
	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

NARRABRI MINE


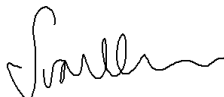
EXTRACTION PLAN

SUBSIDENCE RISK ASSESSMENT

LW 203 – LW 206

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
		WHC_PLN_NAR_COAL RESOURCE RECOVERY PLAN - LW 203 – LW 206	

Prepared by:


Title	Name	Signature	Date
Senior Environmental Consultant	Mike Gale		07 February 2023
Senior Environmental Manager	S. van der Meulen Onward Consulting		07 February 2023

Date of Risk Assessment	27 October 2022
Operations	Narrabri Mine EP LW 203 - LW 206
Department	Health, Safety and Environment
Risk Assessment Title	Subsidence Risk Assessment Narrabri Mine EP LW 203 - LW 206
Person responsible for review	Brent Baker, Manager HSE
Signature	
Date	8 November 2022

This document has been prepared by Onward Consulting to comply with the conditions of the Narrabri Mine Project Approval and has relied upon the relevant information available at the time of writing and all findings, conclusions or recommendations contained herein are based thereon. This document is for the use of Narrabri Coal Operations Pty Ltd and no responsibility will be taken for its use by other parties. Narrabri Coal Operations Pty Ltd may, at its discretion, use this document to inform regulators and the public.



Onward document number: NCO-003-9-0-PLN

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Acronyms and abbreviations

Acronym	Description
°	degrees
AHD	Australian Height Datum
AoD	Angle of draw
CF	Cut and flit
DGS	Ditton Geotechnical Services
DPE	The NSW Department of Planning and Environment
EC	electrical conductivity
EP 203-206	Extraction Plan for LW 203 to LW 206
EP-BFMP	Built Features Management Plan (as Appendix E to the Extraction Plan)
EP-PSMP	Public Safety Management Plan (as Appendix F to the Extraction Plan)
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
H	cover depth
ha	hectare
HSE	health, safety and environment
km	kilometre
LiDAR	light detection and ranging
LW	longwall panel
m	metre
ML	mining lease; megalitre
mm	millimetre
mm/m	millimetre per metre
MOD 5	Modification 5
MOD 7	Modification 7
Mtpa	million tonnes per annum
NCOPL	Narrabri Coal Operations Pty Ltd
NSW	New South Wales
RAP	Registered Aboriginal Party
ROM	run of mine
TSS	total suspended solids
U95%CL	upper 95 % confidence level
WHC	Whitehaven Coal Limited


	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Table of contents

1. Introduction.....	1
1.1 Background	1
1.2 Purpose and scope	1
1.3 Objectives.....	4
1.4 Statutory requirements.....	4
1.4.1 Project Approval.....	4
1.4.2 EPBC Act Approval.....	4
1.4.3 Mining lease.....	4
1.4.4 Extraction Plan Guidelines	4
1.5 Preparation and consultation.....	5
1.6 Access to information.....	5
1.7 Risk assessment participation.....	5
2. Limitations, exclusions, predictions and assumptions	6
2.1 Limitations and exclusions	6
2.2 Predictions and assumptions.....	6
2.2.1 Mining geometry	6
2.2.2 Surface features.....	7
2.2.3 Subsidence effects.....	7
2.2.4 Predicted impacts - natural features	8
2.2.5 Predicted impacts - built features	9
2.2.6 Predicted impacts - Aboriginal heritage	10
3. Hazard identification.....	12
4. Level 2 qualitative risk assessment outcomes.....	13
5. References	21
6. Glossary	22
7. Review history	24
Attachment 1 WHC risk matrix	25


Tables

Table 1-1 Risk Assessment participation.....	5
Table 3-1 Hazard identification techniques	12
Table 4-1 EP 203-206 qualitative risk assessment	14

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Figures

Figure 1-1 Extraction Plan Area and underground mining layout for LW 203 to LW 206..... 3

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

1. Introduction

1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield. It is located approximately 25 kilometres (**km**) south-east of Narrabri and approximately 60 km north-west of Gunnedah, within the Narrabri Shire Council Local Government Area in New South Wales (**NSW**). The Narrabri Mine includes an underground coal mine, a coal handling and preparation plant and associated rail siding and surface infrastructure.

The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture, which consists of two Whitehaven Coal Limited (**WHC**) wholly owned subsidiaries, and other joint-venture partners¹. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominant purpose of mining for coal from the Hoskissons Coal Seam.

Stage 1 of the Narrabri Mine was approved in November 2007 under Part 3A of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**). Construction of the mine and supporting infrastructure commenced in 2008, with production using a continuous miner commencing in 2010. Following the approval of the Stage 2 Environmental Assessment (R.W Corkery & Co., 2009) (the **EA**) and the issue of the Stage 2 Project Approval 08_0144 (**Project Approval**) in July 2010, and *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) approval (**2009/5003**) in January 2011, the Narrabri Mine was converted to an 8 million tonnes per annum (**Mtpa**) run of mine (**ROM**) longwall mining operation, which commenced in 2012.

The Project Approval has subsequently been modified on a number of occasions. The environmental assessment for Modification 5 (Resource Strategies, 2015) (**MOD 5**), approved in December 2015, changed the mine geometry by reducing the number of longwall (**LW**) panels from 26 to 20, increased some LW panel widths and increased the production to 11 Mtpa of ROM coal until July 2031.


Modification 7, the most recent modification of the Project Approval, was approved on 23 November 2021. The environmental assessment for Modification 7 (Resource Strategies, 2021) (**MOD 7**) describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels Cut and Flit (**CF**) 201 to CF 205. There is no change to the previously approved longwall panels LW 203 to LW 209. The bord and pillar mining will occur concurrently with existing longwall operations for a period of approximately five years, with the maximum ROM coal production rate remaining within the approved limit of 11 Mtpa.

1.2 Purpose and scope

This Subsidence Risk Assessment (**Risk Assessment**) for Longwall LW 203 to LW 206 has been prepared in accordance with the NSW Department of Planning and Environment (**DPE**) *Draft Extraction Plan Guideline* (DPE 2022) (**Extraction Plan Guidelines**).

The Extraction Plan Guidelines require all main subplans of the Extraction Plan to give appropriate consideration to risk assessment and risk management, particularly the Extraction Plan - Public Safety Management Plan (**EP-PSMP**) and the Extraction Plan - Built Features Management Plans (**EP-BFMP**). Rather than risk assessments split over a number of documents, the potential risks of subsidence resulting from longwall mining at the Narrabri Mine have been assessed together and reported in this document.

¹ For full details on the joint venture ownership, refer to the introduction of the Extraction Plan.

