Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Geotechnical Assessment Longwalls S1A to S6A, Bargo

Prepared for
Tahmoor Coal Pty Ltd

Project 210597.00
June 2024

Douglas Partners
Geotechnics | Environment | Groundwater

Document History

Document details

Project No.	210597.00	Document No.	R.002.Rev1
Document title	Report on Geotechnical Assessment		
Site address	Longwalls S1A to S6A, Bargo		
Report prepared for	Tahmoor Coal Pty Ltd		
File name	210597.00.R.002.Rev1		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Rev0	Roderick Haselden	John Braybrooke	16 December 2022
Rev1	Roderick Haselden	John Braybrooke	21 June 2024

Distribution of copies

Status	Electronic	Paper	Issued to
Rev0	1	-	Ms April Hudson, Tahmoor Coal Pty Ltd
Rev1	1	-	Ms April Hudson, Tahmoor Coal Pty Ltd

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author	[signature]	21/06/2024
Reviewer	[signature] *pp: John Braybrooke*	21/06/2024

bsi. ISO 9001 Quality Management
FS 604853

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
1/1 Luso Drive
Unanderra NSW 2526
PO Box 486
Unanderra NSW 2526
Phone (02) 4271 1836

Table of Contents

Report on Geotechnical Assessment
Land Management Plan
Longwalls S1A to S6A, Bargo

1. Introduction

This report presents the results of a geotechnical assessment of landscape features within the nominated Study Area of Longwalls (LW) South 1A (S1A) to South 6A (S6A). The assessment was commissioned in an email dated 12 December 2021 by Ms April Hudson of Tahmoor Coal Pty Ltd (TC) and was undertaken in accordance with Douglas Partners' (DP) Proposal 210597.00.P.001.Rev0 dated 8 November 2021.

It is understood that TC plans to mine six panels, LW S1A to LW S6A, in the Tahmoor Mine Tahmoor South Domain using longwall extraction methods. The aim of this geotechnical assessment was to:

- Review the provided information and studies related to mine subsidence to provide context to the impact on surface features for LW S1A to S6A;
- Identify the potential risks to land features, namely cliffs, steep slopes and farm dams within the Study Area due to mine subsidence;
- Risk assess these features to identify the likely consequence of mine subsidence-induced instability;
- Summarise potential impacts on agriculture for inclusion in the Land Management Plan (LMP); and
- Provide a monitoring program and Trigger Action Response Plan (TARP) to manage the risks of mine subsidence-induced impacts.

The assessment comprised a review of the information provided and site inspections by a Senior Engineering Geologist. The details of the assessment are presented in this report, together with comments and recommendations for the items listed above.

This report is based on a high-level assessment and subsequent site inspections conducted for the area. The results of surface subsidence modelling prepared by Mine Subsidence Engineering Consultants (MSEC) were provided by the client for the assessment. Some of the properties within the Study Areas were unavailable for site inspections. Inspections may be required in the future to evaluate the impact of subsidence on those features. It is noted that steep slopes and dams at the Tahmoor Mine site have been excluded from the current assessment, and will be managed through the '*Tahmoor Coal – LW S1A – S6A Management Plan for Potential Impacts to Tahmoor Mine Site*' Report NO. MSEC1247, 2022.

DP has carried out a detailed assessment for road embankments and nominated farm dams within the Study Area as part of the assessment for LW S1A to S6A, which has been reported separately (Project 210597.02.R.001.Rev0 dated 7 September 2022, Projects 210597.03.R.001.Rev1 dated 5 May 2023 and Project 210597.08.R.001.Rev0 dated 29 May 2024).

DP have issued previous versions of the Land Management Plan for the Tahmoor South Project. This report supersedes all previous written and verbal correspondence.

2. Project Definitions

Tahmoor Coal received development consent for the Tahmoor South Project on 23 April 2021. Definitions from the development consent for cliffs and slopes have been adopted for this project and are summarised below. Definitions have also been provided for the Study Area for man-made and natural features referred to in the development consent. The details given in Table 1 are based on the precedents in other coal fields with similar mining and surface conditions.

Table 1: Definitions

Term	Definition
Cliff	A continuous rock face, including overhangs, having a minimum length of 20 m, a minimum height of 10 m and a minimum slope of 1:2 (H:V, > 63.4°)
Steep slope	An area of land having a gradient between 3:1 and 1:2 (H:V, 18.3° ≤ X ≥ 63.4°)
Study Area (SA)	The greater areal extent of either the 20 mm subsidence line and the 35° angle of draw. The Study Area is applicable for man-made landscape features, which comprise road cuttings, road embankments and farm dams.
600 m Study Area for Natural Features	A 600 m zone around the footprint of the proposed longwalls (ie LW S1A to S6A). The Study Area for natural features comprises cliffs and steeps slopes.

3. Site Description and Topography

Tahmoor Mine is an underground coal mine located approximately 80 km southeast of Sydney between the townships of Tahmoor and Bargo in New South Wales (NSW). LW S1A to S6A are located in the 'Tahmoor South Domain', between the townships of Tahmoor and Bargo (refer Figure 1).

Tahmoor Mine, operated by Tahmoor Coal, produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for steel production. Tahmoor Mine has used longwall mining methods since 1987. Tahmoor Coal has mined 35 longwall panels to the north and west of Tahmoor Mine's current pit top location, and at the time of reporting, is about to commence extraction of LW W4. It is anticipated that LW S1A will commence in October 2022.

The Study Area comprise the surface area located within a 600 m zone around the footprint of the longwall panels for natural features (eg for cliffs and steep slopes) and the surface area located within the greater area of the limit of the 20 mm predicted subsidence contour or the 35 degree angle of draw from the margins of LW S1A to S6A for man-made features (eg road embankments, road cuttings and farm dams, refer Figure 2 and Drawing 1 in Appendix B) excluding the Tahmoor Mine site, which will be managed separately. The proposed extraction of LW S1A to S6A will extend underground coal mining to the south east of the Bargo River, to the north east of Hornes Creek and to the north west of Charlies

Point Road. The Study Area includes a section of the Main Southern Railway and Remembrance Drive between the Tahmoor Mine pit top and the township of Bargo (refer Figure 2).

The longwalls (LW S1A to S6A) are planned to be 283 m to 285 m wide, with tailgate chain pillar widths in between the longwalls of 36 m and 38 m. The total lengths for LW S1A to S6A are between 1706 m and 1994 m. The panels will extract the Bulli Seam from south to north. The extraction height is proposed to be between 2.1 m to 2.2 m. The Bulli Seam dips towards the north east with an average gradient of 1.7% across the mining area. Based on the information provided by the client, the lowest level of the seam floor is about RL 126 m relative to Australian Height Datum (AHD). The depth of cover directly above the proposed longwall varies between a minimum of 365 m above northern end of LW S5A and a maximum of 405 m above northern end of LW S1A.

The surface level contours within the SA indicate that the highest point of topography is about 354 m AHD in the ridge line to the west of the northern section of LW S6A. The surface topography comprises a plateau that gently slopes towards the north east with the eastern part of the SA incised by creek line gullies with the lowest point at about 265 m AHD in Teatree Hollow. The surface area primarily comprises a combination of large rural lots that include clear paddocks, hobby farms and orchards, and moderately dense forested and undeveloped land. Tahmoor Mine site is located in the northern part of the area and the Reject Emplacement Area is located in the north eastern part of the SA. Water is obtained generally from the town water supply and to a degree from farm dams or groundwater bores.

Based on the definitions provided in Table 1, the Study Areas for LW S1A to S6A have two sections of cliff associated with the Bargo River and its tributaries. Natural steep slopes within the SA are generally located about incised creek gullies, which are located on undeveloped land. Aboriginal Heritage sites identified in Wirrimbirra Creek have been included in the assessment of steep slopes. Man-made steep slopes comprising four road embankments and one cut batter along Remembrance Drive were also identified by the LiDAR survey. No other properties have been identified as containing structures close to steep slopes (refer Drawing 1).

A total of 45 farm dams were identified within the SA for LW S1A to S6A, of which, 28 dams are located directly over the longwalls (refer Drawing 1). TC advised that Farm Dam FD2, which is located within the Wollondilly Anglican College (WAC), is proposed to be decommissioned in the next 6 – 12 months as part of proposed expansion of the school.

The Study Areas also contains a section of the Main Southern (Railway) Line (MSL). It is understood that MSL, which includes cuttings, embankments, viaducts and bridges, will be the subject of separate geotechnical assessments (included in the Main Southern Railway Management Plan) and are therefore not included in this report. In addition, steep slopes and dams associated with the Tahmoor Mine Site will be discussed and managed in accordance with the Tahmoor Mine Site Management Plan. Constructed steep slopes associated with the Remembrance Drive are assessed in this report, however the monitoring and management of these slopes will be discussed in the Wollondilly Shire Council Management Plan.

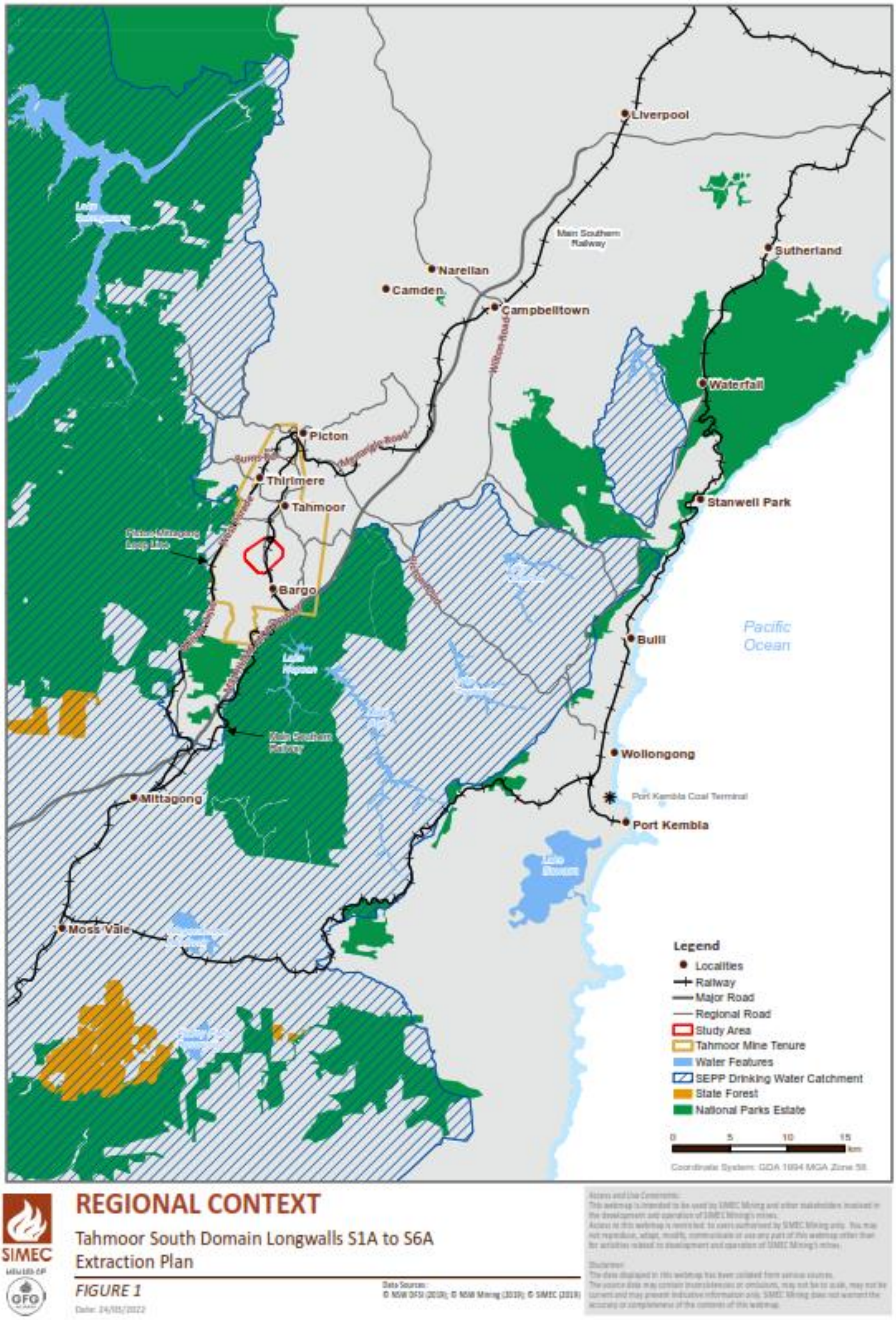


Figure 1: Location Plan (Courtesy TC)

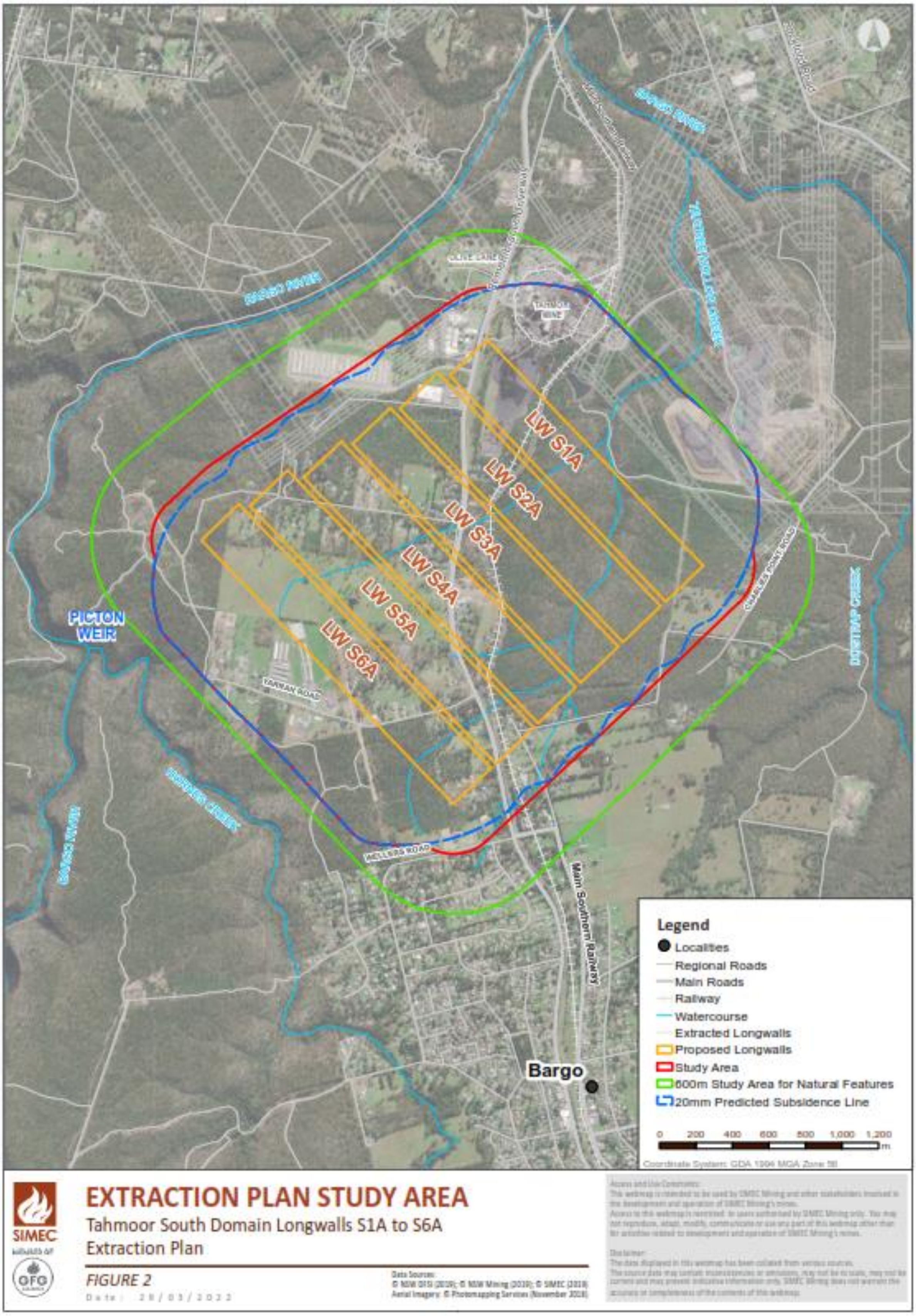


Figure 2: Study Area for Subsidence Effect on Land Features (Courtesy TC)

