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LONGWALLS 301-303

BUILT FEATURES MANAGEMENT PLAN SYDNEY TRAINS

Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DP&E Approval Date
All	LW301-303 BFMP_SYDTRAINS-R01-A	Original – Draft for Consultation	Sydney Trains	-
Section 4.2.1, Tables 3 & 5 and Figure 4	LW301-303 BFMP_SYDTRAINS-R01-B	Revised – Incorporating updates	Sydney Trains and DP&E	11 May 2017*
Section 4.2.2, Tables 2, 5, 7 & 8 and Appendix 3	LW301-303 BFMP_SYDTRAINS-R01-C	Revised – Addressing DP&E and DRG requirements	Sydney Trains and DRG	-
Tables 2,3,5,6 & 8. Section 6, 8 and 16	LW301-303 BFMP_SYDTRAINS-R01-D	Incorporating findings of Cardno report into effects of ground movement on repeater tower and comments from Sydney Trains	Sydney Trains	
Preface, Tables 2 and 5	LW301-303 BFMP_SYDTRAINS-R01-E	Revised TARP. Revised for LW303	Sydney Trains and DRG	
Table 5 and 7, 7.2.1	LW301-303 BFMP_SYDTRAINS-R01-F	Monitoring of rail culverts and valley closure at railway added	Sydney Trains and DRG	

* The approval allows for the extraction of Longwalls 301 and 302 only.

September 2018

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1 INTRODUCTION

Metropolitan Coal is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody). Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) under section 75J of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 22 June 2009. A copy of the Project Approval is available on the Peabody website (http://www.peabodyenergy.com).

The Project comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities at Metropolitan Coal. The underground mining longwall layout is shown on Figure 1. Following the completion of Longwall 27 in 2017, Longwalls 301, 302 and 303 (herein referred to as Longwalls 301-303) define the next mining sub-domain within the Project underground mining area (Figures 1 to 3).

1.1 PURPOSE AND SCOPE

In accordance with Condition 6(f), Schedule 3 of the Project Approval, this Built Features Management Plan – Sydney Trains (Longwalls 301-303 BFMP-SYDTRAINS) has been developed to manage the potential consequences of Longwalls 301-303 extraction on the Sydney Trains assets.

The relationship of this Longwalls 301-303 BFMP-SYDTRAINS to Metropolitan Coal Environmental Management Structure and to the Metropolitan Coal Longwalls 301-303 Extraction Plan is shown on Figure 4.

In accordance with Condition 6, Schedule 3 of the Project Approval, the suitably qualified and experienced experts that have prepared this Longwalls 301-303 BFMP-SYDTRAINS, namely representatives from Mine Subsidence Engineering Consultants (MSEC) and Metropolitan Coal were endorsed by the Director-General of the Department of Planning and Environment (DP&E) on 6 June 2016. This Longwalls 301-303 BFMP-SYDTRAINS has been prepared in consultation with Sydney Trains including consideration of prior consultation with RailCorp (now Sydney Trains) during the development of the previously approved Longwalls 20-22, Longwalls 23-27, and Longwalls 301-303 Built Features Management Plans.

1.2 STRUCTURE OF THE LONGWALLS 301-303 BFMP-SYDTRAINS

The remainder of the Longwalls 301-303 BFMP-SYDTRAINS is structured as follows:

Section 2: Describes the review and update of the Longwalls 301-303 BFMP-SYDTRAINS.

Section 3: Outlines the statutory requirements applicable to the Longwalls 301-303 BFMP-SYDTRAINS.

Section 4: Provides a revised assessment of the potential subsidence impacts and environmental consequences for Longwalls 301-303.

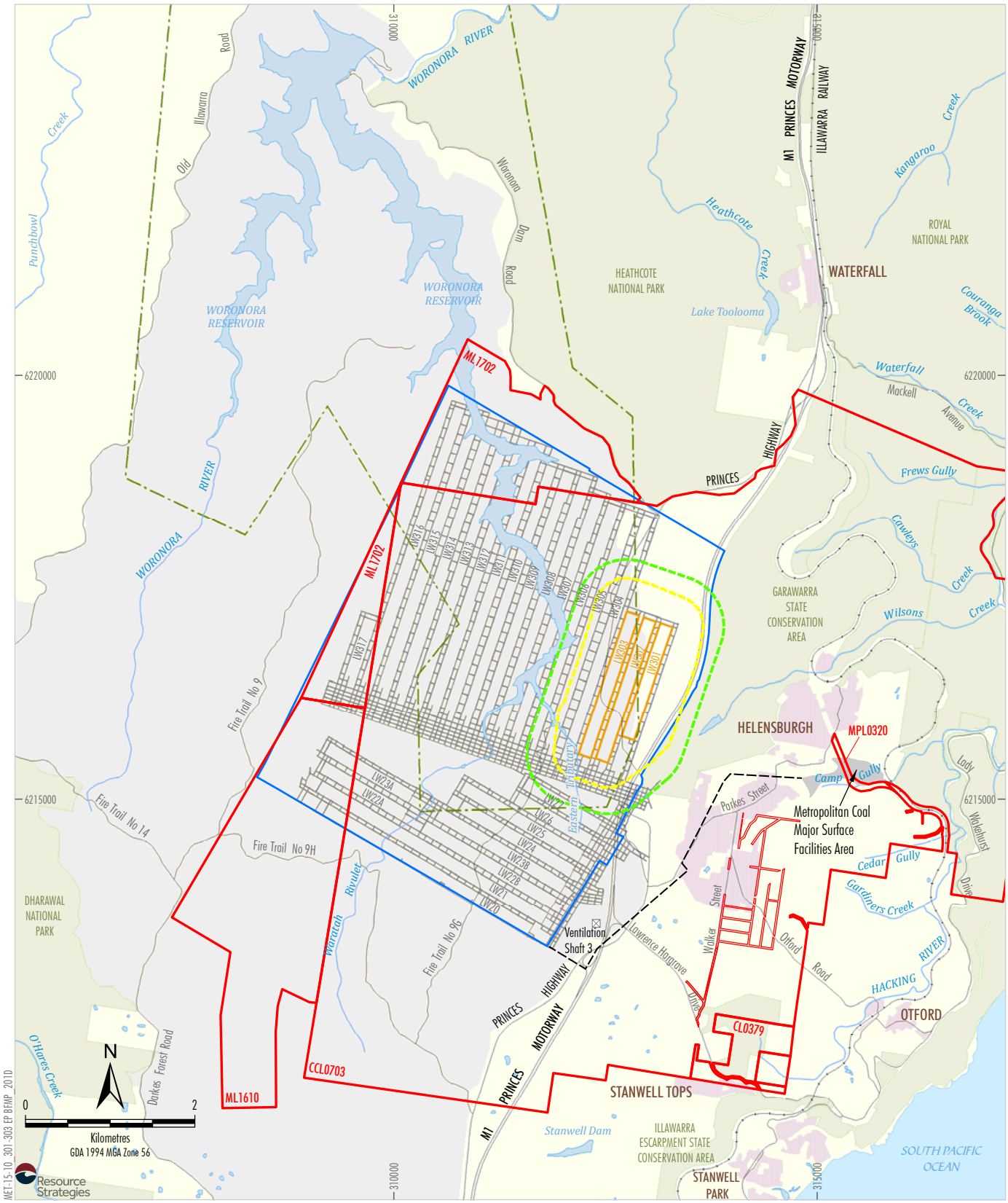
Section 5: Details the performance measures and indicators that will be used to assess the Project.

Section 6: Provides the detailed baseline data.

Section 7: Describes the monitoring program.

Section 8: Describes the management measures that will be implemented.

Section 9: Provides a contingency plan to manage any unpredicted impacts and their consequences.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 301 - 303 Secondary Extraction
- 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Secondary Extraction of Longwalls 301-303
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016)

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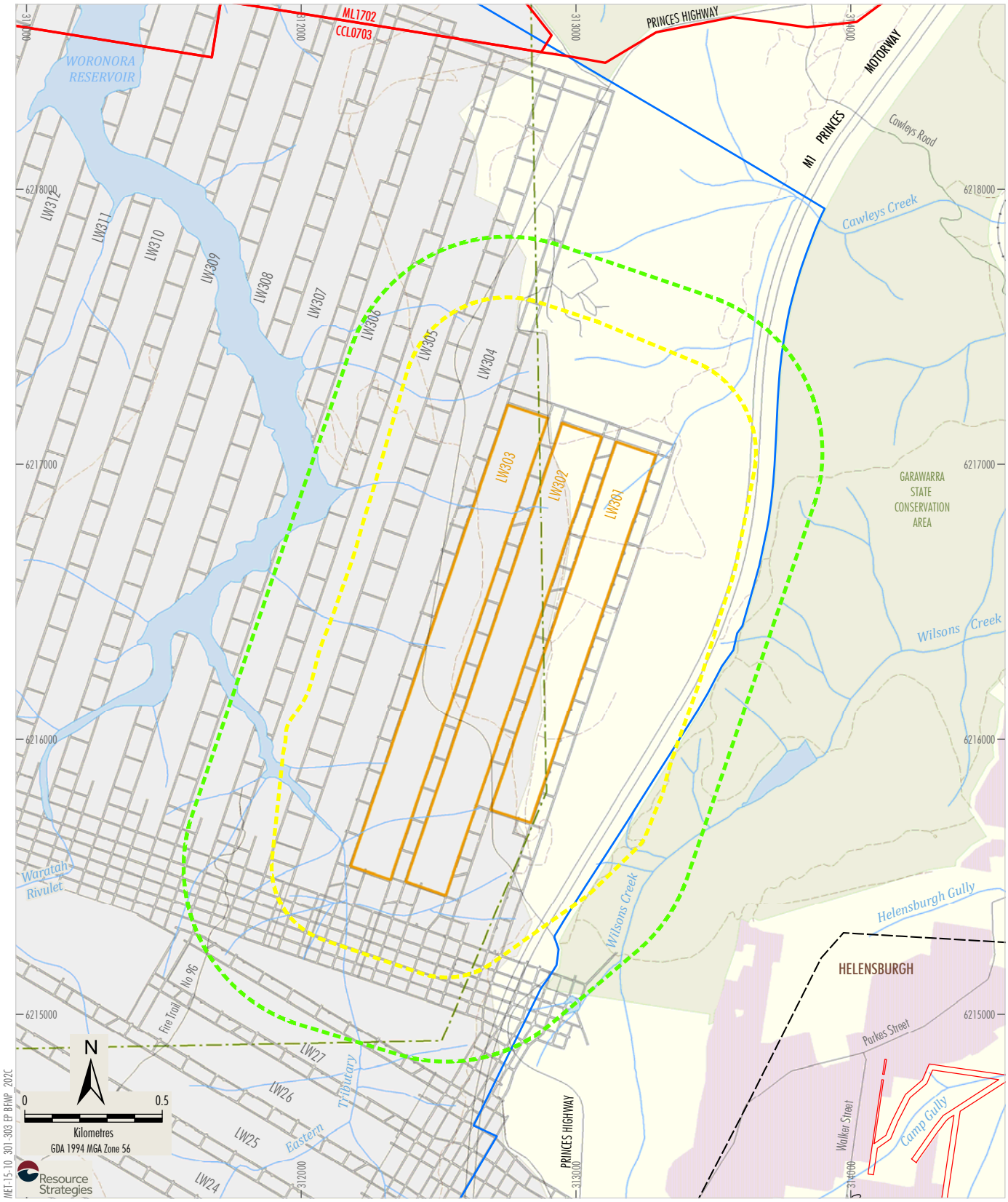
Project Longwalls 20 - 27 and Longwalls 301 - 317 Layout

Figure 1



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 301 - 303 Secondary Extraction
- 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Secondary Extraction of Longwalls 301-303
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- Road
- Vehicular Track

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016)

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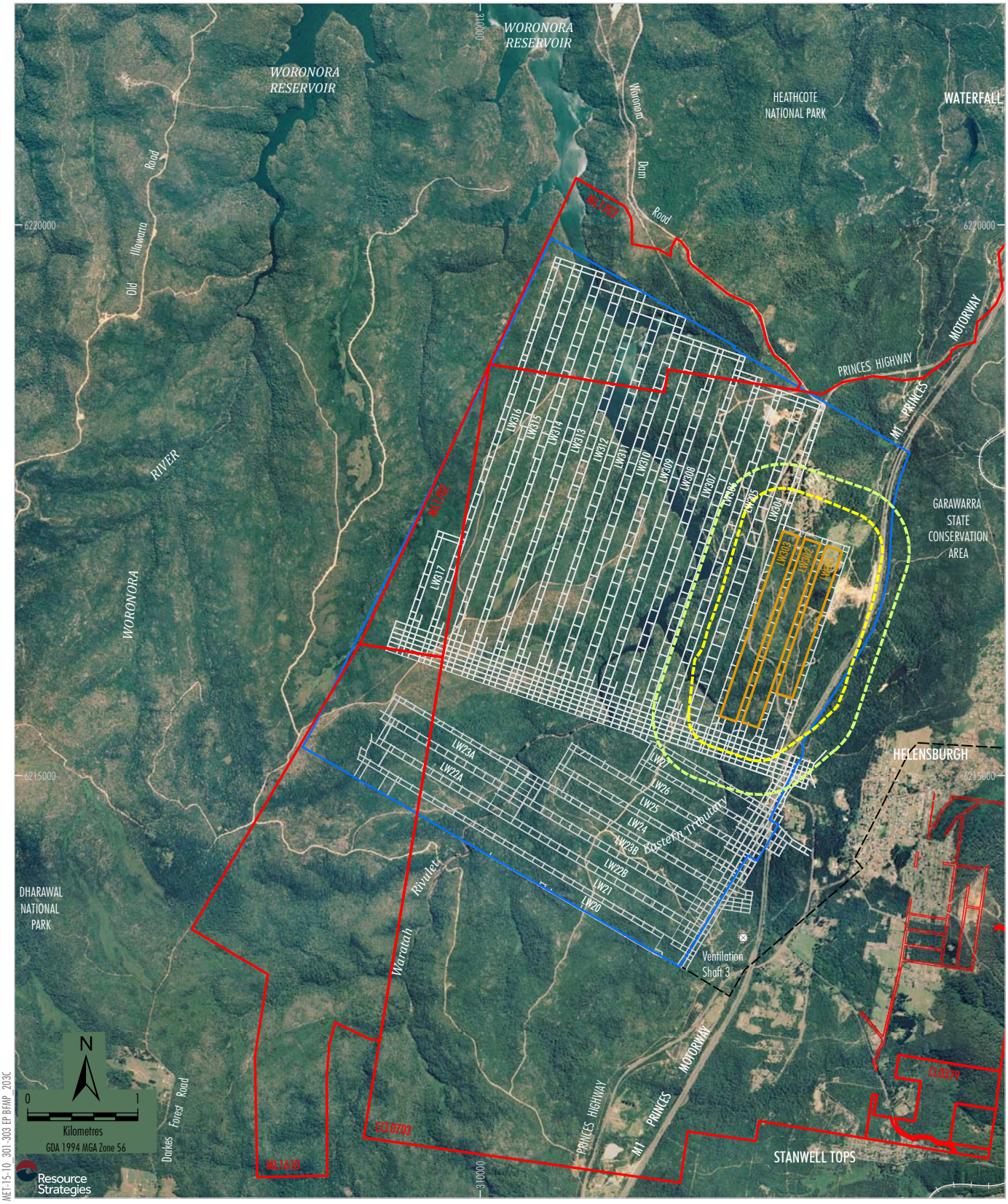
Longwalls 301 - 303 Layout

Figure 2



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LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 301 - 303 Secondary Extraction
- 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Secondary Extraction of Longwalls 301-303
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2016); MSEC (2016)

