monitoring and remediation) prepared to address the predicted subsidence impacts from secondary extraction of Panels 27 to 35 within the Upper Donaldson Seam at Abel Mine; and

- Identifying the review and reporting activities to allow for assessment of the performance of subsidence management measures by Abel Mine, and identification of areas where either continual improvement may be achieved, or management of unpredicted subsidence impacts can be managed.

2.2 DOCUMENT STRUCTURE

The Extraction Plan has been prepared to address conditions of 05_0136 MOD 3, and structured in general accordance with draft *Guidelines for the Preparation of Extraction Plans* provided to Abel Mine by NSW Planning and Environment in 2013.

The document structure includes the following elements:

- **Section 3** includes an overview of the mine planning and design, overall subsidence predictions, and performance objectives,

- **Section 4** includes details on the development of the Extraction Plan, including details of consultation with relevant agencies and other stakeholders within the Extraction Plan area;

- **Section 5** provides an overview of and details of subsidence management measures including plans prepared to address impacts to relevant environmental and/or built features. The individual management plans are contained in Appendices to the Extraction Plan;

- **Section 6** addresses the key elements of how the Extraction Plan is implemented, including reporting, regular review and key responsibilities;

Important components of the Extraction Plan are the individual sub-plans referred to in **Section 4**. These plans are described in **Table 2.1**.

Table 2.1 Extraction Plan Key Component Plans

Plan	Description	Location
Water Management Plan	To manage the potential environmental consequences of second workings on surface and ground water	Appendix E
Land Management Plan	To manage the potential environmental consequences of second workings on steep slopes and land in general	Appendix F
Biodiversity Management Plan	To manage the potential environmental consequences of second workings on terrestrial flora and fauna	Appendix G
Built Features Management Plan	To manage the potential environmental consequences of second workings on any built feature	Appendix H
Heritage Management Plan	To manage the potential environmental consequences of second workings on heritage sites or values	Appendix I
Public Safety Management Plan	To ensure public safety in the Extraction Plan Area	Appendix J
Subsidence Monitoring Program	A program to collect actual measured subsidence data, and conduct inspections for environmental consequences of subsidence to compare against predicted impacts which may trigger a response, or set of responses	Appendix K
Coal Resources Recovery Plan	To demonstrate effective recovery of available resources obtained through underground mining activities	Appendix L

The Subsidence Management Plans prepared for Subsidence Management Plan Approval of the Division of Resources and Energy, and referred to in this Extraction Plan, are included as **SMP Plans** at the end of the Main Extraction Plan text.

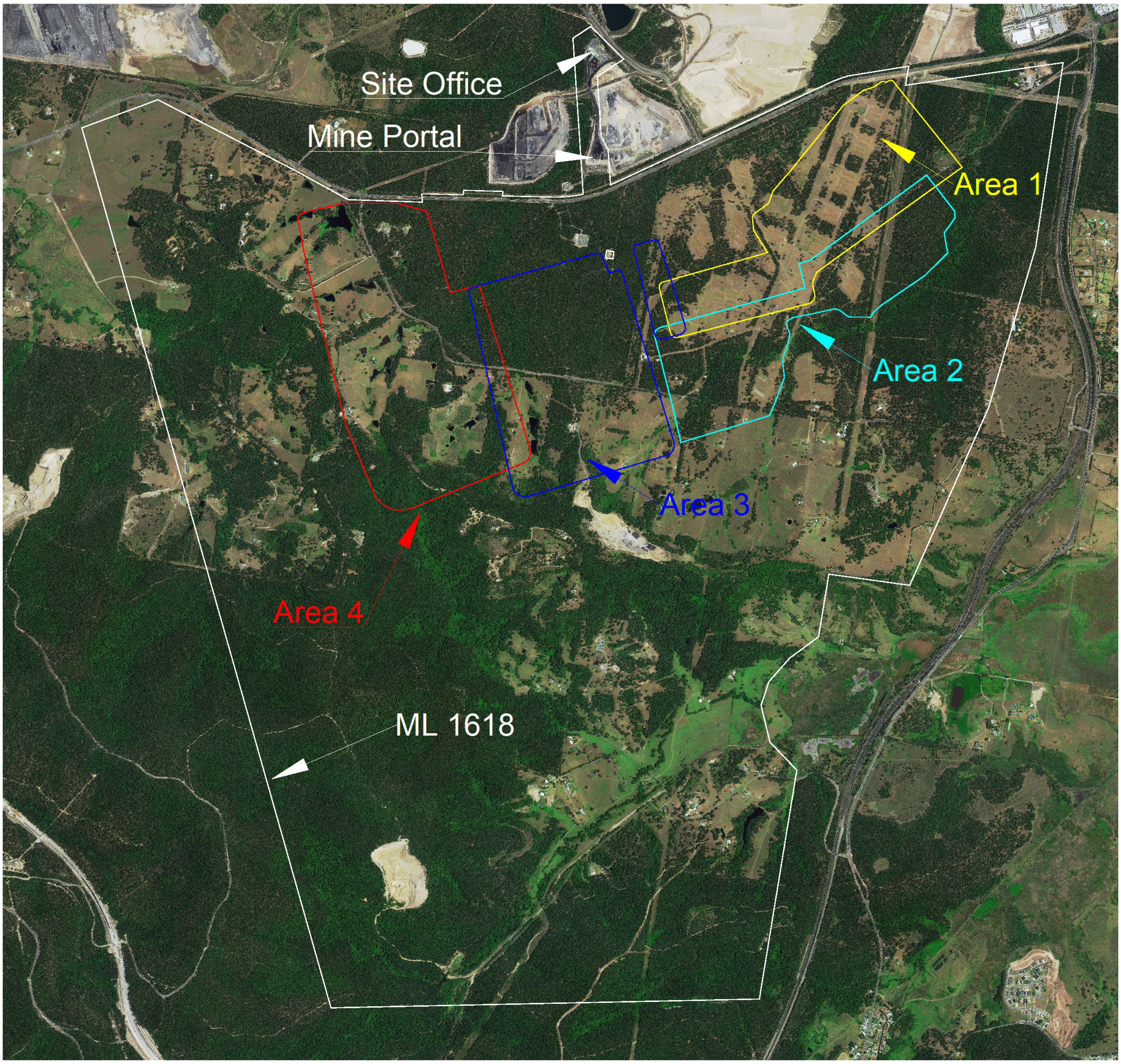


Figure 2.1 Abel Mine Complex

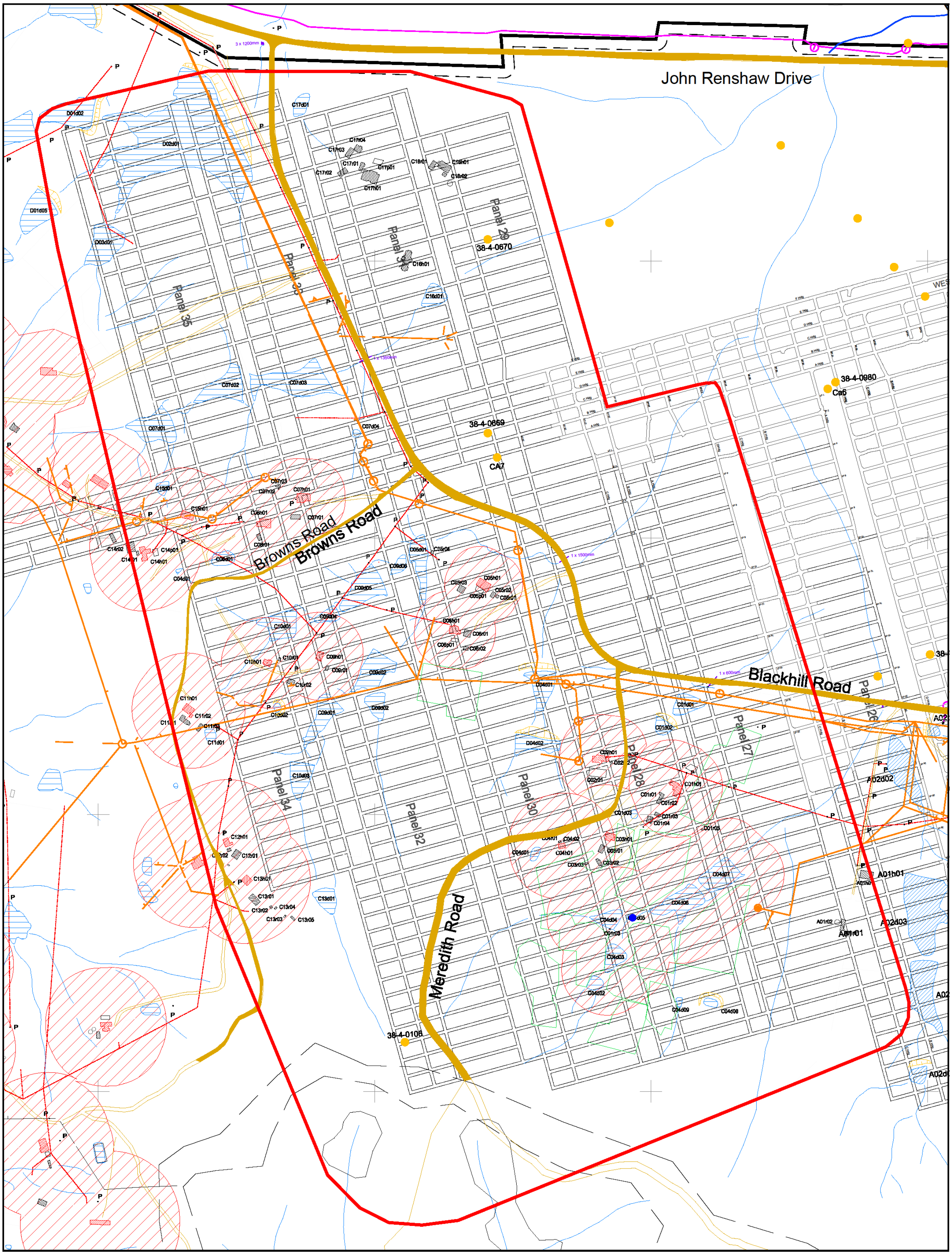


Figure 2.2 Extraction Plan Area 4

3 OVERVIEW

3.1 ENVIRONMENTAL CONTEXT

3.1.1 Environmental Setting

The Extraction Plan surface area is approximately 209 ha and is located within the suburb of Black Hill. The Extraction Plan area is bounded by the depth of cover and the mining lease to the north, the previously approved SMP Area 3 to the east and by resource thickness / quality of the Upper Donaldson seam to the south. The natural surface within the Extraction Plan Area falls towards the north east with the tributaries draining into Four Mile Creek above and downstream of the proposed panels.

The surface levels directly above the proposed panels vary from a low point of approximately 50 metres AHD along the tributary above proposed Panel 29 to a high point of approximately 190 metres AHD above the southern end of Panel 34. The natural surface gradients above the proposed mining area are typically less than 1 in 3 (i.e. 18° or 33%), with natural grades varying up to around 1 in 2 (i.e. 27° or 50%), along the ridgeline in the southern part of the mining area.

3.1.2 Land Ownership and Tenure

Land ownership within and proximate to the Extraction Plan Area is shown in **Figure 3.1** and **SMP Plan 5**. The dominant land uses within and adjacent to the Extraction Plan Area include rural residential, grazing, quarrying, native bushland and mining.

The Extraction Plan Area extends underneath Cessnock City Council roads as well as private rural residential land holdings and privately owned access roads. The north eastern portion of the Extraction Plan area is primarily located beneath Donaldson Coal owned land.

The whole of the Extraction Plan Area is located within Mining Lease 1618 (**Figure 2.1**).

