



**NARRABRI MINE
ENVIRONMENTAL
MANAGEMENT SYSTEM**

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WHC_PLN_NAR_SUBSIDENCE MONITORING PROGRAM LW101 to LW106

Subsidence Monitoring Program LW101 to LW106

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1 **INTRODUCTION**

This Subsidence Monitoring Program has been prepared to document the monitoring of subsidence and associated environmental consequences as a result of longwall mining at the Narrabri Mine. This program applies to extraction of Longwalls (LW) 101 to 106 within the Hoskisson Seam. The original plan was developed by AECOM and related to the extraction of LW101 to LW105. This revision has been developed to incorporate LW106 into this Subsidence Monitoring Program.

A general description of the site locality and longwall extraction area is provided in Section 1.1 of the Extraction Plan. The Extraction Plan also describes the operation of the underground mine to date, and the proposed extraction of LW101 - 106.

An updated assessment of potential subsidence movements related to Hoskissons Seam LW101 - 106 has been prepared by Ditton Geotechnical Services (DGS, 2015). These subsidence predictions have been used as a basis for the updated assessment of impacts contained within the Extraction Plan. DGS's analysis and results are contained, in full, as an appendix to the Extraction Plan.

This Subsidence Monitoring Program has been prepared in accordance with Condition 4(g) of the Project Approval (PA) 08_0144, as modified, for NCOPL which requires that the Extraction Plan includes a program of monitoring to assist with the management of subsidence, validate the subsidence predictions, and assist with the understanding of subsidence impacts and associated environmental consequences.

1.1 **Scope**

This Subsidence Monitoring Program is a sub-set to the Extraction Plan and has been prepared in accordance with Condition 4(g) of Schedule 3 of the PA 08_0144, as modified. This program applies only to monitoring activities related to subsidence associated with the secondary extraction of LW101 - 106 in the Hoskissons Seam (HS). In order to comply with the statutory requirements outlined in Section 1.2, this report provides a description of the:

- Features potentially affected by underground mining in the Extraction Plan area and summary of revised subsidence predictions, categorised into: natural features, public utilities, farm land and facilities, industrial commercial and business establishments and items of archaeological significance;
- Survey monitoring standards, method, and program;
- Summary of monitoring of subsidence consequences to built features (full details are provided in the Built Features Management Plan);
- Summary of monitoring measures provided for environmental features within Narrabri Mine Environmental Management System (full details are provided in each of the relevant environmental management plans);
- Review and reporting mechanisms; and
- Responsibilities of relevant Narrabri Mine personnel under this plan.



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1.1.1 Risk Assessment

A subsidence risk assessment has been undertaken to identify the risks associated with subsidence at the Narrabri Mine. The initial risk assessment was undertaken during February 2012 for LW101 to LW105. This risk assessment has since been reviewed and updated to include LW106, refer to Appendix K of the Extraction Plan.

The initial risk assessment ranked two items as having a high risk level and both related to the 11kV power line that traverses the mining area above LW101 to LW105. This line has since been disconnected and as such, these risk ratings have been reduced to low. As a result, there are no high level risk ratings remaining and the risks associated with subsidence above LW101 to LW106 for the Narrabri Mine have been assessed as low to moderate.

1.2 Statutory Requirements

This document has been prepared in accordance with Project Approval 08_0144 (as modified), relevant legislation and guidelines, and in consultation with relevant government agencies and affected infrastructure owners as discussed below. This plan has been prepared in accordance with the relevant legislation and guidelines.

1.2.1 Project Approval

The Project Approval requires that NCOPL prepare a Subsidence Monitoring Program to the satisfaction of the Division of Resources and Energy (DRE). Specifically, Condition 4(g) of Schedule 3, states inter alia:

4 *The Proponent shall prepare and implement Extraction Plans for the second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must:*

(g) *Include the following to the satisfaction of DRE:*

- *A Subsidence Monitoring Program to:*

Provide data to assist with the management of the risks associated with subsidence;

Validate the subsidence predictions; and

Analyse the relationship between the subsidence effects and impacts under the plan and any ensuing consequences.

Monitoring of environmental impacts not associated with subsidence is addressed elsewhere under the suite of management plans that forms the Narrabri Mine Environmental Management System.

1.2.2 Mining Lease

This report has also been prepared to partially address statutory requirements of the Mining Lease (ML) 1609 with regard to the preparation of Subsidence Management Plans.