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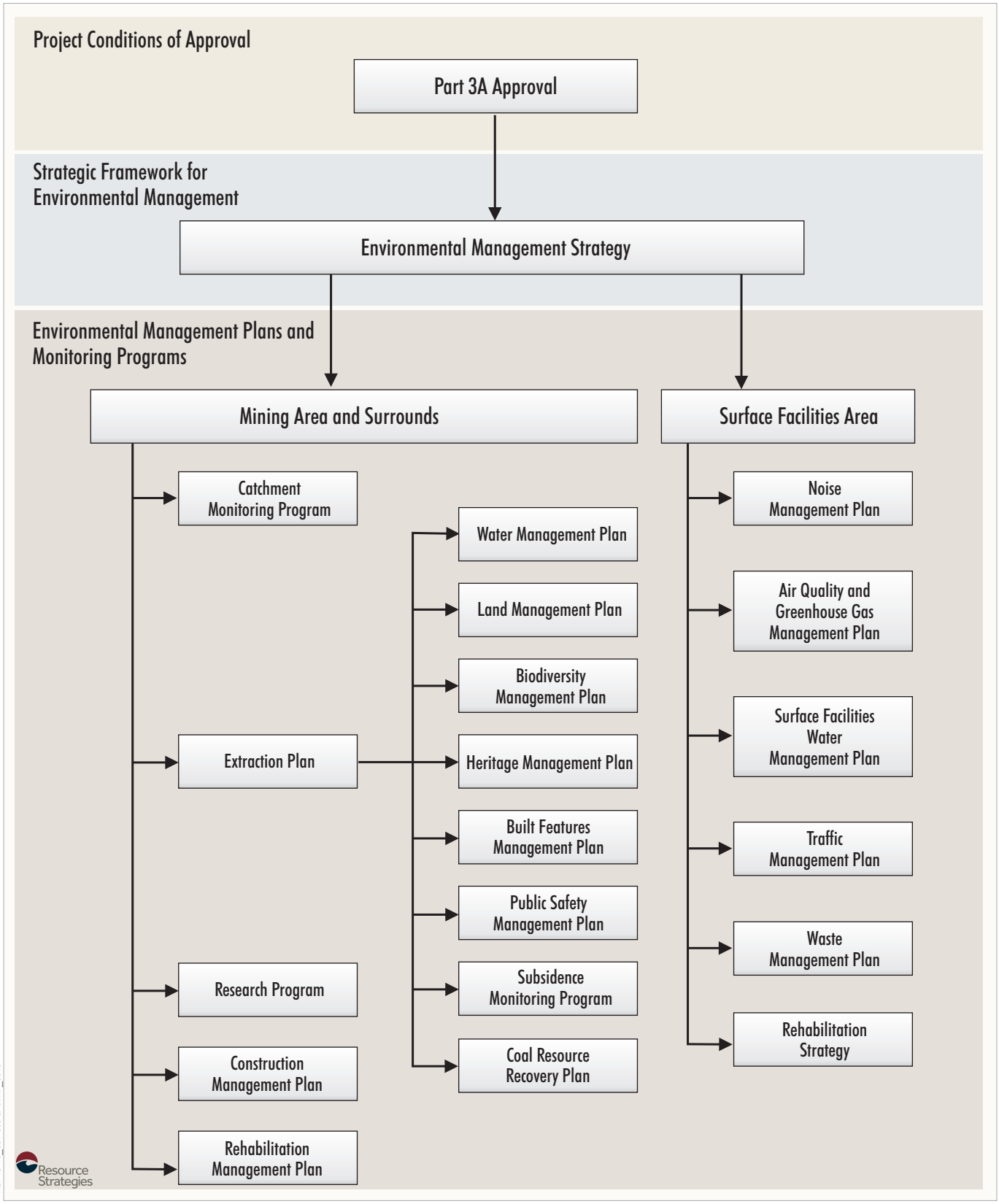
Project Longwalls 20 - 27 and Longwalls 301 - 317 Layout - Aerial Photograph

Figure 3



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Environmental Management Structure

Figure 4

Section 10: Describes the Trigger Action Response Plan (TARP) management tool.

Section 11: Describes the program to collect sufficient baseline data for future Extraction Plans.

Section 12: Describes the annual review and improvement of environmental performance.

Section 13: Outlines the management and reporting of incidents.

Section 14: Outlines the management and reporting of complaints.

Section 15: Outlines the management and reporting of non-compliances with statutory requirements.

Section 16: Lists the references cited in this Longwalls 301-303 BFMP-SYDTRAINS.

2 LONGWALLS 301-303 BFMP-SYDTRAINS REVIEW AND UPDATE

In accordance with Condition 4, Schedule 7 of the Project Approval, this Longwalls 301-303 BFMP-SYDTRAINS will be reviewed within three months of the submission of:

- an audit under Condition 8 of Schedule 7;
- an incident report under Condition 6 of Schedule 7;
- an annual review under Condition 3 of Schedule 7; and

if necessary, revised to the satisfaction of the Director-General (now Secretary) of DP&E, to ensure the plan is updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

This BFMP will also be reviewed within three months of approval of any Project modification and if necessary, revised to the satisfaction of the DP&E.

The revision status of this plan is indicated on the title page of each copy of the Longwalls 301-303 BFMP-SYDTRAINS. The distribution register for controlled copies of the Longwalls 301-303 BFMP-SYDTRAINS is described in Section 2.1.

Revisions to any documents listed within this Longwalls 301-303 BFMP-SYDTRAINS will not necessarily constitute a revision of this document.

2.1 DISTRIBUTION REGISTER

In accordance with Condition 10, Schedule 7 ‘Access to Information’, Metropolitan Coal will make the Longwalls 301-303 BFMP-SYDTRAINS publicly available on the Peabody website. A hard copy of the Longwalls 301-303 BFMP-SYDTRAINS will also be maintained at the Metropolitan Coal site.

Metropolitan Coal recognises that various regulators have different distribution requirements, both in relation to whom documents should be sent and in what format. An Environmental Management Plan and Monitoring Program Distribution Register has been established in consultation with the relevant agencies and infrastructure owners that indicates:

- to whom the Metropolitan Coal plans and programs, such as the Longwalls 301-303 BFMP-SYDTRAINS, will be distributed;
- the format (i.e. electronic or hard copy) of distribution; and
- the format of revision notification.

Metropolitan Coal will make the Distribution Register publicly available on the Peabody website.

Metropolitan Coal will be responsible for maintaining the Distribution Register and for ensuring that the notification of revisions is sent by email or post as appropriate.

In addition, Metropolitan Coal employees with local computer network access will be able to view the controlled electronic version of this Longwalls 301-303 BFMP-SYDTRAINS on the Metropolitan Coal local area network. Metropolitan Coal will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on the Metropolitan Coal computer system and Peabody website.

3 STATUTORY REQUIREMENTS

Metropolitan Coal's statutory obligations are contained in:

(i) the conditions of the Project Approval;

(ii) relevant licences and permits, including conditions attached to mining leases; and

(iii) other relevant legislation.

These are described below.

3.1 EP&A ACT APPROVAL

Condition 6(f), Schedule 3 of the Project Approval requires the preparation of a BFMP as a component of Extraction Plan(s) for second workings. Project Approval Condition 6(f), Schedule 3, states:

> ***SECOND WORKINGS***
>
> ***Extraction Plan***
>
> *6. The Proponent shall prepare and implement an Extraction Plan for all second workings in the mining area to the satisfaction of the Director-General. This plan must:*
>
> *…*
>
> *(f) include a:*
>
> *…*
>
> - *Built Features Management Plan, which has been prepared in consultation with the owner of the relevant feature, to manage the potential environmental consequences of the Extraction Plan on any built features;*
>
> *…*

In addition, Condition 2, Schedule 7 and Condition 7, Schedule 3 of the Project Approval outline management plan requirements that are applicable to the preparation of the Longwalls 301-303 BFMP-SYDTRAINS. Table 1 indicates where each component of the conditions is addressed within this Longwalls 301-303 BFMP-SYDTRAINS.

Table 1
Management Plan Requirements

Project Approval Condition	Longwalls 301-303 BFMP-SYDTRAINS Section
Condition 2 of Schedule 7	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 6
b) a description of:	
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3
• any relevant limits or performance measures/criteria;	Section 5
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 5
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 7, 8, 9 and 10
d) a program to monitor and report on the:	Sections 7, 8 and 12
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 9 and Appendix 3
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 7 and 12
g) a protocol for managing and reporting any;	
• incidents;	Section 13
• complaints;	Section 14
• non-compliances with statutory requirements; and	Section 15
• exceedances of the impact assessment criteria and/or performance criteria; and	Section 9 and Appendix 3
h) a protocol for periodic review of the plan.	Section 2
Condition 7 of Schedule 3	
7. In addition to the standard requirements for management plans (see condition 2 of schedule 7), the Proponent shall ensure that the management plans required under condition 6(f) above include:	
a) a program to collect sufficient baseline data for future Extraction Plans;	Section 11
b) a revised assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Section 4
c) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 8
d) a contingency plan that expressly provides for adaptive management.	Section 9 and Appendix 3

3.2 LICENCES, PERMITS AND LEASES

In addition to the Project Approval, all activities at or in association with Metropolitan Coal will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending issue:

- The conditions of mining leases issued by the DRG (Division of Resources and Geoscience, previously Division of Resources and Energy [DRE]), under the NSW Mining Act, 1992 (e.g. Consolidated Coal Lease [CCL] 703, Mining Lease [ML] 1610, ML 1702, Coal Lease [CL] 379 and Mining Purpose Lease [MPL] 320).

- The Metropolitan Coal Mining Operations Plan 1 October 2012 to 30 September 2019 approved by the DRG.

- The conditions of Environment Protection Licence (EPL) No. 767 issued by the NSW Environment Protection Authority (EPA) under the NSW Protection of the Environment Operations Act, 1997. Revision of the EPL will be required prior to the commencement of Metropolitan Coal activities that differ from those currently licensed.

- The prescribed conditions of specific surface access leases within CCL 703 for the installation of surface facilities as required.

- Water Access Licences (WALs) issued by the NSW Department of Primary Industries – Water (DPI Water) (now the Department of Industry – Water) under the NSW Water Management Act, 2000, including WAL 36475 under the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 and WAL 25410 under the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011.

- Mining and workplace health and safety related approvals granted by the NSW Resources Regulator and WorkCover NSW.

- Supplementary approvals obtained from WaterNSW (previously the Sydney Catchment Authority [SCA]) for surface activities within the Woronora Special Area (e.g. fire road maintenance activities).

3.3 OTHER LEGISLATION

Metropolitan Coal will conduct the Project consistent with the Project Approval and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

The following Acts may be applicable to the conduct of the Project (Helensburgh Coal Pty Ltd [HCPL], 2008):

- *Biodiversity Conservation Act, 2016;*
- *Contaminated Land Management Act, 1997;*
- *Crown Lands Act, 1989;*
- *Dams Safety Act, 1978;*
- *Dangerous Goods (Road and Rail Transport) Act, 2008;*
- *Energy and Utilities Administration Act, 1987;*

- *Fisheries Management Act, 1994;*
- *Mining Act, 1992;*
- *Noxious Weeds Act, 1993;*
- *Protection of the Environment Operations Act, 1997;*
- *Rail Safety (Adoption of National Law) Act, 2012;*
- *Roads Act, 1993;*
- *Water Act, 1912;*
- *Water Management Act, 2000;*
- *Water NSW Act, 2014;*
- *Work Health and Safety Act, 2011; and*
- *Work Health and Safety (Mines and Petroleum Sites) Act, 2013.*

Relevant licences or approvals required under these Acts will be obtained as required.

4 REVISED ASSESSMENT OF POTENTIAL ENVIRONMENTAL CONSEQUENCES

4.1 LONGWALLS 301-303 EXTRACTION LAYOUT

Longwalls 301-303 and the area of land within 600 metres (m) of Longwalls 301-303 secondary extraction are shown on Figures 2 and 3. Longwall extraction occurs from north to south. The longwall layout includes 163 m panel widths (void) with 45 m pillars (solid).

The provisional extraction schedule for Longwalls 301-303 is provided in Table 2.

Table 2
Provisional Extraction Schedule

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
301	June 2017	6 months	February 2018
302	March 2018	7 months	October 2018
303	November 2018	7 months	May 2019

The layout for Longwalls 301-303 (i.e. 163 m panel widths [void] and 45 m pillars [solid]) will be trialled to build on the experience and dataset obtained from Longwalls 20-27. The outcomes of the trial will be used to inform the potential for a similar mine layout to be applied to the next Extraction Plan (i.e. Longwall 304 onwards). The assessment of the trial longwall layout is described in Section 11.1.

The future Extraction Plans will consider the cumulative subsidence effects, subsidence impacts and/or environmental consequences. Note that the total cumulative predicted subsidence effects, subsidence impacts and/or environmental consequences at the completion of the Project are considered in the Metropolitan Coal Project Environmental Assessment (Project EA) (HCPL, 2008) and the Preferred Project Report (HCPL, 2009).

4.1.1 Sydney Trains Assets

Figure 5 illustrates the Sydney Trains assets in relation to Longwalls 301-303 extraction. The assets include:

- Illawarra Railway Line; and
- Telecommunications Tower (and Compound).

The shortest distance from the proposed Longwalls 301-303 to the Illawarra Railway Line is approximately 1,400 m. The telecommunications tower (and compound) is located above the chain pillar between Longwall 302 and Longwall 303.

4.2 REVISED SUBSIDENCE AND IMPACT PREDICTIONS

4.2.1 Revised Subsidence Predictions

Subsidence predictions for Longwalls 20-44 in relation to the Sydney Trains assets was conducted by MSEC (2008) as part of the Metropolitan Coal Project EA. MSEC (2008) includes a table summarising the incremental systematic subsidence parameters for the extraction of each longwall from Longwalls 20-44. These include:

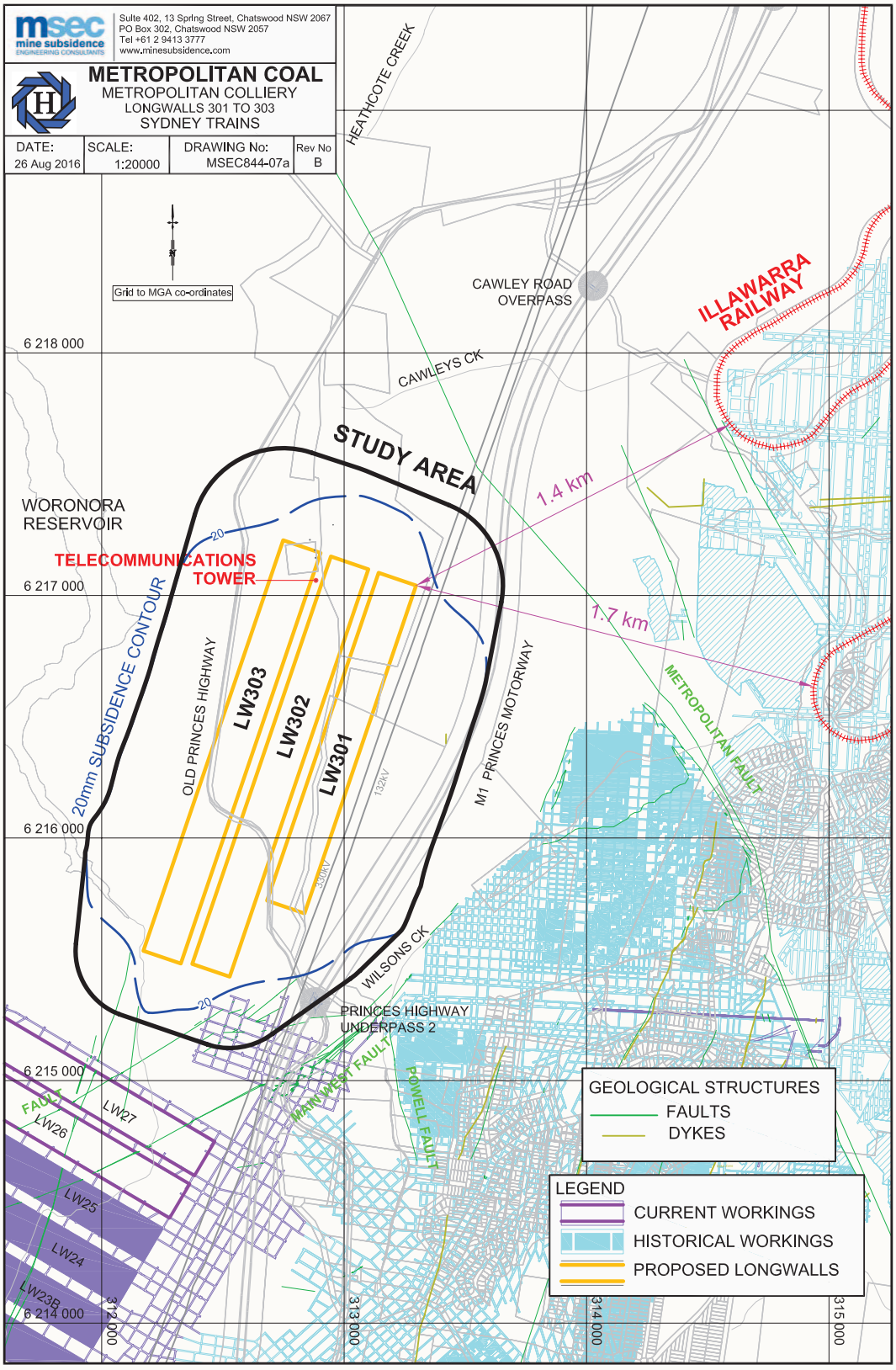
- maximum predicted incremental subsidence (vertical movement);
- maximum predicted incremental tilt along alignment;
- maximum predicted incremental tilt across alignment;
- maximum predicted incremental tensile strain; and
- maximum predicted incremental compressive strain.

Revised subsidence and impact predictions for the extraction of Longwalls 301-303 on Sydney Trains assets were conducted by MSEC and reported in MSEC (2016) (Appendix 1).