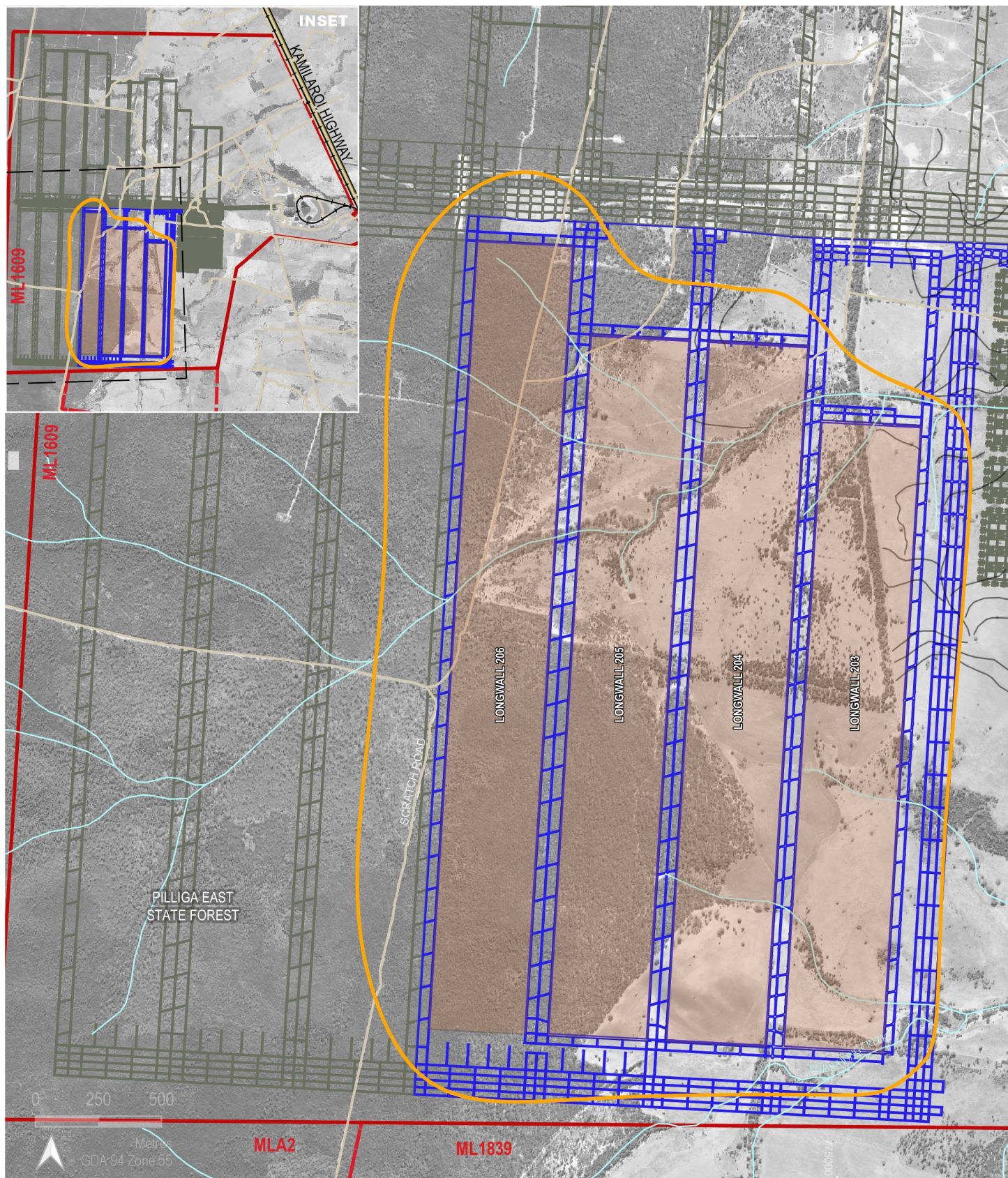
	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Previous risk assessments were completed for subsidence hazards above LW 101 to LW 110. Additionally, a Subsidence Risk Assessment for Panels 201 to Panels 202 was completed in March 2022. The scope of this Risk Assessment is to identify hazards and assess the potential risks to the environment, people, structures and services as a result of the extraction of LW 203 to LW 206, and to identify controls to reduce the potential impacts and consequences to an acceptable level. This Risk Assessment forms Appendix I to the Extraction Plan for LW 203 to LW 206 (**EP 203-206**).

The Ditton Geotechnical Services Pty Ltd (**DGS**) *Mine Subsidence Assessment Report for LW 203 to LW 206* (DGS 2022) (**Mine Subsidence Assessment Report**) has been used as a basis for identifying hazards associated with mine subsidence effects. The Mine Subsidence Assessment Report is presented in full as Appendix J to EP 203-206.

The LW 203 to LW 206 Extraction Plan Area² and underground mining layout is presented in Figure 1-1. A detailed description of the underground mining method is provided within EP 203-206.

² The area located within the 45° Angle of Draw (**AoD**) as shown on Figure 1-1.




LEGEND

- ML 1609
- ML 1839
- MLA2
- Underground mining layout
- Longwalls 203 to 206
- Proposed longwall voids (LW203-206)
- 45 degree angle of draw
- Road
- Watercourse
- Contour bank

NARRABRI MINE

FIGURE 1-1

Extraction Plan Area and Underground Mining Layout for LW 203 to LW 206

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

1.3 Objectives

The objectives of this Risk Assessment are to:

- provide a description of the investigation and analysis methods used in determining the risk control measures and procedure;
- provide a description of all risk and control measures and procedures;
- protect the human health and safety of persons on the surface and underground;
- prevent damage to infrastructure and natural features; and
- provide a program for implementing the proposed risk control measures and procedures.

The risk assessments process will be carried out in accordance with the WHC Risk Management Standard (WHC-STD-RISK MANAGEMENT), which is based on the requirements of Australian Standard AS/NZS ISO 31000:2018 *Risk Management – Guidelines*, MDG1010 - *Risk Management Handbook for the Mining Industry* (2011) and MDG1014 – *Guide to Reviewing a Risk Assessment of Mine Equipment and Operations* (1997).

1.4 Statutory requirements

This Risk Assessment has been prepared in accordance with the applicable conditions and requirements of the Project Approval, EPBC 2009/5003, ML 1609 and all relevant legislation and guidelines as set out in the following sections.

1.4.1 Project Approval

Although not directly relevant to this Risk Assessment, Project Approval Schedule 3 Condition 2 requires NCOPL to ensure that the Narrabri Mine does not cause any additional risk to public safety, which is further addressed in the EP-PSMP, provided as Appendix F to EP 203-206. There are no specific Project Approval conditions related to the completion of a risk assessment. There are no specific commitments in the Statement of Commitments (Appendix 3 of the Project Approval) related to risk management or assessment for mine subsidence.

1.4.2 EPBC Act Approval


The Narrabri Mine is subject to EPBC 2009/5003 issued under the EPBC Act. There are no specific EPBC conditions related to this Risk Assessment.

1.4.3 Mining lease

NCOPL are the holder of ML 1609 issued under the Mining Act 1992 in January 2008. As the holder of a mining lease, NCOPL must take all reasonable measures to prevent, or if that is not reasonably practicable, to minimise, harm to the environment caused by activities under the mining lease.

1.4.4 Extraction Plan Guidelines

As stated in the Extraction Plan Guidelines, all sub-plans should consider risk assessment and risk management, particularly the EP-BFMP and EP-PSMP.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

1.5 Preparation and consultation

This Risk Assessment does not require any specific individual consultation or approval. The overall consultation and approval obligations for the Extraction Plan required by the Project Approval are detailed in EP 203-206.

1.6 Access to information

In accordance with Schedule 6 Condition 10 of the Project Approval, the approved Extraction Plan and all appendices, audits and reports, and summaries of all monitoring data (where relevant) will be made publicly available on the WHC website. All information will be kept up to date.