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Narrabri Mine's ML 1609 was amended to include a reference to Extraction Plans. However, as this is an amendment to an Extraction Plan approved prior to December 2014, the Subsidence Management Plan can be recognised as an Extraction Plan for the purposes of the Mining Lease. As the existing Extraction Plan is in a transition period, a Subsidence Management Plan is to be prepared in accordance with the Division of Resources and Energy's (DRE) Guideline for Applications for Subsidence Management Approvals (Department of Mineral Resources, 2003), also referred to as the "SMP Guidelines". Requirements of the SMP Guidelines specifically addressed under this Program include Section 7.2, Item 8:

The relevance and adequacy of the proposed monitoring, reporting and reviewing programs consistent with the identified management priorities as per Section 6.10. Where relevant, the principal elements of a monitoring program may include:

- 1) *Monitoring of subsidence impacts on surface and sub-surface features;*
- 2) *Monitoring of the effectiveness of any mitigation and/or remedial measures, and*
- 3) *Monitoring of subsidence development.*

1.2.3 Work Health and Safety Legislation

This Extraction Plan has been developed to comply with the Work Health and Safety legislation including but not limited to:

- The Work Health and Safety Regulation 2017; and
- The Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.



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2 SURFACE FEATURES

The surface area impacted by mining of LW101 - 106 is most recently described in extensive detail in the Environmental Assessment (EA) for the Narrabri Coal Mine, Stage 2 Longwall Project (RW Corkery & Co. Pty Ltd, 2009).

The following identification of surface and sub-surface features has been prepared in consideration of the SMP Guidelines (DMR, 2003: p25). It is noted that there are no public amenities, or items of architectural significance that will be impacted by LW101 – 106.

2.1 Natural Features

Natural features potentially impacted by mining activities and monitored under the scope of this document (i.e. LW101 - 106) include:

- *Rivers and creeks:*
 - *Tributaries and contributing catchment area of both Pine and Kurrajong Creeks, both of which are ephemeral and drain to the Namoi River downstream of the Kamilaroi Highway;*
 - *Aquifers, known groundwater resources;*
 - *Alluvial aquifers associated with creeks; and*
 - *Saline groundwater associated with the coal measures.*
- *Land prone to flooding or inundation:*
 - *Floodplain associated with Kurrajong and Pine Creeks and tributaries.*
- *Threatened and protected species:*
 - *No threatened flora species recorded over LW101 - 106, however Coolabah Bertya, Cadeallia pentastylis (Ooline), and Lepidium aschersonii (Spiny Peppercress) may occur – all 'Vulnerable' under state and Commonwealth legislation;*
 - *Inland Grey Box Woodland – Endangered Ecological Community (EEC);*
 - *Fourteen threatened fauna species recorded, four of which were observed over LW101 - 106: Polytelis swainsonii (Superb Parrot), Calyptorhynchus lathami (Glossy Black-cockatoo), Pomatostomus temporalis (Grey-crowned Babbler), and Pyrrholaemus sagittata (Speckled Warbler);*
 - *Two migratory birds listed under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), one of which was observed over LW101 - 106: Hirundapus caudacutus (White-throated Needletail).*
- *Natural vegetation:*
 - *Riparian Forest along Pine and Kurrajong Creeks;*
 - *Inland Greybox Woodland (EEC – as noted above); and*
 - *Cleared open grassland.*



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2.2 **Public Utilities**

Land overlying LW101 - 106 and associated first workings is owned by the Narrabri Mine. A detailed list of all affected built features is provided in the Built Features Management Plan (BFMP).

Potentially affected public utilities include:

- *Roads (and associated bridges and culverts):*
 - *Greylands Road – the portion overlying LW101-106 is now mine owned.*
- *Electricity transmission lines:*
 - 11kV transmission lines – now decommissioned.
- *Telecommunications lines:*
 - No known copper cables are located within the LW101 to LW106 Extraction plan area.

2.3 **Farm Land and Facilities**

The land associated with the Narrabri Mine has been historically used for agriculture (grazing, some cropping) and consists of:

- Agricultural utilisation or agricultural suitability:
 - Pasture (primarily Land Capability Class III above LW101 - 106 with some linear areas of Class IV along drainage lines).
 - Soil conservation banks (contour banks).
- Farm buildings / sheds:
 - Residential dwelling, machinery shed and water tank.
- Fences:
 - Fences delineating property boundaries and internal paddocks for stock/pasture management; and
 - Gates and cattle grids.
- Water storages:
 - Earth dams and various sedimentation basins, including one windmill.

2.4 **Industrial, Commercial and Business Establishments**

No industrial, commercial or business establishments are located within the mining area, with the exception of infrastructure associated with the Narrabri Mine.

Affected mine infrastructure is limited to the surface facilities associated with surface to in-seam gas drainage bores and unsealed access tracks. A buried PED cable occurs immediately outside the area anticipated to be affected by vertical subsidence.



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2.5 Areas of Archaeological and/or Heritage Significance

The surface area overlying LW101 - 106 includes known Aboriginal heritage sites. These are predominantly found along riparian zones associated with Pine Creek and Kurrajong Creek.

The Aboriginal heritage sites potentially affected by mining of LW101 - 106 are identified as part of the environmental assessment and approval process for the project. Potential impacts to these sites will be monitored and managed in accordance with the Heritage Management Plan (HMP) prepared as part of the Extraction Plan for subsidence related impacts. A site-wide Aboriginal and Cultural Heritage Management Plan (ACHMP) addresses the management of potential impacts to heritage sites for other mining-related activities.