In relation to subsidence predictions and potential impacts, MSEC (2016) make the following conclusions:

- The Illawarra Railway is located more than 1.4 kilometres from the longwalls. While the railway could experience low level far-field horizontal movements, the associated tilts, curvatures or strains are not expected to be measurable.
- It is unlikely that the Illawarra Railway and associated infrastructure would experience adverse impacts as a result of Longwalls 301-303.
- The magnitude of tilt predicted at the telecommunications tower (and compound) is very small (less than 1%) and is unlikely to be adversely impacted.
- Based on the predicted conventional curvatures and strains, the building enclosure could potentially experience adverse impacts such as cracking of the brickwork or sticky entry door.
- It is expected that the building enclosure would however remain in safe and serviceable conditions during and after mining.

It is important to note that the above predictions and conclusions are for total subsidence after extraction of the three Longwalls 301, 302 and 303. Subsidence effects predicted for the telecommunications tower and compound during mining of Longwall 301 alone are minimal to nil as the total subsidence profile does not develop until after commencement of Longwall 302 and Longwall 303.



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Sydney Trains Assets

Figure 5

4.2.2 Risk Assessment Meeting

In accordance with the draft *Guidelines for the Preparation of Extraction Plans* (DP&E and DRE, 2014) a risk assessment meeting was held on 18 August 2016. Attendees at the risk assessment meeting included representatives from Sydney Trains, MSEC, Resource Strategies (on behalf of Metropolitan Coal) and Axys Consulting (risk assessment facilitator).

The investigation and analysis methods used during the risk assessment review included:

- preliminary identification of Sydney Trains assets[1];
- review of the revised subsidence predictions and potential impacts on Sydney Trains assets (including consideration of past experience in the Southern Coalfield); and
- development of a preliminary monitoring plan.

A number of risk control measures and procedures relevant to the Sydney Trains assets have been identified which considered the extraction of coal beneath (communications tower and compound) and at distance from (rail line) the assets, and are summarised as follows:

Baseline Data / Validation

1. Carry out an audit on the Sydney Trains communications compound within the Study area, as agreed with Sydney Trains, and document the current condition.
2. Obtain information from Sydney Trains Structural Engineering Group of the footing details of the communication tower.
3. Metropolitan Coal to conduct a review of footing details and provide outcomes to Sydney Trains Structural Engineering Group.
4. Obtain information from Sydney Trains Structural Engineering Group on the potential effect of mining under the communication tower and confirm within the limitation of the current tower services.
5. Obtain from relevant personnel at Sydney Trains (e.g. communications department) if the predicted tilts would have any measurable impact on services supplied by the communications tower.
6. Provide Sydney Trains with additional information on the possible long-term impact of underground mining.
7. Metropolitan Coal to consider if a dilapidation audit of Illawarra Railway, culvert, guard railings, marker posts and signage is required.

Management / Monitoring / Response Measures

8. Include in the BFMP a schedule of times/frequency of communication with Sydney Trains for the status of mining of Longwalls 301-303.
9. Develop a Trigger Action Response Plan (TARP) and include a trigger for rail line conditions that may need to be actioned by Sydney Trains.
10. Include in the BFMP contact information from Sydney Trains for liaison during implementation of management measures and contingency planning.

[1] Since the risk assessment meeting was held, Axicom confirmed that the telecommunication tower and compound (initially considered during the Optus risk assessment) is an Axicom asset which is managed separately in the BFMP-Axicom.

Contingency Planning

11. Metropolitan Coal to arrange further consultation with relevant personnel at Sydney Trains (e.g. communications department) if there is an alternative communication system that can be implemented if the main communication was to become unserviceable.

Metropolitan Coal considers all risk control measures and procedures to be feasible to manage all identified risks.

The proposed risk control measures and procedures have been incorporated where relevant in this BFMP and the program for implementation is summarised in Table 3.

Table 3
Program for Implementation of Proposed Risk Control Measures and Procedures

	Risk Control Measure / Procedure	BFMP Section	Timing
Baseline Data / Validation			
1	Carry out an audit on the Sydney Trains communications compound within the Study area	Section 6	Complete
2	Obtain information from Sydney Trains Structural Engineering Group of the footing details of the communication tower	Section 6	Complete
3	Conduct a review of footing details and provide outcomes to Sydney Trains Structural Engineering Group	Section 6	Complete
4	Obtain information from Sydney Trains Structural Engineering Group on the potential effect of mining under the communication tower and confirm within the limitation of the current Tower services	Section 6	Complete
5	Obtain from relevant personnel at Sydney Trains (e.g. communications department) if the predicted tilts would have any measurable impact on services supplied by the communications tower	Section 6	Complete
6	Provide Sydney Trains with additional information on the possible long-term impact of underground mining	Section 4.3 / Appendix 1	Complete
7	Consider if a dilapidation audit of Illawarra Railway, culvert, guard railings, marker posts and signage is required	Section 4.3	Complete
Management / Monitoring / Response Measures			
8	Include a schedule of times/frequency of communication with Sydney Trains for the status of mining of Longwalls 301-303 in the BFMP	Sections 7 and 10 / Table 2	Complete
9	Include in the TARP a trigger to rail conditions that may need to be actioned by Sydney Trains	Section 10 / Table 7	Complete
10	Include contact information from Sydney Trains for liaison in the BFMP	Section 6.1	Complete
Contingency Planning			
11	Arrange further consultation with relevant personnel (e.g. communications department) for the communications tower for consideration of specific measures (e.g. alternative communication system) and contingency planning	Section 9.1	Complete

4.3 LONG-TERM STABILITY OF OLD MINE WORKINGS

Old (historic) underground mine workings are present beneath and in the vicinity of the Illawarra Railway as shown on Figure 5. There are no old (historic) underground mine workings directly above or below Longwalls 301-303 nor within the relevant Study Area (Figure 5).

An assessment of subsidence above old mine workings has previously been undertaken and presented at the 8th Triennial Conference on Mine Subsidence in 2011 in a paper titled "*An Analysis of Long Term Subsidence at Metropolitan Colliery*". A copy of the paper is provided in Appendix 1. Based on data covering a 14 year period of monitoring, the assessment concluded that the goaf/chain pillar system (similar to Longwalls 301-303) was in a longer term stable condition.

A typical stratigraphic section of the geology at the Metropolitan Colliery is provided in Appendix 1. The section is characteristic of the NSW Southern Coalfield with deep overburden of sedimentary rocks comprising Hawkesbury Sandstone at the surface overlying the Narrabeen Group. There is no Wianamatta Shale present at the surface at the Metropolitan Colliery.

Detailed groundwater modelling and assessment of underground mining at the Metropolitan Colliery has been undertaken including consideration of the long term recovery and flooding of old mine workings. The Groundwater Assessment (Heritage Computing, 2008) is available on the Peabody website.

At more than 1.4 km from Longwalls 301-303, it is considered unlikely that the Illawarra Railway and associated infrastructure would experience adverse impacts from subsidence of old workings as a result of extraction of Longwalls 301-303. At more than 1.4km the Illawarra Railway is not expected to experience measurable conventional vertical subsidence, tilts or curvatures. While the railway could experience low level far-field horizontal movements, the low-level movements comprise a large proportion of survey tolerance and are not expected to measurable. Culverts are located at the Illawarra Railway crossing at Cawleys and Wilsons Creeks. The valley related movements at these creek crossings are predicted to be less than 5 mm upsidence and less than 5 mm closure. The strains associated with these low levels of valley related movements are not expected to be measurable. Therefore, a dilapidation audit of the Illawarra Railway is not proposed to be undertaken for Longwalls 301-303.

4.4 UNDERGROUND BLAST VIBRATION IMPACTS

Use of explosives is not required for existing or proposed general underground coal mining. Occasionally, geological structures (e.g. dykes) may be encountered underground that have to be broken up using very low mass explosives. This underground blasting would be undertaken at significant depth (e.g. greater than 400 m below the surface).

Ground vibration and airblast levels which cause human discomfort are generally lower than the recommended structural damage limits. Therefore, compliance with the lowest applicable human comfort criteria ensures that the potential to cause structural damage is minimal. Based on the assessment results presented in the Metropolitan Coal Project Noise Impact Assessment (Heggies, 2008), ground vibration levels are predicted to meet the most stringent night-time criteria of 1 mm/s at a distance of 500 m from the blast site. As blasting is conducted at least 400 m below the surface, vibration impacts are likely to be minimal (which is consistent with the existing Metropolitan Colliery blasting practices and experience).

5 PERFORMANCE MEASURES AND INDICATORS

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3. The subsidence impact performance measure specified in Table 1 of Condition 1, Schedule 3 in relation to built features is:

Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.

The performance indicators proposed to ensure that the above performance measure is achieved include:

- no defects or deformation of the Illawarra Railway Line due to mining; and
- the structural integrity of the telecommunications tower (and compound) is maintained.

Section 7 of this Longwalls 301-303 BFMP-SYDTRAINS describes the monitoring that will be conducted to assess the Project against the above performance measure. Sections 8 and 9 of this Longwalls 301-303 BFMP-SYDTRAINS provides management measures and a Contingency Plan in the event the performance indicators or performance measure is exceeded.

6 BASELINE DATA

An audit on the Sydney Trains telecommunications compound was conducted within the Study area prior to extraction of Longwall 302 to document the current condition. If available, information from Sydney Trains Structural Engineering Group of the footing details of the telecommunication tower will be obtained, and review outcomes provided to Sydney Trains to confirm within the limitation of the current tower services.

The telecommunications tower and compound are shown on Plates 1 and 2.

Plates 1 and 2 – Telecommunications Tower and Compound (Source: MSEC, 2016)

As described in Section 4.2.1 and Appendix 1, the magnitude of tilt predicted at the telecommunications tower (and compound) is very small (0.35% or 0.2 degrees).

6.1 KEY CONTACTS LIST

The list of key contacts for Peabody and Sydney Trains during the development and implementation of this BFMP are provided in Table 4.

Table 4
List of Key Contacts

Company / Agency	Peabody (Metropolitan Coal)	Sydney Trains
Position	Manager – Technical Services	Program Manager Capital & External Party Works Engineering & Maintenance
Name	Jon Degotardi	Joe O'Brien
Contact	Control Room 24hr 02 4294 7333	131 500

7 MONITORING

A monitoring program has been implemented to monitor the impacts of the Project in consultation with Sydney Trains. Table 5 summarises the Longwalls 301-303 BFMP-SYDTRAINS monitoring components.

It is understood that track inspections occur approximately two times per week in accordance with the Sydney Trains maintenance program.

Where relevant, inspections of subsidence impacts will include photographic record of the impacts for comparison with baseline photographic records.

Sydney Trains or their delegates will conduct the various visual inspections. Metropolitan Coal will be notified of the timing of inspections and accompany Sydney Trains or delegates if considered necessary. All personnel will complete necessary inductions or orientation relevant to the tasks required.

The frequency of monitoring will be reviewed either:

- in accordance with the Annual Review outlined in Section 12; or
- if triggered as a component of the Contingency Plan as outlined in Section 9 of this Longwalls 301-303 BFMP-SYDTRAINS.

Table 5
Longwalls 301-303 BFMP-SYDTRAINS Monitoring Program Overview

Program	Aspect	Method	How	Why	Timing	Frequency
Baseline	Illawarra Railway	Survey	M1 Princes Motorway subsidence line points at approximately 20 m spacing	Establish base condition	Prior to Longwall 301 extraction	Once
	Railway Culverts Wilsons Creek Cawley Creek	Condition assessment	Visual Inspection by structural engineer	Establish base condition	Prior to Longwall 301 extraction	Once
		Survey	Relative survey of fixed survey points inside each culvert	Establish base condition	Prior to Longwall 301 extraction	Once
	Telecommunications Tower (and compound)	Survey	Adjacent optic / water subsidence line points at approximately 20 m spacing	Establish base conditions – to track general land movement*	Prior to Longwall 301 extraction	Once
			Survey marks at Tower	Establish base conditions – to track any 3D movement*	Prior to Longwall 302 extraction	Once
		Condition assessment (including infrastructure, services and cables)		Establish base condition	Prior to Longwall 302 extraction	Once
	Access roads/tracks	Visual inspection (including notes on general condition of access roads/tracks)		Establish base condition	Prior to Longwall 302 extraction	Once

Table 5 (Continued)
Longwalls 301-303 BFMP-SYDTRAINS Monitoring Program Overview

Program	Aspect	Method	How	Why	Timing	Frequency
During Mining	Illawarra Railway	Survey	M1 Princes Motorway subsidence line points at approximately 20 m spacing	Monitor subsidence effects during mining	At the completion of each longwall	Once per longwall
		Remote Continuous Survey with GNSS Telemetry	Valley closure monitoring of Wilsons Creek and Cawley Creek	Monitor for signs of any far field subsidence during mining	Commencing prior to LW303	Daily measurement
		Visual inspection (Sydney Trains)	Identify evidence of subsidence effects or any defects or deformation of the rail line and associated infrastructure		As per Sydney Trains inspection program	Two times per week
	Railway Culverts	Survey	Culvert relative monitoring of brick culverts 15 survey points at both Wilsons Creek and Cawley Creek		Mid panel and end of panel surveys	Two times per longwall
		Condition assessment	Visual Inspection by structural engineer for signs of change (Metropolitan organised)		End of Panel	Once per longwall
	Telecommunications Tower (and compound)	Survey	Adjacent optic / water subsidence line points at approximately 20 m spacing	Monitor subsidence effects during mining	On commencement of LW302 and LW303	Weekly until effects of subsidence no longer detectable
		Survey Tower monitoring	Survey 4 x ground monitoring points Survey 4 x tower leg mounted prisms.	Monitor any structural movements as per Tower TARP	On commencement of LW302 and LW303	Weekly until effects of subsidence no longer detectable
		Visual inspection (for evidence of subsidence effects on compound – movement of building/cables entering compounds)		Monitor structural integrity of compounds and cable entries	On commencement of LW302 and LW303	Weekly until effects of subsidence no longer detectable
	Access roads/tracks	Visual inspection (including notes on general condition of access roads/tracks)		Monitor for surface cracks, buckling and general safety	On commencement of LW302 and LW303	Weekly until effects of subsidence no longer detectable
					As per Longwalls 301-303 LMP	

Table 5 (Continued)
Longwalls 301-303 BFMP-SYDTRAINS Monitoring Program Overview

Program	Aspect	Method	How	Why	Timing	Frequency
Post Mining	Illawarra Railway	Visual inspection (Sydney Trains)		Validation	Post LW303	Once
	Railway Culverts	Visual Inspection by structural engineer (Metropolitan)		Determine level of impact of mining (if any)	Within 3 months of the completion Longwall 303	Once
		Survey culvert, relative monitoring, 15 survey points at both Wilsons Creek and Cawley Creek		Determine level of impact of mining (if any)	Within 3 months of the completion Longwall 303	Once
	Telecommunications Tower (and compound)	Condition assessment (including infrastructure, services and cables)		Determine level of impact of mining (if any)	Within 3 months of the completion Longwall 303	Once
	Access roads/tracks	Visual inspection (including notes on general condition of access roads/tracks)		Determine level of impact of mining (if any)	Within 3 months of the completion Longwall 303	Once

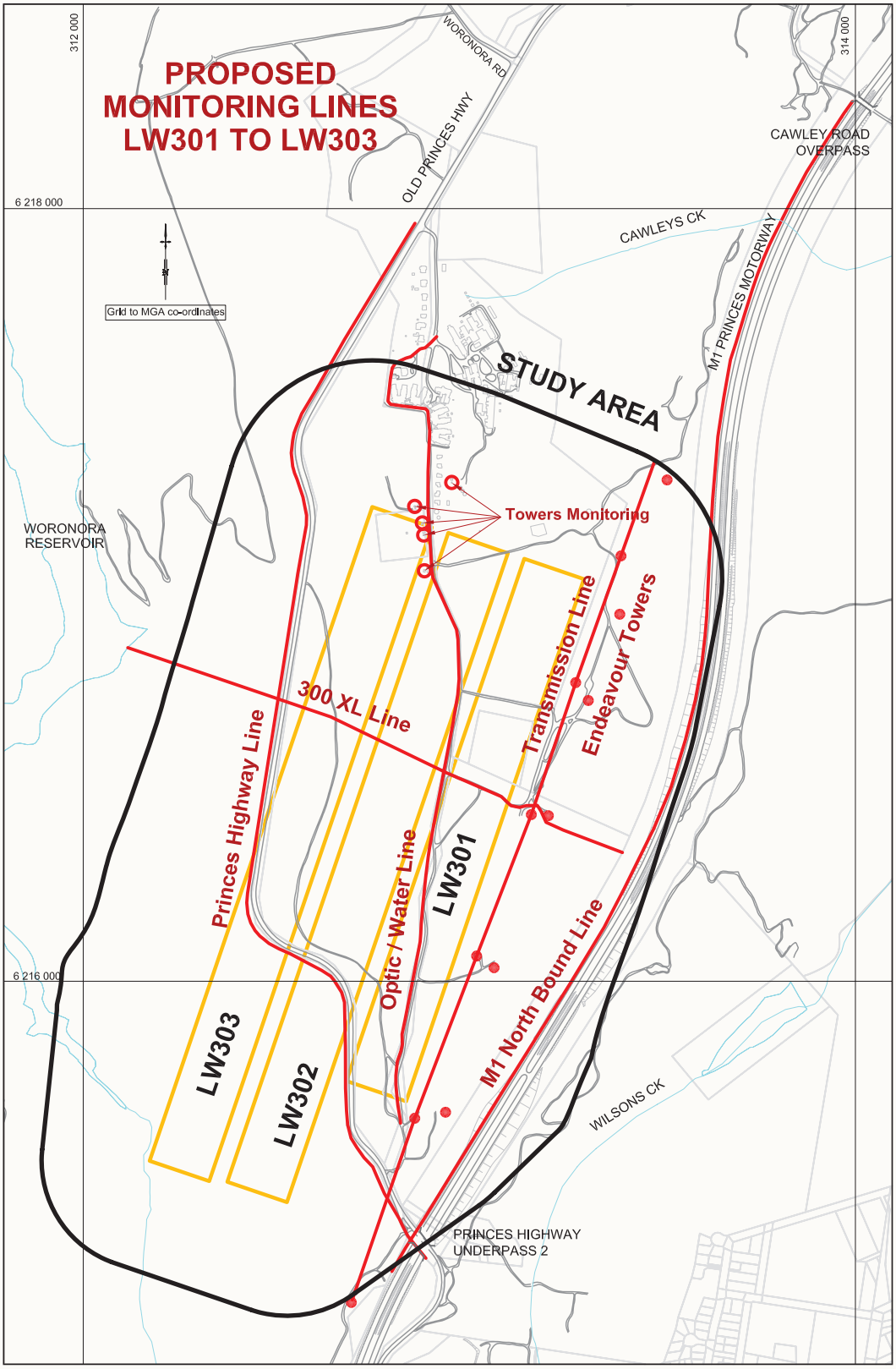
* Subsidence effects predicted for the telecommunications tower (and compound) during mining of Longwall 301 alone are minimal to nil as the total subsidence profile does not develop until after commencement of Longwall 302.