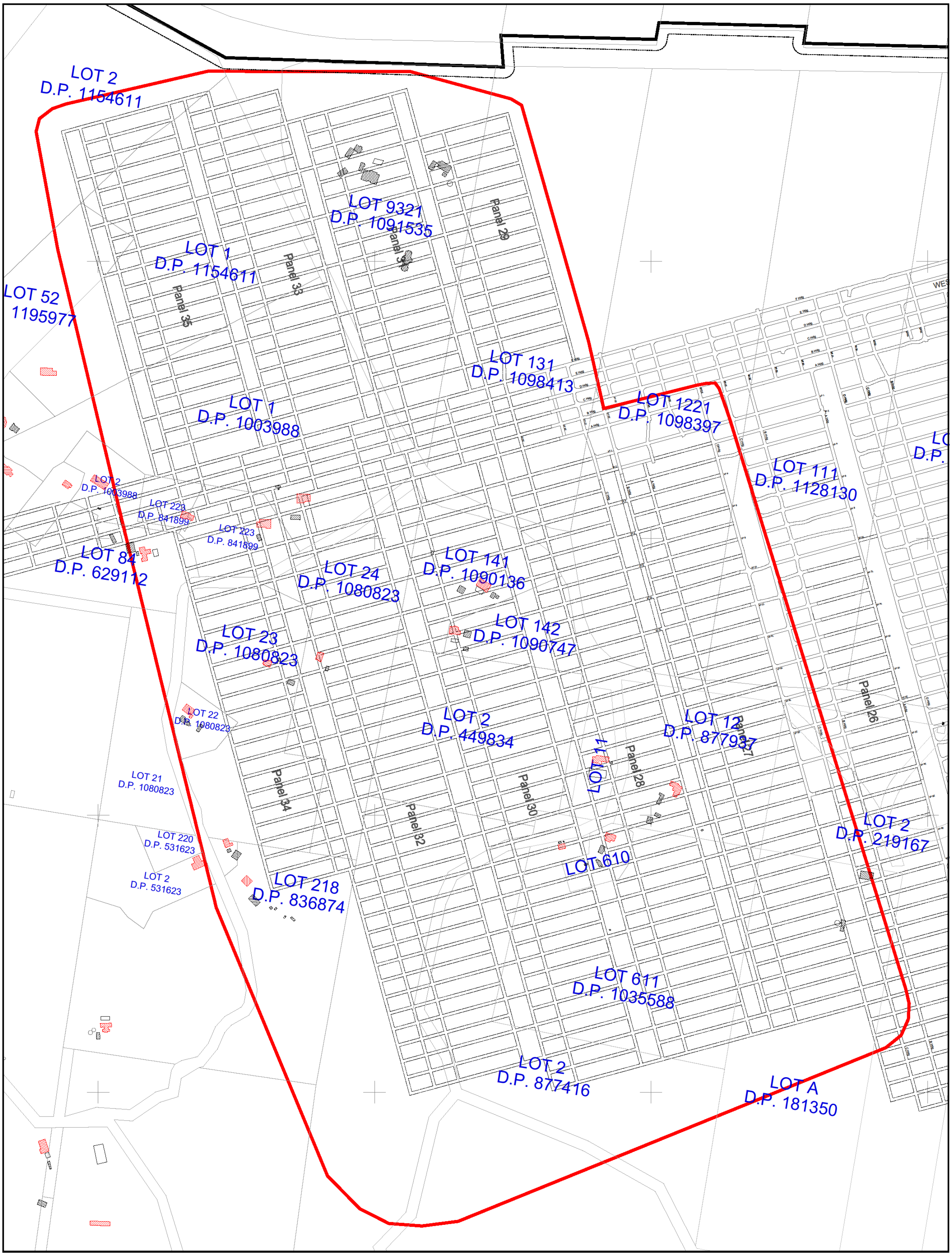


Figure 3.1 Extraction Plan Area 4 Land Ownership

3.1.3 Natural and Built Features within Extraction Plan Area

A number of the natural and built features within the EP Area have been located using:

- aerial photography
- 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.

Natural features within the Extraction Plan Area include:

- Steep slopes on the northern ridgeline of Black Hill (**SMP Plan 2**);
- Ephemeral drainage lines of the Four Mile Creek catchment (**SMP Plan 2**);
- Aquifers or known groundwater resources
- Natural vegetation
- Threatened Species Conservation Act listed native vegetation (**Appendix G Figure 3**) including:
  - EEC Lower Hunter Spotted Gum - Ironbark Forest; and
  - EEC Subtropical Rainforest.
- Grazing pasture lands; and
- Aboriginal Heritage Sites (**Appendix I Figure 2**).

Built features within the Extraction Plan Area are shown on **SMP Plan 2** and include:

- Public roads, culverts and private tracks (Blackhill Road, Meredith Road, Browns Road, and private access road (B1 Access);
- Communications infrastructure (local copper cables and private communication tower);
- Ausgrid above ground powerlines;
- Principal Residences
- Rural property infrastructure (private access roads/driveways, sheds, farm dams, tanks, fences, swimming pools);
- Commercial establishments and improvements (fuel storage)
- Permanent Marks and State Survey Marks (PM's and SSM's).

3.1.4 Seam Information

The Upper Donaldson seam floor falls from the north-east to the south-west within the proposed mining area. The grade of the seam within the extents of the proposed panels is approximately 7 % (i.e. 1 in 14). The thickness of the Upper Donaldson Seam within the extents of the proposed panels varies between approximately 1.4 metres and 3.4 metres. The maximum extraction height is proposed to be 2.8 metres.

The depths of cover directly above the proposed Panels 27 to 35 vary between a minimum of 50 metres above the northern end of the proposed Panel 29, and a maximum of 280 metres above the southern end of the proposed Panel 34.

The seam floor contours, seam thickness contours and depth of cover contours for the Upper Donaldson Seam are shown in **SMP Plans 3A & 3B**.

There are historical workings in the Borehole Seam which are partially located above the southern end of Panel 32. The record tracings indicate that the majority of the pillars in this area have been extracted. The surface and seam levels along a long-section, taken through the southern end of Panel 32, are illustrated in **Figure 3.2**.

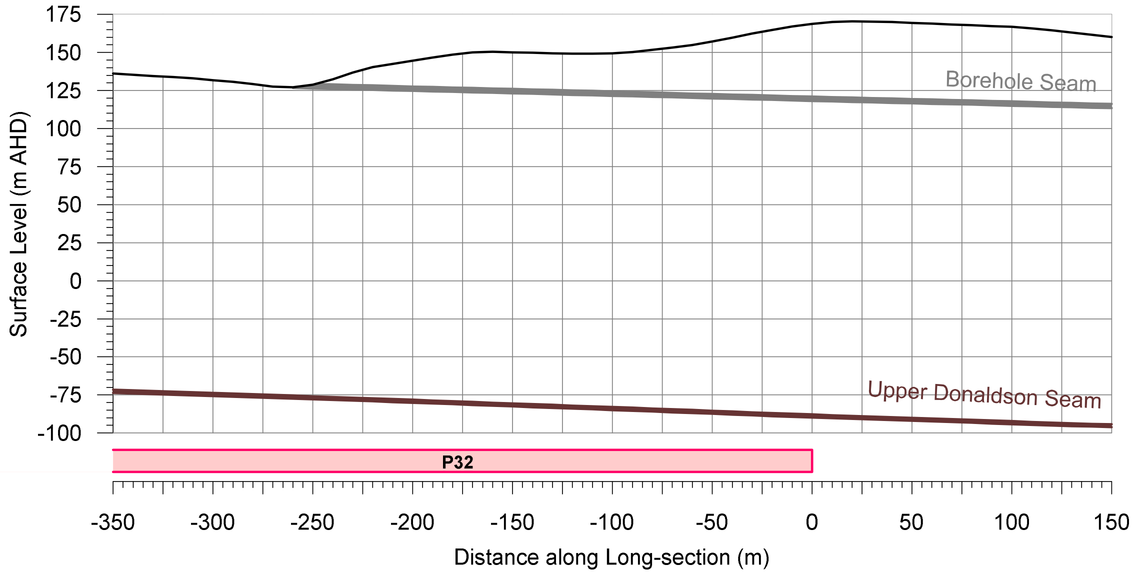


Figure 3.2 Surface and Seam Levels along Long-section

It can be seen in the above figure, that the Borehole Seam outcrops above the proposed Panel 32.

3.1.5 Geological Details

The EP / SMP Area lies in the Newcastle Coalfield, within the Northern Sydney Basin. 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 **Table 3.1**. The strata shown in this table were laid down between the Early Permian and the Middle Triassic Periods.

The panels are proposed to be extracted in the Upper Donaldson Seam, which is located within the Permian Tomago Coal Measures. The immediate overburden comprises frequently interbedded sandstone, shale, carbonaceous mudstone, tuffaceous claystone and coal. The overlying Waratah Sandstone separates the Tomago Coal and the Newcastle Coal Measures.

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.

A north-south oriented dyke crosses the southern part of the proposed Panel 34 and is located immediately to the west of the proposed Panel 32. A second dyke also crosses the southern end of the proposed Panel 32 and immediately to the west of the historic workings in the overlying Borehole Seam. The geological features identified at seam level are shown in **SMP Plans 3**.

A series of faults is also located to the east of the northern end of the proposed Panel 27, which have throws up to around 0.6 metres. The proposed panels are supercritical in this location and, therefore, are predicted to achieve the maximum subsidence for single-seam mining conditions. The presence of these faults, therefore, are unlikely to affect the subsidence predictions and, hence, impact assessments.

Table 3.1 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
	Branxton		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			

3.1.6 Extraction Plan Area (also the SMP Application Area)

The Extraction Plan Area under consideration is that area likely to be affected by the mining of Panels 27 to 35 in the Upper Donaldson coal seam. The **Extraction Plan Area** (**Figure 2.2** also shown as **SMP Application Area** in **SMP Plans**) is defined as the surface area enclosed by a combined limit defined from:

- The 26.5 degree angle of draw line;
- The predicted limit of vertical subsidence, taken as the 20mm subsidence contour resulting from the extraction of the proposed panels; and

The 26.5 degree angle of draw line is described as the “surface area defined by the cover depths, angle of draw of 26.5 degrees and the limit of the proposed extraction area in mining leases for all other NSW Coalfields” (i.e. other than the Southern Coalfield), as stated in Section 6.2 of the Guideline for Applications for Subsidence Management Approvals (DMR, 2003).

3.1.7 Mining Domains

Panels 27 to 35 are the pillar extraction domains in the proposed EP / SMP Area 4 mining area. This is the fourth area of pillar extraction, following on from SMP Area 1 (Panels 1 – 8 and East Mains Headings), SMP Area 2 (Panels 15, 19 – 22, Tailgate Headings and part East Install Headings) and SMP Area 3 (Panels 23 – 26 and part East Installs Headings). The mine plan of the original Project Approval forms the basis of this current Extraction Plan Area.

This Extraction Plan area is contained wholly within Mining Lease ML1618. The panels will be extracted in sequence commencing in Panel 27. Retreat will be from the northern and southern ends of each Panel towards the West Mains Headings. The West Mains Headings will be used to access other areas further to the West and will be extracted at a later date, subject to a separate application.

3.1.8 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 the application area.

The Upper Donaldson coal seam within the application area of the Abel lease ranges from 1.4 to 3.5 metres in thickness. Abel currently mines up to 2.8m of the coal seam. The seam dips generally 1 in 14 towards the south west within the application area. Pillar extraction will take place generally in a south to north / north to south direction towards the West Mains Headings.

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 and dual pass continuous miners. The secondary extraction panel pillars will typically be developed within a range of 45 to 120.5 metre centres and are proposed to be in the order of 24.5 metres wide (rib to rib).