2.6 Residential Establishments

A single residence sits with the southern portion of LW105, and is generally located in the middle of the panel. This dwelling is owned by Narrabri Mine and will be vacated prior to longwall extraction of LW105.

The vacation of this dwelling is a management action described in the Built Features Management Plan.



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3 **SUBSIDENCE MONITORING**

3.1 **Overview**

The subsidence monitoring program consists of survey monitoring to quantify subsidence parameters, i.e. vertical movements, ground tilts and strains (refer to Section 3.2) and a consolidated summary of environmental consequence monitoring (refer to Section 3.3) to identify subsidence-related impacts to environmental and built features. Additional monitoring to identify height of fracturing will be conducted using a network of surface extensometers. The analysis of piezometric data to determine impacts on groundwater is dealt with separately in the Water Management Plan.

The objectives of this monitoring program are to:

- Measure baseline information – establish background data for the surface and environment above the mining area;
- Monitor the effects of mining – monitor identified subsidence parameters and environmental aspects at key positions relative to the longwall position;
- Regularly assess and interpret monitoring – analyse monitoring data to identify any variations to the predictions or unexpected anomalies;
- Report subsidence results (as described in Section 4.3);
- Re-assess subsidence impacts – where variations are greater than predictions, review of impacts will be undertaken; and
- Identify and implement remedial actions / contingency plans – review of impacts may indicate that remedial action is required. Implementation of remedial work and contingency plans will be undertaken in consultation with relevant stakeholders where appropriate.

The monitoring program will also enable NCOPL to obtain data on subsidence parameters and subsidence impacts relating to the extraction of LW101 – 106. This data will be used to confirm that actual subsidence and environmental consequences are within predicted limits, as well as to:

Validate the subsidence modelling methodology and predictions; and

- Establish and develop a subsidence database at Narrabri Mine for the purpose of future mine planning, subsidence prediction and assessment of environmental consequences for subsequent longwall extraction.

3.2 **Subsidence Survey Monitoring**

A subsidence survey monitoring program has been developed which includes the following elements:

- A transverse subsidence line across the longwall panels. The line will be installed to at least the middle of the next adjacent longwall before undermining occurs and will be discontinued in areas where movement has ceased; and
- Longitudinal lines over the starting and finishing point of LW106.



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The installed/proposed subsidence monitoring lines are shown in Appendix A.

Aerial Laser Scanning (ALS) surveys will be conducted, which will allow comprehensive ground movement monitoring over the entire panel. The ALS may be linked into the already established survey markers and provide subsidence data to within +/-0.1m, and will be calibrated using the subsidence line monitoring over LW106.

It is anticipated that ALS scanning will provide a more thorough picture of the subsidence development along creeks and surface terrain generally. Provided the ALS proves adequate as a monitoring technique, the longitudinal monitoring lines will be progressively phased out.

The subsidence line monitoring standards, schedule and methodology is detailed in Appendix B.

All survey monitoring will be undertaken in accordance with the requirements of the Narrabri Mine Health and Safety Management System, including the survey instrumentation and procedural requirements outlined in the Survey and Plan Arrangements Management Plan.

3.3 **Monitoring of Environmental Consequences**

The monitoring proposed under the Extraction Plan and all relevant sub-plans to identify and assist in the management of environmental consequences is summarised in Table 1. All subsidence impacts monitoring is detailed in the relevant environmental management plan or sub-plan to the Extraction Plan for LW101 – 106.

These plans include:

- Built Features Management Plan (BFMP);
- Public Safety Management Plan (PSMP);
- Water Management Plan (WMP);
- Biodiversity Management Plan (BMP);
- Land Management Plan (LMP) ; and
- Heritage Management Plan (HMP).

Various monitoring programs are also proposed as part of the Landscape Management Plan, which includes the Rehabilitation Management Plan and Mine Closure Plan. These monitoring programs are generally an extension of the monitoring contained in the above plans, as suitable for monitoring post-mining remediation and rehabilitation. As such, monitoring under the Landscape Management Plan and sub-plans is not summarised here.

3.4 **Monitoring for Extent of Fracturing**

A monitoring program to determine the height of fracturing and extent of subsidence over the longwall panels is being developed in conjunction with SCT Operations Pty Ltd using surface extensometers. This system will be used to determine spanning horizons and the



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extent of delamination above the goaf void. This monitoring program will contribute to the overall understanding of strata behaviour in the Narrabri area.

Narrabri Mine will investigate methods of determining the depth of large fractures observed on the surface (greater than 100mm). In determining fracture depth, the following methods will be considered:

- Measurement probe inserted from surface into the crack
- Analysis of piezometric data to determine altered water table; or
- Use of shallow coring and subsequent core analysis.