4. Information Review

4.1 Information Provided by TC

TC provided copies of reports and data from a number of investigations conducted as part of the ongoing planning and operation of the longwall panels at Tahmoor Mine. These included:

- MSEC report MSEC1192 titled "Subsidence Predictions and Impact Assessments, Tahmoor South Project – Extraction Plan for Longwalls S1A to S6A, Subsidence ground movement predictions and subsidence impact assessment for natural and surface infrastructure";
- SLR report ref: 630.12732.002 titled "Tahmoor Extraction Plan LW S1A-S6A, Land and Agricultural Resource Assessment";
- MSEC report MSEC1112 titled "Subsidence Predictions and Impact Assessments for Natural and Built Features Due to the Extraction of the Proposed Longwalls W3 and W4 in support for the Extraction Plan Application".
- MSEC report MSEC1073 Rev34 titled "Tahmoor LW W1 Subsidence Monitoring Report"; and
- MSEC report MSEC1019 titled "Subsidence Predictions and Impact Assessments for Natural and Built Features Due to the Extraction of the Proposed Longwalls W1 and W2 in support for the Extraction Plan Application";
- MSEC report MSEC1045-12 titled "Built Structures Management Plan" Tahmoor North Western Domain Longwalls West 1 and West 2;
- GeoTerra report titled "Longwall Panels 31 to 37 – Streams, Dams & Groundwater Assessment";
- SCT report titled "Tahmoor Coal – Investigation into the Potential Impact on the Nepean Fault on Subsidence Adjacent to LW 32;
- GHD report titled "Landslide Risk Assessment of Identified 'Steep Slopes' Specific Properties in Environs of LW 32";
- Glencore report titled "Tahmoor Colliery – Longwall 30 – First 300 m of Extraction, Management Plan for Potential Impacts on Dam at No. 2990 Remembrance Drive";
- GHD report titled "Landslide Risk Assessment of Identified 'Steep Slopes' Principally Affected by Retreat of LW 28"; and
- GHD report titled "Tahmoor Colliery Subsidence Impact Upon 'Steep Slopes' over LW 24 to LW26";

4.2 Geological Setting

The study areas lie within the Southern Coalfield of the Sydney Basin. The Permo-Triassic Sydney Basin extends roughly 300 km along the coast of New South Wales and inland for a distance of up to 200 km. The principal coal-bearing sequence in the Southern Coalfield of the Sydney Basin is the Illawarra Coal Measures which consist of numerous coal seams. The uppermost seam is the Bulli Seam which has been extensively mined in the northern part of the coalfield. The Bulli Seam is immediately overlain by the Narrabeen Group which consists of a series of major sandstone and shale units. The Wombarra Shale and Scarborough Sandstone form the immediate and main roof respectively. The Wombarra Shale consists of shale and claystone with minor thin interbeds of fine-grained sandstone. The Scarborough Sandstone comprises coarse grained quartz-lithic sandstone. It is noted that while the Coal Cliff Sandstone is typically located between the Wombarra Shale and Bulli Seam in the eastern part of the Southern Coalfield, it decreases in thickness towards the west becoming a band within the Wombarra Shale before disappearing entirely. It has not been identified in drill core in the Tahmoor area. Overlying the Narrabeen Group is the Hawkesbury Sandstone, which comprises a series of bedded sandstone units which date from the Middle Triassic and has a thickness of up to 185 m, and Ashfield Shale. The typical stratigraphic section in the SA is shown in Figure 3.

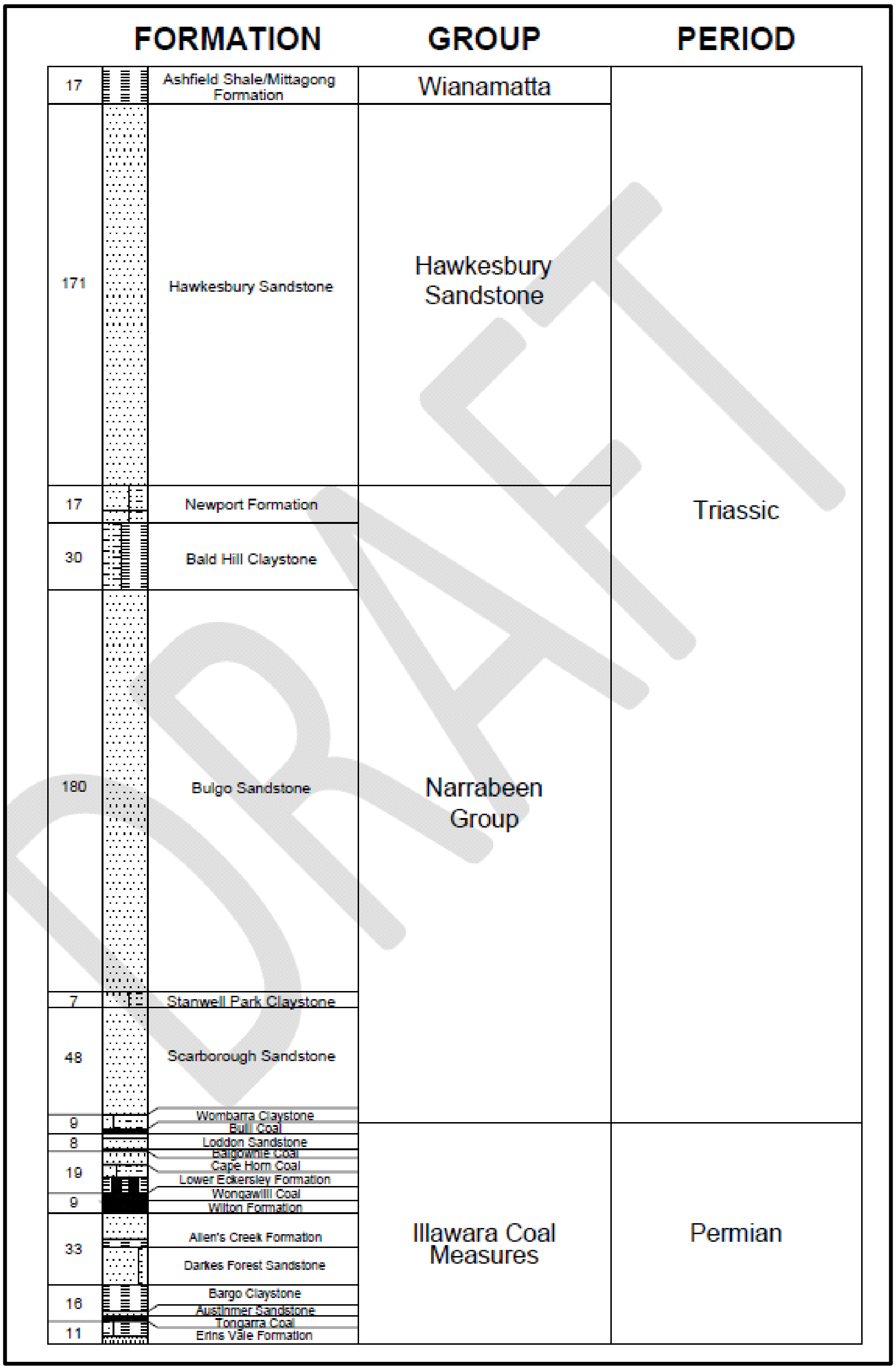


Figure 3: Typical Geological Stratification at Tahmoor (Courtesy MSEC, 2019)

Much of the surface in the study areas is mapped as being underlain by Hawkesbury Sandstone. The Ashfield Shale is mapped in the northern part of the study areas underlying the Tahmoor Mine site and the area immediately to the west. The Mittagong Formation is a transitionary unit between the Ashfield Shale and Hawkesbury Sandstone, which consists of interbedded shale, laminite and fine-grained sandstone, is also expected within the study areas. The Hawkesbury Sandstone crop out along the incised and downstream sections of the local creeks and watercourses and in a road cutting on Remembrance Drive, to the south of the Tahmoor Mine site. Incision tends to follow the dominant joint directions in the rock (ie north and northeast) and it is possible that this influences the orientation of the long axis of the gullies in which the creeks are formed. The sandstone rocks tend to break up into large blocks due to weathering along the near-vertical joint planes and near-horizontal bedding planes.

Regional structural geology mapped within the study area is limited to two faults to the east of the Tahmoor Mine site, which have probably been identified during underground mining or exploration associated with Tahmoor Mine. The closest mapped geological structures to the study area are the Nepean Monocline, which is oriented northwest-southeast and located about 500 m to the southwest, and the Bargo Fault, which is oriented approximately north-south and located approximately 1.7 km to the east.

4.3 Previous Impacts of Mine Subsidence

No slope instability has been reported in the hillsides in previous mined areas to the north of Tahmoor Mine. Soil cracks up to 65 mm wide were reported on both the upper bank and the flank of Myrtle Creek at one location above Longwall 23B. The cracks extended into the soil to depths of between 1.5 m to 2.0 m and over a length of approximately 40 m.

During the extraction of Longwall 24A, Gale and Sheppard (2011) reported that significantly higher displacements, nearly twice the predicted subsidence displacements, were observed. This abnormality was suggested as being due to the weakening of rock material due to weathering, causing reduction in spanning capacity of the weathered section.

MSEC 2022 report provided a summary of observations and impacts of mine subsidence on cliff lines where longwall mining has occurred close to, but not directly beneath cliff including near the Bargo River at Tahmoor, the Cataract River near Appin, and the Nepean River near Douglas Park. Based on previous experience, MSEC concluded that it was unlikely that cliffs beyond the extent of longwall panels will experience large instabilities, and that it was possible that isolated rock falls could occur during the mining period due to natural weathering processes. MSEC concluded that any impacts are expected to represent less than 0.5% of the total face area of the cliffs.

Monthly geotechnical inspection of cliff lines, steep slopes and farm dams were carried out by DP within the zone of active subsidence during the extraction of Longwalls West 1 (W1) to West 4 (W4) in the Western Domain, and at 3-monthly intervals following the completion of active subsidence. In summary, no discernible changes that could be attributed to mine subsidence were observed within the abovementioned features. Trigger Action Response Plan (TARP) levels remained with ‘normal’ range (Level 1) during this period.

4.4 Subsidence Modelling for Longwalls S1A to S6A

Based on the MSEC's 2022 report for LW S1A to LW S6A:

- The maximum predicted incremental subsidence results due to progressive extraction of LW S1A to LW S6A (studies on calibrated numerical model by MSEC1192) are reported in Table 2.

Table 2: Predicted incremental subsidence details for LW S1A to S6A (MSEC1192, 2022)

Longwall	Maximum predicted incremental subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (km^{-1})	Maximum predicted incremental sagging curvature (km^{-1})
LW S1A	800	7.0	0.08	0.22
LW S2A	950	7.5	0.08	0.22
LW S3A	950	8.0	0.09	0.22
LW S4A	950	8.0	0.09	0.22
LW S5A	950	8.0	0.10	0.22
LW S6A	975	8.3	0.09	0.23

- The maximum predicted total subsidence results due to extraction of LW S1A to S6A (studies on calibrated numerical model by MSEC1192) are reported in Table 3 and shown in Figure 4.

Table 3: Predicted total subsidence details for LW S1A to S6A (MSEC1192, 2022)

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LW S1A	800	7.0	0.08	0.22
LW S2A	1000	8.0	0.10	0.22
LW S3A	1200	8.0	0.10	0.22
LW S4A	1250	8.5	0.13	0.22
LW S5A	1350	9.0	0.14	0.22
LW S6A	1350	9.5	0.14	0.24

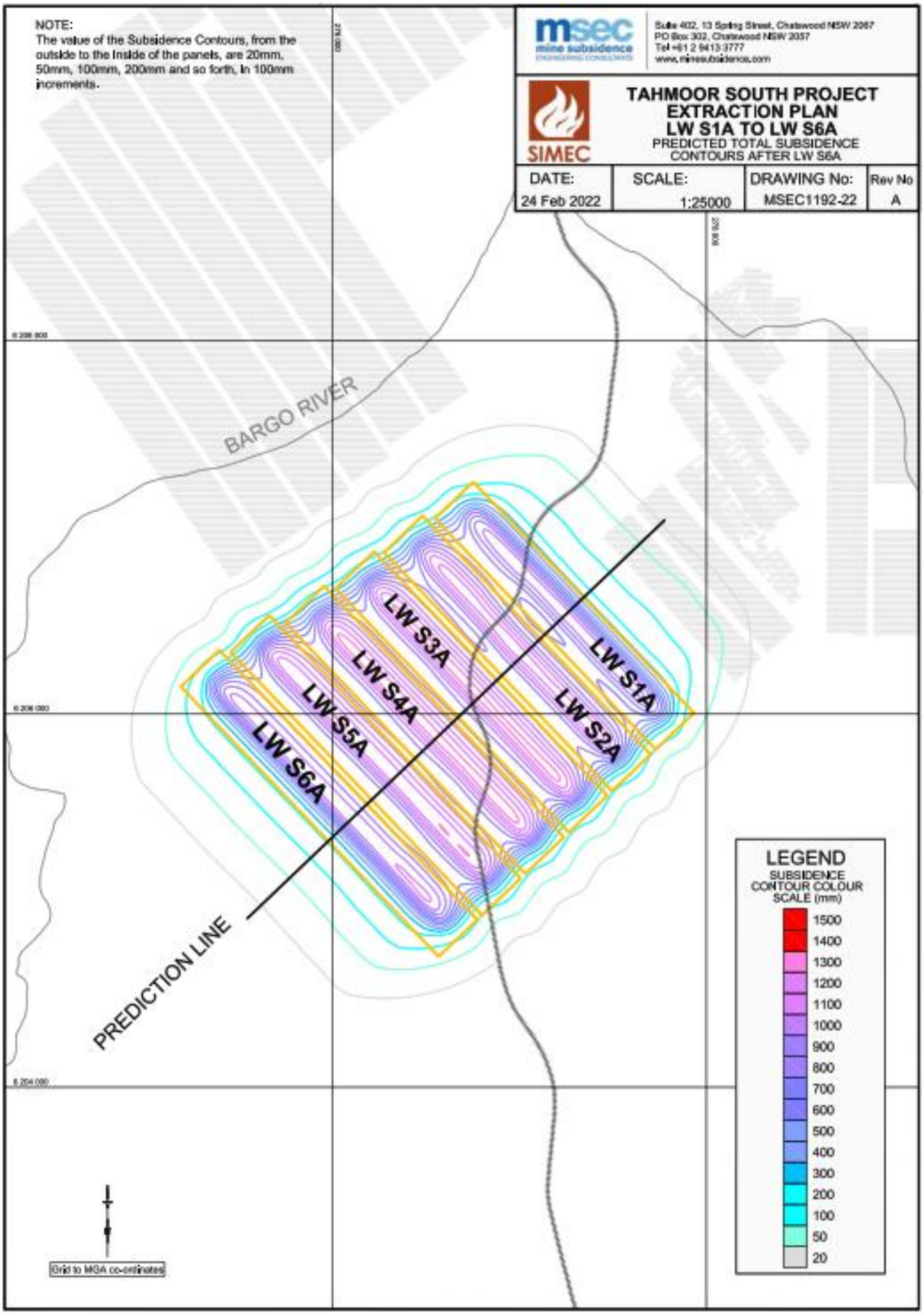


Figure 4: Total mine subsidence following extraction of LW S6A (courtesy MSEC).