7.1 SUBSIDENCE PARAMETERS

Subsidence parameters (i.e. subsidence, tilt, tensile strain, compressive strain) associated with mining will be measured in accordance with the Longwalls 301-303 Subsidence Monitoring Program (Figure 6).

In summary, surveys will be conducted to measure subsidence movements in three dimensions using a total station survey instrument. Subsidence movements (i.e. subsidence, tilt, tensile strain and compressive strain) will be measured along subsidence lines that have been positioned across the general landscape.

Subsidence parameters specific to the Sydney Trains assets include the survey line along the M1 Princes Motorway (located between the longwalls and Illawarra Railway) and the optical fibre and water lines (in the vicinity of the telecommunications tower and compound). These surveys will monitor the general movement about the longwalls and the data will allow evaluation of the likely ground movements about the railway and telecommunications tower and compound (by comparison between measured and predicted movements). Monitoring of towers will also be undertaken as shown on Figure 6.



MET-15-10_301-303 EP BHMP_003A

Resource Strategies

Peabody ENERGY

METROPOLITAN COAL

Longwalls 301-303 Subsidence Monitoring
Layout

Figure 6

7.2 SUBSIDENCE IMPACTS

7.2.1 Rail Line

Visual inspections are conducted in accordance with the Sydney Trains inspection plans for the area. This generally includes:

- track condition;
- structures condition;
- drainage changes; and
- culvert condition.

If any defects or deformation of the rail line (as a result of mining activities associated with Longwalls 301-303) are recorded by Sydney Trains and confirmed with Metropolitan Coal, the information will be recorded in the Built Features Management Plan – Subsidence Impact Register (Appendix 2) and reported in accordance with the Project Approval conditions. Monitoring for far field subsidence at the rail culverts and Wilsons Creek Valley and Cawley Creek Valley by Metropolitan Coal as described in Table 5.

7.2.2 Telecommunications Tower and Compound

Visual inspections of the telecommunications tower and compound will be conducted in consultation with the Sydney Trains. Monitoring of towers will be conducted by Metropolitan Coal as described in Table 5.

7.3 ENVIRONMENTAL CONSEQUENCES

Metropolitan Coal and Sydney Trains will compare the results of the subsidence impact monitoring against the built features performance indicators and performance measure. In the event the observed subsidence impacts exceed the performance indicators or performance measure, Metropolitan Coal and Sydney Trains will assess the consequences of the exceedance in accordance with the Contingency Plan described in Section 9.

8 MANAGEMENT MEASURES

A number of potential management measures in relation to the rail line are considered to be applicable, if required. These may include:

- speed restriction of trains; and
- minor repair of track.

Potential management measures for the telecommunications tower and compound include pre-mining bracing and/or changing splice plates to relieve any mining induced stress and/or implementation of building maintenance techniques.

Follow-up inspections will be conducted to assess the effectiveness of the management measures implemented and the requirement for any additional management measures.

Management measures will be reported in the Annual Review (Section 12).

9 CONTINGENCY PLAN

In the event the subsidence impacts observed exceed the performance indicators or measure detailed in Section 5 of this BFMP, Metropolitan Coal will implement the following Contingency Plan (Appendix 3):

- The observation will be reported to the Manager - Technical Services within 24 hours.
- The observation will be recorded in the Built Features Management Plan - Subsidence Impact Register (Appendix 2) consistent with the monitoring program described in Section 7 of this Longwalls 301-303 BFMP-SYDTRAINS.
- Metropolitan Coal will report any exceedance of the performance indicators or performance measure to the DP&E and Sydney Trains as soon as practicable after Metropolitan Coal becomes aware of the exceedance.
- Metropolitan Coal will assess public safety and where appropriate implement safety measures in accordance with the Metropolitan Coal Longwalls 301-303 Public Safety Management Plan;
- Metropolitan Coal will conduct an investigation to evaluate the potential contributing factors. The investigation will:
  - include the re-survey of relevant subsidence monitoring lines;
  - compare and critically analyse measured versus predicted subsidence parameters;
  - review measured subsidence parameters against the observed impact; and
  - review the subsidence monitoring program and update the program where appropriate.
- The course of action with respect to the identified impact(s), in consultation with specialists and relevant agencies, will include:
  - a program to review the effectiveness of the contingency measures; and
  - consideration of adaptive management.

  Contingency measures are provided in Section 9.1.
- Metropolitan Coal will submit the proposed course of action to the DP&E for approval.
- Metropolitan Coal will implement the approved course of action to the satisfaction of the DP&E.

In accordance with Condition 6, Schedule 6 of the Project Approval, Metropolitan Coal will provide a suitable offset to compensate for the impact to the satisfaction of the Director-General (now Secretary) of DP&E if either the contingency measures implemented by Metropolitan Coal have failed to remediate the impact or the Director-General (now Secretary) determines that it is not reasonable or feasible to remediate the impact.

Metropolitan Coal will comply with the NSW Coal Mine Subsidence Compensation Bill 2017 in the event that property damages occur as a result of mining Longwalls 301-303.

9.1 CONTINGENCY MEASURES

Contingency measures will be developed in consideration of the specific circumstances of the feature (e.g. the location, nature and extent of the impact, and the assessment of consequences).

Contingency measures that could be considered in the event the performance measure for the rail line and telecommunications tower and compound is exceeded are summarised in Table 6. The decision trees for the contingency measures are shown in Appendix 3.

Table 6
Contingency Measures – Rail Line, Telecommunications Tower and Compound

Environmental Consequence	Contingency Measures	
	Measure	**Description**
Impact on:		
Rail Line	Replace lengths of track	• Temporary suspension of rail traffic and replacement of affected tracks.
Telecommunications Tower	Repair of tower	• Additional bracing and/or strengthening members to the frame. • Replace tower leg splice plates with wider aperture plates to remove and detected mining induced stress. • Replacement of tower.
Building Compound	Repair of building	• Building maintenance techniques. • Replacement of building compound.

10 TARP – MANAGEMENT TOOL

The framework for the various components of the Longwalls 301-303 BFMP-SYDTRAINS are summarised in the Longwalls 301-303 BFMP-SYDTRAINS TARP shown in Tables 7 and 8. The Longwalls 301-303 BFMP-SYDTRAINS TARPs illustrates how the various predicted subsidence impacts, monitoring components, performance measures, and responsibilities are structured to achieve compliance with the relevant statutory requirements, and the framework for management and contingency actions.

The TARP comprises:

- baseline conditions;
- predicted subsidence impacts;
- trigger levels from monitoring to assess performance; and
- triggers that flag implementation of contingency measures.

The TARP system provides a simple and transparent snapshot of the monitoring of performance and the implementation of management and/or contingency measures.

Table 7
Trigger Action Response Plan – Illawarra Railway Line

SYDNEY TRAINS Illawarra Railway Line		
SYDNEY TRAINS Illawarra Railway Line	*Risk: Subsidence effect on rail infrastructure resulting in impact to structural integrity and services.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 1 - Normal **Expected subsidence conditions (at M1 Princes Motorway)**	
	Subsidence • less than 50 mm Absolute Horizontal Movements • less than 115 mm Strain (Tensile or Compressive) • less than 0.4 mm/m Valley Closure at Railway • equal to or less than 20 mm closure averaged over 7-day period	**Normal Operations** • Illawarra Railway Line is safe and serviceable. • Negligible impact to infrastructure and no impact to rail services. • Continue monitoring activities as planned.
	Level 2 - Monitor **Subsidence elevated up to +15% of predicted (at M1 Princes Motorway) but rail service condition normal**	
	Subsidence • between 50 and 60 mm Absolute Horizontal Movements • between 115 and 130 mm Strain • between 0.4 and 0.5 mm/m Valley Closure at Railway • greater than 20 mm closure averaged over 7-day period	**Continue operations but report on subsidence anomaly** • Illawarra Railway Line is safe and serviceable. • Negligible impact to infrastructure and no impact to rail services. **Metropolitan Coal** • Immediately resurvey subsidence line in affected area to confirm results. • Engage subsidence expert to assess results. • Confirm results are consistent with adjacent subsidence lines. • Compare and critically analyse measured versus predicted subsidence. • Inform and provide report to Sydney Trains of subsidence results. • Collaboratively share information with Sydney Trains to monitor situation. **Sydney Trains** • Assess information provided by Metropolitan Coal. • Continue to conduct twice weekly inspection program.

Table 7 (Continued)
Trigger Action Response Plan – Illawarra Railway Line

SYDNEY TRAINS Illawarra Railway Line		
SYDNEY TRAINS Illawarra Railway Line	*Risk: Subsidence effect on rail infrastructure resulting in impact to structural integrity and services.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 3 - Cautionary **Anomalous service condition detected or Subsidence beyond +15% of predicted (at M1 Princes Motorway)**	
	Subsidence • greater than 60 mm Absolute Horizontal Movements • greater than 130 mm Strain • greater than 0.5 mm/m Observable subsidence ground deformations at/near railway line Defects or deformation of the rail line or associated structures (e.g. culverts, drainage)	**Investigate & Resolve** • Illawarra Railway Line is safe and serviceable. • Indication of impact to rail infrastructure. **Metropolitan Coal** • Steps as per Level 2 event, plus: ○ Inform Sydney Trains and NSW Principal Subsidence Engineer of subsidence results (immediately following awareness of trigger). ○ Increase frequency of subsidence line surveys to weekly in affected area. ○ In conjunction with Sydney Trains identify impact location and have Sydney Trains assess rail condition. ○ Review the subsidence monitoring program and update the program where appropriate. ○ Provide report on issue to both Sydney Trains and DP&E. **Sydney Trains** • Inform Metropolitan Coal of defects or deformations observed during twice weekly monitoring inspections. • In conjunction with Metropolitan Coal identify impact location, inspect rail infrastructure, assess condition and determine appropriate response (e.g. greater monitoring data or frequency, or schedule maintenance on the rail infrastructure). • Make determination if other measures necessary to avoid further impact.
	Level 4 – Restoration **Rail Service Outage**	
	Service Outage or Fault Occurs	**Implement Contingency Plan** • As per BFMP Section 9 and Appendix 3. **Metropolitan Coal** • As per Level 3 event, plus: ○ General Manager to be involved in all decision making processes. ○ Assess public safety implications and where appropriate implement safety measures in accordance with Metropolitan Coal Longwalls 301-303 Public Safety Management Plan. ○ Report exceedance of the performance measure or indicators to the DP&E and Sydney Trains as soon as practicable. ○ Update the 'Built Features Management Plan – Subsidence Impact Register'. ○ Investigate circumstances of the fault and determine requirement for adaptive management of mining operations prior to future operations. **Sydney Trains** • As per Level 3 event, plus: ○ Sydney Trains to enact emergency measures (e.g. temporary suspension of rail traffic) and determine restoration works required. ○ Complete restoration works. ○ Work in conjunction with Metropolitan Coal to investigate root cause of incident and determine appropriate future control measures.

Table 8
Trigger Action Response Plan – Telecommunications Tower and Compound

SYDNEY TRAINS – Telecommunications Tower (and Compound)		
SYDNEY TRAINS Telecommunications Tower (and Compound)	*Risk: Subsidence effect on tower or compound resulting in impact to structural integrity.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 1 - Normal **Expected subsidence conditions**	
	For LW 301-302 Subsidence • less than 125 mm Tilt • less than 1.5 mm/m Strain • 1.6 mm/m Differential vertical leg movement • less than 1.0 mm Differential horizontal leg movement • less than 5.4 mm For LW 303 Subsidence • less than 225 mm Tilt • less than 3.0 mm/m Strain • 1.1 mm/m Differential vertical leg movement • less than 1.0 mm Differential horizontal leg movement • less than 5.4 mm	**<u>Normal Operations</u>** • Telecommunications tower (and building compound) is safe and serviceable. • Negligible impact to telecommunications tower (and compound). • Continue monitoring activities as planned. • Survey data within predictions.

Table 8 (Continued)
Trigger Action Response Plan – Telecommunications Tower and Compound

SYDNEY TRAINS – Telecommunications Tower (and Compound)		
SYDNEY TRAINS Telecommunications Tower (and Compound)	*Risk: Subsidence effect on tower or compound resulting in impact to structural integrity.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 2 - Monitor **Subsidence elevated up to +15% of predicted but service condition normal**	
	Subsidence For LW 301-302 • between 125 and 145 mm Differential vertical leg movement • between 1.0 and 2.0 mm Differential horizontal leg movements • between 5.4mm and 8.6 mm Strain • between 1.6 and 2.0 mm/m For LW 303 • between 225 and 260 mm Differential vertical leg movement • between 1.0 and 2.0 mm Differential horizontal leg movements • between 5.4mm and 8.6 mm Strain • between 1.1 and 1.3 mm/m	**Continue operations but report on subsidence anomaly** • Telecommunications tower (and building compound) is safe and serviceable. • Negligible impact to telecommunications tower (and compound). **Metropolitan Coal** • Immediately resurvey subsidence line (Optic / Water Line) in affected area to confirm results. • Engage subsidence expert to assess results. • Confirm results are consistent with other subsidence lines. • Compare and critically analyse measured versus predicted subsidence. • Inform and provide report to Sydney Trains of subsidence results. • Collaboratively share information with Sydney Trains to monitor situation. **Sydney Trains** • Assess information provided by Metropolitan Coal.

Table 8 (Continued)
Trigger Action Response Plan – Telecommunications Tower and Compound

SYDNEY TRAINS – Telecommunications Tower (and Compound)		
SYDNEY TRAINS Telecommunications Tower (and Compound)	*Risk: Subsidence effect on tower or compound resulting in impact to structural integrity.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 3 - Cautionary **Anomalous service condition detected or Subsidence beyond +15% of predicted**	

	Subsidence
	
	For LW 301-302
	• greater than 145 mm
	Differential vertical leg movement
	• greater than 2.0 mm
	Differential horizontal leg movements
	• Greater than 8.6 mm
	Strain
	• greater than 2.0 mm/m
	
	For LW 303
	• greater than 260 mm
	Differential vertical leg movement
	• greater than 2.0 mm
	Differential horizontal leg movements
	• Greater than 8.6 mm
	Strain
	• greater than 1.3 mm/m
		Investigate & Resolve
		• Telecommunications tower (and building compound) is safe and serviceable.
		• Indication of impact to telecommunications tower (and compound).
		Metropolitan Coal
		• Steps as per Level 2 event, plus:
		  ○ Increase frequency of subsidence line (Optic / Water Line) surveys to weekly in affected area.
		  ○ In conjunction with Sydney Trains identify impact location and work with Sydney Trains to resolve.
		  ○ Review the subsidence monitoring program and update the program where appropriate.
		  ○ Provide report on issue to both Sydney Trains and DP&E.
		Sydney Trains
		• In conjunction with Metropolitan Coal identify impact location, inspect tower, assess condition and determine appropriate response. (e.g. greater monitoring data or frequency, or schedule maintenance on the structure).
		• Make determination if other measures necessary to avoid further impact.