Data on fracturing behaviour, particularly in relation to the associated changes in hydraulic conductivity and related aquifer properties, will also be assessed using the site groundwater monitoring network. Observed changes in the hydraulic properties of the aquifer will be used to recalibrate current site groundwater models and enable improvements in future prediction of subsidence fracturing behaviour and associated groundwater responses and surface-groundwater interactions (refer to Water Management Plan for further detail).



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Table 1 Environmental Consequences - Monitoring Summary

Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Built Features Management Plan			
Roads and Access Tracks	Pre-subsidence	Survey monitoring of Greylands Road, including: <ul style="list-style-type: none"> - Photographic records of the condition of the road and any drainage structures; - Survey to locate drainage structures; confirm road location/widths; and direction and capacity of table drains. 	BFMP, Appendix A
	Prior to each LW	Narrabri Mine has implemented a Greylands Road Management Plan, in consultation with Narrabri Shire Council, which outlines the road will be closed to the public until NCOPL purchase the land. As such, no Narrabri Shire Council inspections are required for the road.	
	Daily during active subsidence	Visual monitoring of Greylands Road and any affected internal access tracks to note any subsidence impacts that require remediation or implementation of additional traffic controls.	
	Following completion of active subsidence affecting Greylands Road (after each LW pass).	Survey monitoring of Greylands Road, including: <ul style="list-style-type: none"> - Photographic records of the condition of the road and any drainage structures; - Survey to locate drainage structures; confirm road location/widths; and direction and capacity of table drains. 	
	Following each LW	Narrabri Mine has implemented a Greylands Road Management Plan, in consultation with Narrabri Shire Council, which outlines the road will be closed to the public until NCOPL purchase the land. As such, no Narrabri Shire Council inspections are required for the road.	
Water Storage Dams and Soil Conservation Banks	Pre-subsidence	Survey to obtain xyz coordinates along contour banks and water storage dams, using either LiDAR or field survey methods.	BFMP, Appendix A
	Pre-subsidence	Photographic records of all dams and contour banks	
	During undermining of structure.	Visual inspections of dams noting their condition and any indications of the following: <ul style="list-style-type: none"> - Cracking or failure of earth embankment requiring immediate attention; - Erosion of bank or spillway requiring repair. 	
	Post-subsidence	Inspection survey on completion of active subsidence to identify impacts for remediation.	
Property and	Pre subsidence	Baseline aerial survey of fence lines and in-field visual assessment.	BFMP, Appendix



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Livestock Fences	During active subsidence.	Fortnightly visual monitoring during active subsidence.	A
	Post subsidence	Visual inspection survey on completion of active subsidence to identify impacts for remediation.	
Dwellings and Machinery Sheds	Pre subsidence	Dilapidation surveys of any structures not owned by NCOPL prior to active subsidence.	BFMP, Appendix A
	Pre subsidence	Undertake inspection to identify the presence of asbestos or other hazardous building materials/substances unable to remain in situ.	
	Post subsidence	Inspection survey on completion of active subsidence to identify impacts for remediation.	
Utility Infrastructure – electricity transmission lines	Pre subsidence	Survey of power lines for tilt, strain and line clearance of electrical utility infrastructure. Inspection of powerline by Essential Energy to document current condition of asset to determine any mitigation works to minimise/prevent damage during mining, and any remediation required post-mining (e.g. installation of rollers, stays). Narrabri Mine has implemented the Essential Energy Management Plan, in consultation with Essential Energy, which outlines the mitigation measures to be implemented to minimise impacts to the powerline as a result of subsidence.	BFMP
	Post subsidence	Survey of power lines for tilt, strain and line clearance of electrical utility infrastructure. Inspection of powerline by Essential Energy to document current condition of asset to determine any mitigation works to repair subsidence damage. Narrabri Mine has implemented the Essential Energy Management Plan, in consultation with Essential Energy, which outlines the mitigation measures to be implemented to minimise impacts to the powerline as a result of subsidence.	
Utility Infrastructure – Telstra	Pre-subsidence	No known copper cables are located in the LW101 to LW106 Extraction plan area.	
Mine infrastructure	Pre and post subsidence	Inspect decommissioned SIS gas drainage sites to confirm all structures have been safely decommissioned and site is stable and safe	
Mine infrastructure	Pre and post-subsidence	Survey collars of affected piezometers and groundwater monitoring bores to confirm accurate levels for measuring of groundwater levels.	
Water Management Plan			
Surface Water Quality Monitoring			