- The predicted maximum total strains in the SA likely to be experienced at any time during mining are given in Table 4.

Table 4: Predicted maximum strains during extraction of LW S1A to S6A (MSEC1192, 2022)

Longwall	Above goaf		Above solid coal	
	Compressive strain (mm/m)	Tensile Strain (mm/m)	Compressive strain (mm/m)	Tensile Strain (mm/m)
95% confidence level	2.2	1.3	<1.0	<1.0
99% confidence level	4.3	2.0	<1.5	<1.5

- The predicted maximum upsidence and closure that creeks in the SA are likely to be experience at any time during mining are given in Table 5.

Table 5: Predicted Total Upsidence and Closure for Creeks (MSEC1192, 2022)

Location	Maximum Predicted Subsidence (mm)	Maximum Predicted Upsidence (mm)	Maximum Predicted Closure (mm)
Teatree Hollow	1350*	400*	275*
Wirrimbirra Creek	1300	450	375

where: * = Downstream section of Teatree Hollow have previously mined beneath by LW 1 and 2.

4.5 Agricultural Assessment

A Land and Agricultural Resource Assessment (SLR Ref 630.12732.002-v.01 dated April 2022) has been carried out by SLR Consulting Australia Pty Ltd for the project (refer Appendix D). In summary, the assessment made the following findings:

- The majority agricultural land use within the study area is for small-scale cattle and horse grazing areas.
- Agricultural enterprises within the study area include three poultry farms, with the impacts to these expected to be minor and readily remediated.
- The post-mining agricultural economic potential is expected to be very similar to the pre-mining potential.
- Longwall mining will have minor impacts on surface and groundwater resources relied upon by agriculture, comprising two Water Access Licences (WALs) and six private bores. It is noted that any groundwater impacts will be "made good" by Tahmoor Coal.

The Agricultural Assessment concluded that the impacts from the proposed mining of LW S1A to LW S6A are expected to be minor and temporary, and can be managed through the application of appropriate mitigation measures and management strategies.

5. Field Work

Site inspections of the landscape features within the Study Area were undertaken by a Senior Engineering Geologist between 23 December 2021 and 12 April 2022. Due to the constraints of accessibility and lack of permissions from land owners, in some areas the inspection of landscape features was undertaken at a distance from the feature.

The location of cliff lines (BC1 and BC2) were identified from slopes derived from LIDAR data available the public domain. Inspection of the cliff line on the Bargo River (BC1), upstream of the Picton Weir and accessed off the end of Yarran Road, was carried out from accessible locations near the foot of the cliff and above the crest of the cliff line. No permission was provided to carry out an inspection of a second cliff line (BC2), which was located within private property. The cliff lines within the natural study area are shown on Drawing 1 in Appendix B.

The locations of steep slopes were identified from slopes derived from LIDAR data available the public domain. Inspection of steep slopes within the study area comprised a section of Wirrimbirra Creek in the Australian Wildlife Sanctuary, which included a rock shelter (eg overhang) and other Aboriginal Heritage sites (WC1 – WC3). The inspection of man-made slopes included one rock cutting (RC1) and four road embankments (RE1 – RE4) across topographical low points on Remembrance Drive between Tahmoor Colliery and the township of Bargo. No structures were located close to the natural steep slopes identified within the SA. Culverts were located below the four road embankments within the man-made study area. It is understood that as part of the subsidence management for LW S1A to S6A, inspections will be carried out for all structures within the study area. Natural and man-made steep slopes within the study areas are shown on Drawing 1 in Appendix B.

The locations of farm dams (FD1 – FD45) were identified from surface topography contours and LIDAR data (refer Drawing 1 in Appendix B). The farm dams within the study area are man-made structures and rely on rainfall for their impoundment. These farm dams are generally up to about 3.5 m high and appear to have been constructed by forming shallow embankments across dry gullies and/or incision into the natural site slopes. Inspections for the current assessment were carried out during an extended period of above average rainfall. Additional inspection of two farm dams were carried out following flooding events in the region where damage was reported to Tahmoor Coal.

Observations made during inspections of cliffs, steep slopes and farm dams within the man-made study area are summarised in Table 6. Site conditions are shown in Photos 1 – 44 in Plates 1 – 11 in Appendix C.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
RE1	Remembrance Drive intersection with Wellers Road	23/12/2021	– The soil exposed in the embankment comprises clay and gravel fill (refer Photo 1) including shale, carbonaceous siltstone and sandstone. – There is rutting, crocodile cracking, shoving and bleeding in the Remembrance Drive wearing course and a number of patches in both lanes (refer Photo 3). Table drains are located on both sides of the Remembrance Drive roadway to the north of the intersection with Wellers Road. – The surface of the road embankment batter on the eastern side of Remembrance Drive, approximately 130 m to the north of the intersection has an irregular surface. – No signs of deep-seated movement in the pavement. – A high-pressure gas pipeline is located along the eastern side of the embankment.
RE2	Remembrance Drive south of Yarran Road	23/12/2021	– Average batter slopes measured to be 33° to 35°. Mature trees are growing in the embankment (refer Photos 4 and 5). – Cracking in the kerb, offsets of up to 20 mm and gaps of up to 70 mm of the north-bound lane, approximately 170 m south of Yarran Road. – No signs of deep-seated movement in the pavement. – A high-pressure gas pipeline is located along the eastern side of the embankment.
RE3	Remembrance Drive north of Yarran Road	23/12/2021	– The upstream face is generally grassed (refer Photos 6 – 8) while the downstream face was obscured with long grass and shrubs. – No signs of deep-seated movement in the pavement. – A high-pressure gas pipeline is located along the eastern side of the embankment.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
RE4	Remembrance Drive at the Caloola Road	23/12/2021	– Trees growing along the western side of the embankment, approximately 80 m south of Caloola Road, have a slight lean downslope (refer Photo 10). – The toe along the western side of the embankment has been cut-back to construct a drain along the edge of the road (refer Photos 11 and 12). – The soil exposed in the embankment comprises clayey gravel/gravelly clay fill (refer Photo 12) with sandstone cobbles and boulders. – A twin pipe culvert is located in the base of the gully that the road embankment is constructed across. – No signs of deep-seated movement in the pavement. – A high-pressure gas pipeline is located along the eastern side of the embankment.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
RC1	Remembrance Drive (~No.'s 3116 – 3150 and 3105 – 3165)	23/12/2021	– Sandy clay soils up to 1 m deep are located in the upper cut batter. – Average batter slopes measured to be 41° to 45° in the sandstone. – The sandstone in the cut is very low to low strength and highly weathered in the upper cut grading into medium to thickly bedded, medium to high strength, moderately to slightly weathered sandstone in the lower and middle sections of the cut (refer Photos 13 – 15). – A number of burnt tree trunks are located in the cutting (refer Photos 13 and 14). It is understood that the 2020 bushfires affected the area and a number of burnt trees were removed after the fires. – Tension cracking (refer Photo 16) was observed behind the crest above the road cutting opposite No. 3122 Remembrance Drive. – Seepage was observed from the sandstone bedrock adjacent to No. 3150 Remembrance Drive. – A drain is located above the road cutting on the eastern side of the road cutting, adjacent to the central/southern part of No. 3165 Remembrance Drive. – A high-pressure gas pipeline is located above the eastern side of the cutting.
WC1 – WC3	Wirrimbirra Creek	12/04/22	– The gully associated with the creek line is characterised with steep slopes and rocky outcrops of sandstone (refer Photos 17 – 22). The rocky outcrops include preferential weathering and erosion of cross-bedded sandstone resulting in overhangs. Collapsed joint blocks (refer Photos 17, 18 and 20) were observed at a number of locations beneath overhangs. – At the time of the inspection, the grass in the floor of the gully had been 'pushed flat' from high flow levels during recent heavy rainfall.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
BC1	Lot 7311 DP 1141025 (above Bargo River, upstream of Picton Wier)	17/02/2022	– The sandstone cliff line is located in the upper slopes of the incised Bargo River. The slopes above the cliff line include rocky outcrops with a number of large joint blocks on the surface (refer Photos 23 and 24). No discernible signs of recent rock falls or slope instability were observed within the nominated area of the SA. The area had been affected by the January 2020 bushfires, and as a result, numerous trees in the slopes above the cliff line have not recovered from the fires.
-	4 Olive Lane	12/04/2022	– The dam spillway comprises an approximately 250 mm diameter pipe. – The owner advised that the farm dam had overtopped during heavy rainfall in early March 2022 that resulted in scour of the downstream dam embankment. The downstream embankment was repaired in March. Further erosion occurred during a second overtopping event in early April 2022 (refer Photos 25 and 26).
FD1	115 Charlies Point Rd	10/02/2022	– The dam has no spillway. The dam (refer Photo 27) is partially incised into the site slope (ie not within a watercourse). Overflow goes around the south eastern and south western sides of the wall.
FD2 & FD3	Wollondilly Anglican College (WAC), No. 3000 Remembrance Drive, No.'s 1 and 5 Olive Lane)	17/01/2022	– A WAC grounds keeper advised FD2 is a bore-fed dam. FD2 (refer Photo 28 and 29) is partially incised into the site slopes. – FD3 (refer Photo 30) comprise small ponds partially incised in the site slopes above the gully. A WAC grounds keeper advised that it is not a spring-fed dam, rather it collects flows from the nearby shed roof.
FD5	Lot 20 DP 751250		– The dam has no spillway. The dam (refer Photo 31) is incised into the slope (ie not within a watercourse).
FD6	3105 Remembrance Drive (Australian Wildlife Sanctuary)	10/02/2022	– The dam has a spillway on western side. Trees are growing in the embankment. Uneven surface in downstream embankment face where a tree has been removed. Possible burrows in a section of the embankment.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
FD8	10 Caloola Road	01/02/2022	– Large sandstone blocks (refer Photo 32) have been placed on the surface of the dam embankment. – The owner of No. 20 Caloola Road advised that this dam has previously flooded the dwelling at No. 3076 Remembrance Drive (immediately south of the Tahmoor Garden Centre).
FD9	20 Caloola Road	01/02/2022	– Sandstone cobbles and boulders are embedded in the surface of the dam embankment (refer Photo 33).
FD11	40 Caloola Road	01/02/2022	– The dam has no spillway.
FD15	21 Great Southern Road	10/02/2022	– The dam has a steep downstream embankment face (refer Photo 34). The dam spillway includes sandstone rip-rap in the base (refer Photo 35).
FD17	115 Caloola Road	01/02/2022	– The dam has wet soil in its spillway and on the embankment.
FD22	90 Caloola Road	01/02/2022	– The dam has no spillway. The dam (refer Photo 36) is incised in the slope (ie not within a watercourse). The owner advised that it is not a spring-fed dam, rather it collects overland stormwater flows from upslope including stormwater from the dwelling.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
FD27	3210 Remembrance Drive (Chellowdeen Florist)	12/04/2022	– The dam (refer Photo 37) has a low spillway on the northern side of the embankment. The spillway channels runs along the toe of the embankment to the centre of the embankment wall. – The owner advised that the farm dam had overtopped during heavy rainfall in early April 2022 that resulted in erosion and scour (refer Photo 38). The spillway channel at the toe of the embankment also scoured out. – A mature tree is growing through the embankment. – A dwelling and a shed are located in the alluvial gully downstream of the farm dam. The owner advised that overflow from the farm dam during the early April 2022 rainfall event did not get to the level of the shed on the property immediately downstream.
FD31	30 Yarran Road	01/02/2022	– The dam has no spillway. Trees are growing in the downstream embankment face (refer Photo 39). – Erosion and scour (refer Photo 40), possibly from previous overtopping, was observed on the downstream embankment face.
FD33	40 Yarran Road	10/02/2022	– Two erosion rills are present in the downstream face the dam embankment. – There is a spillway on the northern side of the embankment and a tree growing in the embankment.
FD39	95 Caloola Road	01/02/2022	– The dam has no spillway. Mature trees growing in its downstream embankment (refer Photo 41).
FD40	105 Caloola Road	01/02/2022	– The dam (refer Photo 42) is incised in the slope (ie not within a watercourse). The owner advised that it is not a spring-fed dam, rather it collects overland stormwater flows from swales in the paddocks upslope.

Table 6: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Feature ID/s	Address/Site	Date Inspected	Site Observations
FD41	115 Caloola Road	01/02/2022	– The dam (refer Photo 43) was wet in areas of the crest and in the spillway.
FD43	10 Wellers Road	10/02/2022	– The dam has a steep downstream embankment face. Numerous young trees are growing in embankment. The spillway and channel are on the eastern edge of the embankment.
FD44	110 Yarran Road	10/02/2022	– The dam has no spillway. The dam is incised in the slope (ie not within a watercourse). The owner advised that it is not a spring-fed dam, rather it collects overland stormwater flows from the paddocks upslope.
FD45	140 Yarran Road	17/02/2022	– This dam (refer Photo 44) has been recently constructed and includes a spillway with sandstone cobble rip-rap. The owner advised that the dam was a Council requirement for development of the site. The dam is incised in the slope (ie not within a watercourse). The owner advised that it is not a spring-fed dam, rather it collects overland stormwater flows from the paddocks upslope.

6. Comments

6.1 General

Incremental and total subsidence due to longwall mining of LW S1A to S6A could result in surface cracking, heaving, buckling and stepping which can influence various landscape features. DOP (2008) provided a comprehensive summary of the range of potential mine subsidence effects and the environmental management techniques. It recommends that a subsidence risk management zone (RMZ) be defined around sensitive natural features within the mining lease before subsidence occurs. Out of the various features mentioned in DOP (2008), this study focusses on cliff lines and steep slopes. The location of these features is the first step in managing prediction uncertainties and potential impacts associated with subsidence. The final step is to identify the methods of monitoring and mitigation which may reduce the subsidence effects to a ‘repairable level’ or as low as reasonably practicable (ALARP). The features within the SA are assessed in the following sections of this report.

Due to the nature of this assessment, it was decided to adopt a risk management approach to evaluate the impact of subsidence on the features. The features to be assessed are very distinct in nature and hence the approach also varied. As such, the following risk assessment guidelines were utilised for the assessment:

- Cliff lines were evaluated using the Australian Coal Association Research Project *Impacts of Mine Subsidence on the Strata and Hydrology of River Valleys and Management Guidelines for Undermining Cliffs, Gorges and River System* (ACARP, 2002);
- Natural steep slopes were evaluated using the procedures recommended by Australian Geomechanics Society publication *Practice Note Guidelines for Landslide Risk Management 2007* (AGS, 2007);
- Road embankments and cuttings were evaluated using the procedures recommended in the NSW Roads and Maritime Services (RMS) *Guide to Slope Risk Analysis* (NSW RMS, 2014); and
- The farm dams are evaluated using the VIC *Small Dam Consequence Screening Tool* (VIC DEPI, 2014).

6.2 Risk Assessment for Cliff Lines

The ACARP (2002) rating and ranking system is an empirical model that was developed based on similar assessment methods used by NSW RMS (2014) for managing man-made and natural slopes. The model was developed to provide a holistic approach to the response of cliff faces to mine subsidence. The method was developed for cliffs up to heights of 150 m. It includes the following three impact categories:

- The impacts of mining induced deformation (ie expressed in terms of the % length of cliff line affected by rock falls);
- Exposure of the public (and mining personnel) to rock falls and the potential loss of aesthetic appeal of the cliffs; and
- The contribution of the natural instability of the cliffs (ie the ongoing weathering and cliff adjustment process).

Impacts from each of the above categories are assigned a score according to various factors. These scores are multiplied by a weighting value and ranked as a proportion of the maximum possible score for each category. It is not possible in every assessment to have all the factors catered for before mining activity, hence any attempt to assess the likelihood of a cliff collapse or rock fall at a particular location is not possible. The predicted % length of cliff line affected by rock falls due to mining are worst case values and also include rock falls due to weathering process. Furthermore, ACARP (2002) was developed for aesthetically pleasing cliff lines in the southern and western coalfields of NSW.