Table 8 (Continued)
Trigger Action Response Plan – Telecommunications Tower and Compound

SYDNEY TRAINS – Telecommunications Tower (and Compound)		
SYDNEY TRAINS Telecommunications Tower (and Compound)	*Risk: Subsidence effect on tower or compound resulting in impact to structural integrity.*	
	TRIGGER LEVEL	**RESPONSE**
	Level 4 – Restoration **Fault detected**	
	Fault Detected	**Implement Contingency Plan** • As per BFMP Section 9 and Appendix 3. **Metropolitan Coal** • As per Level 3 event, plus: ○ General Manager to be involved in all decision making processes. ○ Assess public safety implications and where appropriate implement safety measures in accordance with Metropolitan Coal Longwalls 301-303 Public Safety Management Plan. ○ Report exceedance of the performance measure or indicators to the DP&E and Sydney Trains as soon as practicable. ○ Update the 'Built Features Management Plan – Subsidence Impact Register'. ○ Investigate circumstances of the fault and determine requirement for adaptive management of mining operations prior to future operations in vicinity of the telecommunications tower (and compound). **Sydney Trains** • As per Level 3 event, plus: ○ Sydney Trains to enact use of alternative communications system. ○ Determine appropriate course of action for restoration of service (e.g. deploy temporary tower) and rebuilding (e.g. construct new tower and foundations). ○ Complete restoration works. ○ Work in conjunction with Metropolitan Coal to investigate root cause of incident and determine appropriate future control measures.

11 FUTURE EXTRACTION PLANS

In accordance with Condition 7, Schedule 3 of the Project Approval, Metropolitan Coal will collect baseline data for the future Extraction Plan (e.g. Longwall 304 onward). The collection of baseline data will be consistent with the baseline data collected for Longwalls 301-303. However, the baseline (and any post-mining) data collected for Longwalls 301-303 will be used as baseline for Longwalls 304 onward as longwall mining progressively moves further away from the Sydney Trains assets.

In addition to the baseline data collection, consideration of the environmental performance and management measures in accordance with the review(s) conducted as part of this Longwalls 301-303 BFMP-SYDTRAINS will inform the appropriate type and frequency of monitoring of the assets relevant to the next Extraction Plan.

11.1 ASSESSMENT OF TRIAL LONGWALL LAYOUT FOR LONGWALLS 301-303

As described in Section 4.1, the layout for Longwalls 301-303 (i.e. 163 m panel widths [void] and 45 m pillars [solid]) will be trialled to build on the experience and dataset obtained from Longwalls 20 to 27. The outcomes of the trial will be used to inform the potential for a similar mine layout to be applied to the next Extraction Plan (i.e. Longwall 304 onwards).

Following the completion of Longwall 301, 302 and during the mining of Longwall 303, Metropolitan Coal will review the available subsidence monitoring results and assess the changes to, and impacts on, Sydney Trains assets.

12 ANNUAL REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

In accordance with Condition 3, Schedule 7 of the Project Approval, Metropolitan Coal will conduct an Annual Review of the environmental performance of the Project by the end of March each year.

The Annual Review will:

- describe the works carried out in the past year, and the works proposed to be carried out over the next year;
- include a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against the:
  - relevant statutory requirements, limits or performance measures/criteria;
  - monitoring results of previous years; and
  - relevant predictions in the EA, Preferred Project Report and Extraction Plan;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the Project;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the Project.

As described in Section 2, this BFMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate.

13 INCIDENTS

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in the Project Approval.

The reporting of incidents will be conducted in accordance with Condition 6, Schedule 7 of the Project Approval. Metropolitan Coal will notify the Director-General (now Secretary) of DP&E and any other relevant agencies of any incident associated with the Project as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Director-General (now Secretary) of DP&E and any relevant agencies with a detailed report on the incident.

Sydney Trains will be notified within 24 hours of any access limitations or restrictions.

14 COMPLAINTS

A protocol for the managing and reporting of complaints has been developed as a component of Metropolitan Coal's Environmental Management Strategy and is described below.

The Superintendent Environmental Services is responsible for maintaining a system for recording complaints.

Metropolitan Coal will maintain public signage advertising the telephone number on which environmental complaints can be made. The Superintendent Environmental Services is responsible for ensuring that the currency and effectiveness of the service is maintained. Notifications of complaints received are to be provided as quickly as practicable to the Manager – Safety & Environmental Services.

Complaints and enquiries do not have to be received via the telephone line and may be received in any other form. Any complaint or enquiry relating to environmental management or performance is to be relayed to the Superintendent Environmental Services as soon as practicable. All employees are responsible for ensuring the prompt relaying of complaints. All complaints will be recorded in a complaints register.

For each complaint, the following information will be recorded in the complaints register:

- date and time of complaint;
- method by which the complaint was made;
- personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
- nature of the complaint;
- the action(s) taken by Metropolitan Coal in relation to the complaint, including any follow-up contact with the complainant; and
- if no action was taken by Metropolitan Coal, the reason why no action was taken.

The Superintendent Environmental Services is responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary.

In accordance with Condition 10, Schedule 7 of the Project Approval, the complaints register will be made publicly available on the website and updated on a monthly basis. A summary of complaints received and actions taken will be presented to the Community Consultative Committee as part of the operational performance review.

15 NON-COMPLIANCES WITH STATUTORY REQUIREMENTS

A protocol for the managing and reporting of non-compliances with statutory requirements has been developed as a component of Metropolitan Coal's Environmental Management Strategy and is described below.

Compliance with all approvals, plans and procedures will be the responsibility of all personnel (staff and contractors) employed on or in association with Metropolitan Coal, and will be developed through promotion of Metropolitan Coal ownership under the direction of the General Manager.

The Manager - Technical Services and/or Superintendent Environmental Services will undertake regular inspections, internal audits and initiate directions identifying any remediation/rectification work required, and areas of actual or potential non-compliance.

As described in Section 13, Metropolitan Coal will notify the Director-General (now Secretary) of the DP&E and any other relevant agencies of any incident associated with Metropolitan Coal as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Director-General (now Secretary) of the DP&E and any relevant agencies with a detailed report on the incident.

A review of Metropolitan Coal's compliance with all conditions of the Project Approval, mining leases and all other approvals and licenses will be undertaken prior to (and included within) each Annual Review. The Annual Review will be made publicly available on the Peabody website.

Additionally, in accordance with Condition 8, Schedule 7 of the Project Approval, an independent environmental audit was undertaken by the end of December 2011, and is undertaken a minimum of once every three years thereafter. A copy of the audit report will be submitted to the Director-General (now Secretary) of the DP&E and made publicly available on the Peabody website. The independent audit will be undertaken by an appropriately qualified, experienced and independent team of experts whose appointment has been endorsed by the Director-General (now Secretary) of the DP&E.

16 REFERENCES

Department of Planning & Environment and Division of Resources and Energy (2014) *Guidelines for the Preparation of Extraction Plans*. Draft.

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Heritage Computing (2008) *Metropolitan Coal Project Groundwater Assessment: A Hydrogeological Assessment in Support of Metropolitan Colliery Longwalls 20 to 44.* Appendix B in the Metropolitan Coal Project Environmental Assessment.

Mine Subsidence Engineering Consultants (2008) *Subsidence Assessment Report on the Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Proposed Extraction of Longwalls 20 to 44 at Metropolitan Colliery in Support of a Part 3A Application.*

Mine Subsidence Engineering Consultants (2016) *Metropolitan Colliery – Proposed Longwalls 301 to 303 - Subsidence Predictions and Impact Assessments for the Sydney Trains Infrastructure*, 8 September 2016.

Cardno (2018) Investigation of potential effects of ground movement due to mining. Helensburgh Repeater Tower. Sydney Trains Infrastructure. 23 March 2018

APPENDIX 1

MSEC (2016) METROPOLITAN COLLIERY – PROPOSED LONGWALLS 301 TO 303 - SUBSIDENCE PREDICTIONS AND IMPACT ASSESSMENTS FOR THE SYDNEY TRAINS INFRASTRUCTURE, DATED 8 SEPTEMBER 2016

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8th September 2016

Jon Degotardi
Peabody Energy Australia
Metropolitan Colliery
PO Box 402
Helensburgh NSW 2508

Ref: MSEC844-07

Dear Jon,

RE: Metropolitan Colliery – Proposed Longwalls 301 to 303 - Subsidence Predictions and Impact Assessments for the Sydney Trains Infrastructure

This letter report summarises the predicted subsidence movements and the assessed subsidence impacts for the Sydney Trains infrastructure resulting from the extraction of the proposed Longwalls 301 to 303 at Metropolitan Colliery.

The locations of the Sydney Trains infrastructure and the proposed longwalls are shown in the attached Drawing No. MSEC844-07. The Illawarra Railway is located to the east of the longwalls at a minimum distance of 1.4 kilometres. A telecommunications tower and compound are located above the chain pillar between Longwalls 302 and 303. Photographs of this installation are provided in Figure 1.

Figure 1 Telecommunications Tower and Compound

The predictions and impact assessments for the Sydney Trains infrastructure are provided in the following sections.

Conventional Subsidence Parameters for the Sydney Trains Infrastructure

The following provides summaries of the maximum predicted conventional movements for the Sydney Trains infrastructure resulting from the extraction of Longwalls 301 to 303. It is possible that localised and elevated movements could develop above and in the vicinity of the longwalls as the result of non-conventional ground movements due to geological structures or valley closure effects. Discussions on the potential for non-conventional movements are provided in this letter report.

The Illawarra Railway is located at a minimum distance of 1.4 kilometres from the longwalls. At this distance, the railway is not expected to experience measurable conventional vertical subsidence, tilts or curvatures. The railway could experience low level far-field horizontal movement. The far-field horizontal movements are expected to be similar to those observed for previous longwall mining in the Southern Coalfield.

The observed incremental far-field horizontal movements, resulting from the extraction of longwalls in the Southern Coalfield, are provided in Figure 2. The data is based on survey marks located outside of the mining area (i.e. above solid coal).

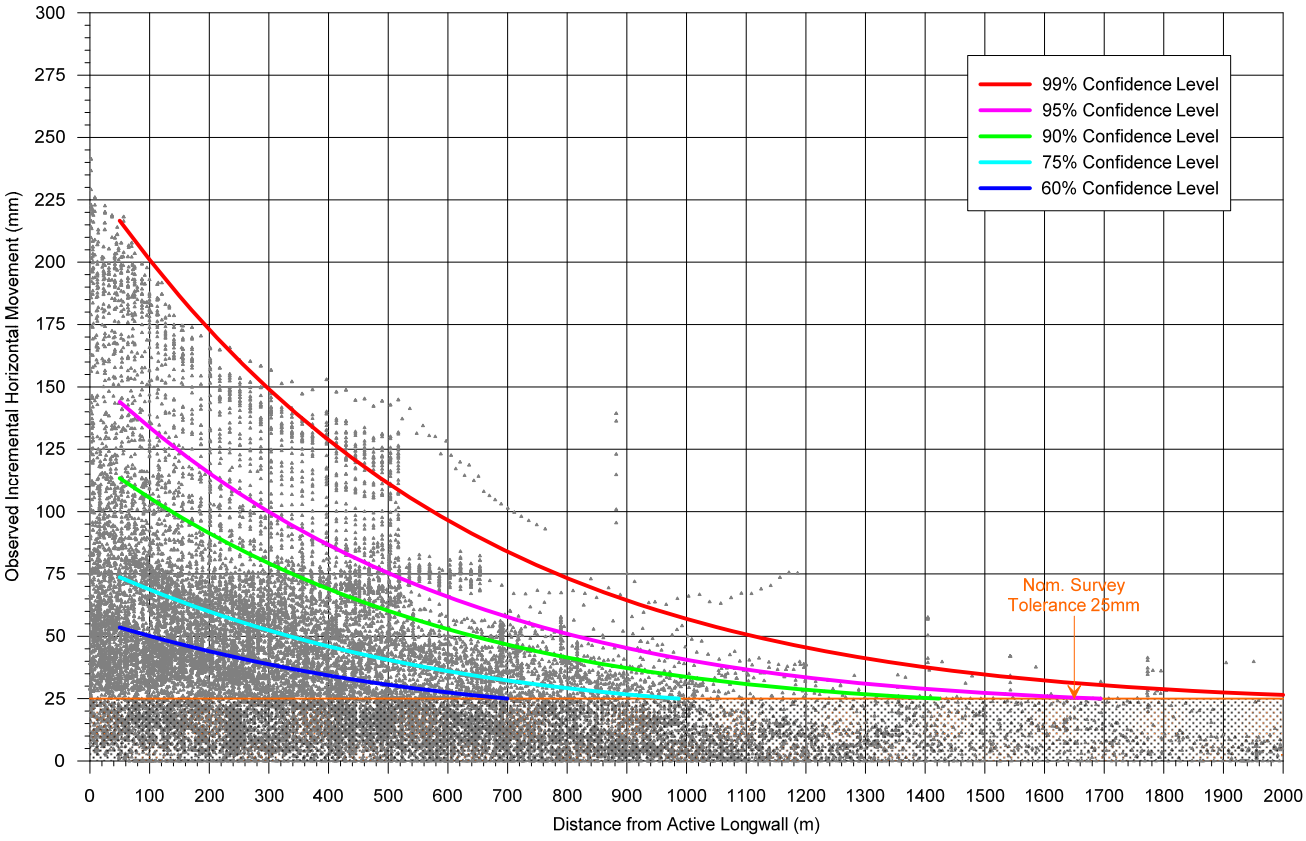

Figure 2 Observed Incremental Far-field Horizontal Movements from the Southern Coalfield (Solid Coal)

The absolute horizontal movements measured at distances greater than 1.4 kilometres from mining are in the order of 30 mm based on the 95 % confidence level. These low level movements comprise a large proportion of survey tolerance. Far-field horizontal movements tend to be bodily movements orientated towards the mining area. The strains associated with these low level horizontal movement are not expected to be measurable.

The telecommunications tower and compound are located above the chain pillar between Longwalls 302 and 303. A summary of the maximum predicted values of total subsidence, tilt and curvature for this installation, resulting from the extraction of Longwalls 301 to 303, is provided in Table 1.

Table 1 Maximum Predicted Total Subsidence, Tilt and Curvature for the Telecommunications Tower and Compound Resulting from the Extraction of Longwalls 301 to 303

Longwall	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
After LW301	< 20	< 0.5	< 0.01	< 0.01
After LW302	125	1.5	0.02	< 0.01
After LW303	500	3.5	0.02	0.04

The maximum predicted conventional tilt for the telecommunications tower and compound is 3.5 mm/m (i.e. 0.35 %, or 0.2 degrees). The maximum predicted conventional curvatures are 0.02 km^{-1} hogging and 0.04 km^{-1} sagging, which equate to minimum radii of curvature of 50 kilometres and 25 kilometres, respectively.

Predicted Strains

The prediction of strain is more difficult than the predictions of subsidence and tilt. 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.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the average relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values.

Adopting a linear relationship between curvature and strain provides a reasonable prediction for the conventional tensile and compressive strains. In the Southern Coalfield, it has been found that a factor of 15 provides a reasonable relationship between the predicted maximum curvatures and the predicted maximum 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.

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. We have therefore provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of predicted strains for the Sydney Trains infrastructure has been determined using the monitoring data from Metropolitan Colliery and other nearby collieries. 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. The strains resulting from damaged or disturbed survey marks have also been excluded.

The transmission tower and compound are located above the longwalls. A histogram of the maximum tensile and compressive strains measured in survey bays located above previously extracted longwalls in the Southern Coalfield is provided in Figure 3. The probability distribution functions, based on a fitted *Generalised Pareto Distribution (GPD)*, have also been shown in this figure.