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Pine and Kurrajong Creeks	Prior to active subsidence (baseline) and daily during runoff events	Obtain baseline data on surface water quality in Pine and Kurrajong Creeks prior to mining, and daily during runoff events for level, electrical conductivity (EC), oil and grease, pH, total suspended solids (TSS), total organic carbon (TOC).	WMP
Surface ponding	Monthly during ponding formation	Sampling for EC.	
Ground Water Level Monitoring			
Namoi River Alluvials	Baseline and throughout duration of mining	Monitoring of groundwater levels: weekly monitoring – manual sampling locations, and recording at automatic groundwater level sampling at vibrating wire piezometers (VWPs) every 4 hours (data downloaded monthly).	WMP
Permian to Jurassic hard rock aquifers	Baseline and throughout duration of mining	Monitoring of groundwater levels: weekly monitoring – manual sampling locations, and recording at automatic groundwater level sampling at vibrating wire piezometers (VWPs) every 4 hours (data downloaded monthly).	
Hydraulic conductivity	Pre-mining and post-subsidence	In-situ hydraulic testing of monitoring bores prior to passing of longwall and 3 months after passing of longwall. In-situ hydraulic testing during installation of new and replacement bores or VWPs.	
Mine water inflows	Daily	Measurement of groundwater volumetric flow rates at extraction bores, sumps, and box cut sump.	
Springs	Monthly	Spring discharge rate including the Mayfield spring.	
Ground Water Quality Monitoring			
Monitoring bores	Quarterly	Sampling of monitoring bores for EC and pH.	WMP
Bore water quality	Annually	Sampling of full suite of parameters (Refer WMP for list of parameters to be tested).	
Mine water inflows	Monthly	Measurement of mine water pumped into and out of the mine (EC pH,).	
Mine water inflows	Quarterly	Sampling of full suite of parameters (Refer WMP for list of parameters to be tested).	



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Biodiversity Management Plan			
Woodland and Riparian Vegetation Monitoring			
General	Baseline, Annually (Spring)	LiDAR and multi-spectral imaging to measure changes in topographic form, woodland parameters (i.e. extent, cover, biomass) extent of erosion.	BMP
Native overstorey (canopy)	Baseline, Annually (Spring)	Field survey (Twelve, 100 x 20m transects) to observe crown cover, foliage cover, species health, species richness and recruitment.	
Native midstorey (shrub and small tree)	Baseline, Annually (Spring)	Field survey (Twelve, 100 x 20m transects) to observe crown cover and species richness.	
Native ground layer	Baseline, Annually (Spring)	Field survey (Twelve, 100 x 20m transects) to observe foliage cover and species richness.	
Exotic species	Baseline, Annually (Spring)	Field survey (Twelve, 100 x 20m transects) to observe crown cover, foliage cover and species richness.	
Groundcover	Baseline, Annually (Spring)	Field survey (Twelve, 100 x 20m transects) to observe presence/size of woody debris, organic litter, bare ground and exposed rock.	
Terrestrial Fauna and Habitat Monitoring			
Superb Parrot	Baseline, Annual (Autumn)	Field survey - standardised search methodology at dawn and dusk using randomly-selected meander transects (two from each fixed monitoring point).	BMP
Grey-crowned Babblers	Baseline, Annual (Spring)	Field survey - standardised search methodology at dawn and dusk using randomly-selected meander transects (two from each fixed monitoring point).	



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Woodland birds	Baseline, Annual (Spring and winter)	Field survey - standardised search methodology at dawn and dusk using randomly-selected meander transects (two from each fixed monitoring point).	
Koalas	Baseline, Annual (Spring)	Searches at each mammal monitoring site, including observations along a transect line, noting direct sightings, scratching and scats.	
Mammal species diversity	Baseline, Annual (Spring)	Hair tubes (5 large and 5 small funnels) placed on the ground and/or in habitat trees along a trap line at each mammal monitoring site to establish presence of species. Infra-red camera with a closed bait trap to establish presence of species.	
Bat detection	Baseline, Annual (Spring)	Establish species presence and habitat usage in accordance with methodology outlined in the BMP.	
Feral species	Baseline, Annual (Spring)	Anabat detection devices at each mammal monitoring site to establish presence and habitat usage.	
Aquatic Biota and Habitat Monitoring			
Aquatic Biota	Baseline Annually (Spring 2011)	Rapid sampling and assessment of the macroinvertebrates and vertebrates in the farm dams to confirm earlier surveys. Following these surveys ongoing monitoring, if any, should be developed considering the range of specific species found. Sampling of any ponding in ephemeral creeks that forms post subsidence.	BMP
Land Management Plan			
Surface Cracking			
Surface Cracking behind longwall face.	Weekly and following rainfall events >10mm	Visual inspections for surface impacts (including surface cracking, ponding, landslips and erosion) of areas immediately behind the longwall face passage.	LMP