Based on the field inspections and data from the LIDAR map, the assessment of subsidence impacts on cliff lines above the Bargo River (BC1) and a tributary of the Bargo River (BC2) was conducted in accordance with the procedure given in ACARP (2002). The details of the assessment are presented in Table 7. There is no direct access to the BC1 and BC2 cliffs by the public. There are no existing structures in the near vicinity (within 50 m) of the BC1 and BC2 cliff lines. BC1 and BC2 are located more than 500 m from the closest edge of the proposed longwall panels.

Table 7: Assessment of Cliff Lines as per ACARP (2002)

Reference	Aesthetic Quality	Natural instability	Mining Impact	Mining impact proportion	Overall Risk Level	% Rock falls
BC1	Insignificant	Moderate	Very Low	0.14	Very Low	2%
BC2	Very Low	Moderate	Very Low	0.14	Very Low	2%

Using the ACARP 2002 risk assessment method, cliff lines described above have been assessed to have a *Very* Low overall risk level with less than 2% of the cliff lines are predicted to be affects by slope instability during mining. The assessment is within a similar range to MSEC's experience in the Southern Sydney Basin Coalfield, where slope instability has previously affected less than 0.5% of the cliff area during mining.

The MSEC 2022 report provided a summary of observations and impacts of mine subsidence on cliff lines where longwall mining has occurred close to, but not directly beneath cliffs including near the Bargo River at Tahmoor, the Cataract River near Appin, and the Nepean River near Douglas Park. Based on previous experience, MSEC concluded that it was unlikely that cliffs beyond the extent of longwall panels will experience large-scale instability, and that it was possible that isolated rock falls could occur during the mining period due to natural weathering processes. MSEC concluded that any impacts are expected to represent less than 0.5% of the total face area of the cliffs. Tahmoor Coal commits to completing a calculation of the face areas of the BC1 and BC2 cliffs by March 2023.

It is considered possible that cracking, localised rockfall and dislocation of loose boulders could occur during mine subsidence, which is likely to include in natural processes that would occur regardless of the proposed longwall mining.

6.3 Assessment of Steep Slopes

6.3.1 General

As discussed in Section 2, steep slopes are defined as an area of land having a natural slope angle of between 18.3° and 63.4°. The 1 m surface level contours, generated from the LIDAR survey of the area, provided information regarding the steep slopes in the study area. The study area above LW S1A to S6A is generally limited to natural steep slopes associated with Wirrimbirra Creek. In this section, assessment of steep slopes is discussed with reference to the presence of aboriginal heritage sites (ie structures) including a rock shelter and art (WC1 – WC3). These natural structures were identified during the Aboriginal Heritage assessment conducted for the proposed development. The steep slopes are evaluated by considering the likelihood of failure and the impact on the site. Field inspection was carried out to ascertain the vulnerability of the identified sites. WC1 – WC3 are directly above LW S2A and S3A and will be affected by the predicted mine subsidence.

The landslide risk assessment conducted for this study involved the following steps:

- Identify the landslide processes currently occurring, factors contributing to instability, and likely triggers to future instability;
- Assess the likelihood that these landslide hazards or events will occur in the future;
- Assess the potential consequences in terms of potential damage to property;
- Combine the estimates of likelihood and consequence to derive an assessed risk of slope instability in the pre-mining state;
- Review the estimated subsidence effects on the LW S1A to S6A; and
- In light of the above, assess the risk of slope instability post-mining.

The slope risk assessment was undertaken in accordance with the methods and principles presented in the Australian Geomechanics Society publication “Practice Note Guidelines for Landslide Risk Management 2007” (AGS, 2007). The risk assessment takes into account the current site surface conditions and potential effects of the proposed longwall mining. Each of the sites was assessed on the basis of the estimated likelihood and extent of slope instability in relation to heritages sites that was able to be identified from the site walkover assessment. Due to the limited accessibility of the properties, the specifics of impacts like cracking is beyond the scope of the assessment. The sites considered in the assessment are shown on Drawing 2 in Appendix C.

6.3.2 Definitions

The qualitative terminology for use in assessing risk to property in the report is as follows:

- Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability and consequence. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.
- Acceptable Risk – A risk which, for the purposes of life or work, society is prepared to accept as is with no regard to its management. Society does not generally consider expenditure justifiable in further reducing such risks.
- Annual Exceedance Probability (AEP) – The estimated probability that an event of specified magnitude will be exceeded in any one year.
- Consequence – The outcomes or potential outcomes arising from the occurrence of slope instability expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

- Danger – The natural phenomenon that could lead to damage, described in terms of its geometry, mechanical and other characteristics. The danger can be an existing one, such as a creeping slope, or a potential one, such as a rock fall.
- Elements at Risk – The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by slope instability.
- Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time.
- Hazard – A condition with the potential for causing an undesirable consequence. The description of slope instability hazard should include the location, volume (or area), classification and velocity of the potential instability and any resultant detached material, and the probability of their occurrence within a given period of time.
- Individual Risk to Life – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide or who follows a pattern of life that might subject him or her to the consequences of the landslide.
- Slope Instability Intensity – A set of spatially distributed parameters related to the destructive power of slope instability. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.
- Slope Instability Susceptibility – A quantitative or qualitative assessment of the classification, volume (or area) and spatial distribution of slope instability, which exist or potentially may occur in an area. Susceptibility may also include a description of the velocity and intensity of the existing or potential slope instability.
- Probability – A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity or the likelihood of the occurrence of the uncertain future event.
- Risk Assessment – The process of risk analysis and risk evaluation.
- Risk Control or Risk Treatment – The process of decision making for managing risk and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
- Risk Estimation – The process used to produce a measure of the level of health, property or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis and their integration.
- Risk Evaluation – The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.
- Tolerable Risk – A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
- Vulnerability – The degree of loss to a given element or set of elements within the area affected by the slope instability hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for

persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by slope instability.

- Zoning – The division of land into homogeneous areas or domains and their ranking according to degrees of actual or potential landslide susceptibility, hazard or risk.

AGS (2007) recommends a series of descriptors to evaluate the landslide hazard perception. The recommended descriptors are outlined in Tables 8 and 9.

Table 8: Landslide Hazard Descriptor

Hazard Descriptor	Rock falls from natural cliffs or rock cut slope	Slides of cuts and fills on roads or railways	Small landslides on natural slopes	Individual landslides on natural slopes
	Number/annum/km of cliff or rock cut slope	Number/annum/km of cut of fill	Number/square km/annum	Annual probability of active sliding
Very High (VH)	> 10	> 10	> 10	10^{-1}
High (H)	1 to 10	1 to 10	1 to 10	10^{-2}
Moderate (M)	0.1 to 1	0.1 to 1	0.1 to 1	10^{-2} to 10^{-4}
Low (L)	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	10^{-5}
Very Low (VL)	<0.01	<0.01	<0.01	10^{-8}

Table 9: Descriptor for Risk Zoning using Property Loss Criteria

Likelihood		Consequences to property (with indicative approximate cost of damage as a percentage of the replacement cost)				
	Indicative value of approximate annual probability	1 Catastrophic 200%	2 Major 60%	3 Medium 20%	4 Minor 5%	5 Insignificant 0.5%
A. Almost certain	10^{-1}	VH	VH	VH	H	M or L
B. Likely	10^{-2}	VH	VH	H	M	L
C. Possible	10^{-3}	VH	H	M	M	VL
D. Unlikely	10^{-4}	H	M	L	L	VL
E. Rare	10^{-5}	M	L	L	VL	VL
F. Barely credible	10^{-6}	L	VL	VL	VL	VL

AGS (2007b) (Table C1) outlines acceptable and tolerable risk to life criteria for various international and Australian organizations. These risk levels vary from 10^{-3} per annum to 10^{-7} per annum. The AGS guidelines for risk management (2007) suggest a tolerable risk to property from instability of existing slopes of 10^{-4}. This level has been adopted for the purposes of risk calculations in this study.

6.3.3 Steep Slopes Sites at Risk

A review of aerial photography indicates that no structures are located in the vicinity of steep slopes. As requested by Tahmoor Coal, Aboriginal Heritage sites (WC1 – WC3) in Wirrimbirra Creek have been included in the steep slope assessment (refer Drawing 2 in Appendix B). The structures are tabulated in Table 10.

Table 10: Details of Steep Slopes and Rocky Outcrops

Slope	Details of the slope		Slope Height (m)	Horizontal Extent of the Slope (m)
	Maximum Elevation of Slope (m AHD)	Minimum Elevation of Slope (m AHD)		
WC1	289	283	6	40 – 60
WC2	284	278	5	70
WC3	283	276	6	80

6.3.4 Factors affecting Landslide

Slope instability is governed by the slope geometry, soil/rock strength including consideration of existing defects, and moisture within the soil or rock mass. Instability within the LW S1A to S6A study area may occur in a variety of forms and incorporate varying proportions of soil, rock, and water. While the gully would be subject to a variety of potential slope instability hazards, for the Aboriginal Heritage sites, which are located within the steep slopes, the types of slope instability that may impact the sites is:

- Very rapid, rock falls including localised collapse of 'over-hanging' sections of rocky outcrop within the steep slopes in the Wirrimbirra Creek gully. Cracking of the rock mass and/or opening of jointing may be a precursor for rockfalls.

Sites WC 1 – WC3 (refer Drawing 2 in Appendix B) have the potential to be damaged by rockfalls. The natural triggers for such failures can include major storms, extended periods of rainfall and earthquake events.

6.3.5 Mine Subsidence Effect on the Landslide Risk

The potential increased risk of slope stability associated with the expected mine subsidence impacts can be caused due to following conditions:

- Tilting – During mine subsidence, minor tilts may alter the angle of potential slide planes. In situations where sliding could occur on low angle slide planes, sliding can be triggered where tilts increases the angle of the slide planes in the downslope direction. Anticipated tilts are expected to be up to about 5 mm/m at the identified locations within the study area. These tilt movements are not expected to be sufficient to trigger slope instability, although low shear strength on some bedding planes could make them sensitive to some movement in combination with other contributing factors such as saturation during extended rainfall events;
- Tensile Strain – mine subsidence movements, particularly in areas where there are large differential movement over a relatively short distance and due to upsidence and valley closure, can result in concertation of tensile strains resulting in cracking. MSEC (2022) has assessed maximum upsidence in Wirrimbirra Creek to be up to 450 mm and valley closures of up to 375 mm.

- Reduced shear strength – mine subsidence movements can reduce the shear strength of a slope or rock mass by introducing cracking. Tensile cracks can form in areas of bulging and areas periphery to the longwall panels. Also, differential movement along low angle bedding planes, which can occur during relaxation of the ground towards a subsidence bowl, can introduce shearing along the plane. These shear movements reduce the available shear strength of the plane and can contribute to slope failure. The anticipated mean compressive and tensile strains are expected to be up to about 0.9 mm/m within this study area are minor and are not expected to produce significant cracking or differential lateral movements; and
- Water concentration – The cracks developed due to tensile or shear failures can allow ingress of water into a slope. This can potentially trigger instability due to saturation and/or piping (ie internal erosion). The water in these cracks may also increase porewater pressures in the soil and rock. Due to the magnitude of predicted upsidence and closures values across the Wirrimbirra Creek in the vicinity of WC1 – WC3, some cracking may be expected, which could impact the sites.

Maximum total mine subsidence predictions for WC1 – WC3 are order of 900 mm. Subsidence will take place over a broad subsidence bowl, due to the depth of mining (greater than 380 m), such that incrementally the changes in relief across the area will generally be minor. Slope instability incidents may occur in the areas with large subsidence gradients (ie above the goaf). During mining of subsequent longwalls, the subsidence bowl will also result in incremental subsidence above the previous longwall panels. There are other possible mechanisms that may affect slope instability risk due to mine subsidence such as curvature, stress and strains, however stress and strain associated with upsidence and valley closure were considered more likely to influence slope instability risk rather than these other mechanisms within the incised gully. The sites directly above the longwall excavation could experience cracking and damage.

The assessed risk levels to property due to slope instability are provided in Table 11. The assessment indicates that the risk of slope instability for the assessed hazards prior to mining is in the range of *Low to Moderate*, which is within the *Acceptable* to *Tolerable* risk ranges when assessed in accordance with AGS (2007). The assessed level of risk were slightly increased during and immediately following longwall mining (ie due to mine subsidence) of LW S1A to S6A provide management and monitoring of the regions is carried out during active mine subsidence through the Trigger Action Response Plan (TARP), however the risk level was still within a *Tolerable* risk range.

Table 11: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting The Nominated Sites

Slopes	Geotechnical Landslide Hazard	Consequence to the property	Before Mining		During and Post Mining(1)	
			Likelihood of hazard occurring	Assessed risk to the property	Likelihood	Assessed risk to the property
WC1 – WC3	Isolated rock falls	Medium for rock shelter	Unlikely to Possible	Low to Moderate	Possible	Moderate
		Major for art	Rare	Low	Unlikely	Moderate

Notes: (1) Assessed likelihood and risk levels are based on management and monitoring of the sites during active mine subsidence through the TARP.

6.4 Risk Assessment for Road Embankments Cuttings

6.4.1 Traffic Data

NSW Transport's online traffic volume viewer has a station on Remembrance Drive, Station ID T0492, located 580 m to the west of Lupton Road and approximately 4 km south of the SSA, which indicates an average annual daily two-way traffic volume of 4644 vehicles for 2022. The traffic distribution is 90% cars and light vehicles and 10% heavy vehicles. The station has been recording since 2015. Over the last eight years, annual average daily traffic volumes have varied between 4532 – 5033, and the traffic distribution has varied between 90-92% light vehicles and 8-10% heavy vehicles.

6.4.2 NSW RMS Slope Risk Analysis Methodology

The NSW RMS slope risk analysis method is based upon an underlying quantitative framework and derives an Assessed Risk Level (**ARL**) for a slope from specific rules to rate source qualitative descriptive elements such as the annual average daily traffic, describing likelihood (eg the probability of fall of material or an embankment failure to extend to a traffic lane) and consequence of slope hazards on such traffic. These are then combined using matrices to give the **ARL**.

There are five **ARL** levels ranging from **ARL1** (the highest risk level) to **ARL5** (the lowest risk level). The medial quantitative probabilities of loss of life implied by the **ARL** levels are approximately one order of magnitude apart, with **ARL1** approximately equating to an annual risk of death of $>10^{-3}$, **ARL3** approximately equating to an annual risk of death of 10^{-5} and **ARL5** an annual risk of death of $<10^{-6}$.

Road embankments (RE2 – RE4) and cutting (RC1) are located above Longwall panels S3A to S5A. The predicted subsidence that the road embankments and road cuttings located above the longwall panels will be subjected to is up to 1350 mm total subsidence with differential subsidence along the length of these features estimated to be up to 600 mm.

Road Embankments RE2 – RE4 and Road Cutting RC1 all have shoulder lanes on either side of the carriageway which are at least 2.7 m wide. RE1 has a reduced should width of between approximately 1.5 m and 2.3 m. The carriageway (ie trafficked lanes) are setback back at least 3.0 – 4.0 m for RE2 – RE4 and about 2.0 – 3.0 m for RE1 from the crest of the road embankment. The toe of the road cutting for RC1 is estimated to be 4.4 – 5.4 m from the edge of the trafficked lanes.

For the road embankments (RE1 – RE4) and cutting (RC1) under consideration, the relevant inputs and outcomes are considered to be:

Likelihood: the product of the probability value [*P(d)*] for a hazard occurring (eg small block (<0.3 m) falls or an intermediate depth failure) and the travel distance probability value [P*(t)*] of the hazard extending/regressing into the trafficked lane, which result in Likelihood ratings. For the current assessment, likelihoods are in the range **L3** to **L4** have been assessed. Failure mechanisms include mine subsidence-induced cracking (particularly within the sandstone exposed in the road cutting) as well as natural processes including root jacking and slow deterioration of rock (particularly within the weathered rock in the upper cutting) within the road cutting, and east coast low storm events and extended periods of rainfall resulting in the saturation and reduction of shear strength of site soils. It is noted that the likelihood also reflects the risk that the failure will or will not extended into the trafficked lane.