Note that any printed copies of this Risk Assessment are uncontrolled.

1.7 Risk assessment participation

The participants of the Risk Assessment, their roles at the Narrabri Mine and their level of experience are listed in Table 1-1. Detailed responsibility descriptions are provided in each sub-plan.

Table 1-1 Risk Assessment participation

Participant	Organisation	Role	Experience (yrs)
Owen Salisbury	NCOPL	Technical Services Manager	40
Brent Baker	NCOPL	Manager Health Safety and Environment (HSE)	13
Shane Rily	NCOPL	Environmental Superintendent	10
Servaes van der Meulen	Onward Consulting	Environmental Consultant	25
Mike Gale	Onward Consulting	Environmental Consultant	20
Carmen Osborne	Onward Consulting	Environmental Consultant	9

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

2. Limitations, exclusions, predictions and assumptions

2.1 Limitations and exclusions

The following limitations have been applied to the risk assessment:

- this risk assessment will concentrate on LW 203 to LW 206 only, consisting of the extraction of coal from LW 203 to LW 206;
- this risk assessment is undertaken based on subsidence predictions and measured values above LW 101 to 109;
- water liberated by mining will not be considered once it has been pumped out of the mine and discharged into the surface storage ponds; and
- disposal of brine-rich waters into any previously mined longwall goaves will not be considered.


2.2 Predictions and assumptions

The Mine Subsidence Assessment Report has been used as a basis for this Risk Assessment. The Mine Subsidence Assessment Report analysis and results are contained, in full, as Appendix J to the Extraction Plan and the predictions and assumptions that have been used in this Risk Assessment are listed in the following sections.

2.2.1 Mining geometry

The proposed mining geometry will be as follows:

- the lower Hoskissons (HS2) Seam will be extracted with a nominal extraction height of approximately 4.3 m.
- the longwall void widths for LW203 to LW 206 will range from 395.3 metres (m) to 402.8 m.
- the cover depth (H) over the proposed longwalls will range from 185 m to 330 m.
- the W/H (panel width to cover depth ratio) for the proposed longwall panels will range from 1.27 to 2.01, based on cover depths at the centre of the panels. This indicates supercritical subsidence behaviour will occur above each panel.
- three heading gate-roads are planned to be formed between LW 203 and LW 206 with two rows of diamond-shaped chain pillars with an acute rib-rib angle of 70°. The pillars will have minimum 'solid' widths ranging from 29.4 m to 39.5 m with lengths of 144.3 m.
- the distance between the pillar reduction panels to the east of the proposed longwall panels will be 266 m where the cover depth is approximately 200 m (i.e at an AoD of 53°).
- gate roads will be 3.7 m high and 5.4 m wide. Main headings roadways will be 5.4 m or 6.0 m wide, depending on operational requirements.
- the proposed chain pillar geometries will be 'squat' with chain pillar width to height ratios (w/h) ranging from 7.9 to 10.7.
- the end-of-panel barriers for LW203 to 206 will be effectively 159 m at the starting ends and range from 103 m to 770 m wide at the finishing ends. The barriers are designed to protect the main headings from abutment loading conditions adjacent to the longwall goaf. The finishing end barriers for LW203 to 205 are significantly wider than LW206 due to geological structure.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

2.2.2 Surface features

The land within the Extraction Plan Area is exclusively owned by NCOPL. The eastern portion of the Extraction Plan Area is largely cleared and has historically been used for livestock grazing and occasional cereal cropping. The western portion fringes the Pilliga East State Forest and is vegetated with several plant communities in both woodland form and derived native grassland form.

Topographic relief within the Extraction Plan Area ranges from 279 m Australian Height Datum (**AHD**) to 340 m AHD. The surface terrain is generally flat with slopes ranging from 1° to 5°. Slopes increase to 10° to 35° in several rocky 'hillock' locations, including the ephemeral creeks and tributaries (or gullies), which drain the Extraction Plan Area towards the north-east. The hillocks have Pilliga Sandstone exposures with local topographic relief ranging between 10 m and 15 m above the surrounding plains.


The following is a summary of the existing surface and subsurface features within and surrounding the Extraction Plan Area:

- gently undulating terrain with ephemeral watercourses associated with Kurrajong Creek and its tributaries.
- agricultural land predominately used for grazing cattle (one lessee associated with the 'Mayfield' property).
- riparian vegetation areas along the creeks.
- steep rocky slopes up to 15 m high.
- sub-surface groundwater aquifers at depths ranging from 5 m to 50 m (typically of poor quality).
- one Aboriginal cultural heritage site 'Mayfield' (many grinding grooves in a sandstone outcrop) is located above the proposed LW 205. The site has 'moderate' scientific significance.
- one NCOPL owned dwelling partly constructed over chain pillars between LW 204 and LW 205. An olive tree orchard is located south of the residence and was in poor condition at the time of inspection in 2019.
- one NCOPL-owned dwelling and machinery sheds exist above the proposed LW 203 and LW 204 ('Westhaven').
- two NCOPL owned residences located adjacent to the Extraction Plan Area (i.e. outside the 45° AoD) to the east.
- one unsealed public access road (Scratch Road) above LW 205 and LW 206.
- seventeen farm dams for livestock watering (D40-D51, D61-D64, D70).
- soil conservation (contour) banks and property fencing (post and wire).
- two NCOPL-owned groundwater supply bores (stock and domestic) and four groundwater monitoring bores.
- one State Survey Mark above LW 205.

The surface conditions, land use and underground mining geometry within the Extraction Plan Area will be similar to the completed LW 101 to LW 109.

2.2.3 Subsidence effects

The subsidence predictions for the Extraction Plan Area have been based on several empirical and calibrated analytical models of overburden and chain pillar behaviour developed in the New South Wales Coalfields.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

The predicted values may be occasionally exceeded (up to 5% of the time) due to discontinuous strata behaviour associated with near surface cracking, joint displacement, geological features (e.g. faults) and/or rapid changes in topography (creek beds).

The maximum subsidence effect predictions for LW 203 to LW 206 are presented below:


- first maximum panel subsidence ranges from 2.58 m to 2.75 m (60% longwall extraction height [T] to 64%T).
- final maximum panel subsidence ranges from 2.65 m to 2.80 m (62%T to 65%T).
- final maximum chain pillar subsidence ranges from 0.23 m to 0.49 m (5%T to 11%T).
- final maximum panel tilt ranges from 20 millimetres per metre (**mm/m**) to 54 mm/m.
- final maximum panel concave curvatures range from 0.7 per kilometre (km^{-1}) to 3.5 km^{-1} (radii of curvature 1.4 km to 0.29 km).
- final maximum panel convex curvatures range from 0.7 km^{-1} to 3.2 km^{-1} (radii of curvature 1.4 km to 0.31 km).
- final maximum panel compressive strains range from 7 mm/m to 35 mm/m.
- final maximum panel tensile strains range from 7 mm/m to 32 mm/m.

The predicted values may be occasionally exceeded (up to 5% of the time) due to discontinuous strata behaviour associated with near surface cracking, joint displacement, geological features (e.g. faults) and/or rapid changes in topography (creek beds).