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Surface Cracking in drainage lines	Following rainfall events > 10mm	Monitor drainage lines to identify erosion and potential erosion following rain events.	
Remote Sensing			
Topography and landscape morphology	Baseline, Every 3 years	LiDAR survey to identify changes in topographic form over time, including creek slope, width and depth.	LMP
Pasture characteristics	Baseline, Annually (early spring)	Multi-spectral imaging, processed into a normalised difference vegetation index (NVDI) to measure variability in vegetative biomass and cover (pasture) over time and compared to control sites, followed by targeted field survey where analysis (ANOVA) indicates potential impacts have/are occurring – for example weed infestation or erosion impacts to vegetation.	LMP
Soil Characteristics	Every 3 – 5 years.	EM38 survey to provide information on variability to soil conductivity (relates strongly to soil moisture, soil ions, and soil texture variation) within Extraction Area compared to control sites and over time.	LMP
Agricultural Surveys			
Pasture Characteristics	Annually (early spring)	Quadrat sampling to observe pasture biomass, pasture composition, weed presence and percentage cover. Sampling design and analysis using BACI (Before-After-Control- Impact) principles to assess annual variability and identify impacts from mining.	LMP
Soil characteristics	Annually (early spring)	Sampling from each monitoring quadrat and testing of key soil parameters (pH, EC, organic matter, N, P). Sampling design and analysis using BACI principles to assess annual variability and identify impacts from mining.	



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Aspect / Feature	Frequency	Monitoring Measures (full details provided in relevant management plan)	EP Management Plan Reference
Weeds	Annually (early spring)	Observe number of weed species and % cover - comparison using BACI principles to assess annual variability and identify impacts from mining.	
Creek line Surveys			
Geomorphic survey	Baseline, Annually (in late winter/spring).	Geomorphic survey to define geomorphic zones – mapping and description, survey (100m reaches).	LMP
Channel survey	Baseline, Annually (in late winter/spring).	Cross-sectional survey to monitor change in channel parameters (width, depth, cross-sectional area).	
Heritage Management Plan			
Known archaeological sites	Prior to and following each longwall	Visual inspection (including photographic record) by qualified archaeologist to record pre and post subsidence condition of each archaeological site to assess whether any intervention and remediation works are required.	HMP
Known archaeological sites	Monthly during undermining	Monthly inspection by site environmental personnel to observe relation of surface cracking or erosion (if any) in relation to archaeological sites.	HMP
Artefact find	As required	If artefacts or potential artefacts are identified during subsidence rectification works.	HMP
Artefact disturbance	As required	If artefacts or potential artefacts are disturbed during subsidence or subsidence rectification works.	HMP



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4 PLAN IMPLEMENTATION

4.1 Responsibilities

To ensure adequate implementation of this monitoring program, the following NCOPL responsibilities have been assigned to relevant NCOPL personnel (see Table 2). It is also noted that additional responsibilities are referred to within the relevant management plans.

Table 2 Roles and Responsibilities

Roles	Responsibilities
General Manager	- Ensure that adequate resources are available to NCOPL personnel to facilitate the completion of their responsibilities under this program.
Mine Manager	- Ensure this Subsidence Monitoring Program is implemented and adhered to.
Technical Services Manager	- Ensure that all monitoring and reporting under the BFMPs and Subsidence Monitoring Program is carried out within the timeframes specified, and is checked, processed and filed appropriately.
	- Liaise with stakeholders regarding subsidence impact management.
	- Authorise changes to this Subsidence Monitoring Program.
Environmental Superintendent	- Ensure that all environmental monitoring and reporting is undertaken in accordance with the relevant environmental management plans and various approval requirements, and is checked, processed and filed appropriately.
Mine Surveyor	- Ensure that all subsidence monitoring is carried out to the accuracy required, within specified timeframes and are checked, processed and filed appropriately.

4.2 Reporting

Subsidence reporting will be undertaken in accordance with Schedule 6 of the Project Approval as described in Section 5.2 of the Extraction Plan.

Information generated as a result of monitoring surveys carried out on subsidence lines shall be supplied to the Principal Subsidence Engineer, via the Subsidence Data Portal.

Results after each survey will be forwarded promptly after they have been received at Narrabri Mine. Results will be in the format of an excel file with subsidence, tensile/compressive strains and tilts computed and also displayed graphically.

4.3 Review

An internal review of this Subsidence Monitoring Program will be conducted in response to:

- An incident recorded as a result of the operations that has significant implications for how subsidence impacts and consequences are monitored (i.e. exceedance of predicted subsidence values);
- A change in operations that significantly changes the impacts to the surface overlying LW101-106;



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- Statutory requirements or directions/conditions of approvals requiring such action; or
- Recommendations as a result of internal or external audits.

In the event of the management plan being changed a copy will be sent to the relevant agencies.