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

3.1.9 Mine Plan

The method of extraction selected allows for high 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 EP / 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, 2 and 3 have become available. Future mine plan reviews may be conducted to further optimise the mine plan.

The resultant mine plan provides for optimised 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 Development Consent conditions.

3.1.10 Schedule of Proposed Mining

The mining schedule plan for the EP / SMP application area is shown on **Figure 3.3**. Pillar extraction will generally progress in a direction towards the West Mains Headings 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 maintenance operations (e.g. stonedusting, roadway maintenance etc) are typically undertaken on Sundays.

Panel 27 extraction is scheduled to commence in late September 2014.

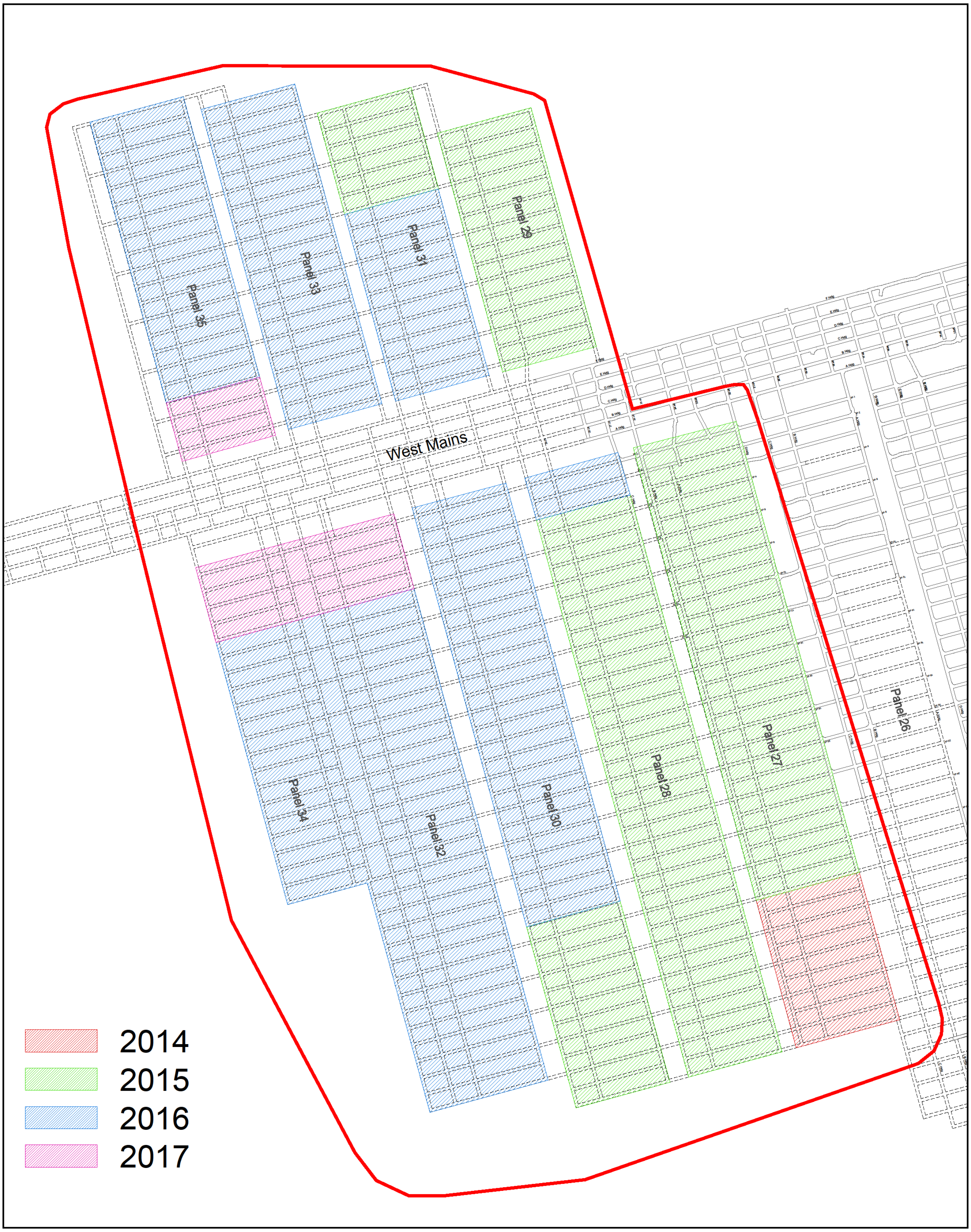


Figure 3.3 Mining Schedule

3.1.11 Mining Parameters

As noted in **Section 3.1.4** the Upper Donaldson coal seam within the EP / SMP Application Area is up to 3.4 metres in thickness. Abel currently mines between 2.4 and 2.8 metres of coal in development and between 2.0 and 2.8 metres in extraction of the Upper Donaldson coal seam.

The estimated recovery of the resource for the Application Area is provided in **Table 3.2**.

Table 3.2 Extraction Plan Area Estimated Resource Recovery

Total tonnes of coal (Resource within extraction area)	7.6Mt (based on angle of draw)
Total tonnes extracted through development	1.4Mt
Tonnes extracted by pillar extraction	3.06Mt
Percentage recovery	59%

Particulars relating to each Panel is given in **Table 3.3**, **Table 3.4** and **Table 3.5**.

Table 3.3 Estimated Individual Panel Tonnages

Panel	Panel Length (m)	Panel Width (void m)	Panel Development Tonnes (t)	Panel Extraction Tonnes (t)
Panel 27	1,110	190	222, 438	536, 545
Panel 28	1,110	170	197, 410	415, 469
Panel 29	450	180	93, 659	207, 969
Panel 30	1,110	170	197, 584	431, 639
Panel 31	540	170	191, 796	243, 488
Panel 32	1,050	170/230	216, 308	453, 641
Panel 33	600	170	117, 583	276, 549
Panel 34	630	170	36, 966	158, 611
Panel 35	630	170	118, 381	334, 743

Table 3.4 Expected Panel Extraction Rate and Sequence

Panel	Start Date	End Date	Estimate Duration (Days)
Panel 27	September 2014	August 2015	335
Panel 28	April 2015	January 2016	260
Panel 29	July 2015	October 2015	120
Panel 30	September 2015	June 2016	280
Panel 31	November 2015	April 2016	155
Panel 32	March 2016	June 2017	450
Panel 33	January 2016	June 2016	165
Panel 34	October 2016	June 2017	245
Panel 35	August 2016	February 2017	240

Table 3.5 Panel Geological Attributes

Panel	Depth of Cover (m)	Seam Thickness (m)	Roof and Floor Conditions	Geological Anomalies
Panel 27	70 – 160	1.75 – 2.95	Competent with localised soft floor zones at start of panel.	Faulted zone (up to 0.5m throw) expected in first third of panel. Igneous dyke at end of panel
Panel 28	90 – 180	1.65 – 3.00	Competent with localised soft floor zones at start of panel.	Faulted zone (up to 0.5m throw) expected half way through panel.
Panel 29	50 – 85	1.40 – 2.00	Competent with localised soft floor zones at beginning of panel.	Nil expected.
Panel 30	100 – 220	1.60 – 3.30	Competent roof conditions with strong floor.	Faulted zone (up to 0.5m throw) expected towards end of panel.
Panel 31	55 – 85	1.65 – 2.70	Competent with localised soft floor zones at beginning of panel.	Nil expected.
Panel 32	120 – 280	1.70 – 3.40	Competent roof conditions with strong floor.	Igneous dyke expected on South Western side of panel.

Panel	Depth of Cover (m)	Seam Thickness (m)	Roof and Floor Conditions	Geological Anomalies
Panel 33	60 – 100	2.10 – 3.00	Competent with localised soft floor zones.	Nil expected.
Panel 34	140 – 200	2.00 – 3.40	Competent roof conditions with strong floor.	Igneous dyke expected on Western side of panel.
Panel 35	70 – 120	2.20 – 3.15	Competent with localised soft floor zones.	Nil expected.

Exploration drilling has encountered seams below the Upper Donaldson seam in the EP / SMP area, including the Lower Donaldson, Big Ben 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 within this area.

3.1.12 Mine Design In Relation to Subsidence Management

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 C**.

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 between 25m and 35m and be approximately 450m to 1,100m long. The pillar height will range from approximately 2.0m to 3.2m, depending on the seam thickness. The inter-panel barrier will have w/h ratios ranging from 7.6 to 15.8. 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 27 to 35 and the adjacent West Mains Headings will generally be from 19.5m to 35.5m wide with pillar width/height ratios of 8.1 to 10.4 and are also expected to behave elastically in the long term.

Subsidence control zones (SCZ’s) have been established around each principal residence, based on 26.5 degree angle of draw lines to protect the dwellings from subsidence impacts. These principal residences are predicted to experience less than 20mm of vertical subsidence and it is unlikely, that the principal residences would be adversely impacted even if the predictions were exceeded by a factor of 2 times. The SCZ’s are shown in the **SMP Plans**.

3.2 SUBSIDENCE PARAMETERS

3.2.1 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 EP / SMP application area.

Development headings are first workings, involving the formation of a series of headings (tunnels) typically driven up to 5.5 metres wide and up to approximately 2.8m 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 EP / SMP application area involves the progressive removal of substantial portions of the coal seam (the pillars formed during development), creating a void up to 230 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.

3.2.2 Overview of Conventional Subsidence Parameters

The normal ground movements resulting from the extraction of panels 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 he 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 1mm/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 distance between two points increases and **Compressive Strains** occur when the distance 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 the seam divided by 20.

  Whilst mining induced normal strains are measured along monitoring line, 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 measures 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 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 deformation along monitoring lines (i.e. normal strains) are generally measured where high deformation 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 3.4**.

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.

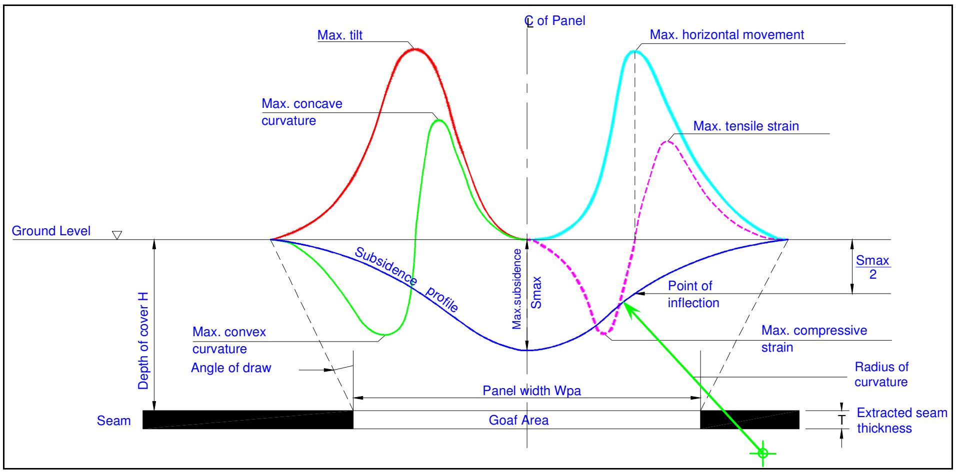


Figure 3.4 Typical Profiles of Conventional Subsidence Parameters for a Single Extraction Panel

3.2.3 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 **Section 3.4.5** of this report.

3.2.4 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 more 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.

3.2.5 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 3.5**.