2.2.4 Predicted impacts - natural features

The results of the Mine Subsidence Assessment indicate that the surface deformations due to mining are likely to cause the following impacts within the Extraction Plan Area:

- surface cracking and shearing within tensile and compressive strain zones. Crack widths in relatively 'flat' terrain (slopes $<18^\circ$) are estimated to range from 210 millimetres (**mm**) to 330 mm in sand or loam and from 420 mm to 650 mm in clay or rock. The crack widths are based on the upper 95% confidence level (**U95%CL**) and may be exceeded 5% of the time.
- Light Detection and Ranging (**LiDAR**) surveys and ground truthing inspections indicate that there are approximately 0.875 ha of steep rocky slope (slope gradients 18° to 28° with heights ranging from 6 m to 12 m).
- it is estimated that the steep slope (S12 above LW 204) will be subsided by up to 2.8 m with tilts of up to 15 mm/m and tensile/compressive strains of $\pm 15 \text{ mm/m}$ due to the transitional subsidence 'wave' development with a final compressive strain of 15 mm/m. Subsidence is expected to cause cracking with widths ranging from 385 mm to 770 mm, depths from 3 m to 15 m and lengths from 30 m to 100 m based on observations. The impact to the steep slope is estimated to range from 0.1% to 0.2%. The impacts are likely to be within the expected performance measure of 7%.
- general and localised slope instability (soil and rockslides) along the steep rocky slopes are considered 'very unlikely' to develop due to the predicted cracking and tilting.
- surface gradients are likely to increase or decrease by up to 2.5% ($\pm 1.5^\circ$) along creeks.
- connective cracking is estimated to range from 146 m to 256 m above the proposed panels (i.e. 68% to 87% of the cover depth; 0.51 to 0.65 times the effective panel width or 34 to 60 times the face extraction height of 4.3 m).


	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

- direct hydraulic connection to the mine workings due to sub-surface fracturing is estimated to encroach within 26 m to 55 m depth below the surface, with the closest value occurring above the proposed LW203. The U95%CL A/H ratio ranges between 0.82 and 0.87 above the proposed LW 203 to LW 206. It should be noted that the database of sub surface fracturing (used for empirical modelling) contains four out of fifteen supercritical cases where seam to surface connective cracking developed and when A/H exceeded 0.8. The predicted heights of cracking for these cases were also estimated to extend to within 20 m of the surface.
- it is assessed that the A/H = 0.8 line represents the point at which there is a risk (25% probability) that the predicted connective fracture zone could interact with the surface cracking zone but also depends on the near-surface geology (see below).
- investigation boreholes and site observations indicate that the near-surface strata consist of weathered, thinly bedded sandstone and siltstone associated with the Purlawaugh Formation and Garrawilla Volcanics. These units are likely to shear into thinner units and 'unlikely' to develop deep vertical cracks that extend into the A Zone (below 20 m depth).
- another consideration is that Pilliga Sandstone outcrops may develop deeper cracking than the more thinly bedded Purlawaugh formation sequences. As the Pilliga Sandstone units exist only above LW 204 and LW 206 where cover depth is > 220 m, it is considered 'unlikely' that A Zone cracking will encroach within 20 m of the surface and cause a surface to seam connection in these areas.
- based on a depth of surface cracking of 15 m and possible connectivity between the A and B-Zones, it is assessed that there is a < 25% probability ('unlikely' to 'possible') that connective cracking could impact the surface for the proposed longwalls. It is recommended that NCOPL continue to monitor changes in ventilation during extraction and repair surface cracks as soon as practicable.
- the Geology and Geometry Pi-Term Models predict 'discontinuous', or B-Zone, sub surface fracturing is likely to interact with surface cracks (D-Zones) where cover depths are < 375 m above the 400 m wide longwalls (i.e.e all of the proposed longwalls). Creek flows could be temporarily rerouted into open cracks to below-surface pathways and re-surface downstream of the mining extraction limits in the mining area.
- as discontinuous fracturing is expected to occur to the surface above the proposed mining area, there will be an increase in rock mass storage capacity and horizontal permeability in the overburden. Groundwater levels will be lowered in the medium to long terms as a consequence of these impacts.
- a total of six potential ponding locations have been identified for the Extraction Plan Area. Five of the potential ponding areas already exist and extend laterally up to 270 m away from the watercourses. The predicted subsidence contours indicate ponding may increase by a further 140 m or up to 410 m from the creeks. The maximum changes in pond depths are estimated to decrease by 0.04 m and increase up to 1.3 m. The ponded areas are estimated in change by -0.42 ha to +2.92 ha, with ponded volumes ranging from -0.23 megalitres (ML) to +20.6 ML.

2.2.5 Predicted impacts - built features

The results of the Mine Subsidence Assessment indicate that the surface deformations due to mining are likely to cause the following impacts within the Extraction Plan Area:

- there are seventeen farm dams for livestock watering (D40-D51, D61-D64, D70) within the Extraction Plan Area. The dams are located within the 20 mm subsidence contour from the proposed panels and estimated to be impacted by tensile and compressive strains ranging from 3 mm/m to 20 mm/m.
- several farm dams have already been subsided by LW101 to LW 109 but have not required remedial works to be undertaken. Notwithstanding, non-engineered farm dams and water storages are susceptible to surface cracking and tilting (i.e. storage level changes) due to mine subsidence. The

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			


tolerable tilt and strain values for the dams (before remediation is required) will depend upon the dam wall materials, construction techniques, and foundation type. NCOPL will repair and/or re-establish the dam's function and pre mining storage capacity (if necessary).

- the expected phases of tensile and compressive strain development may result in breaching of up to 18 dam walls or water storage areas. Loss or increase of storage areas may also occur due to the predicted tilting. Maximum tensile crack widths across dam wall or storage areas are estimated to range between 30 mm and 400 mm.
- there is one un-tenanted single storey weatherboard clad and timber framed residence on timber stump footings (12 m x 8.5 m) and two galvanised iron clad timber post sheds that are owned by NCOPL above LW204 ('Westhaven'). It is likely that the structure will be subsided between 1.7 m to 2.0 m by LW204 with tilts ranging from 7 mm/m to 22 mm/m, hogging and sagging curvatures of 0.2 to 0.5 per kilometre (km^{-1}) (radii of 5 kilometres [km] to 2 km) and tensile and compressive strains 2 to 5 mm/m. The building is likely to be 'moderately' to 'significantly' impacted by tilt and 'slightly' to 'moderately' impacted by curvatures and strains in accordance with AS2870, 2011.
- the 'Un-named' residence was recently purchased by NCOPL and is an untenanted and incomplete dwelling that is located between the LW204 and 205 chain pillars. Built features include an incomplete two-storey circular steel-framed residence with a diameter of approximately 15 m, supported on a central column. There are no other fixed features except for an olive grove to the south of the residence in a 'poor' condition (likely drought and pest animal affected). It is likely that the structure will be subsided 0.45 m by LW204 to 205 with tilts ranging from 5 mm/m to 15 mm/m, hogging curvature of 0.5 km^{-1} (radius of 2 km) and tensile strains of up to 10 mm/m. The building is likely to be 'moderately' to 'significantly' impacted by mine subsidence effects in accordance with AS2870, 2011.
- un-inhabitable houses may be demolished to avoid unsafe conditions after mining.
- domestic power and telecommunications lines to any of the existing houses are mainly pole suspended with some underground sections extending from the access roads. The services have already been disconnected.
- post and wire fences around the dams and along property boundaries could also be damaged and may require repairs after mining.
- the unsealed gravel access roads (Red Hills, Scratch Roads) and tracks are likely to be damaged by cracking and shearing/heaving in the tensile and compressive strain zones, respectively, above the Extraction Plan Area. Maximum tensile crack widths across or along roads are estimated to range between 50 mm and 420 mm. Surface 'steps' or humps due to compressive shear failures are estimated to range between 30 mm and 320 mm. Some sections of road may require re grading or drainage remediation works after subsidence development.
- some sections of road may also require re-grading or drainage remediation works after subsidence development. Warning signs should be erected outside the limits of mining impact.
- there is one State Survey mark that will be subsided up to 1.52 m by LW205. State Survey Marks affected by mine subsidence will be required to be relocated after mining is completed.