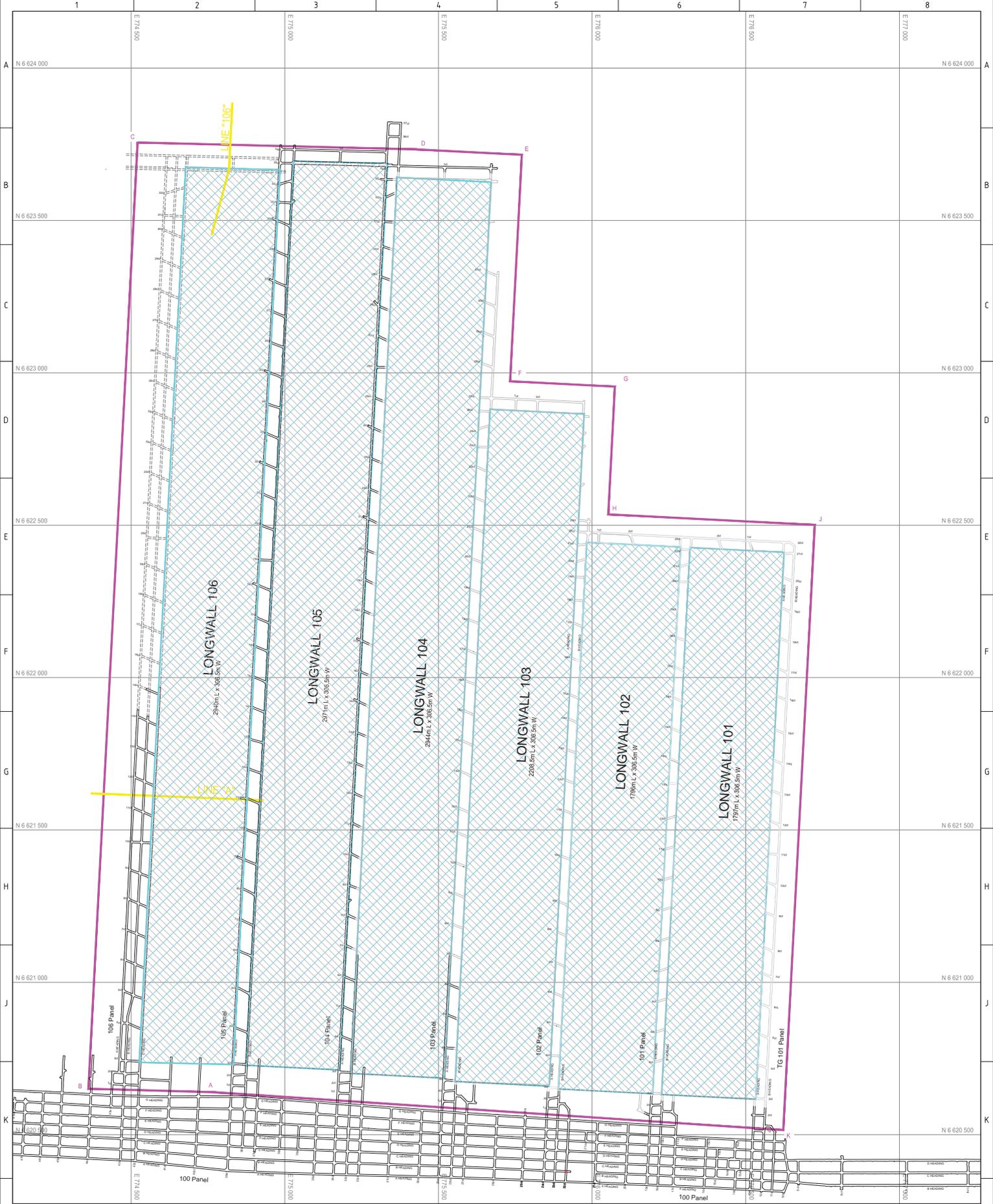
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Appendix A

Subsidence Monitoring Plan



- LEGEND**
- PROPOSED LONGWALL EXTRACTION AREAS
 - CURRENT FIRST WORKINGS
 - DESIGNED FIRST WORKINGS
 - APPLICATION AREA
 - SUBSIDIENCE LINES

APPLICATION AREA COORDINATES

POINT	EASTING	NORTHING
A	774773.14	6620639.38
B	774360.83	6620661.07
C	774521.42	6623755.81
D	775430.37	6623733.00
E	775771.48	6623715.36
F	775733.05	6622972.30
G	776074.16	6622954.65
H	776052.49	6622535.66
J	776724.69	6622500.00
K	776621.97	6620515.18

NOTES:
 ALL DIMENSIONS IN METRES.
 COORDINATE DATA IN MAP GRID OF AUSTRALIA 1994 (MGA) AND HEIGHT DATA IN AUSTRALIAN HEIGHT DATUM (AHD).
 WORKINGS AS AT 25/06/2015.

REV	DESCRIPTION	DATE	DRN	CKD
1	Update to Subsidence Lines	28/02/17	PN	SF
2	Update to Subsidence Lines	1/11/18	ZN	SF

WHITEHAVEN COAL
NARRABRI MINE
 Narrabri Coal Operations Pty Ltd
 Locked Bag 1002, Narrabri, NSW 2390 Australia

Name	Date	Title
DRN	PAC	25/06/2015
CKD		
APP		
SCALE	1 : 4000	

DRAWING NUMBER	REV
APN_06.09	1



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Appendix B

Survey Monitoring Method and Schedule



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STANDARDS

All monitoring will be planned and surveyed to ensure these surveys satisfy the conditions to achieve a standard of accuracy of “Class D” as prescribed in ICSM SP1 (The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 “Standards and Practices for Control Surveys”). Target accuracy for survey of all points in the following tables will have a relative accuracy of +/- 3mm between co-ordinated monitoring points. Each survey will be conducted in 3D. The monitoring schedule is explained in greater detail in the following sections.