Temporal Probability: based on an Annual Average Daily Traffic (AADT) of up to 5033, a traffic volume of 2517 vehicles/lane/day has been adopted for this assessment. This traffic volume results in a temporal probability rating of **T3** for road embankments and road cuttings. While it is noted that a direct impact of a rockfall onto the lane would result in a modified temporal probability rating of **T4,** the more likely scenario of a vehicle hitting a block on the carriageway indicates that T3 is considered to be more appropriate.

Vulnerability: for impact by a vehicle with a block, void or stepped surface, vulnerability is a function of both block/void size and vehicle speed. For the assessment, an average speed of 80 km/hr has been used. The combination of a speed of 80 km/hr and blocks with minimum dimensions in the 0.1 – 0.2 m, 0.2 – 0.5 m and 0.5 – 1.0 m ranges results in vulnerability ratings of **V5** to **V3** respectively. The combination of a speed of 80 km/hr and irregular surfaces (<0.1m steps), and stepped surfaces with 0.1 – 0.2 m and 0.2 – 0.5 m step ranges results in vulnerability ratings of **V5** to **V3** respectively.

Assessed Risk Levels: the application of the above ratings for various hazards along the assessed road section to the RMS risk matrix determination of **ARL** levels is summarised in Table 12.

Table 12: Summary of Assessed Risk Levels

Hazard	Location	Likelihood Rating (L)		Temporal Probability (T)	Vulnerability Rating (V)	Consequence Rating (C)	ARL
		P(d)	P(t)				
Shallow soil slump	RE1 – RE4, RC1	0.1	0.01	T3	V4	C4	ARL5
		L4					
Intermediate-depth failure	RE1 – RE4	0.01	0.1	T3	V4	C4	ARL5
		L4					
Deep-seated failure	RE1 – RE4	0.001	1.0	T3	V3	C3	ARL4
		L4					
Detached blocks 0.1 – 0.2 m	RC1	1.0	0.01	T3	V5	C5	ARL5
		L3					
Detached blocks 0.2 – 0.5 m	RC1	1.0	0.01	T3	V4	C4	ARL4
		L3					
Detached blocks 0.5 – 1.0 m	RC1	0.1	0.01	T3	V3	C3	ARL4
		L4					

The above assessment indicates that all hazards were assessed to be **ARL4** and **ARL5**, which are generally considered to be within an *Acceptable* risk level.

The road embankments and road cuttings within the study area may require periodic surveillance with regards to visual inspection for crack development in the embankment and wearing course surface, but also in rock faces. The removal of loose blocks and/or the installation of support (eg rock bolts and/or mesh) may be required along sections of the road cutting following the identification of adverse cracking. Reduction in speed limits may also be considered as an option during mining to further reduce the risk levels. Road embankments may also require remedial works to restore the embankment to its pre-mining condition.

DP has carried out a detailed stability assessments for RE1 – RE4 as part of the assessment for LW S1A to S6A (Project 210597.02.R.001.Rev0).

6.5 Assessment of Farm Dams

Site inspection of the farm dams was carried out with the exception of FD4, 12 – 14, 18 – 21, 23 – 26, 28, 29, 34, 37, 38 and 42, where permission to access was not granted. The following information was obtained by the site inspection, the LiDAR survey, aerial photography, contour and topographic maps.

In total, 45 small farm dams were identified within the SA of LW S1A to S6A (refer Drawing 3 in Appendix B). According to ANCOLD, a small dam refers to a dam that does not meet the ANCOLD definition of a large dam having a volume of greater than 500 ML. The characteristics of these farm dams are given in Table 13. The farm dam capacities vary from <0.1 ML to about 7.0 ML. The topography around the identified farm dams can be classified as gentle with farm dams either located in broad gullies or excavated into the gentle slopes of the sandstone plateau. The predicted subsidence that the farm dams located above the longwall panels will be subjected to is up to 1350 mm total subsidence with predicted changes in freeboard estimated to be up to 500 mm. The dams are of earth fill construction and have probably been established by localised cut and fill operations. The farm dams are generally shallow with the maximum wall heights estimated to up to about 3.5 m.

Table 13: Details of Farm Dams

Farm Dam No.	Northing (MGA)	Easting (MGA)	Estimate Maximum Wall Height (m)	Approximate Surface area (m^2)	Estimated Volume (ML)	Predicted Total Vertical Mine Subsidence (mm)*
FD1	277840	6205830	2.5	550	0.6	50
FD2	276610	6207410	3.0	1000	1.5	30
FD3	276640	6207480	2.0	500	0.5	20
FD4	276380	6207010	<1.0	380	0.2	225
FD5	277390	6205380	2.0	500	0.5	45
FD6	276690	6206090	2.5	200	0.4	800
FD7	276600	6206410	<1.0	50	<0.1	1200
FD8	276480	6206530	2.0	1200	2.5	1200
FD9	276430	6206540	3.0	150	0.3	1300
FD10	276350	6206560	1.0	70	<0.1	1200
FD11	276250	6206520	1.5	450	0.7	850
FD12	276180	6206580	<1.0	90	<0.1	820
FD13	275830	6206810	3.0	2300	2.3	45
FD14	277320	6205040	2.5	1600	1.6	<20

where: * = approximate values.

Table 13: Details of Farm Dams (Continued)

Farm Dam No.	Northing (MGA)	Easting (MGA)	Estimate Maximum Wall Height (m)	Approximate Surface area (m^2)	Estimated Volume (ML)	Predicted Total Vertical Mine Subsidence (mm)*
FD15	277270	6205090	3.0	4800	7.0	<20
FD16	277090	6205040	1.5	350	0.2	30
FD17	277200	6205220	2.0	600	0.6	50
FD18	276380	6206160	<1.0	150	<0.1	1300
FD19	276290	6206110	1.0	600	0.3	1000
FD20	276220	6206000	1.0	300	0.1	860
FD21	275870	6206550	<1.0	90	<0.1	400
FD22	275870	6206620	2.0	250	0.5	200
FD23	275730	6206460	2.0	300	0.5	500
FD24	277040	6204800	<1.0	130	<0.1	<20
FD25	277030	6204780	<1.0	350	0.2	<20
FD26	276970	6204710	<1.0	25	<0.1	<20
FD27	276630	6205130	2.0	1600	1.6	700
FD28	276540	6205050	1.0	200	<0.1	900
FD29	276510	6205500	1.5	2600	2.0	1250
FD30	276440	6295470	2.5	1600	1.6	800
FD31	276340	6205390	2.0	1500	1.2	800
FD32	276320	6205300	1.0	400	0.2	1100
FD33	276230	6205370	1.5	1600	1.0	1050
FD34	276150	6205660	2.5	300	0.5	750
FD35	276020	6205640	2.0	700	1.4	900
FD36	276000	6205640	1.0	150	<0.1	925
FD37	276010	6205820	3.5	1900	2.7	750
FD38	275750	6205920	2.2	1900	1.7	950
FD39	275740	6206330	2.0	125	0.3	1200
FD40	275610	6206220	3.0	125	0.3	700
FD41	275470	6206170	1.5	200	0.4	900
FD42	275420	6206120	1.5	350	0.3	700
FD43	276810	6204560	2.0	1000	1.0	<20
FD44	275620	6205690	1.0	800	0.9	180
FD45	275340	6205710	1.5	1000	1.6	75

where: * = approximate values.

Australian National Committee on Large Dams (ANCOLD) Guidelines on the Consequence Categories for Dams (2012) defines the consequences of dam failure as 'the outcome or result of a dam failure in terms of loss of life and damage to property and/or services, as well as environmental damage'. In this study, a consequence screening tool was used to arrive at the impact of subsidence on the farm dams. The tool is broadly consistent with the Initial Consequence Assessment level of ANCOLD (2012). The screening tool identifies the consequence of a dam breakage and provides a preliminary basis for determining dam safety management requirements. It covers the aspects such as surveillance and monitoring; emergency preparedness and response; operational procedures, requirement of additional investigation and dam safety improvement works.

The key inputs for assessment of farm dams are listed as following:

- Dam volume;
- Downstream topography;
- Extent of downstream impact;
- Population at Risk (PAR); and
- Location of PAR.

The PAR includes all people who would be directly exposed to flood waters assuming they took no action to evacuate. The PAR should be assessed using demographic data including dwelling occupancy rates, school populations, work sites and other places where people assemble (eg industrial, hospital, commercial and retail areas). The PAR may vary according to time of day, day of week and season. The framework of screening of ANCOLD Consequence Categories for small dams is made as per following steps:

1. Assess the inundation area by estimating the downstream extent of dam break impact and PAR within the downstream extent;
2. Initial screening based on PAR and assessing the proximity of PAR to the dam; and
3. Establishing consequence categories for each dam under very low to low; significant or above.

For the current assessment, farm dams having capacities of 1 ML or more have been considered for the analysis based on the volume that could have a significant impact (refer Table 13). Farm Dams FD6 – 12, 18 – 20 and 27 – 42 lie directly above the longwall panels where the predicted total subsidence varies between 700 mm to 1350 mm after the extraction of LW S1A to S6A. Farm Dams FD8, 19, 23, 27, 29 – 31 and 42 will also be subject to total differential subsidence in excess of 100 mm. Cracking of the top surface of a dam embankment may cause loss of water pondage and eventually breaching of the dam. As per the ANCOLD Consequence Categories for small dams, the consequence of a farm dam break has been categorised as Very Low to Significant (refer Table 14). These categorises are independent of the cause of failure (eg mining/overtopping/piping failure).

Based on the DEPI Consequence Screening Tool for Small Dams, it is assessed that potentially occupied structures located downslope of FD2, FD8, FD13 and FD29 are at risk of inundation due to dam break if a dam break were to occur. When also considering cascading failure (ie if the farm dams failed in series, one after another), structures downstream of FD35, FD37 and FD38 and Remembrance Drive downstream of FD 29 – 31 are also considered to be at risk of inundation. Due to the relatively low storage volumes within the abovementioned farm dams and the likelihood that dam break will occur through incremental failure, it is unlikely that a dam break scenario will result in the loss of life, however, damage to property and/or services could be expected.

Table 14: Assessment of Farm Dams Consequence Categories

Dam ID	Volume (ML)	Predicted Total Vertical Mine Subsidence (mm)*	Downstream Topography	Population at Risk (PAR)	Consequence Category^
FD2	1.5	30	Hilly	1 – 10	Significant
FD8	2.5	1200	Gentle	1 – 10	Significant
FD11	1.0	850	Hilly	< 1	Very Low
FD13	2.3	45	Gentle	1 – 10	Significant
FD14	1.6	<20	Hilly	< 1	Very Low
FD15	7.0	<20	Hilly	< 1	Very Low
FD27	1.6	700	Hilly	< 1	Low
FD29	2.0	1250	Hilly	1 – 10 ƚ	Significant
FD30	1.6	800	Hilly	1 – 10 ƚ	Significant
FD31	1.2	800	Hilly	1 – 10 ƚ	Significant
FD33	1.0	1050	Hilly	< 1	Very Low
FD35	1.4	900	Hilly	1 – 10 ƚ	Significant
FD37	2.7	750	Hilly	1 – 10 ƚ	Significant
FD38	1.7	950	Hilly	1 – 10ƚ	Significant
FD43	1.0	<20	Hilly	< 1	Very Low
FD45	1.6	75	Gentle	< 1	Very Low

where: * = approximate values. ƚ = When considering cascading failure
^ = For Sunny Day dam break event

Farm dams constructed with compacted clayey material can generally withstand low levels of strain that would result in conventional cracking; however, localised cracking and deformations may occur which may require remediation. It is noted that a number of the farm dams appear to be constructed from sandy soil and crushed sandstone, which would be more susceptible to cracking (eg due to mine subsidence) and erosion from overland stormwater flows during heavy rainfall events. Farm Dams FD8, 19, 23, 27, 29 – 31, 38 and 42 could potentially experience cracking due to mining induced subsidence, which may cause loss of water storage capacity due to differential settlements across the footprint of the dam. To assess the quality of construction of the farm dams with 'Significant' consequence categories (refer Table 14), it was recommended that a geotechnical investigation including dam break analyses be carried out to assess the likelihood and extent of the assessed risk and to provide recommendations on remedial and precautionary works, if required. This investigation is to be completed prior to any impact from mining. It is noted that some of these dams are a risk regardless of mining.

As an alternative for FD2, which it is understood will be decommissioned in the next 6 to 12 months, Tahmoor Coal could carry out a risk assessment to nominate risk mitigation measures (ie in addition to the monitoring and TARP recommended in Sections 7 and 9) during and following mining of LW S1A to S6A. The risk assessment should include relevant stakeholders and consultants (including DP) to provide input. The risk assessment will consider additional risk control measures to manage (or reduce) the risk levels at FD2.

DP has carried out preliminary stability and dam break assessments for FD8, FD13, FD29 – FD31, FD35, FD37 and FD38 as part of the assessment for LW S1A to S6A (Project 210597.03.R.001.Rev1 and Project 210597.08.R.001.Rev0). The assessments indicated that farm dams have performed to date with industry accepted expectations for earth-fill embankments, however, many of the farm dam have undersized spillways (or no spillway) and/or inadequate freeboard for severe storm events. The hydraulic assessments indicated that flooding from a 1 in 100 year flood event (ie without a dam break) would affect properties, structures and roads downstream. While dam break events did not increase the assessed hazard vulnerability classifications, increased consequence categories of 'High C', 'High B' and 'High A' were assessed downstream of FD8, FD29 – FD 31, and FD35, FD37 and FD38 during severe storm events, respectively. The consequence category for FD13 was reduced to 'Low' including for a 1 in 100 year flood event following the hydraulic assessment.

The farm dams may require periodic surveillance with regards to water level and visual inspection for crack development. Remediation may be required to restore any affected dam. It may also be necessary to reduce the volume of stored water in some dams during the mine subsidence period. The farm dams that were not inspected should be inspected by DP when site access is available, preferably prior to mining, to confirm the assumptions in the current assessment or to allow for re-assessment where conditions vary from those anticipated.

7. Monitoring Program

It is noted that the monitoring of constructed slopes (ie slopes associated with roads, the Main Southern Railway, and the Tahmoor Mine Site) will be monitored and managed in accordance with the specific infrastructure management plans for these structures (eg Wollondilly Shire Council Management Plan, Main Southern Railway Management Plan, and the Tahmoor Mine Site Management Plan). This section of the report and onwards will only discuss the monitoring and management of natural steep slopes. A geotechnical review of the WSCMP will be carried out by DP to confirm that the requirements of this report have been incorporated in the infrastructure management plan, or to suggest amendments to meet the requirements of this report.

Vertical and horizontal ground movement, bulging, local stress redistribution, ground strains and other subsidence related effects on cliffs, natural steep slopes and farm dams may pose the following hazards:

- Slope instability of cliffs and natural steep slopes resulting in the regression of steep slopes or rockfalls resulting in damage to Aboriginal Heritage sites; and
- Cracking and piping (ie internal erosion) of dam walls potentially resulting in dam failure.

To facilitate the early detection of signs of distress and the implementation of remedial works (if any), management of the identified hazards will require the following:

- Baseline monitoring including record photography and dilapidation surveys prior to active subsidence;

- Regular monitoring and reporting on changes which have the potential to develop into slope instability, before, during and after longwall mining;
- Regular inspections and possibly subsurface investigation; and
- Action plans for response to defined events.

The Monitoring Plan outlined within Table 15 has been developed to assess the subsidence impacts on cliffs, natural steep slopes and farm dams that can occur due to mine subsidence during and following the extraction of LW S1A to S6A. The monitoring plan includes the following components:

- Cliff monitoring;
- Natural steep slope; and
- Farm dam monitoring.