2.2.6 Predicted impacts - Aboriginal heritage


There is one grinding groove site ('Mayfield GG1') located above proposed LW 205. The site is located on sandstone bedrock or possibly 'loose' boulders. The quality of the grinding grooves is considered to be 'excellent' and regionally rare for the size of the groove cluster.

The results of the Mine Subsidence Assessment indicate that the surface deformations due to mining are likely to cause the following impacts within the Extraction Plan Area:

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

- impacts on isolated and scattered surface artefacts are not anticipated; and
- the Mayfield GG1 grinding grooves are expected to be subject to transient tensile strains of up to 5 mm/m and final compressive strains of 5 mm/m.

Impact management strategies for Aboriginal cultural heritage sites are presented in the Extraction Plan - Heritage Management Plan and have been developed in consultation with the Registered Aboriginal Parties (**RAPs**). The Narrabri Mine Aboriginal Cultural Heritage Management Plan is also applicable for the ongoing management of Aboriginal cultural values for the Narrabri Mine.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			


3. Hazard identification

The hazard identification techniques listed in Table 3-1 were utilised to assist in the identification of subsidence hazards within the Extraction Plan Area.

Table 3-1 Hazard identification techniques

Hazard identification techniques	Adopted Y/N
<ul style="list-style-type: none"> Incident reports Inspections, surveys, and audits (including specialist audits) Workplace observations Specific reviews (e.g. noise, air quality, machine guarding etc.) Review and analysis of incident report data 	Y
<ul style="list-style-type: none"> Technical or scientific evaluations (including the Mine Subsidence Assessment Report) Information from equipment designers, manufacturers, suppliers and other parties Communication forums, including safety committee meetings Information from regulators (e.g. safety alerts, safety bulletins) Australian Standards Industry Codes of Practice (e.g. Codes of Practice approved under the WHS Act) 	Y
<ul style="list-style-type: none"> Brainstorming 	N
<ul style="list-style-type: none"> Use of previous Extraction Plan risk assessments 	Y
<ul style="list-style-type: none"> Scientific or historical data that identifies and/or quantifies the level of the hazard present across the mine site (refer to the Mine Subsidence Assessment Report, presented as Appendix J to EP 203-206) 	Y

Using the above hazard identification techniques, the predicted subsidence effects were considered against a series of aspects that could be impacted to determine the risk ratings (section 4).

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

4. Level 2 qualitative risk assessment outcomes

Table 4-1 provides the risk assessment outcomes. The risk ratings were assessed based on the aspect, hazard and existing and proposed controls.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Table 4-1 EP 203-206 qualitative risk assessment

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
Subsidence impacts to natural features										
1	Natural water courses and streams	Water quality (Total Suspended Solids [TSS] and Electrical Conductivity [EC]) is impacted by subsidence in Namoi River tributaries	<ul style="list-style-type: none">Monitoring and repairing of surface cracks conductedOngoing monitoring of water quality upstream and downstream of the Extraction Plan AreaRemediation of ponded areas if increase in electrical conductivity (EC) detected downstreamImplementation of appropriate erosion and sediment controls	2	D	L	<ul style="list-style-type: none">Implementation of management measures for subsidence remediation in accordance with the Extraction Plan - Land Management PlanImplementation of the surface water quality monitoring program and erosion and sediment controls in accordance with the Extraction Plan - Water Management Plan	2	D	L
2	Natural water courses and streams	Channel stability is compromised leading to increased erosion and channel realignment	<ul style="list-style-type: none">Monitoring and repairing of surface cracks conductedOngoing monitoring of water quality upstream and downstream of the Extraction Plan AreaCreek line monitoring program implementedLiDAR surveys conductedSubsidence monitoring lines installed along creeks	2	D	L	Implementation of management measures for subsidence remediation and creek line monitoring in accordance with the Extraction Plan - Land Management Plan	2	D	L
3	Natural water courses and streams	In channel / over bank ponding leading to loss of farming land and / or loss of riparian vegetation	<ul style="list-style-type: none">Monitoring and assessment of ponding conductedRiparian vegetation health monitoring conductedRemote sensing conducted to detect changes in land morphology and vegetation health	2	D	L	<ul style="list-style-type: none">Implementation of management measures for ponding creek line monitoring in accordance with the Extraction Plan - Land Management PlanImplementation of vegetation health monitoring in accordance with the Extraction Plan - Biodiversity Management Plan	2	D	L
4	Natural water courses and streams	Reduction in stream flow during rain events	<ul style="list-style-type: none">Conduct modelling to confirm any interconnection between surface and seam due to depth of cover and height of fracturing (25% probability of surface to seam connectivity for LW 203)Monitoring and repairing of surface cracks conductedMonitoring height of fracturing via borehole extensometers and piezometers	3	D	M				
5	Natural water courses and streams	Flooding of mine leading to stoppage of mining	<ul style="list-style-type: none">Conduct modelling to confirm any interconnection between surface and seam due to depth of cover and height of fracturing (25% probability of surface to seam connectivity for LW 203)Mine dewatering system to remove water from	3	E	M				

	NARRABRI MINE	Document owner:	Environmental Superintendent
	ENVIRONMENTAL	Document approver:	General Manager
	MANAGEMENT	Revision period:	3 years
	SYSTEM	Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
			the mine <ul style="list-style-type: none"> Monitoring of water quantities being pumped out of mine Monitoring height of fracturing via borehole extensometers and piezometers Monitoring and repairing of surface cracks conducted Implementation of the procedures identified in the Inrush Principal Mining Hazard Management Plan 							
6	Creek or river catchments	Water quality (TSS and EC increased) in the Namoi River is impacted by subsidence	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted Ongoing monitoring of water quality upstream and downstream of the Extraction Plan Area Remediation of ponded areas if increase in EC detected downstream Implementation of appropriate erosion and sediment controls 	1	D	L				
7	Groundwater dependent ecosystems	No 'high potential' groundwater dependent ecosystems occur within the Extraction Plan Area	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted Ongoing monitoring of water quality upstream and downstream of the Extraction Plan Area Remediation of ponded areas if increase in EC detected downstream Implementation of appropriate erosion and sediment controls 	1	E	L				
8	Land prone to flooding or inundation	Change in flooding behaviour impacting farming land or surface improvements along Kurrajong Creek and tributaries	<ul style="list-style-type: none"> Flood study was conducted revealing limited impacts of flooding Monitoring and assessment of ponding conducted Riparian vegetation health monitoring conducted Remote sensing conducted to detect changes in land morphology and vegetation health 	1	E	L				
9	Escarpments / cliff lines / steep slopes	General and localised slope instability (soil and rockslides) along steep rocky slopes	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted Implementation of appropriate erosion and sediment controls Remote sensing conducted to detect changes in land morphology 	2	D	L	<ul style="list-style-type: none"> Implementation of controls for steep slopes and erosion in accordance with the Extraction Plan - Land Management Plan Implementation of controls for restricting access in accordance with the Extraction Plan - Public Safety Management Plan 	2	D	L
10	Escarpments / cliff lines / steep slopes	Steep slope (S12 above LW 204) subject to subsidence up to 2.8 m with tilts of up to 15 mm/m and tensile/compressive strains of +/- 15 mm/m. Cracking with widths ranging from 385 mm to 770	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted Implementation of appropriate erosion and 	2	D	L	<ul style="list-style-type: none"> Implementation of controls for steep slopes and erosion in accordance with the Extraction Plan - Land Management Plan 	2	D	L