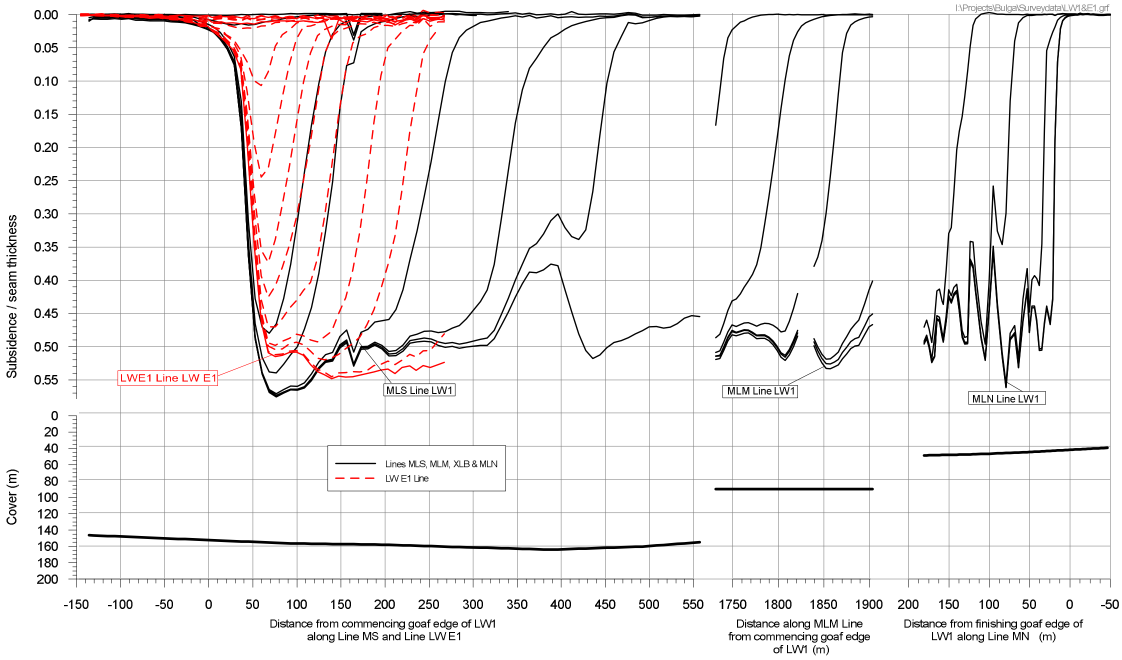


Figure 3.5 Observed Subsidence Profiles at South Bulga Colliery

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.

3.2.6 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 in 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.

3.2.7 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 and along the sides 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.

3.2.8 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 3.6**. The potential for these natural movements are influenced by the geomorphology of the valley.

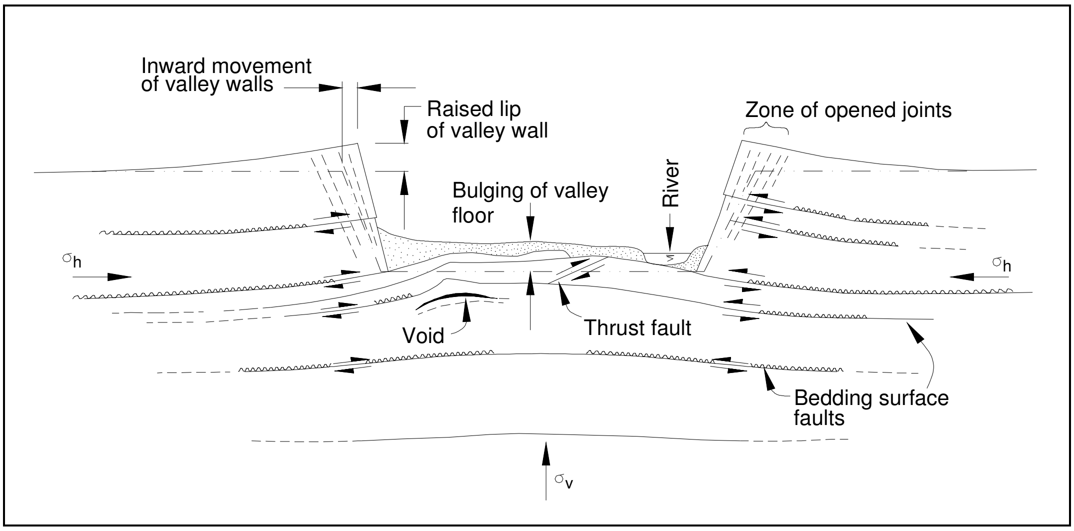


Figure 3.6 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

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** refers 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.

3.3 SUBSIDENCE PREDICTIONS

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 modelling. 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.

3.3.1 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 27 to 35 at the Abel Underground Mine are provided in **Section 3.3.2**.

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 IPM, 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.

3.3.2 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.

There are historic workings in the Borehole Seam located partially above the southern end of the proposed Panel 32 (i.e. multi-seam mining conditions). Elsewhere, above the majority of the proposed mining area, there are no historic workings above the proposed panels (i.e. single-seam mining conditions). The following sections provide discussions on the calibration of the Incremental Profile Method for single-seam and multi-seam mining conditions.

Single-seam mining conditions

The Incremental Profile Method was then refined for local single-seam mining 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. MSEC676-01 in **Appendix C**. The monitoring lines located above Panels 1 to 6 in SMP Area 1 and above Panels 23 and 24 in SMP Area 3 in the Upper Donaldson Seam have been used to refine the Incremental Profile Method for local single-seam mining conditions.

The comparisons between the observed and the back-predicted subsidence, tilt and curvature for Centreline and Crossline monitoring lines above Panels 1 to 6 in SMP Area 1 are shown in Figs. C.01 to C.12, in **Appendix C**. 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).

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 1,300 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.

The comparisons between the observed and the back-predicted subsidence, tilt and curvature along Black Hill Road and along the centrelines of Panels 23 and 24 in SMP Area 3 are shown in Figs. C.13 to C.15, in **Appendix C**. Panels 23 and 24 have overall void widths of 220 metres at depths of cover between 110 metres and 160 metres along the monitoring lines and, therefore, the width-to-depth ratios are between 1.4 and 2.0 (i.e. supercritical in width).

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 1,000 mm represents around 38 % of the seam thickness of 2.6 metres. The maximum predicted subsidence, based on supercritical mining conditions, is 51 % of the extraction height.

The magnitudes of the maximum observed subsidence are less than what would normally be expected for single-seam supercritical mining conditions. Whilst, the prediction model could be calibrated to reduce the magnitudes of the predicted subsidence, it was considered appropriate to maintain the current levels of conservatism, since the observed subsidence were much closer to those predicted in SMP Area 1.

The profiles of observed subsidence reasonably match those predicted inside of panel edges, i.e. on the steep parts of the subsidence profiles away from the maximum observed subsidence. In some cases, there are lateral shifts between the observed and predicted profiles, which could be the result of surface dip, seam dip, or variations in the overburden geology.

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.

Based on these comparisons along the selected monitoring lines at the Abel Underground Mine, 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 Panels 27 to 35 within the Upper Donaldson Seam for single-seam mining conditions.

Multi-seam mining conditions

The southern end of the proposed Panel 32 will be partially extracted beneath the historic workings in the Borehole Seam. The record tracings indicate that the majority of the pillars in this area have been extracted.

Monitoring data from multi-seam mining operations in the NSW Coalfields and overseas show that the maximum subsidence, as proportions of the extracted seam heights, are greater than those for equivalent single-seam mining cases. The monitoring data from the multi-seam cases also show that the shapes of the subsidence profiles are affected by the locations and stabilities of the overlying goafs and pillars in the previously extracted seam as the panels in the lower seam passes underneath.

The overall void width of the proposed Panel 32 is 230 metres. The depth of cover to the Upper Donaldson Seam at the southern end of this panel varies between 220 metres and 260 metres and, therefore, the width-to-depth ratio varies between 0.9 and 1.1. The Interburden thickness between the Upper Donaldson Seam and the Borehole Seam in this location is around 200 metres.

The available multi-seam monitoring data from the NSW Coalfields was reviewed in the subsidence report which supported the Abel Modification Application (MSEC, 2012a). The empirical multi-seam data for is illustrated in **Figure 3.7**, below, which shows the maximum observed subsidence, as a proportion of the extracted seam thickness, versus the panel width-to-depth ratio. The multi-seam cases for mining beneath bord and pillar workings are shown as the red diamonds and the cases for mining beneath longwalls are shown as the blue diamonds. Single-seam mining cases are also shown in this figure, for comparison, as the light grey diamonds.

It can be seen from the figure below, that the maximum observed subsidence, as a proportion of the extracted seam thickness, for multi-seam cases are greater than those for single-seam cases having similar width-to-depth ratios.

The typical prediction curves used for single-seam mining conditions are shown as the grey lines, in **Figure 3.7**, for various mine geometries. These prediction curves have been scaled up, so as to achieve a maximum predicted incremental subsidence of 90 % of extracted seam thickness, which are shown as the red curves in this figure. It can be seen, that these prediction curves provide reasonable estimates of the maximum subsidence for the multi-seam cases for mining beneath bord and pillar workings (i.e. red diamonds).

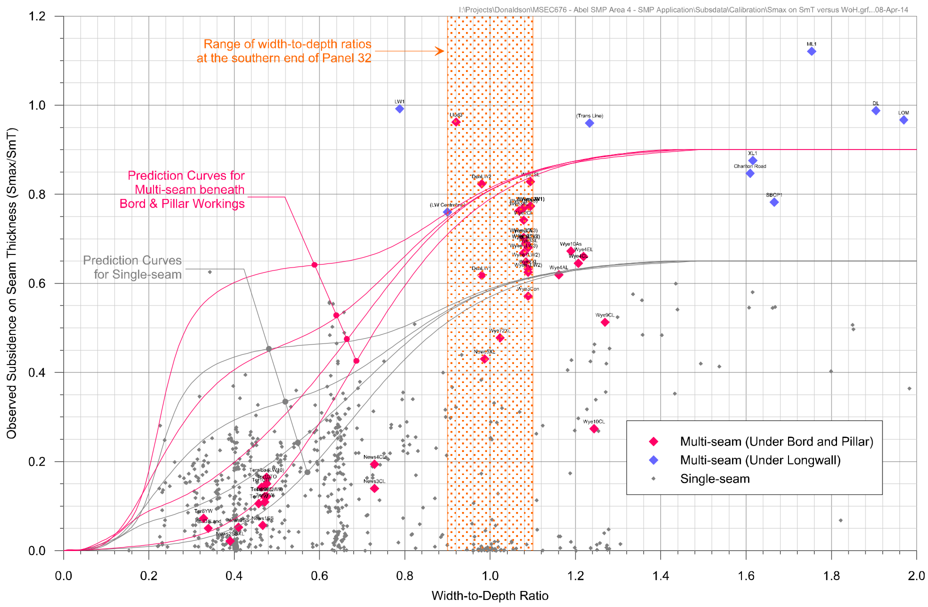


Figure 3.7 Maximum Observed Subsidence versus Panel Width-to-Depth Ratio for Historical Multi-seam Mining Cases

The multi-seam prediction curves provide subsidence around 40 % greater than those obtained using the standard single-seam prediction curves. In reality, the additional subsidence, due to multi-seam mining conditions, will be dependent on a number of factors, including the interburden thickness, the extraction heights in both seams, the conditions of the remnant pillars in the overlying seam.

It is considered, that the multi-seam prediction curves, illustrated in **Figure 3.7** as the red curves, should provide conservative predictions for the multi-seam mining conditions above the southern end of Panel 32, since the interburden thickness of 200 metres is greater than those for the case studies and since the majority of the pillars in the historic workings have been extracted.

The predicted additional subsidence above the southern end of the proposed Panel 32, due to the effects of the historic workings in the overlying Borehole Seam, is 100 mm. The predicted subsidence contours and the impact assessments for the natural and built features in this location include the additional subsidence due to the multi-seam conditions.