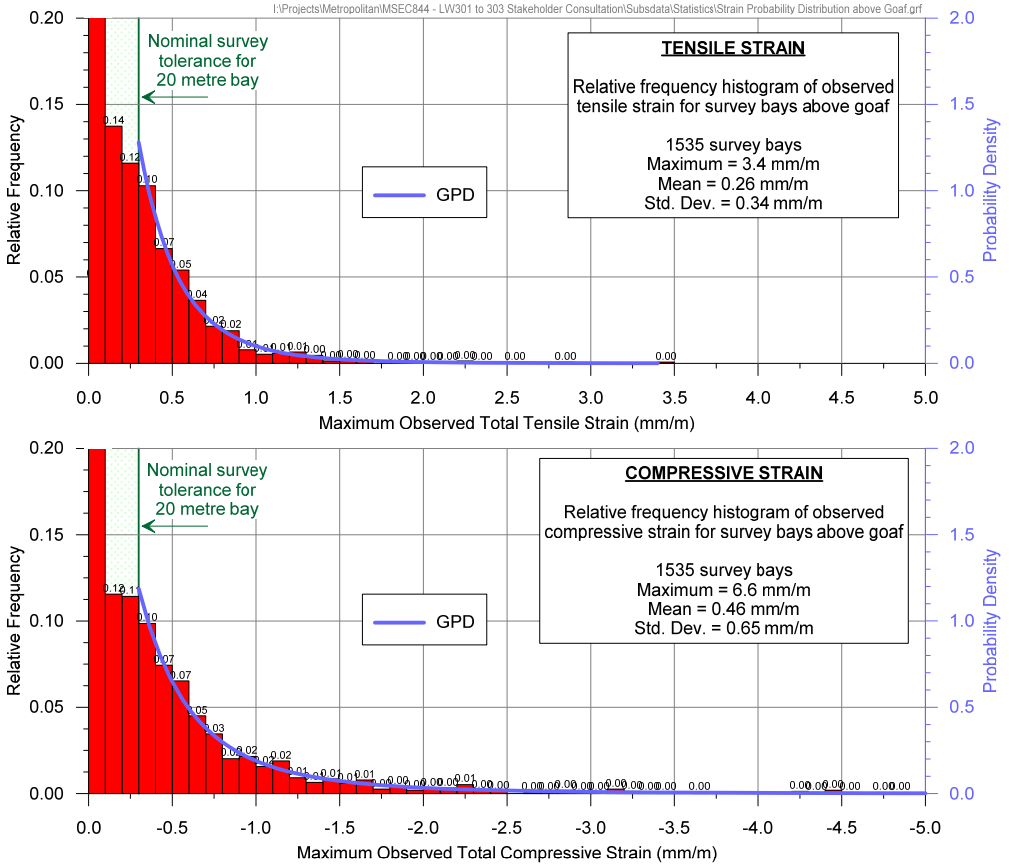

Figure 3 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls in the Southern Coalfield Above Goaf

Confidence intervals have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall 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).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above goaf, based on the fitted GPDs, is provided in Table 2.

Table 2 Probabilities of Exceedance for Strain for Survey Bays Located above Goaf

Strain (mm/m)		Probability of Exceedance
Compression	-8.0	1 in 1,300
	-6.0	1 in 570
	-4.0	1 in 185
	-2.0	1 in 35
	-1.0	1 in 9
	-0.5	1 in 3
	-0.3	1 in 2
Tension	+0.3	1 in 3
	+0.5	1 in 6
	+1.0	1 in 30
	+2.0	1 in 300
	+3.0	1 in 1,800

The 95 % confidence intervals for the maximum total strains that the individual survey bays above goaf experienced at any time during mining are 0.9 mm/m tensile and 1.6 mm/m compressive. The 99 % confidence intervals for the maximum total strains that the individual survey bays above goaf experienced at any time during mining are 1.5 mm/m tensile and 3.2 mm/m compressive.

Potential for Non-Conventional Movements

Non-conventional movements can develop due to the presence of geological structures or valley related effects. In some cases, non-conventional movements can develop with no known cause and these are often referred to as 'anomalous' movements.

The Illawarra Railway is located more than 1.4 kilometres from the longwalls. At this distance, it is unlikely that the railway would experience measureable movements due to the presence of geological structures.

It is possible that the telecommunications tower and compound could experience localised and elevated strains due to unknown geological structures (i.e. anomalies). The range of strains provided in the previous section include those resulting from irregular anomalous movements.

The locations of the major streams are shown in Drawing No. MSEC844-07. The Illawarra Railway crosses Cawleys and Wilsons Creeks. The valley related movements at these creek crosses are predicted to be less than 5 mm upsidence and less than 5 mm closure. The strains associated with these low levels of valley related movements are not expected to be measurable.

Impact Assessments for the Illawarra Railway

The Illawarra Railway is located more than 1.4 kilometres from the longwalls. Whilst the railway could experience low level far-field horizontal movements, the associated tilts, curvatures or strains are not expected to be measurable. It is unlikely that the railway and associated infrastructure would experience adverse impacts as a result of Longwalls 301 to 303.

Old workings are present beneath and in the vicinity of the Illawarra Railway as shown in Drawing No. MSEC844-07a. At more than 1.4 kilometres from the longwalls, it is unlikely that the railway and associated infrastructure would experience adverse impacts from old workings as a result of the extraction of Longwalls 301 to 303. An assessment of subsidence above old workings was undertaken and presented in a paper at the 8th Triennial Conference on Mine Subsidence in 2011 in a paper titled "*An Analysis of Long Term Subsidence at Metropolitan Colliery*". A copy of the paper is attached. The assessment covered data over a 14 year period of monitoring and found that the goaf/chain pillar system was in a longer term stable condition and ongoing subsidence movements appeared to be reducing to zero. The old workings beneath and in the vicinity of the Illawarra Railway as shown in Drawing No. MSEC844-07a are likely to be more than 50 years old.

Impact Assessments for the Telecommunications Tower

The telecommunications tower and compound are located above the chain pillar between Longwalls 302 and 303.

The maximum predicted tilt for this installation is 2.0 mm/m (i.e. 0.2 %, or 1 in 500). The magnitude of tilt is very small (i.e. less than 1 %) and therefore are unlikely to adversely impact on the tower or compound. Tilt can potentially effect directional antennas and therefore it is recommended that the radio engineer reviews the predicted change in alignment.

The maximum predicted conventional curvatures are 0.04 km^{-1} hogging and 0.07 km^{-1} sagging, which equate to minimum radii of curvature of 25 kilometres and 14 kilometres, respectively. The predicted strains are 0.9 mm/m tensile and 1.6 mm/m compressive based on the 95 % confidence level and 1.5 mm/m tensile and 3.2 mm/m compressive based on the 99 % confidence level.

It is recommended that the structural engineer review the structural integrity of the tower based on the predicted conventional subsidence, tilt and curvatures and the predicted distributions of strain. If adverse impacts were anticipated, then preventive measures should be installed that could include the installation of additional bracing members and/or strengthening members to the existing frame.

The building enclosure could potentially experience adverse impacts such as cracking of the brickwork or a sticky entry door. It is expected that the enclosure would remain in safe and serviceable conditions during and after mining. Adverse impacts could be remediated using normal building maintenance techniques.

Summary

The Illawarra Railway is located more than 1.4 kilometres from Longwalls 301 to 303. At this distance, it is unlikely that the railway and associated infrastructure would experience adverse impacts as a result of these longwalls.

A telecommunications tower and compound is located above the chain pillar between Longwalls 302 and 303. It is recommended that the predicted movements are reviewed by the radio and structural engineers. Preventive measures for the tower should be installed if adverse impacts are anticipated. It is expected that adverse impacts to the building enclosure could be remediated using normal building maintenance techniques.

It is expected that the potential impacts on the Sydney Trains infrastructure can be managed with the implementation of the necessary monitoring and management strategies.

Yours sincerely

Peter DeBono

Attachments:

Drawing No. MSEC844-07 – Longwalls 301 to 303 – Sydney Trains Infrastructure

DeBono and Tarrant (2011). *An Analysis of Long Term Subsidence at Metropolitan Colliery.* Proceedings of the 8th Triennial Conference on Mine Subsidence, 2011, pp 81 to 88.

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METROPOLITAN COAL

METROPOLITAN COLLIERY
LONGWALLS 301 TO 303
SYDNEY TRAINS

DATE:	SCALE:	DRAWING No:	Rev No
26 Aug 2016	1:20000	MSEC844-07a	B

Grid to MGA co-ordinates

HEATHCOTE CREEK
CAWLEY ROAD OVERPASS
ILLAWARRA RAILWAY
CAWLEYS CK
STUDY AREA
WORONORA RESERVOIR
TELECOMMUNICATIONS TOWER
20mm SUBSIDENCE CONTOUR
OLD PRINCES HIGHWAY
LW303
LW302
LW301
132kV
330kV
M1 PRINCES MOTORWAY
1.4 km
1.7 km
METROPOLITAN FAULT
WILSONS CK
PRINCES HIGHWAY UNDERPASS 2
MAIN WEST FAULT
POWELL FAULT
FAULT
LW26
LW27
LW25
LW24
LW23B
6 218 000
6 217 000
6 216 000
6 215 000
6 214 000
312 000
313 000
314 000
315 000

GEOLOGICAL STRUCTURES
FAULTS
DYKES

LEGEND
CURRENT WORKINGS
HISTORICAL WORKINGS
PROPOSED LONGWALLS

An Analysis of Long Term Subsidence at Metropolitan Colliery

P. DeBono, Mine Subsidence Engineering Consultants
G. Tarrant, Metropolitan Coal

Summary

Metropolitan Coal commenced longwall extraction in 1995 and extracted 18 longwall panels to the end of 2009. Longwalls 1 to 7 were extracted at approximately 126 m void width, Longwalls 8 to 10 were extracted at 140 m void width, and Longwalls 11 to 18 were extracted at 163 m void width. The chain pillars were 35 m (rib to rib) for each longwall. A subsidence survey line (D-Line) was established perpendicular to the longwall panels and has been re-surveyed at the end of each extracted panel. The subsidence data has been analysed to better understand the long term behaviour of conventional subsidence movements at the survey monitoring peg locations. The detailed analysis focuses specifically on the long term subsidence that occurs after the active subsidence phase and residual subsidence phase during which it is typically considered that the maximum subsidence has been attained. The analysis is expected to better inform the longer term management of subsidence effects and consequential impacts on natural and built surface features.

1. Introduction

It is generally accepted that conventional vertical subsidence resulting from longwall coal mining occurs in two phases: an active dynamic subsidence phase as the face advances, and a residual subsidence phase after all extraction has been completed near a point. The dynamic subsidence over a series of longwall panels results from both caving of strata into the goaf, and yielding of the chain pillar and/or the strata above and below the pillars.

The dynamic subsidence profiles are influenced by many variables, including the rate of extraction, geological setting and longwall geometry. Time dependent residual subsidence over a series of longwalls generally reduces with time and increased distance of the active mining from a point. In most instances, subsidence is commonly considered to have been completed once subsidence rates reduce sufficiently below agreed limits, which are typically set based on the type of surface feature being monitored and its sensitivity to subsidence movements. Ongoing minor subsidence movements can occur, however, for several years beyond the cessation of monitoring as a result of factors that may include far field vertical subsidence, deterioration of the confined pillar, deterioration of the materials above and/or below the pillar, and goaf consolidation.

Prior to longwall extraction, management plans are developed to manage the various features on the surface that are likely to be influenced by subsidence. Some features that may be sensitive to small subsidence movements may require the introduction of detailed and accurate monitoring methods and/or mitigation measures, to manage the subsidence as the longwalls are extracted. Following extraction, and once subsidence is deemed to have been completed, which may be subject to an agreed rate of subsidence or some other indicator, monitoring and management of the feature is discontinued. Subsidence may, however, continue to develop at slow rates for many years following the completion of mining near or below a surface feature.

With this in mind, the rates of subsidence movements at each survey peg along the D-Line and over Longwalls 1 to 18 have been analysed to assess the long term subsidence behaviour.

2. Mine Layout and Extraction Geometry

The layout of the Metropolitan Colliery Longwalls 1 to 18 and the D Line are shown in Figure 1. The longwalls, which are extracted in the Bulli Seam, form a north westerly expansion of pillar extraction areas to the south east.

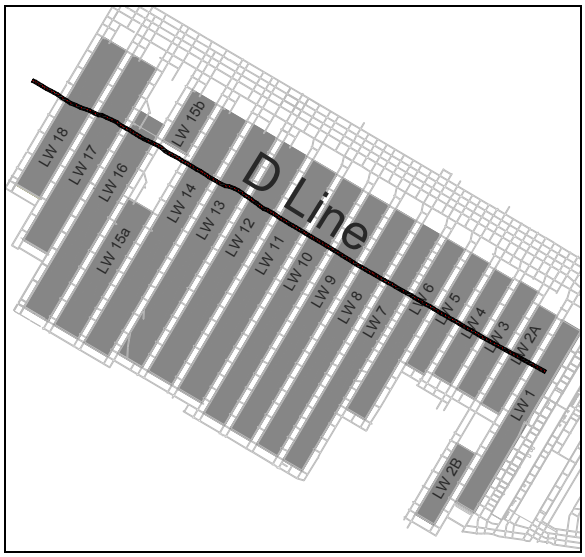


Figure 1 Metropolitan Colliery Longwalls 1 to 18 and D Line Monitoring Line

A summary of the extraction geometry of Metropolitan Colliery Longwalls 1 to 18 is provided in Table 1. The extraction direction of all of these longwalls was from the South West to the North East.

Extraction of the Longwalls 1 to 18 commenced in 1995 and was completed in 2009. The extraction dates of each of the longwalls is summarised in Table 2.

Table 1 Panel and Pillar Widths

Longwall	Panel Void Width (m)	Pillar Width (m)
LW1	123	35
LW2	126	35
LW3	126	35
LW4	125	35
LW5	127	35
LW6	127	35
LW7	140	35
LW8	140	35
LW9	140	35
LW10	163	35
LW11	163	35
LW12	163	35
LW13	163	35
LW14	163	35
LW15A	163	35
LW15B	163	35
LW16	163	35
LW17	163	35
LW18	163	35

2.1. Monitoring Data

The D-Line is located approximately perpendicular to the longwalls as shown in Figure 1. A plot of the surface levels, depth of cover, seam thickness, and observed subsidence along the D-Line is shown in Figure 2. The D-Line crosses several streams, the largest of which is the Waratah Rivulet.

Monitoring of the D-Line was carried out at the completion of each extracted longwall, which was extracted over a period ranging from 6 months to 12 months. The total monitoring period of the D-Line covers approximately 13 years.

Table 2 Extraction Dates

Longwall	Start Date	End Date
LW1	31-07-95	01-05-96
LW2	03-11-96	17-09-96
LW3	23-05-97	24-09-97
LW4	11-10-97	02-03-98
LW5	14-05-98	20-11-98
LW6	25-02-00	20-11-00
LW7	13-12-00	28-09-01
LW8	25-10-01	23-08-02
LW9	16-09-02	09-08-03
LW10	30-08-03	08-05-04
LW11	29-05-04	19-03-05
LW12	02-04-05	03-12-05
LW13	17-12-05	16-09-06
LW14	30-09-06	22-08-07
LW15A	10-09-07	08-03-08
LW15B	24-03-08	25-05-08
LW16	15-06-08	26-02-09
LW17	25-03-09	08-10-09
LW18	03-11-09	20-04-10

The layouts of Longwalls 15 and 16 were modified due to the presence of geological structures. The modified layouts can be seen in Figure 1. As a result of the modifications, Longwall 15 was not mined beneath the D-Line, which was located close to the finishing end of Longwall 16.

The subsidence profiles presented in Figure 2 show that only minor incremental subsidence profiles were observed for Longwalls 15 and 16.

The data used for the analysis of long term subsidence in this paper, are based on monitoring results for the period following active and residual subsidence. At Metropolitan Colliery, this occurs after a 5 to 6 year period from the commencement of active subsidence at a survey peg location. As a result, many of the monitoring pegs for the later, wider, longwalls (163 metres width) do not have monitoring data within this range of long term subsidence. Similarly, the survey pegs 1 to 15 were not monitored for a sufficient period to be included in the long term subsidence data.

2.2. Geology

The Metropolitan Colliery is located in the NSW Southern Coalfield which is characterised by a deep overburden of sedimentary rocks, with depths of cover over extracted coal seams commonly exceeding 300 metres.

Longwalls 1 to 18 were extracted in the Bulli Seam with thicknesses varying from 2.9 metres to 3.4 metres. The depth of cover above the Bulli Seam along the D Line varies from approximately 400 metres to 520 metres. The Bulli Seam thickness and depth of cover along the D-Line are shown in Figure 2.

The Bulli Seam is located in the upper part of the Illawarra Coal Measures. A typical stratigraphic section of the overburden material is shown in Figure 3

The major geological structures identified within the footprint of Longwalls 1 to 18 are shown in Figure 4. Most of these structures have been identified at seam level or projected from known locations. The most significant structure is the Madden Fault/Dyke Zone, which is up to approximately 700 metres in width and is associated with at least one known diatreme in Darkes Forest Colliery.