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
		mm, depths from 3 m to 15 m and lengths from 30 m to 100 m.	sediment controls <ul style="list-style-type: none"> Remote sensing conducted to detect changes in land morphology 				<ul style="list-style-type: none"> Implementation of controls for restricting access in accordance with the Extraction Plan - Public Safety Management Plan 			
11	Threatened species including Endangered Ecological Communities	Potential loss of individuals species or habitat or degradation of Endangered Ecological Communities	<ul style="list-style-type: none"> Ongoing monitoring and condition assessment conducted Well established vegetation Conduct modelling to confirm any interconnection between surface and seam due to depth of cover and height of fracturing (25% probability of surface to seam connectivity for LW 203) Monitoring and repairing of surface cracks conducted Depth of cover is increasing east to west reducing potential subsidence impacts to vegetation and habitat Ongoing monitoring of water quality upstream and downstream of the Extraction Plan Area Remediation of ponded areas if increase in EC detected downstream 	2	D	L				
12	Native fauna	Injuries to native fauna	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted 	1	D	L				
13	Native fauna	Loss of habitat	<ul style="list-style-type: none"> Ongoing monitoring and condition assessment under Biodiversity Management Plan and Landscape Management Plan Well established vegetation Conduct modelling to confirm any interconnection between surface and seam due to depth of cover and height of fracturing (25% probability of surface to seam connectivity for LW 203) Monitoring and repairing of cracks carried out - included in Land Management Plan Increasing depth of cover reducing subsidence impacts to vegetation and habitat 	1	D	L				
Subsidence impacts to built features										
14	Tracks / roads / bridges	Damage to vehicles or machinery	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks conducted Warning signage erected in subsidence area Predominantly mine-owned land, authorised access only (with the exception of Scratch Road) 	2	D	L	Demarcate active subsidence areas in accordance with the Extraction Plan - Built Features Management Plan.	2	D	L
15	Tracks / roads / bridges	Injury to persons	<ul style="list-style-type: none"> Monitoring and repairing of surface cracks 	2	D	L				

	NARRABRI MINE	Document owner:	Environmental Superintendent
	ENVIRONMENTAL	Document approver:	General Manager
	MANAGEMENT	Revision period:	3 years
	SYSTEM	Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
			conducted <ul style="list-style-type: none"> Warning signage erected in subsidence area Predominantly mine-owned land, authorised access only (with the exception of Scratch Road) Lease arrangements for the 'Mayfield' property 							
16	Transmission lines	No transmission lines within Extraction Plan Area	N/A							
17	Power and telecommunications	Underground power and telecommunications running to residences (Westhaven and Un-named)	Power is disconnected	1	E	L				
18	Pipelines	<ul style="list-style-type: none"> No hazard identified to gas drainage pipelines from subsidence. No other pipelines identified within the Extraction Plan Area No subsidence of infrastructure corridor Any future mine infrastructure to be designed appropriately 	N/A							
19	Mine infrastructure	Damage to goaf gas drainage boreholes and associated infrastructure	<ul style="list-style-type: none"> Steel cased boreholes Flexible connection from borehole top to gas drainage surface pipeline Goaf drainage units / mobile extraction units can be located outside active subsidence area or have the ability to be re-levelled if within active subsidence area 	2	D	L				
20	Mine Infrastructure	Damage to PED cable buried on surface	PED cable has been designed/installed with sufficient slack to accommodate subsidence	2	D	L				
21	Mine infrastructure	Far field impacts on life of mine operational area not considered a credible risk	N/A							
22	Survey control stations	Loss of function of State Survey Marks	At the completion of subsidence, or otherwise as required by the Surveyor General, ensure that the functionalities of any survey marks affected by subsidence are fully restored to the satisfaction of the Surveyor General	2	D	L				
23	Public facilities / amenity / users	No public facilities / amenity / users will be undermined by LW 203 to LW 206	N/A							
24	Environmental monitoring stations	Damage to piezometers / standpipes and water supply bores.	<ul style="list-style-type: none"> Life-of-mine groundwater monitoring network installed outside of Extraction Plan Area Replace piezometers / standpipes as required 	1	E	L	Management measures implemented in accordance with the Extraction Plan - Water Management Plan	1	E	L
25	Drainage structures	Flooding and erosion of road	<ul style="list-style-type: none"> Monitor and repair drains as required Routine visual inspection of roads and carrying out repairs as required Signage 	2	D	L	Monitoring and management in accordance with the Extraction Plan - Built Features Management Plan	2	D	L
26	Drainage structures	Injury to personnel due to flooding and erosion of road	<ul style="list-style-type: none"> Monitor and repair drains as required 	3	D	M	<ul style="list-style-type: none"> Culvert and road design to be based on anticipated water flow / volume to minimise 	2	D	L

	NARRABRI MINE	Document owner:	Environmental Superintendent
	ENVIRONMENTAL	Document approver:	General Manager
	MANAGEMENT	Revision period:	3 years
	SYSTEM	Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
			<ul style="list-style-type: none"> Routine visual inspection of roads and carrying out repairs as required Requirement not to drive through flooded areas Signage 				localised flooding <ul style="list-style-type: none"> Demarcate / repair eroded areas / roads 			
27	Farmhouses and sheds	Moderate to significant damage to existing buildings and tanks	If present, septic tanks will be drained prior to undermining	2	D	L				
28	Industrial / commercial / business establishments	No industrial / commercial / business establishments impacted by predicted subsidence	N/A							
29	Declared dams and / or other Dams Safety Act 2015 structures	No declared dams and /or other Dams Safety Act structures within the Extraction Plan Area	N/A							
30	Other surface improvements	Breaching of farm dam walls resulting in personal injury	<ul style="list-style-type: none"> Monitor dams and drain / remediate as required Low-capacity dams Earthen dams Each dam is to be assessed for the need to lower water level based on impacts to farm dams from previous longwall subsidence impacts 	2	D	L				
31	Other surface improvements	Breaching of water storage dam resulting in personal injury	Monitor and drain dams if required	2	E	L				
32	Other surface improvements	Drainage of water storage dam into mine workings resulting in flooding of mine	Conduct modelling to confirm any interconnection between surface and seam due to cover depth and height of fracturing (25% probability of surface to seam connectivity for LW 203-206)	2	E	L				
33	Other surface improvements	Damage to drainage contour banks	<ul style="list-style-type: none"> Pre- and post-mining survey and remediate as required Remote sensing conducted to detect changes in land morphology 	2	D	L				
34	Other surface improvements	Damage to fences releasing livestock and impacting with vehicles	<ul style="list-style-type: none"> Exclusion of stock from active subsidence area Rectify any impacts to property or livestock fences/gates. 	2	E	L				
35	Telecommunications	Suspended services at the access road	N/A							
36	Railway	Far field impacts to railway not expected	N/A							
Impacts to subsurface										
37	Groundwater resources (quantity and quality)	Drawdown or base flow reduction in Namoi River alluvial	<ul style="list-style-type: none"> Drawdown of more than 2 m (i.e. the Aquifer Interference Policy threshold) is not predicted to occur at any privately-owned water supply bores that extract water from the Namoi Alluvium Life-of-mine groundwater monitoring program implemented 	3	E	M				