The Agricultural Assessment (SLR, 2022) recommends that all residents and business within the study area are notified of mining prior to the commencement of all first and second workings, and that unspecified monitoring is carried out regularly during extraction. TC advised that this monitoring will be completed as part of the monitoring program as described in the relevant management plan for the residents and businesses.

Table 15: Monitoring Program for Geotechnical Features

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Cliffs	Cliffs (BC1 and BC2) within the 600 m Environmental Features Study Area, subject to land access.	Visual Inspection baseline prior to the commencement of mining by a geotechnical engineer, subject to land access (Cliff BC1 prior to LW S6A and Cliff BC2 prior to LW S3A).	None required (as the identified cliffs are located near the finishing ends of the longwalls).	Visual inspection at the completion of longwall panels by a geotechnical engineer, subject to land access (Cliff BC1 after LW S6A, Cliff BC2 after LW S3A, S4A, S5A and S6A).
Natural steep slopes	Natural steep slopes (WC1, WC2 and WC3), within the study area.	Visual Inspection baseline one month prior to the active subsidence period by a geotechnical engineer, subject to land access.	Monthly visual inspection during the active subsidence period by a geotechnical engineer, subject to land access.	Quarterly visual inspection for 12 months following the active subsidence period by a geotechnical engineer, or as required in accordance with a Rehabilitation Management Plan, subject to land access.
Farm Dams	Farm Dams (FD1 – FD45) within the study area, subject to land access.	Dam embankment integrity and water level observation by a geotechnical engineer one month prior to the active subsidence period using fixed location photo points, subject to land access.	Dam embankment integrity and water level observation every month during the active subsidence period by a geotechnical engineer using fixed location photo points, subject to land access.	Dam embankment integrity and water level observation using fixed location photo points on a quarterly basis for 12 months following the completion of active subsidence, by a geotechnical engineer, or as required in accordance with a Rehabilitation Management Plan, subject to land access.

8. Performance Measures

The relevant performance measures from the Development Consent for the Tahmoor South Project, as described in Table 7 and 8 of the Development Consent, are listed below:

- All cliffs within the Subsidence Area beyond the limits of the longwalls: Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not affect more than 0.5% of the total face area of such cliffs within the Subsidence Area).
- All land within the Subsidence Area, including steep slopes: No greater subsidence impact or environmental consequences than predicted in the Environmental Impact Study (EIS).
- Other privately-owned built features and improvements, including farm dams:
    - ‘Always safe’;
    - Serviceability should be maintained wherever practicable;
    - Loss of serviceability must be fully compensated; and
    - Damage must be fully repairable, and must be fully investigated and repaired or else replaced or fully compensated at the cost of the Applicant (ie Tahmoor Coal).

The above performance measure have been incorporated into the Trigger Action Response Plans (TARPs) (Tables 16 – 18), where performance indicators have been set and a management plan has been proposed.

It is noted that the performance measure for ‘Any cliff located directly above longwalls’ is not relevant to Longwalls S1A to S6A, as there are no cliff lines located directly above these longwalls.

Performance monitoring for mine subsidence impacts within the nominated study areas will comprise the following:

- Visual inspections and field measurements in cliff lines, natural steep slopes (excluding constructed steep slopes associated with roads, railway and the Tahmoor Mine site) and farm dam embankments including of cracking, bulging, buckling, displacement or dislodgement of boulders or slabs, rockfalls and slope instability potentially related to mine subsidence (eg not including natural cracking related to soil shrinkage and swell). The results of visual inspections and measurements will be compared to nearby survey results to assess the potential contribution from mining subsidence and the magnitude of the contribution, where possible.
- Farm dam water levels and seepage through farm dam embankments will be monitored to assess changes from their ‘normal operating range’ and the potential impacts of mine subsidence. Farm dam water level monitoring will include photo records of dams levels. Additionally, incremented posts will also be installed in the ‘larger’ dams where a ‘*Significant*’ risk has been identified. Visual inspections of farm dam embankments will be carried out by a geotechnical engineer to assess the potential for seepage through embankments. The results of visual inspections and measurements will be compared to nearby survey results to assess the potential contribution from mining subsidence and the magnitudes of the contribution, where possible.

9. Trigger Action Response Plan

A contingency plan has been developed in the form of a Trigger Action Response Plan (TARP), as outlined on Tables 16 – 18, to monitor and respond to mine subsidence as it develops within the study areas. The actions developed within the TARP are to address any potential significant subsidence related impacts related to cliffs, natural steep slopes (excluding constructed steep slopes associated with roads, railway and the Tahmoor Mine site) and farm dams.

It is recommended that a monitoring program be undertaken to facilitate the early detection of signs of distress and the implementation of remedial works (if any). A monitoring program has been provided as part of the TARP in the report. In the event that monitoring indicates that the measured parameters are exceeding predicted values, the TARP escalates the monitoring requirements and the need for remedial or precautionary measures to be implemented. It is considered that with periodic inspections and visual observations and timely actions, it will be possible to manage the identified risks and to keep them within tolerable levels.

The Agricultural Assessment (SLR, 2022) assessed the agricultural impacts as being minor, and as such, provided recommendations for mitigation measures and management strategies to minimise potential agricultural impacts, which are summarised below:

- The application of gypsum for any remedial earthworks where sodic subsoils are exposed;
- Sealing of fractures and voids in affected watercourses where little sediment is present;
- 'Make Good' provisions for any groundwater users shown to be adversely affected by mining operations and associated impacts;
- Repair of structures in accordance with the *Coal Mine Subsidence Compensation Act 2017;* and
- Remediation of damage to fence tensioning and farm gates.

Table 16: Trigger Action Response Plan for Cliffs

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management: Trigger	Management: Action	Management: Response
Performance Measure Feature Any cliff within Subsidence Area[1] beyond the extent of longwalls[2]. **Performance Measure** Negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total do not impact more than 0.5% of the total face area of such cliffs within Subsidence Area). **Performance Indicator** This performance measure will be considered to be triggered if more than 0.5% of the total face area of the cliffs within the 600 m Environmental Features Study Area is impacted by mining (eg by occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing). **TARP Objective** This TARP defines measures to manage potential impacts on cliff lines and the actions required to be implemented in response to exceedance of defined trigger levels. **Assessment Criteria** Extent of surface cracking, rockfalls, displacement or dislodgement of boulders or slabs observed.	**Locations** Cliffs (BC1 and BC2) within the 600 m Environmental Features Study Area as illustrated in Figure 3 of the Land Management Plan. **Monitoring Frequency** **Pre-mining** Visual inspection baseline before mining by a geotechnical engineer, subject to land access (Cliff BC1 prior to LW S6A, Cliff BC2 prior to LW S3A). **During Mining** None required (as the identified cliffs are located near the finishing ends of the longwalls). **Post-mining** Visual inspection at the completion of mining by a geotechnical engineer, subject to land access (Cliff BC1 after LW S6A, Cliff BC2 after LW S3A, S4A, S5A and S6A).	**Normal Range of Condition**		
		• Surface cracking < 10 mm wide above the cliff line, on the cliff face, or in the underside of overhangs. AND/OR • No rockfalls, displacement or dislodgement of boulders or slabs observed.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Surface cracking > 10 mm wide above the cliff line, on the cliff face, or in the underside of overhangs. AND/OR • No rockfalls, displacement or dislodgement of boulders or slabs observed.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Discuss findings and obtain other relevant information from key specialises (eg subsidence monitoring results). If it is concluded that the cliff has been damaged by subsidence impacts: • Consider and decide on reasonable and feasible options to support the cliff line, where relevant (eg repairing cracks, installation of support (eg rockbolts). • Erect hazard/warning signs and restrict access to areas where necessary. • Consider increasing monitoring and review of data frequency at sites where Level 1 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional subsidence above longwall, consequences of potential cliff instability and monitoring results relevant to the cliff locations.	• Report trigger exceedance to DPHI and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. • Provide DPHI and key stakeholders with proposed corrective management actions (CMAs) for consultation (eg repairing cracks, installation of support). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
		Level 2		
		• Rockfalls, collapse of overhang, displacement or dislodgement of boulders or slabs observed.	• *Actions as stated in Level 1.* • Determine the percentage area of impacted area relative to the total face area. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (eg whether there has been subsidence induced fracturing, or the effect is unrelated to mining such as environmental effects, tree root jacking). If it is concluded that cliff line has been damaged by subsidence impacts: • Increase frequency of monitoring by geotechnical consultant during active subsidence period at sites where Level 2 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional subsidence above longwall, consequences of potential cliff instability and monitoring results relevant to the cliff locations. • Notify and consult with affected landowner(s). • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options. • Review Land Management Plan and modify if necessary. • Undertake an investigation to determine if an exceedance of the performance measure is likely.	• *Responses as stated in Level 1.* If it is concluded that cliffs have been damaged by subsidence impacts: • Offer site visit with DPHI and key stakeholders. • Develop a Rehabilitation Management Plan in consultation with DPHI and key stakeholders if relevant. • Notify Commonwealth DCCEEW of any predictions of an exceedance of a performance measure (if relevant) within two business days. • Provide findings of CMA review to DPHI and key stakeholders for consultation. • Implement additional CMAs, subject to land access. • Advise DPHI and key stakeholders of any required amendments to Land Management Plan.

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
		Exceeds Performance Measure		
		• More than 0.5% of the total face area of the cliffs within the 600 m Environmental Features Study Area is impacted due to mining (eg by occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing).	• *Actions as stated in Level 2.* • Investigate reasons for the performance measure exceedance. • Review predictions of subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation. • Consider modifying mine plan for future longwalls located near cliffs.	• *Responses as stated in Level 2.* • Submit a report to DPHI (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPHI) describing remediation options and any preferred remediation measures or other course of action. • Implement reasonable remediation measures as directed by DPHI, subject to land access. • Notify Commonwealth DCCEEW of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to Commonwealth DCCEEW (in accordance with Condition 11 of the Commonwealth DCCEEW Consent for the Tahmoor South Project).

Notes:
[1] Subsidence Area is defined as the ‘Subsidence Study Area’ as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] It is noted that there are no cliff lines located directly above Longwalls S1A-S6A. Therefore, the performance measure for ‘Any cliff located directly above longwalls’ is not relevant.

Table 17: Trigger Action Response Plan for Natural Steep Slopes (Excluding Constructed Steep Slopes Associated with Roads, Railway and the Tahmoor Mine Site)

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="4"><u>Performance Measure Feature</u>
All land within the Subsidence Area[1,2].

<u>Performance Measure</u>
No greater subsidence impact or environmental consequences than predicted in the EIS[3].

<u>Performance Indicator</u>
This performance measure will be considered to be triggered if mining results in mine subsidence-induced slope instability, which would be a greater subsidence impact or consequence than predicted in the EIS.

<u>TARP Objective</u>
This TARP defines measures to manage potential impacts on natural steep slopes[4,5] and the actions required to be implemented in response to exceedance of defined trigger levels.

<u>Assessment Criteria</u>
Extent of surface cracking and stepping, ground bulging, buckling and shearing for steep slopes4.</td><td rowspan="4"><u>Locations</u>
Natural steep slopes (WC1, WC2 and WC3)

Locations of natural steep slopes shown in Figure 3 of the Land Management Plan.

<u>Monitoring Frequency</u>
Pre-mining
Visual inspection baseline one month before active subsidence period by a geotechnical engineer, subject to land access.

During Mining
Monthly visual inspection during active subsidence period by a geotechnical engineer, subject to land access.

Post-mining
Quarterly visual inspection for 12 months following active subsidence period by a geotechnical engineer, or as required in accordance with a Rehabilitation Management Plan, subject to land access.</td><td colspan="3">Normal Range of Condition</td></tr>
<tr><td>• Discontinuous surface cracking < 10 mm wide on steep slope (eg other than natural desiccation cracking).
AND/OR
• No localised ground bulging, buckling or shearing.</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Persistent[6] surface cracking 10 – 20 mm wide or stepping (including shearing) across a crack 10 – 20 mm high on steep slope.
AND/OR
• Localised ground bulging or buckling (between 100 – 200 mm) is observed on steep slope.</td><td>• Actions as required for Normal Condition.
• Geotechnical consultant inspection to assess cause and determine need for further action/investigation.
• Discuss findings and obtain other relevant information from key specialists (eg subsidence monitoring results).
If it is concluded that the slope has been damaged by subsidence impacts:
• Consider and decide on reasonable and feasible options for remediation as relevant (eg backfilling or grout filling of surface cracking, re-profiling of compression humps).
• Erect warning signs and restrict access to areas where necessary.
• Consider increasing monitoring and review of data frequency at sites where Level 1 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional subsidence above longwall, consequences of potential slope instability and monitoring results relevant to the steep slope locations.</td><td>• Report trigger exceedance to DPHI and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
• Provide DPHI and key stakeholders with proposed corrective management actions (CMAs) for consultation (eg backfilling or grout filling of surface cracking, re-profiling of compression humps, re-direct drainage)
• Implement CMAs, subject to land access.
• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
</table>

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
			• Consider additional specific monitoring at the impact site and implement if feasible and effective.	
		Level 2		
		• Persistent[5] surface cracking > 20 mm wide or stepping > 20 mm high on slope. AND/OR • Localised ground bulging or buckling > 200 mm is observed on steep slope. AND/OR • Slope instability < 300 m^3 is observed or assessed as likely by a geotechnical engineer based on the extent of surface cracking or deformation.	• *Actions as stated in Level 1.* • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (eg whether there has been subsidence induced cracking, or the effect is unrelated to mining such as wet weather or other environmental effects). If it is concluded that the slope has been damaged by subsidence impacts: • Increase frequency of monitoring by geotechnical consultant during active subsidence period at sites where Level 2 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional subsidence above longwall, consequences of potential slope instability and monitoring results relevant to the steep slope locations. • Assess potential for slope instability (and if an exceedance of the performance measure is possible). • Consider actions to avoid or reduce the likelihood and/or consequence of slope instability and implement if feasible and effective. • Notify and consult with affected landowner(s). • Review CMAs with regards to the findings from further investigations and consider additional remediation options. • Review Land Management Plan and modify if necessary.	• *Responses as stated in Level 1.* If it is concluded that the slope has been damaged by subsidence impacts: • Offer site visit with DPHI and key stakeholders. • Develop a Rehabilitation Management Plan in consultation with DPHI and key stakeholders if relevant. • Notify Commonwealth DCCEEW of any predictions of an exceedance of a performance measure (if relevant) within two business days. • Provide findings of CMA review to DPHI and key stakeholders for consultation. • Implement additional CMAs, subject to land access. • Advise DPHI and key stakeholders of any required amendments to Land Management Plan.
		Exceeds Performance Measure		
		• Subsidence-induced impacts or environmental	• *Actions as stated in Level 2.* • Investigate reasons for the performance measure exceedance.	• *Responses as stated in Level 2.*

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
		consequences that result in slope instability > 300 m^3.	• Review predictions of mine subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation.	• Submit a report to DPHI (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed with DPHI) describing temporary protection measures and long-term remediation options and any preferred remediation measures or other course of action. • Implement reasonable remediation measures as directed by DPHI, subject to land access. • Notify Commonwealth DCCEEW of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to Commonwealth DCCEEW (in accordance with Condition 11 of the Commonwealth DCCEEW Consent for the Tahmoor South Project).