3.3.3 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.

3.4 PREDICTED SUBSIDENCE PARAMETERS

3.4.1 Introduction

Subsidence predictions for the EP / SMP Area have been provided by Mine Subsidence Engineering Consultants Pty Ltd (MSEC) using the calibrated Incremental Profile Method. Detailed description of the prediction technique used, factors that may affect the development of subsidence, and the relevance of input data are provided in Report No. MSEC676 (2014) in **Appendix C**.

The following sections provide the maximum predicted conventional subsidence parameters resulting from the extraction of the proposed Panels 27 to 35 in the Upper Donaldson Seam. The predicted subsidence parameters and the impact assessments for the natural and built features are provided in **Appendix C.**

The predicted subsidence, tilt and curvature have been obtained using the standard Incremental Profile Method for the Newcastle Coalfield, as described in **Section 3.3.1** and **Section 3.3.2**. 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, 2 and 3 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 **Appendix C.**

3.4.2 Maximum Predicted Conventional Subsidence, Tilt and Curvature

The locations of the proposed Panels 27 to 35 in the Upper Donaldson Seam are shown in **SMP Plan 1**. A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to extraction of each of the proposed panel is provided in **Table 3.6**.

Table 3.6 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 Coventional Tilt (mm/m)	Maximum Predicted Incremental Conventional Hogging Curvature (km^{-1})	Maximum Predicted Incremental Conventional Sagging Curvature (km^{-1})
Due to Panel 27	1,400	70	>3.0	>3.0
Due to Panel 28	1,350	50	>3.0	>3.0
Due to Panel 29	1,050	40	>3.0	>3.0
Due to Panel 30	1,400	40	3.0	3.0
Due to Panel 31	1,200	40	>3.0	>3.0
Due to Panel 32	1,350*	35*	1.5*	1.5*
Due to Panel 33	1,300	60	>3.0	>3.0
Due to Panel 34	750	10	0.5	0.5
Due to Panel 35	1,350	60	>3.0	>3.0

Note: * denotes that locally increased subsidence could occur above the southern end of Panel 32 where it is located beneath the historic workings in the Borehole Seam. The predicted parameters in this location, however, are less than the maxima provided in the above table due to the higher depths of cover. The maximum predicted parameters above the southern end of Panel 32, for multi-seam conditions, are 800 mm subsidence, 15 mm/m tilt and 0.5 km^{-1} curvature. The calibration of the prediction method for multi-seam conditions is discussed in **Appendix C**.

The predicted total conventional subsidence contours, resulting from the extraction of the proposed Panels 27 to 35, are shown in Drawing No. MSEC676-14 of **Appendix C**. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of series of proposed panels, is provided in **Table 3.7**.

Table 3.7 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature after the Extraction of Each Series of the Proposed Panels

Panel Series	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Coventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Panels 27, 28, 30, 32 and 34	1,450	70	>3.0	>3.0
Panels 29, 31, 33, and 35	1,450	70	>3.0	>3.0

The maximum predicted total subsidence after the completion of the proposed panels, is 1,450 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.

The predicted conventional subsidence parameters vary across the EP / 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 No. MSEC676-14 of **Appendix C**.

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 C**. 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. The predicted total profiles after the completion of the approved Panels 23 to 26 are shown as the solid cyan lines.

The maximum predicted subsidence parameters for the proposed Panels 27 to 35 are the same as those predicted for the approved Panels 23 to 26 in SMP Area 3 at the mine. The subsidence predictions and impact assessments for the currently active panels in SMP Area 3 were provided in Report No. MSEC596 (MSEC, 2012b).

3.4.3 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 27 to 35, 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 27 to 35 has been determined using the monitoring data from the previously extracted bord and pillar total extraction panels in SMP Areas 1 to 3 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 27 to 35 vary between 0.8 (at a maximum depth of cover of 280 metres) and 3.6 (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.

Donaldson Coal has previously extracted bord and pillar total extraction panels in SMP Areas 1, 2 and 3 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 27 to 35 with the previously extracted panels in SMP Areas 1, 2 and 3 are provided in **Table 3.8**.

Table 3.8 Comparison of the Mine Geometry for the Proposed Panels 27 to 35 with the Previously Extracted Panels in SMP Areas 1, 2 and 3 at the Mine

Parameter	Proposed Panels 27 to 35		Existing Panels in SMP Areas 1, 2 and 3	
	Range	Average	Range	Average
Width	170 - 230	175	120 - 220	160
Depth of Cover	50 - 280	125	50 - 140	80
Overall W/H Ratio	0.8 – 3.6	1.4	1.2 – 3.2	2.0
Extraction Height	1.4 – 2.8	2.5	2.2 – 2.8	2.6

It can be seen from the above table, that the range of width-to-depth ratios for the proposed Panels 27 to 35 is similar to, but, wider than the range of width-to-depth ratios for the existing panels in SMP Areas 1, 2 and 3. The average width-to-depth ratio for the proposed panels of 1.4, however, is less than that for the existing panels of 2.0. Also, the extraction heights for the proposed Panels 27 to 35 are similar to, but, slightly less than those for the existing panels in SMP Areas 1, 2 and 3.

The strain analysis using the monitoring data from the existing panels in SMP Areas 1, 2 and 3 should, therefore, provide a reasonable indication of the range of potential strains for the proposed Panels 27 to 35 where the width-to-depth ratio is around 2.0, i.e. around an average depth of cover of 90 metres. Higher strains are expected to occur above the proposed panels where the width-to-depth ratios are greater than 2.0 and, conversely, lesser strains are expected to occur where the width-to-depth ratios are less than 2.0.

The locations of the available ground monitoring lines for the previous mining at the Abel Underground Mine are shown in Drawing No. MSEC676-01 of **Appendix C**. The strain analysis utilised the Centreline and Crossline monitoring lines above Panels 1 to 6 in SMP Areas 1 and 2 and the Black Hill Road monitoring line in SMP Area 3.

The frequency distribution of the maximum observed tensile and compressive strains measured in survey bays located directly above the previously extracted panels in SMP Areas 1, 2 and 3 is provided in **Figure 3.8**. The probability distribution functions, based on the fitted Generalised Pareto Distributions (GPDs), are also shown in this figure.

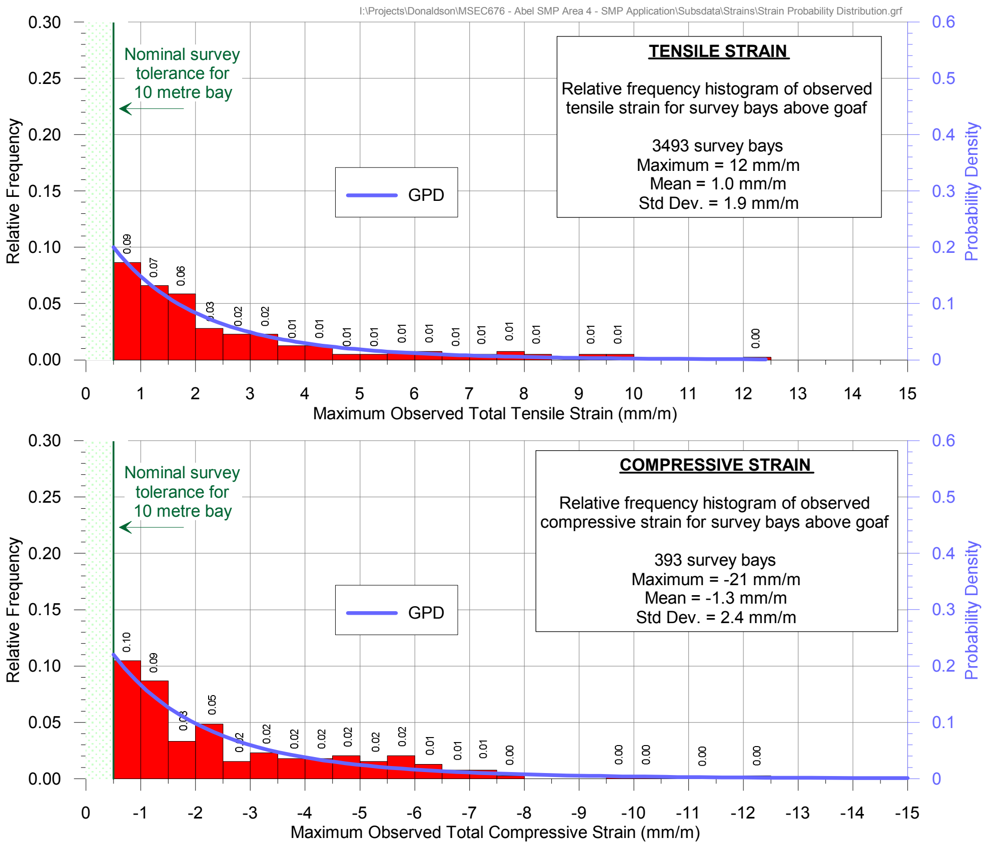


Figure 3.8 Distributions of the Measured Maximum Tensile and Compressive Strains for the Previously Extracted Panels in SMP Areas 1, 2 and 3 at Abel Underground Mine

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 9 mm/m tensile and 11 mm/m compressive.

3.4.4 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 EP / 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 **Appendix C**.

3.4.5 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 3.9**. The confidence levels, based on fitted GPDs, have also been shown in this figure to illustrate the spread of the data.

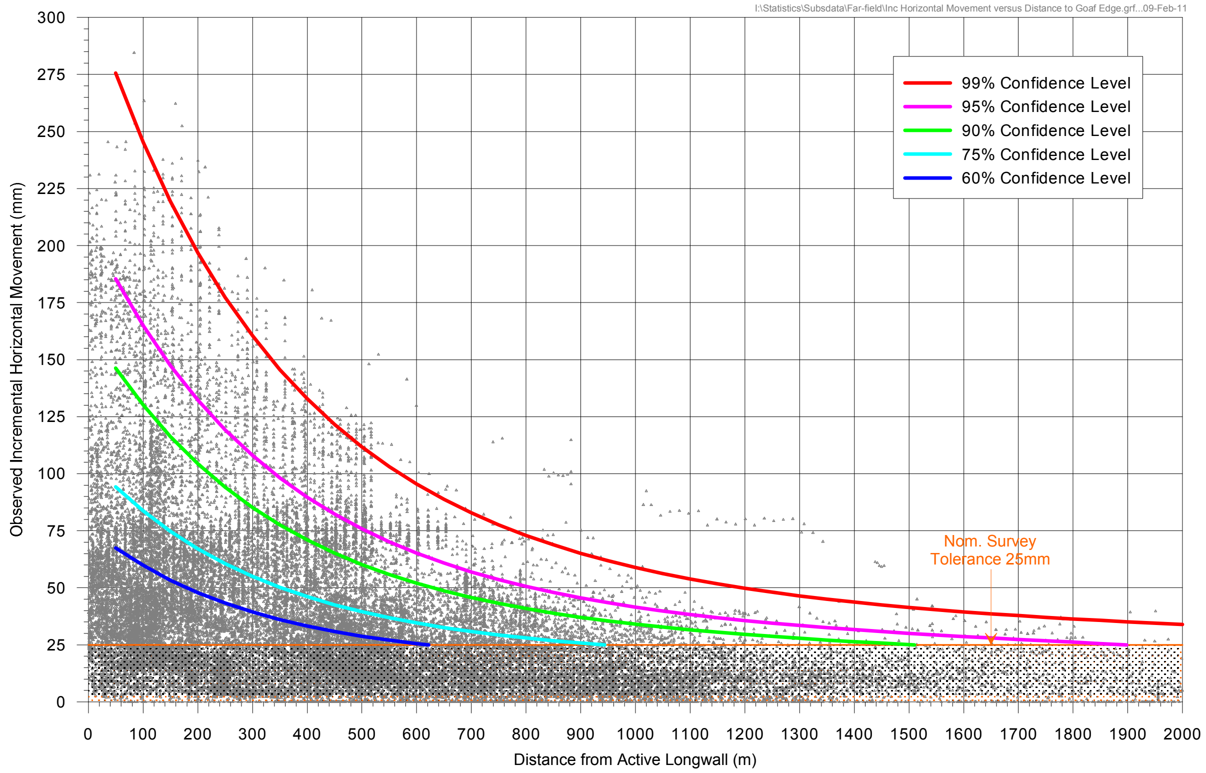


Figure 3.9 Observed Incremental Far Field Horizontal Movements

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.