Subsidence Line Monitoring

Subsidence Line A

Subsidence Line A to be installed to monitor subsidence, tilt, strain and angle of draw across Longwall 106. The design and monitoring schedule is shown on Plan A (Appendix A). The installation and monitoring details for Line A are shown in Table 3. Before mining commences in a given longwall block, Line A will be installed into the adjacent longwall panel. Line A subsidence markers A1-A180 have been removed as movement has ceased.

Table 3 Subsidence Line A Details

Mark Type	Star Pickets driven to refusal at 10m intervals
Depth of Cover (Extension)	160m
Survey Monitoring Method	Total station traverse from terrestrial baseline
Monitoring Frequency	Prior & Post Mining each Longwall
	106 CH881
	6 monthly

Subsidence Line B

Removed as movement has ceased.

Subsidence Line C

Superseded – dam has been decommissioned, therefore monitoring no longer required.

Subsidence Line D

Removed as movement has ceased.

Subsidence Line E

Removed as movement has ceased.

Subsidence Line F

Removed as movement has ceased.

Subsidence Line G

Removed as movement has ceased.

Subsidence Line 101

Removed as movement has ceased.



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Subsidence Line 102

Removed as movement has ceased.

Subsidence Line 103

Removed as movement has ceased.

Subsidence Line 104

Removed as movement has ceased.

Subsidence Line 105

Removed as movement has ceased.

Subsidence Line 106

Subsidence Line 106 to be installed to monitor subsidence, tilt, strain and angle of draw along the start of LW106. The design and monitoring schedule is shown on Plan A (Appendix A). The installation and monitoring details for Line 106 are shown in Table 4. This monitoring line is to be installed and base survey complete prior to commencement of mining. The start-up zone will be defined as being 210m north of the installation roadway through to 220m out-by the LW106 installation roadway. The takeoff zone will not be monitored but supplemented with ALS survey. This will also assist in limiting the amount of clearing of native vegetation in the south of LW106.

Table 4 Subsidence Line 106 Details

Mark Type	Star Pickets driven to refusal at 10m intervals
Depth of Cover (Extension)	Start 210m
Survey Monitoring Method	Total station traverse from terrestrial baseline
Monitoring Frequency	Prior & Post Mining LW106
	At 50m retreat intervals through to 300m out-by the installation roadway
	6 monthly until movement ceases

Electricity Transmission lines – 11kV Power Poles

The power poles have been removed and as such no longer require monitoring.



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Appendix C

Visual Monitoring Method



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Visual Inspection of Roads and Access Tracks

Visual monitoring of affected sections of unsealed access road will be conducted daily whilst affected by active subsidence. Monitoring to note and document where appropriate:

1. Location of longwall relative to the affected section of road;
2. Confirmation that any required signage under the BFMP and PSMP is located in an appropriate location and is visible / legible to road users;
3. Presence and width of any subsidence cracking within the road pavement;
4. Any subsidence effects that on inspection may affect the road formation and safe use of the road (i.e. compression humps or ground tilts);
5. Affected cattle grids (i.e. sharp edges protruding or gaps) or gates not able to be easily opened /closed;
6. Any damage/alteration to table drains or culverts that may result in water ponding or inadequate drainage during rainfall; and/or
7. Any other road obstructions.

Any observations of subsidence impacts requiring remediation or repair are to be recorded in the checklist provided in the BFMP and reported to the Technical Services Manager.

Visual Inspection of Water Storages

Daily visual inspection of water storages/dams (if storing water) during active subsidence to note and document where appropriate:

- 1) Any sudden changes (drops) in stored water level compared to previous day's inspection (use painted wooden survey stake or similar);
- 2) Condition of the dam wall and spillway, in particular noting any:
 - a) Cracking within embankment;
 - b) Signs of possible embankment failure (i.e. slumping or collapse of partial section);
 - c) Formation of erosion (particularly formation of tunnel erosion or holes);
 - d) Water seepage through wall; and/or
 - e) Spillway damage (should be level, lower than embankment height and non-eroding).

If any of the above signs are noted, they should be reported to the Technical Services Manager. Assessment of the dam undertaken and works implemented in accordance with the Built Features Management Plan.

Visual Inspection of Property and Livestock Fences

Visual monitoring of affected sections of fence lines will be conducted fortnightly whilst affected by active subsidence. Monitoring to note and document where appropriate:

- 1) Any breakage of permanent or temporary fencing; and
- 2) Location of grazing stock in relation to damaged fencing and confirmation that they are safely contained (or otherwise).



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Where damage to fence lines may result in unplanned movement of livestock onto public roads (i.e. Greylands Road or further afield to the Kamlaroi Highway), this is to be reported to the Environmental Officer.