Notes:
[1] Subsidence Area is defined as the 'Subsidence Study Area' as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] Steep slopes are defined as greater than 18.4°. There are three steep slopes identified within the 600 m Environmental Features Study Area that are also located within the Subsidence Area[1]. As no other steep slopes have been identified within the 600 m Environmental Features Study Area, the performance measure for 'all land outside the subsidence area' is not relevant.
[3] EIS predictions are summarised in the Subsidence Predictions and Impact Assessment Report by MSEC (2022), and the relevant predictions for steep slopes is provided in Section 4.2 of the Land Management Plan.
[4] All road embankments and road cutting identified in Figure 3 of the Land Management Plan will be managed in accordance with the Wollondilly Shire Council Management Plan. All railway embankments within the Study Area will be managed in accordance with the Main Southern Railway Management Plan. All steep slopes on the Tahmoor Mine Site will be managed in accordance with the Tahmoor Mine Site Management Plan.
[5] TARPs for the management of constructed steep slopes will be provided as part of the Wollondilly Shire Council Management Plan (road embankments and cuttings), Main Southern Railway Management Plan (rail embankments) and the Tahmoor Mine Site Management Plan (mine site slopes). These yet to be prepared TARPs will be included in this Appendix B Master TARP following preparation and approval by the infrastructure owner.
[6] For the purpose of this TARP, persistent cracking is a tension crack/s that combine to form a potential backscarp or failure plane for slope instability. The length is proportional to the size of the failure surface.

Table 18: Trigger Action Response Plan for Farm Dams

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="6"><u>Performance Measure Feature</u>
Other privately-owned built features and improvements, including farm dams.

<u>Performance Measure</u>
• 'Always safe'.
• Serviceability should be maintained wherever practicable.
• Loss of serviceability must be fully compensated.
• Damage must be fully repairable, and must be fully investigated and repaired or else replaced or fully compensated at the cost of the Applicant.

<u>Performance Indicator</u>
This performance measure will be considered to be triggered if mining results in damage to a farm dam such that the dam is not safe and serviceable and/or any damages cannot be fully repairable and/or compensated.

<u>TARP Objective</u>
This TARP defines measures to manage potential impacts on farm dams and the actions required to be implemented in response to exceedance of defined trigger levels.

<u>Assessment Criteria</u>
Dam embankment integrity, water level and seepage observations.</td><td rowspan="6"><u>Locations</u>
Identified farm dams within the Study Area.
Locations shown in Figure 8 of the Land Management Plan.

<u>Monitoring Frequency</u>
Pre-mining
Dam embankment integrity and water level observation by a geotechnical consultant one month before active subsidence period using fixed location photo points.

During Mining
Dam embankment integrity and water level observation monthly during the active subsidence period by a geotechnical consultant, using fixed location photo points, subject to land access.

Post-mining
Dam embankment integrity and water level observation using fixed location photo points on a quarterly basis for 12 months following completion of active subsidence by a geotechnical consultant, or as required in accordance with a Rehabilitation Management Plan.</td><td colspan="3">Normal Range of Condition</td></tr>
<tr><td>• No cracks develop within dam embankment (eg other than natural desiccation cracking).</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Development of isolated cracks (> 10 mm wide) within the dam wall (eg other than natural desiccation cracking).
AND/OR
• Development of isolated seepage without suspended solids (eg clear water) from the face or toe of the farm dam embankment.</td><td>• Actions as required for Normal Condition.
• Geotechnical consultant inspection to assess cause and determine need for further action/investigation.
• Discuss findings and obtain other relevant information from key specialists (eg subsidence monitoring results).
If it is concluded that dam has been damaged by subsidence impacts:
• Consider and decide on reasonable and feasible options for remediation as relevant (eg backfilling surface cracking, reinstatement).
• Notify and consult with affected landowner.
• Erect warning signs and restrict access to areas where necessary and permitted by the landowner.</td><td>• Report trigger exceedance to DPHI, SA NSW and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
• Provide DPHI, SA NSW and landowner with proposed corrective management actions (CMAs) for consultation (eg backfilling surface cracking, reinstatement).
• Implement CMAs, subject to land access.
• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Development of persistent longitudinal or arcuate cracking within dam wall > 20 mm.
AND</td><td>• Actions as stated in Level 1.
• Consider increasing monitoring and review of data frequency at sites where Level 2 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional</td><td>• Responses as stated in Level 1.
• Advise DPHI, SA NSW and key stakeholders of any required amendments to Land Management Plan.</td></tr>
</table>

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td></td><td></td><td>• Development of seepage with suspended solids (eg turbid water) from the face or toe of the farm dam embankment.</td><td>subsidence above longwall, consequence of potential dam break, and monitoring results relevant to the dam locations.
• Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.
• Review Land Management Plan and modify if necessary.
• Geotechnical Consultant to advise on the need for a reduction in the dam water level (eg half dam volume) to reduce the risk of a dam break failure.</td><td>• Provide findings of CMA review to DPHI, SA NSW and landowner for consultation.
• Implement additional CMAs, subject to land access.</td></tr>
<tr><td></td><td></td><td colspan="3">Level 3</td></tr>
<tr><td></td><td></td><td>• Development of persistent longitudinal or arcuate cracking within dam wall > 50 mm.
AND
• Subsidence monitoring identifies subsidence-induced impacts or environmental consequences that result in any slope instability to the farm dam embankment.</td><td>• Actions as stated in Level 2.
• Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (eg whether there has been subsidence induced fracturing, or the effect is unrelated to mining such as environmental effects).
If it is concluded that the dam has been damaged by subsidence impacts:
• Increase frequency of monitoring by geotechnical consultant during active subsidence period at sites where Level 3 has been reached, subject to land access. Considerations will take into account position of LW face relative to impact site, rate of longwall retreat, current weather conditions, development of conventional subsidence above longwall, consequence of potential dam break, and monitoring results relevant to the dam locations.
• Reduction of dam water level in accordance with advice from Geotechnical Consultant.
• Review predictions of mine subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation.</td><td>• Responses as stated in Level 2.
If it is concluded that the dam has been damaged by subsidence impacts:
• Offer site visit with DPHI and key stakeholders.
• Repair or replace farm dam in consultation with DPHI and SA NSW and landowner.
• Provide alternate water supply for landowner, if required.
• Notify Commonwealth DCCEEW of any predictions of an exceedance of a performance measure (if relevant) within two business days.</td></tr>
</table>

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
			• Assess potential for the safety and serviceability of the dam to be lost (and if an exceedance of the performance measure is possible).	
		Exceeds Performance Measure		
		• Mining results in damage to a farm dam such that the dam is not safe and serviceable and/or any damages cannot be fully repairable and/or compensated.	• *Actions as stated in Level 3.* • Investigate reasons for the performance measure exceedance. • Review predictions of mine subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation.	• *Responses as stated in Level 3.* • Submit a report to DPHI (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed with DPHI) describing temporary protection measures and long-term remediation options and any preferred remediation measures or other course of action. • Implement reasonable remediation measures as directed by DPHI, subject to land access. • Notify Commonwealth DCCEEW of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to Commonwealth DCCEEW (in accordance with Condition 11 of the Commonwealth DCCEEW Consent for the Tahmoor South Project).

10. Conclusions

A high-level geotechnical assessment has been conducted on the land features within the study areas of LW S1A to S6A. The geotechnical assessment included a risk-based assessment of cliffs, steep slopes (including road embankments and road cuttings) and farm dams. A monitoring program and Triger Action Response Plan (TARP) have been developed. The geotechnical assessment was based on the mine inputs received from Tahmoor Coal and the subsidence prediction report by MSEC. Inspections were conducted adjacent to cliffs, steep slopes and farm dams within the study area.

The risk assessments of cliffs were evaluated by the procedure recommended by ACARP (2002). Steep slopes were assessed using AGS Landslide Risk Management Guidelines. Road embankments and road cuttings were assessed using the methods described in the RMS Guide to Slope Risk Analysis. The Small Dam Consequence Screening Tool (DEPI, 2014) was used to analyse farm dams.

The risk assessment of cliffs indicated a *Very Low* risk of mining impacts and overall *Very Low* risk at two sites located near the edge of the natural feature study area, with cracking or slope instability conservatively estimated to affect 0.5% to the cliff face area.

The risk assessment of steep slopes indicated a *Moderate* and Tolerable risk of mining impacts at three Aboriginal Heritage sites located near or above the longwall panels.

The risk assessment of road embankments and road cuttings indicated a *Very Low* and *Acceptable* risk to road users for slope instability scenarios. For the remainder of the hazards assessed for road users, the impacts were assessed to have a *Very Low to Low* and *Acceptable* risk level.

The consequence of farm dam failure to property or human lives was assessed to be in the *Significant* range for four farm dams with capacities in the range of 1.5 – 2.5 ML in the study area, due to properties located within the potential flooding area downstream that are expected to be affected if a dam break occurred. When considering cascading failure for farm dams in series, five additional farm dams were assessed in the *Significant* range. The remaining farm dams were assessed to be in the *Very Low* to *Low* ranges. It is recommended that a detailed assessment is carried out for farms dams assessed as significant, to assess the quality of construction of the dams, together with dam break analyses to assess the extent of the flooding impact downstream. Due to FD2 being decommissioned in the next 6 to 12 months, an alternative option to carry out a risk assessment to nominate addition risk mitigation control measures, has been provided.

It is recommended that a monitoring program be undertaken to facilitate the early detection of signs of distress and the implementation of remedial works (if any). A monitoring program has been provided as part of the TARP in the report. In the event that monitoring indicates that the measured parameters are exceeding predicted values, the TARP escalates the monitoring requirements and the need for remedial or precautionary measures to be implemented. It is considered that with periodic inspections, visual observations and timely actions, it will be possible to manage the identified risks and to keep them with tolerable levels.

11. References

ACARP. (2002). *Impacts of Mine Subsidence on the Strata and Hydrology of River Valleys and Management Guidelines for Undermining Cliffs, Gorges and River System .* Waddington & Associates Pty Ltd: ACARP Project C9067.

AGS. (2007). *Practice Note Guidelines for Landslide Risk Management.* Australian Geomechnics, Volume 42, No 1: Australian Geomechanics Society, Landslide Taskforce, Landslide Practice Note Working Group.

ANCOLD. (2012). *Guidelines on the Consequence Catergories for Dams.* Australian National Committee on Large Dams.

DP. (2020). *Report on Geotechnical Investigation, Farm Dams FD5 and FD7, Longwall W1 to W2, Picton.* Project 89541.03.R.001.Rev1 dated 25 March 2020: Douglas Partners Pty Ltd.

MSEC. (2011). *Appin Colliery – Longwalls 901-904. Subsidence Predictions and Impact Assessments for the Natural Features and Surface Infrastructure in support of the Extraction Plan .* Report No. MSEC448 Rev 3. : Mine Subsidence Engineering Consultants.

MSEC. (2019). *Tahmoor Coking Coal Operations - Longwalls W1 and W2, Subsidence Predictions and Impact Assessment for Natural and Built Features due to the Extraction of the Proposed Longwalls W1 and W2 in Support of the Extraction Plan Application.* Report No. MSEC1019 Rev A: Mine Subsidence Engineering Consultants.

NSW DoP. (2008). *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield: Strategic Review .* NSW Department of Planning.

NSW RMS. (2014). *Guide to Slope Risk Analysis, Version 4.* NSW Transport - Roads and Maritime Services.

VIC DEPI. (2014). *Consequence Screenig Tool for Small Dams.* VIC Department of Environment and Primary Industries.

12. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Longwalls S1A to S6A at Bargo in accordance with DP's Proposal 210597.00.P.001.Rev1 dated 8 November 2021 and email acceptance received from Tahmoor Coal dated 12 December 2021. The work was carried out under TC's and DP's Umbrella Agreement for Consultancy Services (Contract TAHC0612 executed on 15 October 2019). This report is provided for the exclusive use of Tahmoor Coal Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or be relied upon for other projects or purposes on the same or another site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

DP's advice is based upon the conditions encountered during this assessment. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across and below the site. The advice may also be limited by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

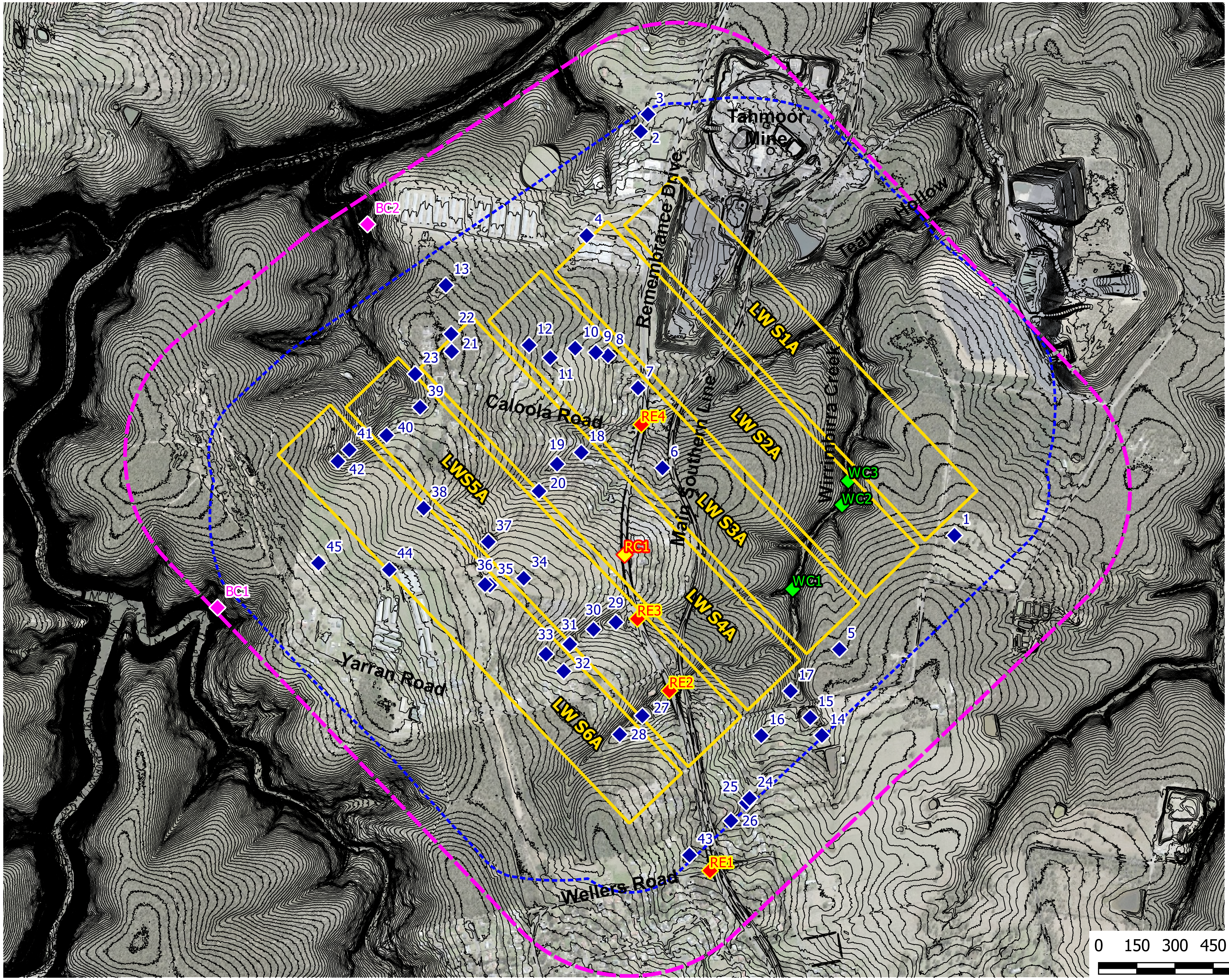
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings 1 – 3



0 150 300 450 600 750 900 1050 1200 1350 1500 m

Locality Plan

Notes: Aerial photography from Metromap.com

Legend

- Cliffs
- Steep Slopes
- Road Embankments
- Road Cutting
- 1m LiDAR Contours
- Study Area for Man-Made Features (Combined 20mm Subsidence Contour & 35 Degree Angle of Draw)
- Farm Dams
- Longwalls
- Study Area for Natural Features