3.4.6 Non-Conventional Ground Movements

It is likely non-conventional ground movements will occur within the EP / 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.

3.4.7 General Discussions on Mining Induced Ground Deformations

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 partially 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 in the northern part of the proposed mining area, 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 in the northern part of the proposed mining area 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 measures above these panels is illustrated in **Figure 3.10.**

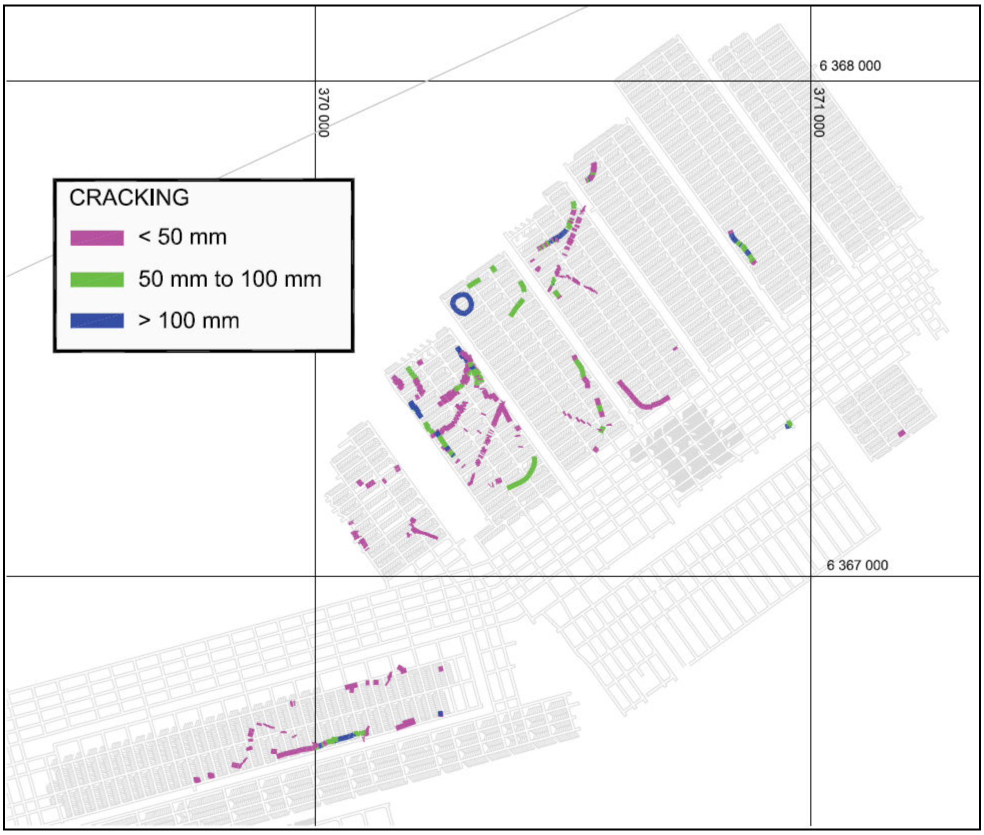


Figure 3.10 Surface Cracking Observed above the Panels in SMP Areas 1 and 2

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. The depth of cover above the panels in SMP Areas 1 and 2 varies between 50 metres and 100 metres. Currently cracking in SMP Area 3 is similar to that experienced in SMP Areas 1 and 2.

The size and extent of surface cracking in the southern part of the proposed mining are expected to be similar to or less than those observed above the currently active Panels 23 and 24 in SMP Area 3, due to the higher depths of cover. The observed crack widths are typically between 25 mm and 50 mm, with localised surface crack widths greater than 100 mm.

It is possible, that larger surface cracking could occur along the steep slopes due to down slope movements resulting from the extraction of the proposed panels.

Photographs of typical surface cracking observed from previous mining in SMP Areas 1 and 3 at the Abel Underground Mine are provided in **Figure 3.11** and **Figure 3.12**, respectively.

Figure 3.11 Photographs of Typical Surface Cracking in SMP Area 1 at the Abel Underground Mine (50 metres to 100 metres Depth of Cover)

Figure 3.12 Photographs of Typical Surface Cracking in SMP Area 3 at the Abel Underground Mine (110 metres to 140 metres Depth of Cover)

3.4.8 Estimated Height of 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 3.13**.

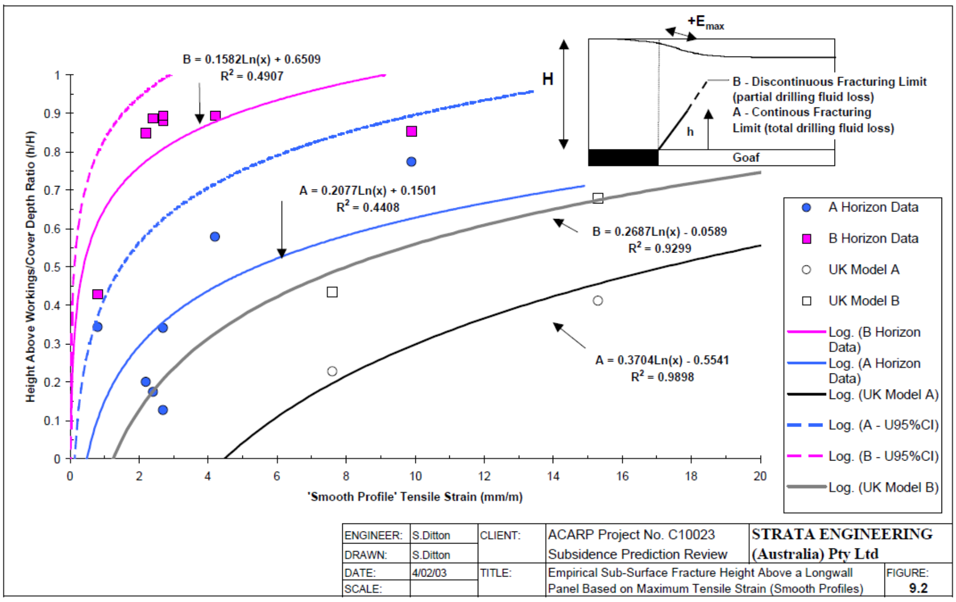


Figure 3.13 Estimated Heights of the A and B Horizons (ACARP, 2003)

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*

$$B = 0.1694 Ln\left(S_{max} / W^2\right) + 1.381$$ *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 3.9**. The heights of fracturing have been based on the greater of those determined using the maximum conventional tensile strain and the maximum subsidence.

Table 3.9 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 27 to 35	50	>30	1,450	50 - 140	100 - 200
	280	5	1,000		

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 mining area. It is also possible, that discontinuous cracking could extend near to the surface above the southern part of the proposed mining area.

It is noted, that the height of continuous fracturing could be towards the lower end of the range predicted using the Ditton et al (2003) model, as extensometer measurements at the nearby West Wallsend Colliery indicate that the caved zone extended 71 metres above the West Borehole Seam (DoP, 2012).

3.5 PERFORMANCE OBJECTIVES

Performance objectives in relation to subsidence impacts are presented in **Table 3.10**. These objectives have been used when developing management strategies of this Extraction Plan.

Table 3.10 Performance Objectives from Abel Project Approval 05_0136 MOD 3

Condition No.	Condition Requirement
Schedule 3, Condition 1	The Proponent shall ensure that the project does not cause any exceedance of the performance measures in Table 2, to the satisfaction of the Director-General.

Table 2: Subsidence Impact Performance Measures (applicable to EP / SMP Area 4)

Water Resources	
All other watercourses in the mining area	*No greater environmental consequences than predicted in the EA and EA (MOD 3)*
Land	
Steep Slopes	*Minor environmental consequences (that is, occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing that in total do not impact more than 5% of the total face area of each such type of feature within the mining area).*
Biodiversity	
Threatened species and endangered ecological communities (including unspecified Lowland Rainforest EEC)	*Negligible environmental consequences.*
Heritage Sites	
Aboriginal heritage sites	*No greater subsidence impacts or environmental consequences than predicted in the EA and EA (MOD 3).*
Mine Workings	
-First workings under an approved Extraction Plan beneath any feature where performance measures in this table require negligible subsidence impacts, negligible environmental consequences.	*To remain long-term stable and non-subsiding.*
-Second workings	*To be carried out only in accordance with an approved Extraction Plan.*

Note: The Proponent will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this approval.
Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Director-General will be the final arbiter.
The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of MOD 3.

Condition No.	Condition Requirement
Schedule 3, Condition 3	The Proponent shall ensure that the project does not cause any exceedances of the performance measures in Table 3, to the satisfaction of the Director-General. Any dispute between the Proponent and the owner of any built feature over the interpretation, application or implementation of the performance measures in Table 3 is to be settled by the Director-General, following consultation with the MSB and the Executive Director Mineral Resources. Any decision by the Director-General shall be final and not subject to further dispute resolution under this approval.

Table 3: Subsidence Impact Performance Measures (applicable to EP / SMP Area 4)

Built Features	
Other Public Infrastructure: *-Timber power poles;* *-Roads; and*	*-Always safe and serviceable.* *-No greater subsidence impact or environmental*

<table>
<tr><th>Condition No.</th><th>Condition Requirement</th></tr>
<tr><td></td><td>
<table>
<tr><td>-Telecommunications cables</td><td>consequences than predicted in the EA and EA (MOD 3).
-Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</td></tr>
<tr><td>Key Privately-Owned Built Features:
-Principal residences;
-The 4 largest dams at the commercial orchard on Lots 11 and 12 DP877937 and Lots 610 and 611 DP1035588, while this land is used for this purpose.</td><td>-First workings only within a 26.5^{0} angle of draw of the structure, except with the prior written agreement of the relevant landowner.
-Always safe.
-Serviceability should be maintained wherever practicable.
-Damage must be fully repairable, and must be fully repaired, or else replaced or fully compensated.</td></tr>
<tr><td>Other Privately-Owned Built Features:
-Rural buildings;
-Farm dams;
-Tracks and Fences.</td><td>-Always safe.
-Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated.
-Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</td></tr>
<tr><td>Public Safety</td><td></td></tr>
<tr><td>Public safety.</td><td>Negligible additional risk.</td></tr>
</table>
Note: The Proponent will be required to define more detailed performance indicators for each of these performance measures in Built Features Management Plans or a Public Safety Management Plan Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Director-General will be the final arbiter.
Requirements under this condition may be met by measures undertaken in accordance with the Mine Subsidence Compensation Act 1961.
Requirements regarding safety or serviceability do not prevent preventative or mitigatory actions being taken prior to or during mining in order to achieve or maintain these outcomes.
</td></tr>
<tr><td>Schedule 4, Condition 27</td><td>
The Proponent shall rehabilitate the site to the satisfaction of the Executive Director Mineral Resources. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the EA, and comply with the objectives in Table 12.