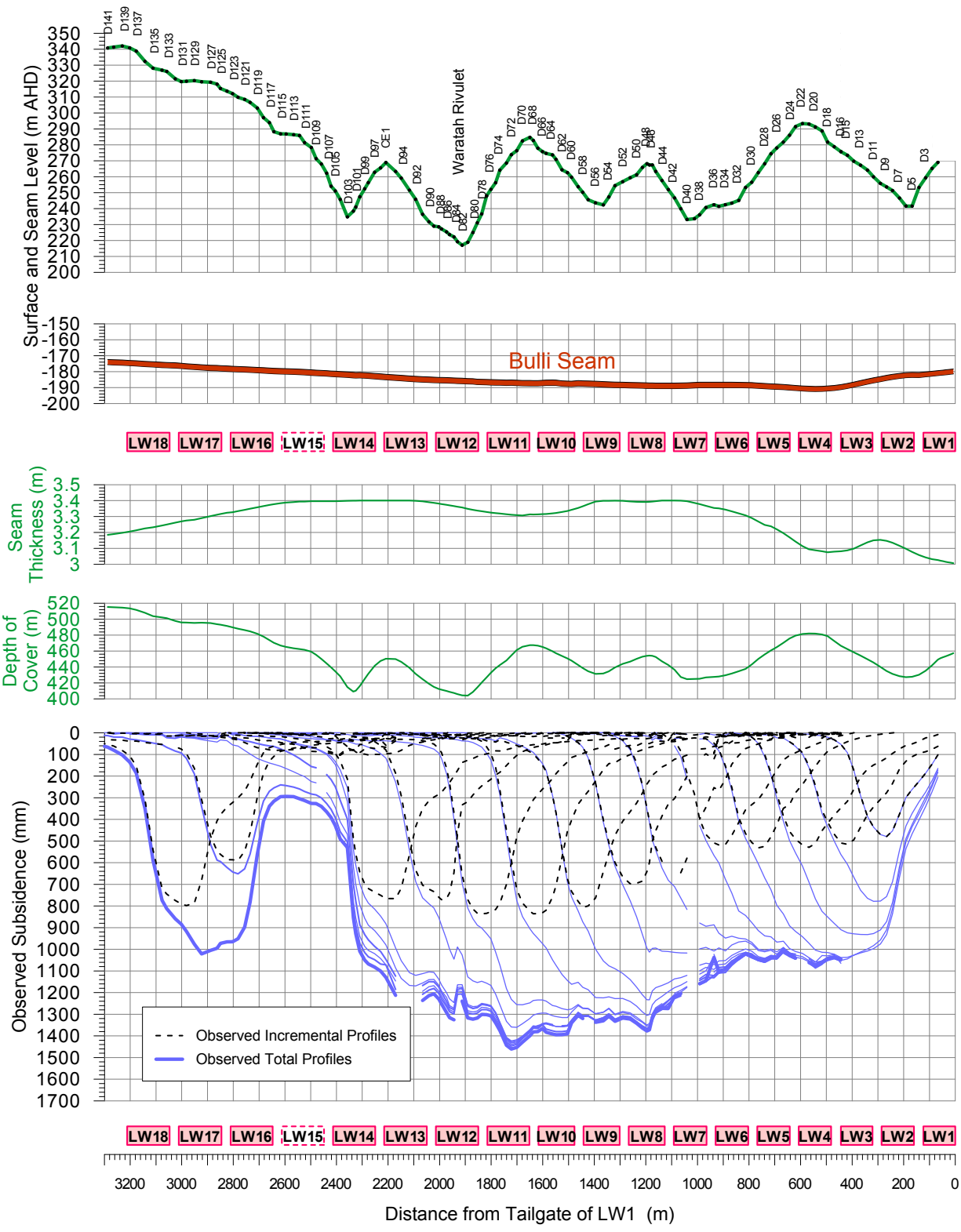


Figure 2 D-Line Monitoring Data

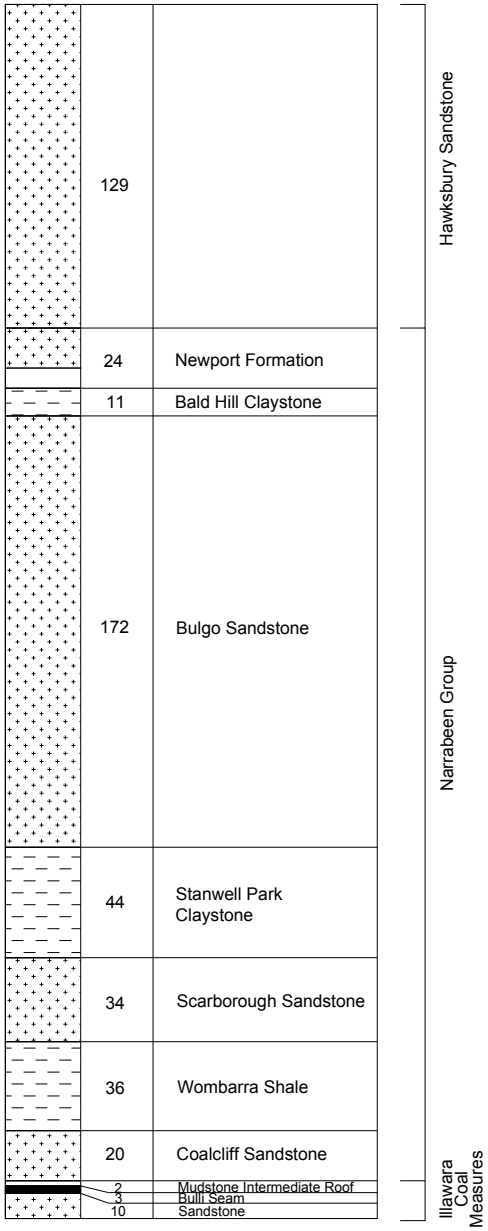


Figure 3 Typical Stratigraphic Section

The D-Line monitoring data for the longwalls in this fault/dyke zone are not however, used in the analysis, as described in Section 2.1. With the exception of the north western part of the extracted Longwalls 15 to 18, there are no significant geological structures in the vicinity of the D-Line.

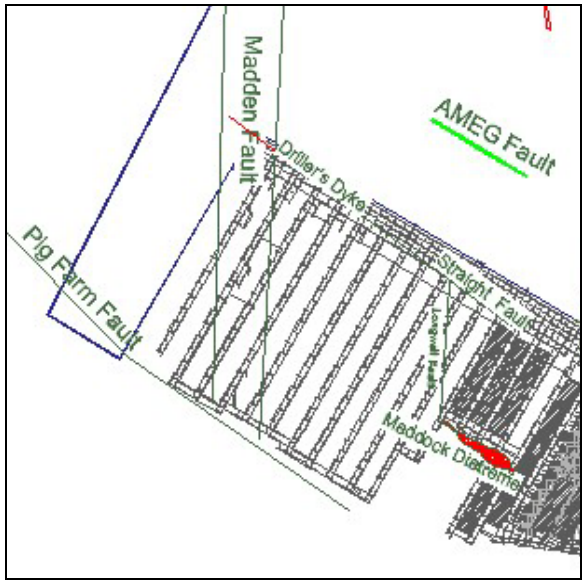


Figure 4 Geological Structures

3. Subsidence Analysis

In order to analyse the long term behaviour of subsidence it is necessary to present the temporal characteristics of subsidence to show the subsidence behaviour that occurs following the active and residual subsidence phases. The observed subsidence profiles were therefore, plotted against time. A plot of the observed total subsidence versus the date of survey for each of the D-Line monitoring pegs is shown in Figure 5

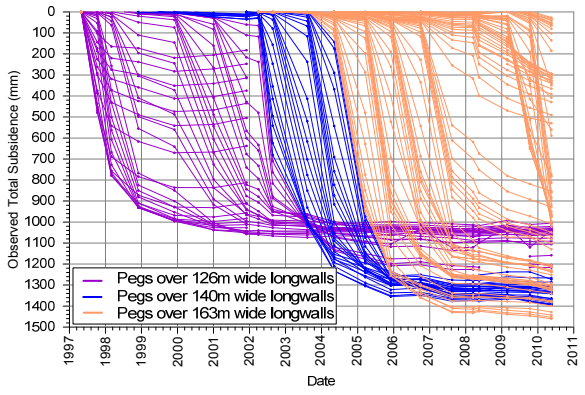


Figure 5 Observed Total Subsidence Versus Survey Date

This plot was further refined to show subsidence versus the time from the approximate commencement of active subsidence. The resulting plot is shown in Figure 6.

It is apparent from Figure 6 that following the active subsidence phase and residual subsidence phase, the subsidence reaches a relatively uniform rate after approximately 5 to 6 years from the commencement of active subsidence. The close up view of this rate from years 5 to 14 shows, however, that subsidence continues to develop at a slow, but reasonably uniform rate.

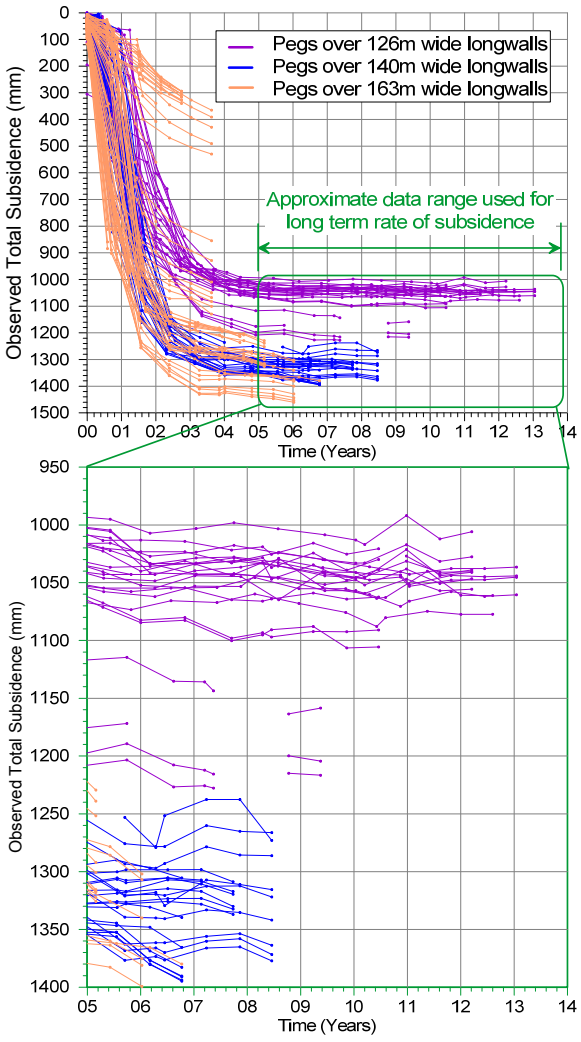


Figure 6 Observed Total Subsidence Versus Time

Most of the survey pegs located above the narrow 126 metre wide longwalls have approximately 8 years of survey data during this long term period following the active and residual subsidence phase. There is approximately 4 years of monitoring data during this period for the 140 metre wide longwalls, and only some of the data from the 163 metre wide longwalls are just entering this period.

The data in Figure 6 has been reproduced to present in Figure 7, a rate of subsidence per survey epoch for each of the monitored survey pegs, instead of observed total subsidence. The rate of subsidence was calculated as the change in subsidence over the time between survey epochs for each survey peg.

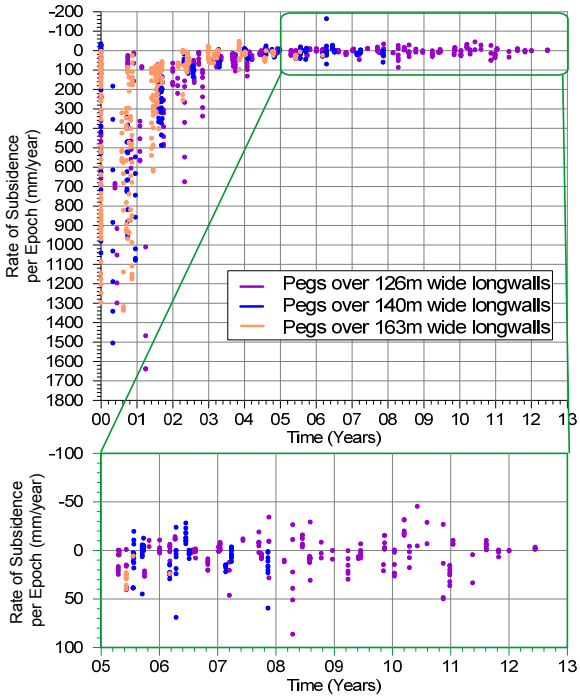


Figure 7 Observed Rate of Subsidence Versus Time

There is some scatter in the rates during this long term period in the order of ±50 mm. The distribution of data is shown in the histograms of the periods 5 to 7 years, 7 to 9 years, and 9 to 12 years presented in Figure 8.

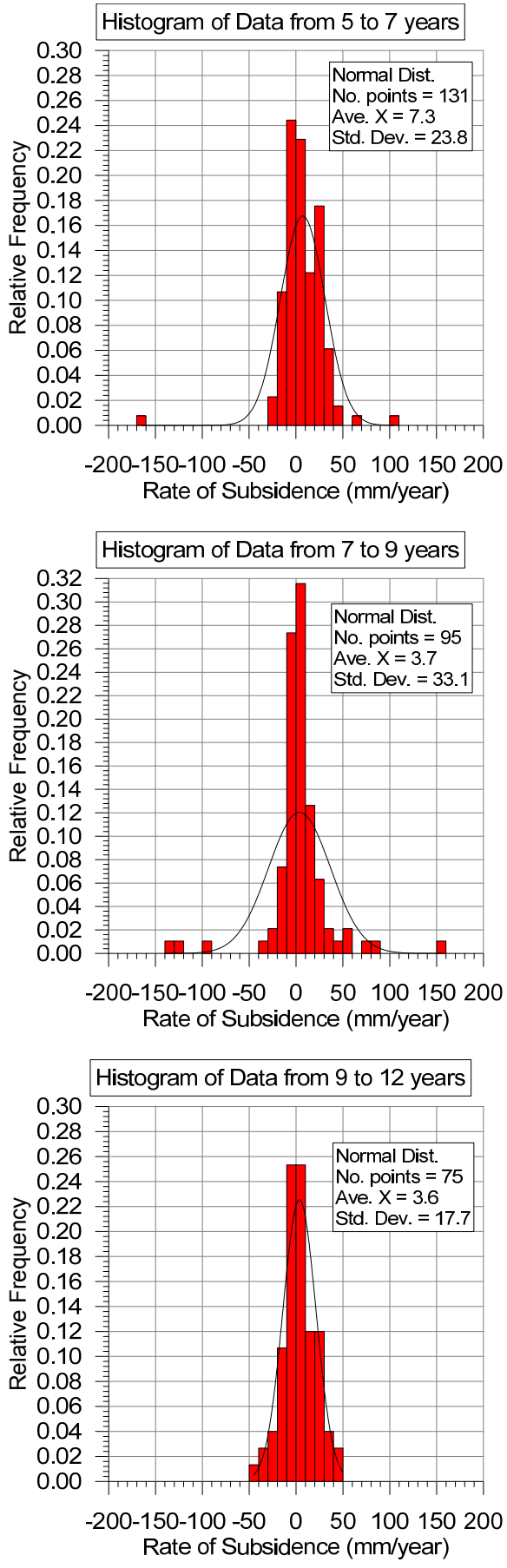


Figure 8 Rate of Subsidence Histograms

A longer period was selected for the final data subset due to the limited number of data points. The histograms show that the average rate of subsidence continues to reduce and has reduced to within 3 to 4 mm/year based on current monitoring data.

The spatial distribution of the rates of subsidence is shown in Figure 9 for the data used in the analysis. The data shows a greater scatter of the rates for the survey pegs that are located towards the base of the deep valley. It is possible that the wider scatter in these rates is the result of the influence of valley related upsidence and closure movements.

In addition to the rates of subsidence between each epoch, an average rate of subsidence was also calculated for each survey peg over the monitoring period between 5 and 14 years by taking the slope of a linear regression line through the subsidence plot for this time period. These results based on linear regression show peaks and troughs, with the peaks coinciding in most cases with the pillar locations.

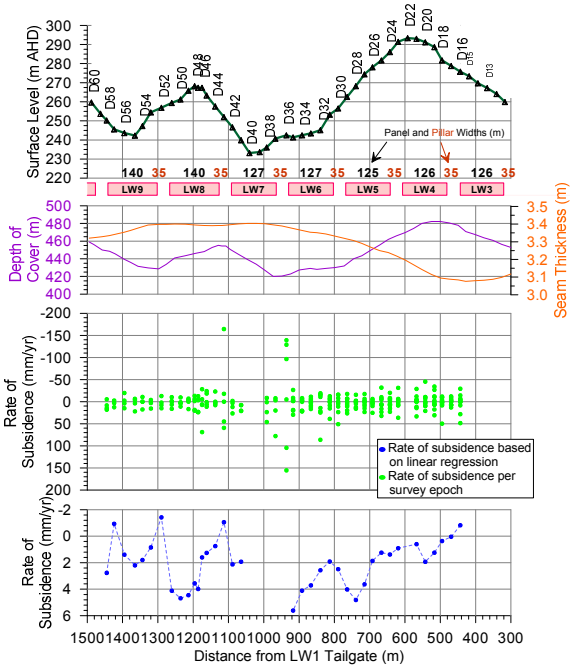


Figure 9 Rate of Subsidence at Monitoring Peg Locations

Four of the peaks have an overall negative rate of subsidence, indicating that at these locations, the ground surface may have rebounded to some degree.

4. Discussion

It is considered that there are two key points to note from this analysis of the long term subsidence monitoring data: firstly, that subsidence continues to develop for many years after mining has passed an area and the active and residual subsidence has been completed and; secondly, that the goaf/chain pillar system is indicated to be in a longer term stable condition.

It is acknowledged that the degree of ongoing subsidence is small and in many cases, these movements would have little to no effect on surface features and may be less than ground movements from other sources, such as seasonal shrink/swell behaviour. It should also be recognised, however, that while small subsidence rates were encountered at Metropolitan Colliery, much higher long term rates could be encountered at other locations depending on geological conditions and extraction geometry. Preliminary assessment of data from other collieries confirms that this is the case.