	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
			<ul style="list-style-type: none"> Western edge of the Namoi alluvium approximately 5 km from Extraction Plan Area Periodic recalibration of groundwater model using observed data whilst longwall is being extracted Significant barrier of low permeability strata between the Namoi River alluvium and the mine Neither the Hoskissons Seam nor the other rocks of the Black Jack Group are directly in contact with the Namoi Alluvium in the Extraction Plan Area 							
38	Groundwater resources (quantity and quality)	Decreased volume of groundwater available for other users	<ul style="list-style-type: none"> Drawdown of more than 2 m (i.e. the Aquifer Interference Policy threshold) is not predicted to occur at any privately-owned water supply bores that extract water from the Namoi Alluvium Life-of-mine groundwater monitoring program implemented Conduct modelling to confirm any interconnection between surface and seam due to cover depth and height of fracturing (25% probability of surface to seam connectivity for LW 203-206) Groundwater take for the mine is licenced and periodically reviewed 	2	C	M				
39	Increased mine water discharge	Increased water take into the mine workings due to fracturing the aquifer above the goaf resulting in flooding of mine workings	<ul style="list-style-type: none"> Life-of-mine groundwater monitoring program implemented Conduct modelling to confirm any interconnection between surface and seam due to cover depth and height of fracturing (25% probability of surface to seam connectivity for LW 203-206) Groundwater take for the mine is licenced and periodically reviewed Periodic recalibration of groundwater model using observed data whilst longwall is being extracted Appropriate capacity of surface water dams Contingency for construction of additional storages Implementation of the procedures identified in the Inrush Principal Mining Hazard Management Plan 	4	D	M	Installation of proposed calibration borehole extensometer and piezometer above LW 203	4	D	M

Impacts to Aboriginal cultural and archaeological heritage and European / historic heritage

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
40	European heritage	No heritage sites identified	<ul style="list-style-type: none"> Unexpected finds procedure Subsidence monitoring program 	1	E	L				
41	Cultural heritage sites	Damaging, defacing or destruction of archaeological sites	<ul style="list-style-type: none"> Surveys completed and identified sites have been fenced Heritage Management Plan identifies appropriate management measures Subsidence monitoring program 	3	D	M	Heritage Management Plan includes additional management measures for Mayfield GG1	3	D	M
42	Mayfield GG1 (LW 205)	<ul style="list-style-type: none"> Subject to transient tensile strains of up to 5 mm/m and final compressive strains of 5 mm/m. It is therefore 'possible' to 'likely' that the site may be impacted by cracking. Moderate scientific significance, high cultural significance 	<ul style="list-style-type: none"> Management measures proposed in consultation with the RAPs Avoid direct surface impacts 	3	B	H	<ul style="list-style-type: none"> Further investigation to determine potential connection to bedrock with an appropriately qualified specialist (e.g. archaeologist, geologist, geomorphologist) and the RAPs Future test excavation and salvage programs in consultation with the RAPs Monthly monitoring for cracking and subsidence impacts during active subsidence Develop action plan for the management of this site to outline potential mitigation options in the event cracking occurs. 	3	B	H
Impacts to agriculture										
43	Agricultural suitability/ productivity	Reduction in agricultural capability of land	<ul style="list-style-type: none"> Minimal to no impacts to agricultural production predicted Subsidence will not result in significant changes to Land and Soil Capability classes Land Management Plan with Trigger Action Response Plan includes management measures and monitoring program Rehabilitation Management Plan includes weed management and control and pasture species requirements 	2	D	L				

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

5. References

Department of Planning and Environment (October 2022). *Extraction Plan Guideline*.

Ditton Geotechnical Services (2022). *Mine Subsidence Assessment for Longwalls LW203 to LW206 at the Narrabri Underground Mine*. Prepared for Narrabri Coal Operations Pty Ltd.


NSW Department of Planning, Industry and Environment (November 2021). *Project Approval Narrabri Coal Project – Stage 2*.

R.W. Corkery & Co. Pty. Limited (2009). *Environmental Assessment for the Narrabri Coal Mine Stage 2 Longwall Project*. Prepared for Narrabri Coal Operations Pty Ltd.


	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

6. Glossary

Term	Definition
Active subsidence	The period of time that movement of the ground can occur after underground mining.
Angle of Draw (AoD)	The angle with the vertical, made by a straight line extending away from the limits of extraction at seam level to the ground surface, spanning the horizontal distance in which subsidence may occur.
Chain pillar	The pillar(s) of coal left between adjacent longwall panels. This forms a barrier that allows the goaf to be sealed off and facilitates tailgate roof stability.
Compressive strain	A decrease in the distance between two points on the surface. This can cause shear cracking or steps at the surface if > 3 millimetres per metre (mm/m).
Cover depth	The depth of coal seam from the ground surface (metres).
Department	Planning and Assessment Group within the NSW Department of Planning and Environment (DPE).
Development	The Stage 2 development described in the EA as modified by the Project Approval.
Environmental consequences	The environmental consequences of subsidence impacts including: damage to built features; loss of surface flows to the subsurface; loss of standing pools; adverse water quality impacts; development of iron bacterial mats; cliff falls; rock falls; damage to Aboriginal heritage sites; impacts to aquatic ecology; ponding.
Extraction Plan Area	The area predicted to be affected by the proposed secondary extraction of the approved longwall panels LW 203 to LW 206.
Far-field subsidence	Mining-induced movements of the ground surface in areas where vertical subsidence is less than 20mm.
First workings	Development of the main headings and gate roads to establish access to the coal in the mining area.
Goaf	The mined-out area into which the immediate roof strata breaks.
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Incident	A set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits of performance measures/criteria in the Project Approval.
Material harm	Material harm to the environment is defined in section 147 of the POEO Act.
MOD 5	Reduced the number of longwall panels from 26 to 20; increased the longwall panel widths for LW 107 to LW 120 from approximately 295 m to approximately 400 m; extended the western footprint approximately 60 m; and increased the maximum ROM coal processing rate from 8 Mtpa to 11 Mtpa.
MOD 7	Describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205.
Narrabri Mine	The development approved under the Project Approval 05_0102 and Project Approval 08_0144.
Pollution incident	Has the same meaning as in the POEO Act.