Table 12: Rehabilitation Objectives (applicable to EP / SMP Area 4)
<table>
<tr><th>Feature</th><th>Objective</th></tr>
<tr><td>Mine site (as a whole)</td><td>Safe, stable & non-polluting; and
Final land use compatible with surrounding land uses.</td></tr>
<tr><td>Watercourses within project area</td><td>Hydraulically and geomorphologically stable.</td></tr>
<tr><td>Other land affected by the project</td><td>Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems comprised of:
- Local native plant species (unless the Executive Director Mineral Resources agrees otherwise); and
- A landform consistent with the surrounding environment.</td></tr>
<tr><td>Built features damaged by mining operations</td><td>Repair to pre-mining condition or equivalent unless:
-The owner agrees otherwise; or
-The damage is fully restored, repaired or compensated under the Mine Subsidence Compensation Act 1961.</td></tr>
<tr><td>Community</td><td>Ensure public safety; and
Minimise the adverse socio-economic effects associated with mine closure.</td></tr>
</table>
Note: These rehabilitation objectives apply to all subsidence impacts and environmental consequences caused by mining taking place after the date of this approval; and to all surface infrastructure sites and other disturbance which forms part of the project, whether constructed prior to or following the date of this approval.
</td></tr>
</table>

Project Approval 05_0136 MOD 3 conditions and commitments relevant to the Extraction Plan are shown in **Appendix A.**

4 DEVELOPMENT

4.1 EXTRACTION PLAN TEAM

The team that has prepared the Extraction Plan was endorsed by the Director General of P&E on 13 March 2014. The Extraction Plan Team is presented in **Table 4.1**.

Table 4.1 Extraction Plan Team

Extraction Plan Component	Team Members
Extraction Plan coordination and preparation	Donaldson Coal; • Tony Sutherland – Technical Services Manager • Phil Brown- Environment & Community Relations Manager • Matthew Wright – Registered Statutory Mining Surveyor • Daniel Lee – Registered Surveyor • John Krick- Geotechnical Engineer
Built Features Management Plan	Donaldson Coal - Tony Sutherland, Phil Brown, Matthew Wright, Daniel Lee, John Krick
Public Safety Management Plan	Donaldson Coal - Tony Sutherland, Phil Brown, Matthew Wright, Daniel Lee, John Krick
Land Management Plan	Donaldson Coal - Tony Sutherland, Phil Brown, Matthew Wright, Daniel Lee, John Krick
Rehabilitation Management Plan	SLR – Rod Masters - Executive SLR – Jeremy Pepper (Principal Environmental Consultant)
Biodiversity Management Plan	Hunter Eco – Dr Colin Driscoll
Heritage Management Plan	South East Archaeology – Peter Kuskie
Water Management Plan	Groundwater Exploration Service Pty Ltd – Andy Fulton Evans & Peck – Dr Steven Perrens
Subsidence Predictions	Mine Subsidence Engineering Consultants – James Barbato

4.2 AGENCY CONSULTATION

4.2.1 Planning and Environment

The Extraction Plan is required to be completed to the satisfaction of the Director General of NSW Planning and Environment (P&E).

4.2.2 Division of Resources and Energy

There are several components of the Extraction Plan that are required to be completed to the satisfaction of the DRE. These components include:

- A Coal Resource Recovery Plan;
- Revised predictions of subsidence effects;
- Subsidence Monitoring Program; and
- Public Safety Management Plan.

There is also a parallel Subsidence Management Plan approval requirement of Abel Mine's Mining Lease ML 1618 which requires approval of the Director General of the Division of Resources and Energy. The Subsidence Management Plan process, including approval of the Subsidence Management Plan will satisfy the DRE requirements of Project Approval 05_0136.

4.2.3 Office of Environment & Heritage

The Aboriginal Cultural Heritage Management Plan (ACHMP) was prepared in consultation with the Registered Aboriginal Parties and Office of Environment and Heritage (OEH). This plan, including the original consultation requirements was approved by P&E in February 2008, and an update was undertaken during the modification of the Abel Consent during April, 2012 which was submitted to P&E as part of the 75 W modification.

OEH was consulted in the development of the Biodiversity Management Plan (BMP) and this builds off the current Abel Mine Flora and Fauna Management Plan and the Abel Mine (whole of site) BMP currently being prepared as per Schedule 3 Condition 20 of the PA05_0136 (MOD3).

4.2.4 Mine Subsidence Board

The Mine Subsidence Board has been consulted in the preparation of the process for Built Features Management Plans in the approved SMP Areas 1, 2 and 3, and in the early parts of the EP / SMP Area 4 mining area, including the stakeholder presentation and will continue to be consulted during preparation of individual Built Features Management Plans in conjunction with the Built Feature owners.

4.3 COMMUNITY CONSULTATION

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

Relevant Stakeholder Identification

Stakeholders who were identified as having an interest in subsidence issues relating to the EP / 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 EP / SMP area;
- Mindaribba Local Aboriginal Land Council;
- Environmental Protection Agency;
- NSW Office of Water;
- NSW Planning and Environment;
- Dams Safety Committee;
- Department of Primary Industries - NSW Fisheries;
- Ausgrid;
- Telstra;
- Cessnock City Council;
- Mine Subsidence Board; and
- Abel Mine Community Consultative Committee (CCC)

4.3.1 Private Landholders

Relevant Stakeholder Identification

Stakeholder / Community consultation conducted to date has consisted of:

1. Abel Mine Community Consultative Committee meetings
2. EP / SMP stakeholder presentation meeting and site inspection on 27 March 2014
3. EP / SMP advertisement 6 March 2014

A presentation followed by a site inspection was made to DTIRIS and identified stakeholders on 27 March 2014 to outline the EP / SMP process and progress to date, relating to mine design, environmental considerations, results of mining in SMP Areas 1, 2 and 3, subsidence predictions and potential impacts.

The day was structured as follows;

1. Introduction and Meeting Objectives
2. Donaldson Coal Background

3. The Extraction Plan process
4. Abel Mine
    a. Mine Planning
    b. Mining Methods
    c. SMP Areas 1, 2 and 3
    d. EP / SMP Area 4
5. SMP Areas 1, 2 and 3 Approval Conditions, Management Plans and Monitoring Programs
6. SMP Areas 1, 2 and 3 progress to date
7. Subsidence Results in SMP Areas 1 and 3, impacts and remediation
8. EP / SMP Area 4 Key surface features, manmade and natural features potentially impacted by subsidence (properties, roads, power lines, telephone lines, dams and other infrastructure)
9. EP / SMP Area 4 Subsidence Assessment and Predictions
10. EP / SMP Area 4 Subsidence Impacts
11. EP / SMP Area 4 Proposed Monitoring
12. EP / SMP Area 4 Mining Schedule
13. Property Subsidence Management Plan (PSMP) process
14. Field Visit to 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, 2 and 3 to date, outline the planning and baseline studies conducted in relation to EP / SMP Area 4 and consult with interested parties (relevant stakeholders) to identify potential issues and relevant concerns to be considered and addressed in the preparation of the Extraction Plan / Subsidence Management Plan.

Following this meeting a copy of the presentation was forwarded to all relevant stakeholders and placed on the company website. A copy of presentation can be viewed at http://www.doncoal.com.au/environment/abel/subsidence-management-plans-4.php

EP / SMP Advertisement

As per the SMP Guideline 2003, Abel prepared an advertisement to notify the community of the intention to submit an EP / SMP application for approval. The advertisement included a map of the

EP / SMP Area, existing workings and regional locality. Donaldson placed the advertisement in the Newcastle Herald on 1 March 2014 and a copy in The Land on 6 March 2014. A copy of this advertisement is provided in the stakeholder presentation.

4.4 RISK ASSESSMENT

A risk assessment was conducted on 3 April 2014 to identify, assess and review any potential subsidence impacts to the surface and sub-surface as a result from the mining of the proposed EP / SMP application area at Abel. A copy of the risk assessment is included in **Appendix D**.

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 water, Telstra and a member of the Abel CCC / local resident.

A key step in the process was the gathering of 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 was 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 nine (29) risk issues were identified. Of those risks assessed, there was four (4) "High" risks identified by the risk assessment team. One (1) risk was assessed as having a potentially "Catastrophic" consequence. These high risk issues are shown in **Table 4.2** with the risk assessed as having a potentially "Catastrophic" consequences being risk SP#3.05.02.

Table 4.2 High Risks

SP#	Risk Issue	Existing Controls	Further Actions
2.01.01	Injury to road user on Blackhill Rd, Meredith Rd and Browns 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 5. Experience from SMP Area 3	1. Review and update Built Features MP including Road MP and Public Safety MP 2. Review Blackhill Rd risk assessment to include Meredith and Browns Rd 3. Panel design to minimise impact to Blackhill Rd
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
3.05.02	Personal injury from dam wall failure including flooding of John Renshaw Dr and	1. 3 x 1200mm diameter culverts under John Renshaw Dr 2. Develop Dam Monitoring and	1. Develop specific DMMS and PSMP 2. Consider partial extraction system under dam

SP#	Risk Issue	Existing Controls	Further Actions
	Blackhill Rd	Management Strategy (DMMS) for all dams prior to any mining occurring which will impact on the dams 3. PSMP process	3. Consider installing an extensometer and piezometer in adjacent Panel prior to undermining dam 4. Survey dam 5. Conduct dam specific RA including public safety on John Renshaw Dr and inrush potential 6. CL88 process 7. review impacts on previously undermined dams 8. Consult with RMS
7.01.01	Injury to persons and/or animals, due to sinkholes (shallow workings)	1. No extraction <50m depth of cover 2. Full extraction in Area 4 3. Full extraction in borehole seam workings 200m above Panels 30 and 32 4. Archival research on historical workings	1. Borehole seam reactivation issue to be assessed in MSEC report 2. Assess 50m depth of cover over Panel 29

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 management of potential high risk issues will be managed by 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.

The full risk assessment report including a full list of risks in assessment order, risk rank order and consequence order respectively are shown in **Appendix D**.

5 SUBSIDENCE MONITORING AND MANAGEMENT

5.1 FRAMEWORK

The overall framework for subsidence monitoring and management of impacts of this Extraction Plan may be described as:

- A **Subsidence Monitoring Program** (actual measured subsidence, and inspections for environmental consequences of subsidence to compare against predicted impacts) which may trigger a response, or set of responses.