These subsidence rates may be of significance to features that are sensitive to very small ground movements. As a result, certain sensitive features may require a long term monitoring program to assess the ongoing rates of subsidence to verify that subsidence has reduced to an acceptable level and the risk of long term impact to the feature is below an acceptable level.

The indications from the analysis are that the goaf/chain pillar system is in a long term stable condition. This longer term monitoring data indicates that the continued strength and integrity of the confined pillar core is performing as it was designed to do and gives greater confidence that it will continue to do so.

It should be recognised that this assumes continuance of sufficient pillar strength and confining conditions, which potentially could change with a change to those conditions. Such changes could include future mining of other coal seams, possible seismic events, or contact with water or air.

Current methods of subsidence prediction and impact assessment do not take into account long term subsidence behaviour beyond the active and residual subsidence phase. It is considered prudent, however to recognised that these long term rates of subsidence do occur and whilst they are relatively small at Metropolitan Colliery, higher rates may encountered.

5. Conclusions

The findings of this case study indicate that the goaf/chain pillar goaf system at Metropolitan colliery is in a longer term stable condition and the ongoing subsidence movements appear to be reducing to zero. It is known that significantly higher long term rates of subsidence have occurred at other collieries.

It is hoped that further analysis of data from other collieries could be carried out to develop a more detailed database of long term subsidence movements that could be used for the management of surface features that may be sensitive to small movements, as well as to provide information on the long term behaviour of the goaf/chain pillar system.

6. References

Doyle, J., Newland, A. (2008). "*A Compilation of Surface Geological Features in the Western Portion of Metropolitan Colliery*". Geosensing Solutions.

Kratzsch, H. 1983 "*Mine Subsidence Engineering"* ISBN 3-540-11930-2, pp 320-321.

APPENDIX 2

BUILT FEATURES MANAGEMENT PLAN – SUBSIDENCE IMPACT REGISTER

Built Features Management Plan - Subsidence Impact Register

Impact Register Number[1]	Built Feature[2]	Impact Description	Does Impact Exceed the Built Feature Performance Measure/Indicators? (Yes/No)	Management Measures Implemented	Were Management Measures Effective? (Yes/No)

Notes:

1: Fill out all details in the Assessment Form and record the register number here.

2: Built feature (e.g. tower, rail line, etc.).

Built Feature Management Plan – Subsidence Impact Register
Assessment Form

Date:	
Observer (Name and position):	
Register Number (i.e. Number 1, 2, etc.):	
Longwall Number and Chainage:	

Location of Observed Impact:

(Examples: location of viaduct, include GPS co-ordinates and a sketch)

Description of Observed Impact:

(Examples: nature and extent of impact - cracks in road etc any relevant information, attach photographs)

Person Notified:	Manager - Technical Services	☐

Description of Photographs:

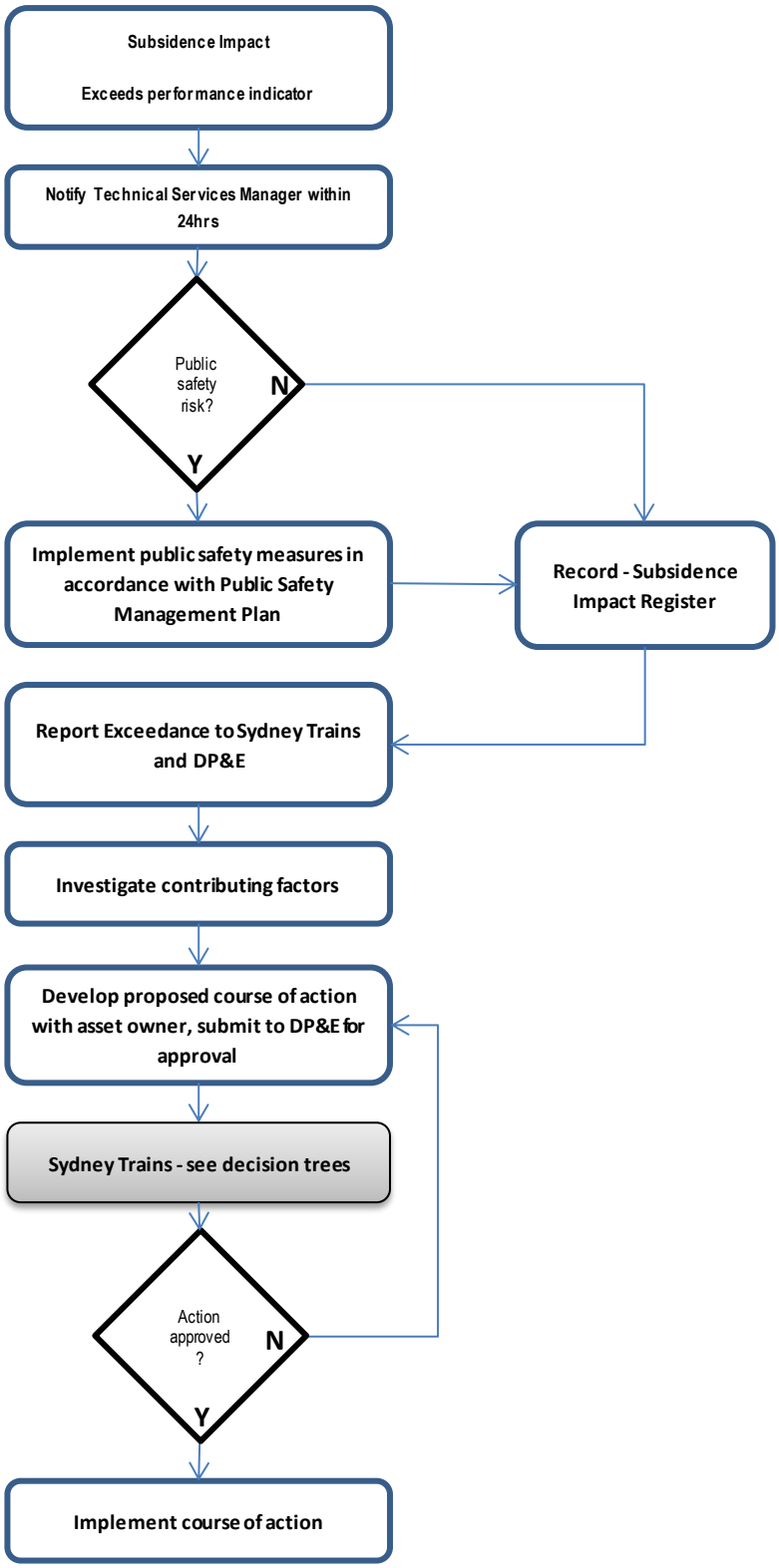
Actions Required:	Contingency Plan Initiated	☐
	Incident Notification	☐
	Safety Measures/Public Safety Management Plan Requirements	☐

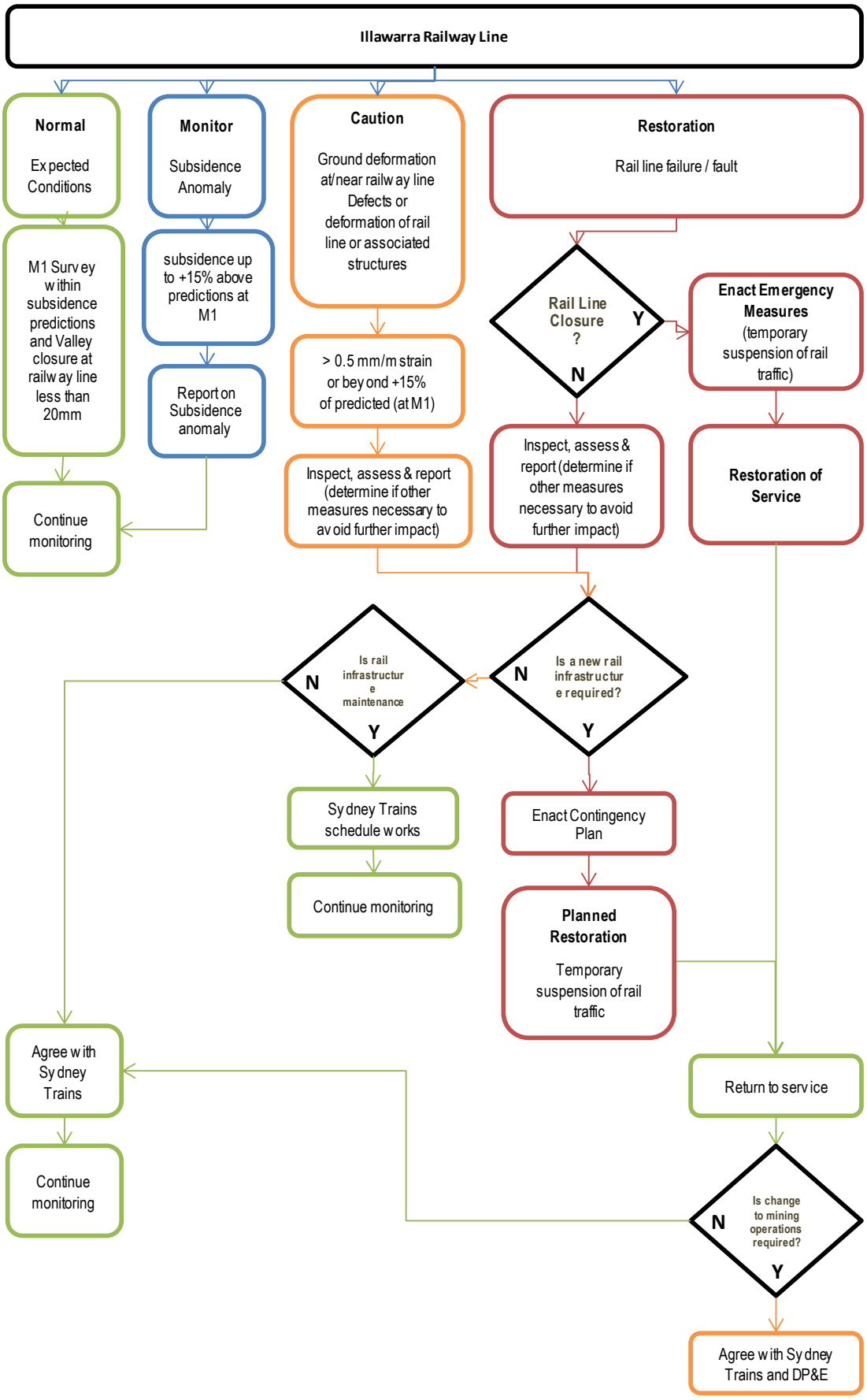
Management or Contingency Measures Implemented:

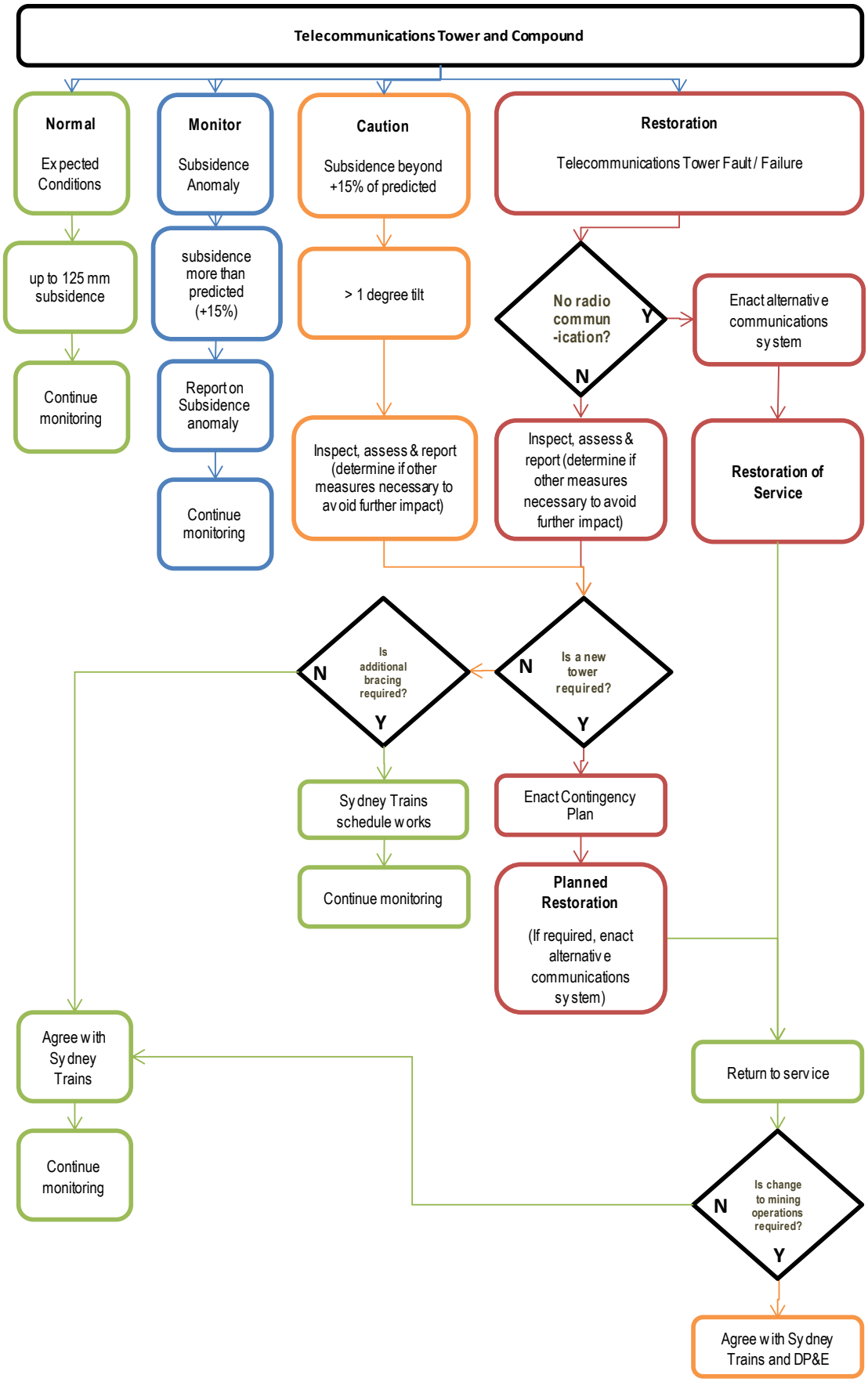
Effectiveness of Management or Contingency Measures:

APPENDIX 3

CONTINGENCY PLAN PROCEDURE AND DECISION TREES


Subsidence Impact
Exceeds performance indicator
Notify Technical Services Manager within 24hrs
Public safety risk?
N
Y
Implement public safety measures in accordance with Public Safety Management Plan
Record - Subsidence Impact Register
Report Exceedance to Sydney Trains and DP&E
Investigate contributing factors
Develop proposed course of action with asset owner, submit to DP&E for approval
Sydney Trains - see decision trees
Action approved ?
N
Y
Implement course of action


Illawarra Railway Line
Normal
Expected Conditions
Monitor
Subsidence Anomaly
Caution
Ground deformation at/near railway line Defects or deformation of rail line or associated structures
Restoration
Rail line failure / fault
M1 Survey within subsidence predictions and Valley closure at railway line less than 20mm
subsidence up to +15% above predictions at M1
> 0.5 mm/m strain or beyond +15% of predicted (at M1)
Rail Line Closure ?
Y
N
Enact Emergency Measures (temporary suspension of rail traffic)
Report on Subsidence anomaly
Inspect, assess & report (determine if other measures necessary to avoid further impact)
Inspect, assess & report (determine if other measures necessary to avoid further impact)
Restoration of Service
Continue monitoring
Is rail infrastructure maintenance
N
Y
Is a new rail infrastructure required?
N
Y
Sydney Trains schedule works
Enact Contingency Plan
Continue monitoring
Planned Restoration
Temporary suspension of rail traffic
Agree with Sydney Trains
Return to service
Continue monitoring
Is change to mining operations required?
N
Y
Agree with Sydney Trains and DP&E


Telecommunications Tower and Compound
Normal
Expected Conditions
Monitor
Subsidence Anomaly
Caution
Subsidence beyond +15% of predicted
Restoration
Telecommunications Tower Fault / Failure
up to 125 mm subsidence
subsidence more than predicted (+15%)
> 1 degree tilt
No radio commun -ication?
Y
N
Enact alternative communications system
Continue monitoring
Report on Subsidence anomaly
Inspect, assess & report (determine if other measures necessary to avoid further impact)
Inspect, assess & report (determine if other measures necessary to avoid further impact)
Restoration of Service
Continue monitoring
Is additional bracing required?
N
Y
Is a new tower required?
N
Y
Sydney Trains schedule works
Enact Contingency Plan
Continue monitoring
Planned Restoration
(If required, enact alternative communications system)
Agree with Sydney Trains
Return to service
Continue monitoring
Is change to mining operations required?
N
Y
Agree with Sydney Trains and DP&E