	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Term	Definition
Project Approval	Development consent (PA 08_0144) issued on 26th July 2010 under Section 75J of the <i>Environmental Planning and Assessment Act 1979</i> by the Department of Planning & Infrastructure (as modified).
Rehabilitation	The treatment or management of land disturbed by the project for the purpose of establishing a safe, stable and non-polluting environment including the remediation of impacts.
Remediation	Activities associated with partially or fully repairing or rehabilitating the impacts of the project or controlling the environmental consequences of this impact.
Second workings	Extraction of coal from longwall panels, mini-wall panels, or pillar extraction.
Secretary	Planning Secretary under the EP&A Act, or nominee.
Stage 1	The project approval granted by the Minister Planning for the Narrabri Coal Project, dated 14 November 2007.
Stage 2	Narrabri Mine Stage 2 approved under Project Approval 08_0144.
State of Commitments	The Proponent's revised commitments in Appendix 3 of the Project Approval, dated May 2010.
Subsidence	The totality of subsidence effects, subsidence impacts and environmental consequences of subsidence impacts.
Subsidence effects	Deformation of the ground mass due to mining, including all mining-induced ground movements, such as vertical and horizontal displacement, tilt, strain and curvature.
Subsidence impacts	Physical changes to the ground and its surface caused by subsidence effects, including tensile and shear cracking of the rock mass, localised buckling of strata caused by valley closure and upsidence and surface depressions or troughs.
Tailgate	Refers to the tunnels or roadways down the side of a longwall block which provides a ventilation pathway for bad or dusty air away from the longwall face. It is usually located on the side of the longwall panel adjacent to extracted panels or goaf.
Tensile strain	An increase in the distance between two points on the surface. This is likely to cause cracking at the surface if it exceeds 2 mm/m. Tensile strains are usually associated with convex (hogging) curvatures near the sides (or ends) of the panels.
the Proponent	Narrabri Coal Operations Pty Ltd
Tilt	The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10m). Tilt is plotted at the mid-point between the points and is a measure of the amount of differential subsidence.
Upsidence	Relative vertical upward movements of the ground surface associated with subsidence.
Vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch or tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: In a natural channel, whether artificially modified or not, or in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

7. Review history

Revision	Comments	Author	Authorised by	Date

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			


Attachment 1 WHC risk matrix

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

CONSEQUENCE

		Insignificant	Minor	Medium	Major	Catastrophic
		1	2	3	4	5
LIKELIHOOD	Almost Certain A	Moderate	High	High	Critical	Critical
	Likely B	Moderate	Moderate	High	High	Critical
	Occasional C	Low	Moderate	High	High	High
	Unlikely D	Low	Low	Moderate	Moderate	High
	Rare E	Low	Low	Moderate	Moderate	High

Critical	Risks that significantly exceed the risk acceptance threshold. Immediate attention needed, stop the job.
High	Risks that exceed the risk acceptance threshold. Additional risk control measures required. If further risk control measures are not practicable the responsible Manager must sign off.
Moderate	Risk acceptance threshold. Additional control measures could be implemented to control risks further. Active monitoring of risk control measures required.
Low	Risks that are below the risk acceptance threshold. No additional control measures required. Monitoring of risks may be needed.

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

CONSEQUENCE

Level	Descriptor	Safety	Health	Environment	Reputation	Community	Compliance	Economic
5	Catastrophic	Single or multiple fatalities	Exposure to health hazards (significantly exceeding the OEL) resulting in single or multiple fatalities	Unconfined detrimental impact requiring long term recovery leaving major residual damage (typically years)	On-going severe impact on WHC reputation On-going public exposure in international media Serious public outrage	Widespread mistrust / opposition among stakeholders setting the agenda for key decision makers	Cancellation of approval to operate imposed by regulators Prosecutions with custodial sentencing	>\$50M
4	Major	Severe impairment or irreversible damage to one or more persons (typically a permanent disability injury)	Exposure to health hazards (significantly exceeding the OEL) resulting in irreversible impact on health with loss of quality of life (typically a permanent disability illness)	Unconfined detrimental impact requiring medium term recovery leaving residual damage (typically months)	Severe impact on WHC reputation Major public exposure in national media Significant public outrage	Tangible mistrust / opposition among stakeholders with significant influence on key decision makers Irreparable damage to site or item of high cultural significance	Suspended or severely reduced operations imposed by regulators Breach of legislation, regulation or approval, or repeated non-compliance, with high potential for prosecution Systemic non-conformance with WHC standards with high impact	\$10M - \$50M
3	Medium	Reversible injury or moderate irreversible damage or impairment to one or more persons (typically a restricted work day or lost time injury)	Exposure to health hazards (exceeding the OEL) resulting in reversible impact on health, or permanent change with no disability or loss of quality of life (typically a restricted work day or lost time illness)	Near source confined detrimental impact requiring medium term recovery (typically months) Unconfined detrimental impact requiring short term recovery (typically weeks)	Adverse impact on operation's reputation Significant public exposure in regional media	Mistrust / opposition among some stakeholders with moderate influence on public opinion and decision makers Reparable damage to site or item of high cultural significance	Non-compliance with external, or non conformance with internal, requirement with moderate impact and / or issue of a financial penalty	\$2M - \$10M

	NARRABRI MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document owner:	Environmental Superintendent
		Document approver:	General Manager
		Revision period:	3 years
		Revision:	0
		Last revision date:	07 February 2023
WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - LW 203 – LW 206			

Level	Descriptor	Safety	Health	Environment	Reputation	Community	Compliance	Economic
2	Minor	Reversible injury requiring treatment but does not restrict duties (typically a medical treatment injury)	Exposure to health hazard resulting in symptoms requiring medical intervention and full recovery with no restrictions or lost time (typically a medical treatment illness)	Near source confined reversible impact requiring short term recovery (typically weeks)	Operation's reputation is adversely affected with a small number of stakeholders Local public or media attention and complaints	Tangible mistrust / opposition among a few stakeholders with some influence on public opinion and decision makers Irreparable damage to site or item of low cultural significance	Non-compliance with external, or non conformance with internal, requirement with low impact and / or issue of a regulatory notice without financial penalty	\$100K - \$2M
1	Insignificant	Low level short term inconvenience or symptoms (typically a first aid or no treatment injury)	Exposure to health hazard resulting in temporary and reversible discomfort (typically a first aid or no treatment illness)	Near source confined negligible or temporary impact (typically a shift)	Low level interest from local media Complaints able to be resolved following existing procedures	Tangible mistrust / opposition among individual stakeholders with minimal influence on public opinion and decision makers Reparable damage to site or item of low cultural significance	Non-conformance with internal requirement with very low potential for impact	<\$100K

LIKELIHOOD

Level	Descriptor	Description	Quantification
A	Almost Certain	The event is expected to occur in most circumstances	Typically occurs once per day to one week
B	Likely	The event will probably occur in most circumstances	Typically occurs once per week to one month
C	Occasional	The event should occur at some time	Typically occurs once per month to one year
D	Unlikely	The event could occur at some time	Typically occurs once in one to five years
E	Rare	The event may only occur in exceptional circumstances	Typically occurs once in five to ten years