The response is commensurate with the nature of the measurement or the impact which has been identified. The Extraction Plan relies on a set of individual management plans which are intended to address impacts to particular environmental or built features within the Extraction Plan Area. These plans include:

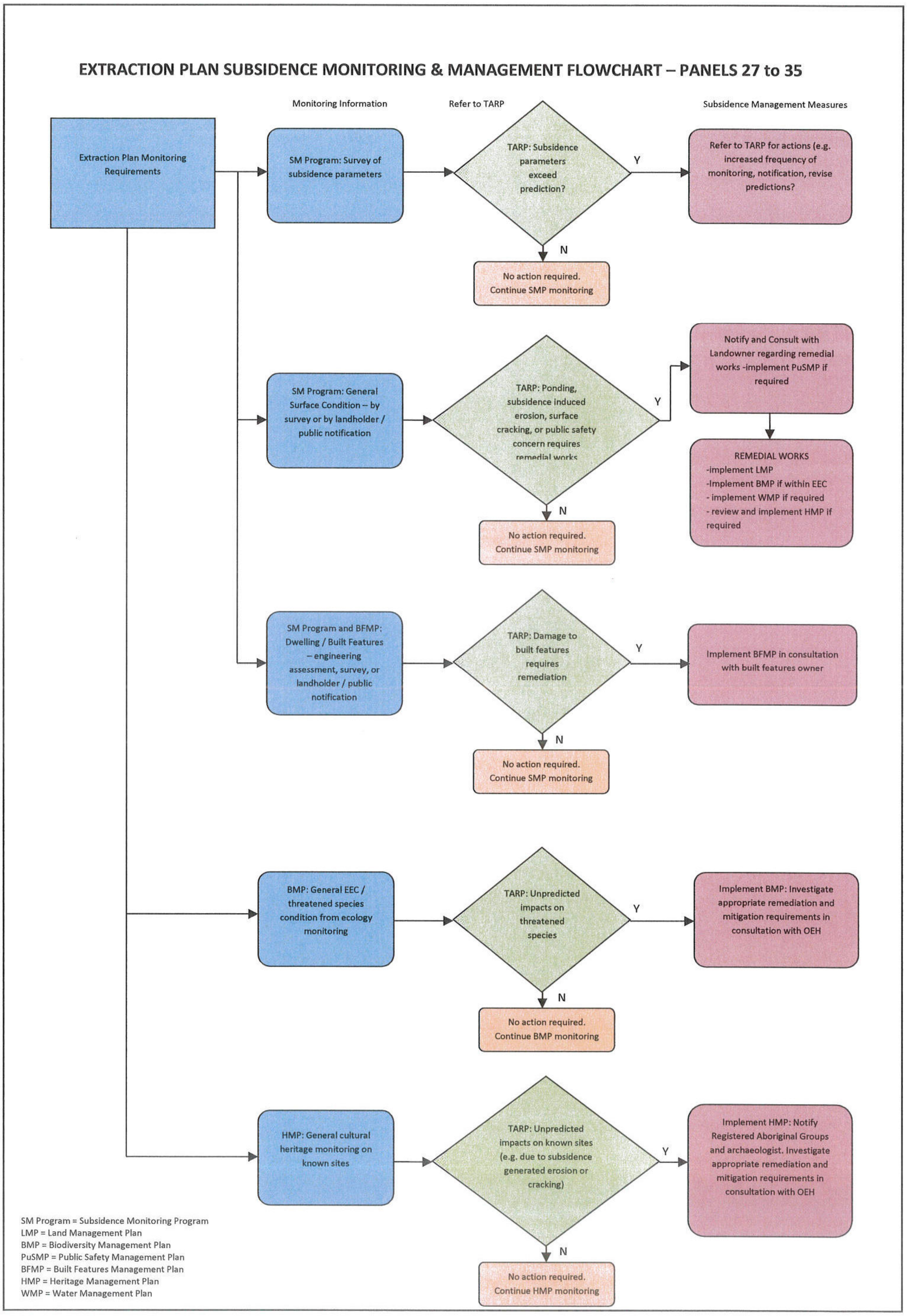
- **Water Management Plan** – to manage the potential environmental consequences of second workings on surface and ground water;
- **Land Management Plan** – to manage the potential environmental consequences of second workings on steep slopes and land in general;
- **Biodiversity Management Plan** – to manage the potential environmental consequences of second workings on terrestrial flora and fauna (additional **monitoring** specific to Biodiversity is also collected to assess impact);
- **Built Features Management Plan** – to manage the potential environmental consequences of second workings on any built feature;
- **Heritage Management Plan** – to manage the potential environmental consequences of second workings on heritage sites or values (additional **monitoring** specific to Aboriginal Cultural Heritage is also collected to assess impact); and
- **Public Safety Management Plan** – to ensure public safety in the Extraction Plan area.

5.2 EXTRACTION PLAN TARP

Donaldson has developed an overall subsidence management **Abel Mine Panel 27 to 35 Extraction Plan Trigger Action Response Plan** (TARP) to manage subsidence within the Extraction Plan Area. This TARP is included in **Appendix B** and includes individual triggers to instigate actions, including public safety activities, remedial works or review of subsidence predictions. The TARP also specifically includes both adaptive and contingency management based on results of the Subsidence Monitoring (SM) Program and specific management plans.

5.3 EXTRACTION PLAN SUBSIDENCE MONITORING AND MANAGEMENT FLOWCHART

Donaldson has developed a **flowchart** to illustrate the mechanics of how the relevant Subsidence Monitoring Program, sub-management plans, and the TARP are used at Abel Mine to manage subsidence impacts. The flowchart is provided below and is included in **Appendix B** with the TARP.


EXTRACTION PLAN SUBSIDENCE MONITORING & MANAGEMENT FLOWCHART – PANELS 27 to 35
Monitoring Information
Refer to TARP
Subsidence Management Measures
Extraction Plan Monitoring Requirements
SM Program: Survey of subsidence parameters
TARP: Subsidence parameters exceed prediction?
Y
Refer to TARP for actions (e.g. increased frequency of monitoring, notification, revise predictions?
N
No action required. Continue SMP monitoring
SM Program: General Surface Condition – by survey or by landholder / public notification
TARP: Ponding, subsidence induced erosion, surface cracking, or public safety concern requires remedial works
Y
Notify and Consult with Landowner regarding remedial works -implement PuSMP if required
REMEDIAL WORKS
-implement LMP
-Implement BMP if within EEC
- implement WMP if required
- review and implement HMP if required
N
No action required. Continue SMP monitoring
SM Program and BFMP: Dwelling / Built Features – engineering assessment, survey, or landholder / public notification
TARP: Damage to built features requires remediation
Y
Implement BFMP in consultation with built features owner
N
No action required. Continue SMP monitoring
BMP: General EEC / threatened species condition from ecology monitoring
TARP: Unpredicted impacts on threatened species
Y
Implement BMP: Investigate appropriate remediation and mitigation requirements in consultation with OEH
N
No action required. Continue BMP monitoring
HMP: General cultural heritage monitoring on known sites
TARP: Unpredicted impacts on known sites (e.g. due to subsidence generated erosion or cracking)
Y
Implement HMP: Notify Registered Aboriginal Groups and archaeologist. Investigate appropriate remediation and mitigation requirements in consultation with OEH
N
No action required. Continue HMP monitoring
SM Program = Subsidence Monitoring Program
LMP = Land Management Plan
BMP = Biodiversity Management Plan
PuSMP = Public Safety Management Plan
BFMP = Built Features Management Plan
HMP = Heritage Management Plan
WMP = Water Management Plan

6 PLAN IMPLEMENTATION

6.1 REPORTING FRAMEWORK

6.1.1 Annual Review / Annual Environmental Management Report (AEMR)

The Annual Review / AEMR is prepared to summarise Abel Mine's environmental performance for the reporting year and is prepared in accordance with Schedule 6 Condition 4 of Project Approval 05_0136 MOD 3 and to satisfy Mining Lease conditions.

In relation to the Extraction Plan, the Annual Review / AEMR will:

(a) Describe the development (including any rehabilitation) that were carried out in the past calendar year, and the development that is proposed to be carried out over the current calendar year;

(b) Include a comprehensive review of the monitoring results and complaints records of the project over the past calendar year, which includes a comparison of these results against the:

- the relevant statutory requirements, limits or performance measures/criteria;
- requirements of any plan or program required under the MOD 3 approval;
- the monitoring results of previous years; and
- the relevant predictions in the EA and Extraction Plan;

(c) Identify any non-compliance over the past calendar year, and describe what actions were (or are being) taken to ensure compliance;

(d) Identify any trends in the monitoring data over the life of the project;

(e) Identify any discrepancies between the predicted and actual impacts of the project, and analyse the potential cause of any significant discrepancies; and

(f) Describe what measure will be implemented over the current calendar year to improve the environmental performance of the mine complex.

The Annual Review / AEMR will be published on the Donaldson Coal website upon completion and submission to P&E and DRE.

6.1.2 Regular Stakeholder Extraction Plan Update Reporting

The results of monitoring undertaken in accordance with this Extraction Plan will be provided on a quarterly basis to the Abel Mine Community Consultative Committee. The results will also be published on the Donaldson Coal website.

Landholders and stakeholders within the affected Extraction Plan area will be provided with regular updates on the progress of mining, results of subsidence monitoring, and of any particular subsidence induced consequences and the remediation measures employed. The frequency of reporting will be determined in the individual BFMP's and Property Subsidence Management Plans (PSMP).

6.1.3 Incident Reporting

In accordance with Condition 7 Schedule 6 of Project Approval 05_0136 MOD 3 Donaldson shall notify, at the earliest opportunity, the Director-General and any other relevant agencies, of any incident that has caused, or threatens to cause, material harm to the environment. For any other incident associated with the project, Donaldson shall notify the Director-General and any other relevant agencies as soon as practicable after Donaldson becomes aware of the incident.

Within 7 days of the date of the incident, Donaldson shall provide the Director-General and any relevant agencies with a detailed report on the incident, and such further reports as may be requested.

6.2 REVIEW OF THE EXTRACTION PLAN

Regular review of the Extraction Plan and/or any of the sub-plans is required by Project Approval 05_0136 MOD 3. In particular, Donaldson is required to review, and if necessary revise, the strategies, plans, and programs of this Extraction Plan within 3 months of the submission of an:

- Annual review under condition 4 of schedule 6;
- Incident report under condition 7 of schedule 6;
- Audit report under condition 9 of schedule 6; and
- Any modification to the conditions of PA05_0136 MOD 3.

Any revision to the Extraction Plan including component sub-plans must be completed to the satisfaction of the Director-General.

6.3 COMPLAINTS HANDLING

Complaints in relation to the management of subsidence will be managed using the established protocols in the Abel Mine Environmental Management System.

6.4 EXTRACTION PLAN ROLES AND ACCOUNTABILITIES

Detailed below are key personnel involved with implementing this Extraction Plan to manage subsidence, their roles and responsibilities.

Role	Responsibilities
Operations Manager (OM)	• Make appropriate resources available for the implementation of this Extraction Plan • Conduct underground mining activities in accordance with the Extraction Plan Coal Resource Recovery Plan. • Notify and liaise with DRE Inspectors (if required)
Technical Services Manager (TSM)	• Owner of the Extraction Plan • Liaise with Government Agencies and Community members in relation to subsidence matters and the Extraction Plan subsidence predictions and monitoring program • Manage / implement subsidence management actions required by the Extraction Plan in relation to Built Features and general landform • Coordinate Registered Mine Surveyor to ensure subsidence monitoring is undertaken in accordance with the Extraction Plan • Review subsidence monitoring data against predictions and TARPs in order to trigger any actions required on the basis of subsidence results • Manage / implement subsidence management actions required by the Extraction Plan in relation to Infrastructure • Review subsidence predictions based on monitoring information and the TARPs • Liaise with Mine Subsidence Board in relation to Built Features impacts • Review and update the Extraction Plan and sub plans as required • Provide support and guidance in relation to subsidence effects to Environment & Community Relations Manager

Role	Responsibilities
Environment and Community Relations Manager (ECM)	• Ensure that all environmental monitoring and reporting is undertaken in accordance with the Extraction Plan and sub environmental management plans • Train remediation contractors on mitigation measures for remedial works • Liaise with Government Agencies in relation to environmental consequences of subsidence and proposed management strategies • Liaise with Landholders in relation to environmental consequences of subsidence and in relation to access for the Extraction Plan monitoring program • Notify and liaise with neighbours and community in relation to mining timing and monitoring performance
Registered Mine Surveyor (RMS)	• Ensure that all subsidence monitoring is completed to the requirements of the Subsidence Monitoring Program and provided to the TSM for review • Liaise with the Environment & Community Relations Manager to gain required access for subsidence monitoring • Provide training for subsidence impact measurements and observations in accordance with SM program

7 REFERENCES

Department of Planning and Infrastructure – Draft *Guidelines for the Preparation of Extraction Plans*

HMS, 2014, Donaldson Coal, *Extraction Plan / Subsidence Management Plan Area 4 Risk Assessment Final Report*, April 2014, Report No. HMS1283

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*

MSEC, 2014, *Abel Underground Mine: EP / SMP Area 4 – Proposed Panels 27 to 35, Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the EP / SMP Application*, Report No. MSEC676, Revision A