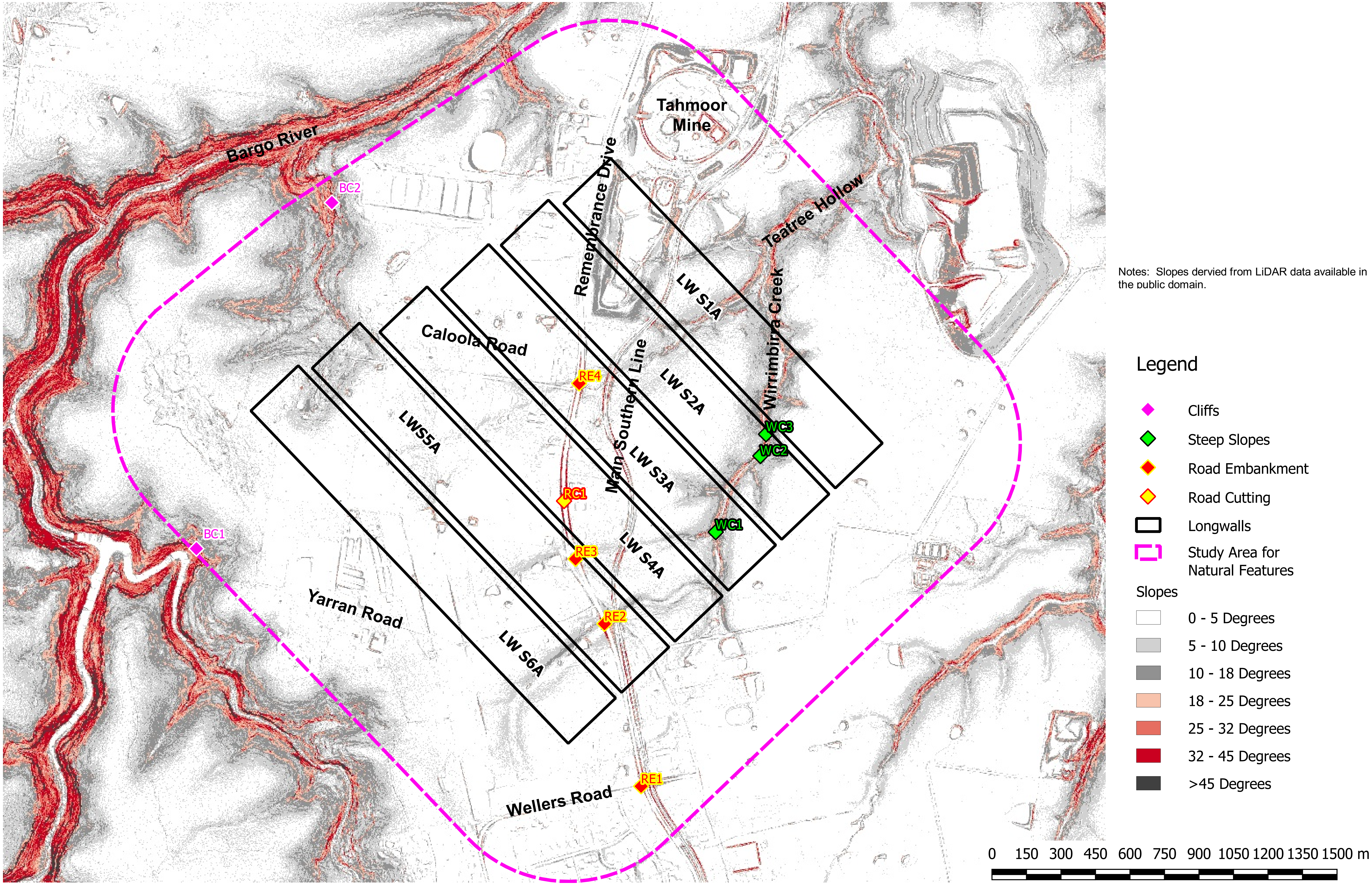
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Tahmoor Coal Pty Ltd		
OFFICE:	Wollongong	DRAWN BY:	RJH
SCALE:	1:15,000 @ A3	DATE:	7 Sep 2022

TITLE: **Subsidence Study Area and Landscape Features**
Geotechnical Land Management Plan
Longwalls S1A to S6A, Bargo

N

PROJECT No:	210597.00
DRAWING No:	1
REVISION:	1



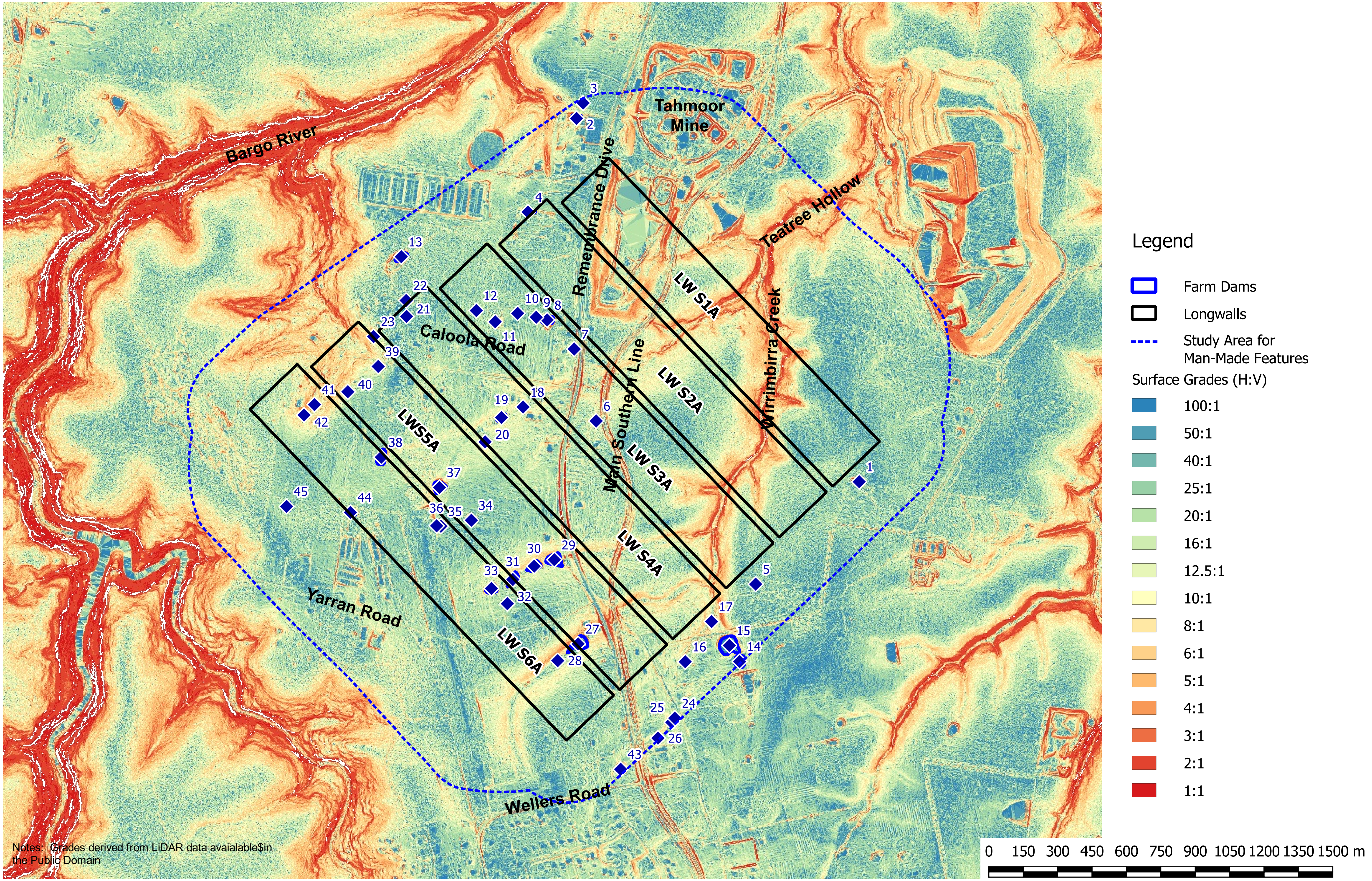
Notes: Slopes dervied from LiDAR data available in the public domain.

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Tahmoor Coal Pty Ltd		
OFFICE:	Wollongong	DRAWN BY:	RJH
SCALE:	1:15,000 @ A3	DATE:	7 Sep 2022

TITLE: **Cliffs and Steep Slopes**
Land Management Plan
Longwalls S1A to S6A, Bargo

PROJECT No:	210597.00
DRAWING No:	2
REVISION:	1



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Tahmoor Coal Pty Ltd		TITLE: Farm Dam Locations and Regional Topography	PROJECT No: 210597.00
OFFICE: Wollongong	DRAWN BY: RJH	Land Management Plan	DRAWING No: 3
SCALE: 1:15,000 @ A3	DATE: 7 Sep 2022	Longwalls S1A to S6A, Bargo	REVISION: 1

Appendix C

Plates 1 – 11 (Site Photographs 1 – 44)

Photo 1: View looking south towards the Wellers Road overpass bridge, along the crest of the downstream face for the RE1 road embankment.

Photo 2: View looking south east across the south western corner of the RE1 road embankment.

Photo 3: View looking north west at rutting and crocodile cracking in the Remembrance Drive wearing course to the south of the intersection with Wellers Road (RE1).

Photo 4: View looking north along the upstream face for RE2.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 1 to 4**	PROJECT No: 210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No: 1
	SCALE: NTS	DATE: 23 Dec 2021	**Longwall S1A to S6A, Bargo**	REVISION: 0

Photo 5: View looking north along the upstream face for RE2. Note: the dwelling at the toe of the embankment, which is downstream from FD51.

Photo 6: View looking north along the downstream face for RE3.

Photo 7: View looking towards the upstream culvert for RE3.

Photo 8: View looking south along the downstream face crest for RE3.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 5 to 8**	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No:	2
	SCALE: NTS	DATE: 23 Dec 2021	**Longwall S1A to S6A, Bargo**	REVISION:	0

Photo 9: View looking south along the crest of the downstream face foir RE4.

Photo 10: View looking along the crest of the upstream face for RE4.

Photo 11: View looking south along the upstream face of RE4 opposite No. 3100 Remembrance Drive. Note: the drain cut into the toe of the embankment.

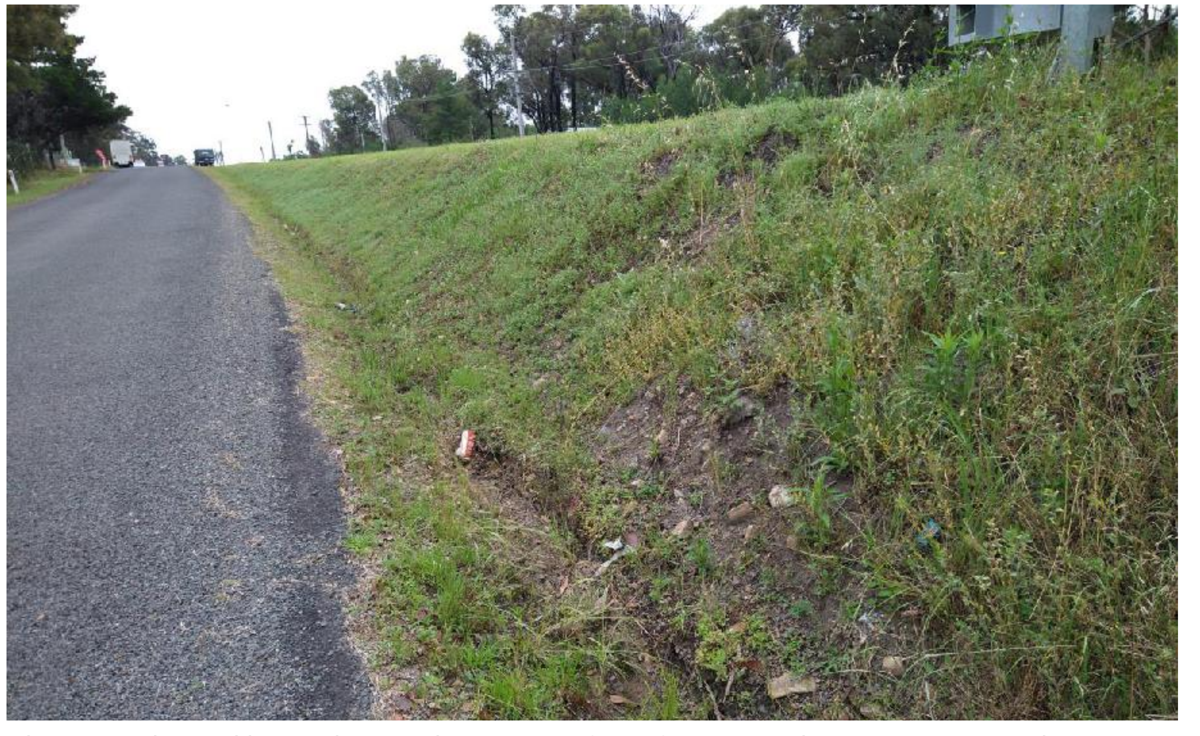


Photo 12: View looking north along the upstream face of RE4 opposite No. 3088 Remembrance Drive.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 9 to 12**	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No:	3
	SCALE: NTS	DATE: 23 Dec 2021	**Longwall S1A to S6A, Bargo**	REVISION:	0

Photo 13: View looking southwest towards the road cutting adjacent to No. 3140 Remembrance Drive. Note: the soil and weathered rock in the upper cut and medium to thickly bedded rock in the

Photo 14: View looking north west towards the road cutting adjacent to No. 3116 Remembrance Drive. Note: the soil and weathered rock in the upper cut and medium to thickly bedded rock in the middle and lower.

Photo 15: View looking east towards the cutting adjacent to No. 3165 Remembrance Drive. Note: the weathered rock in the upper cut and medium to thickly bedded rock in the middle and lower cut.

Photo 16: View looking at tension cracks setback behind the crest of opposite No. 3122 Remembrance Drive.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 13 to 16**	PROJECT No: 210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No: 4
	SCALE: NTS	DATE: 23 Dec 2021	**Longwall S1A to S6A, Bargo**	REVISION: 0

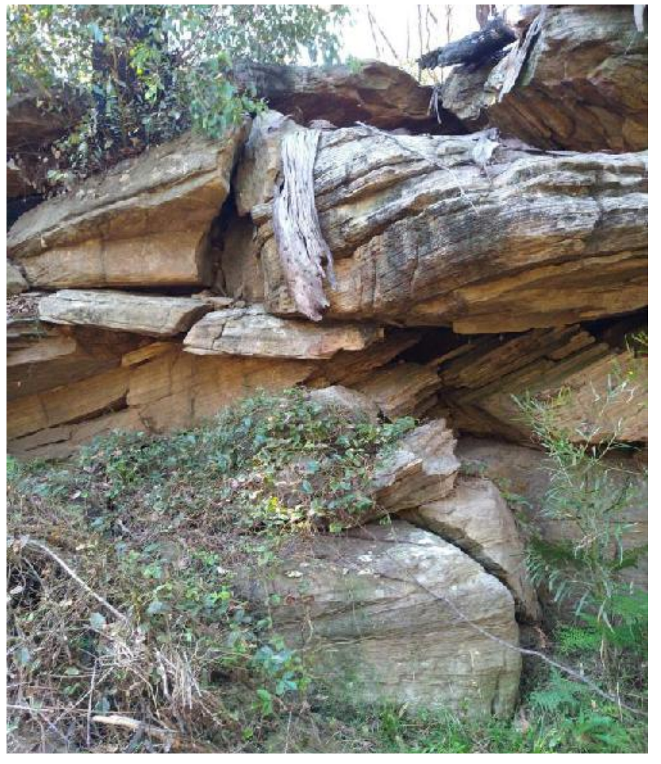


Photo 17: View looking open jointing and dislodged joint blocks near the 'Big Pool' (WC1) in Wirrimbirra Creek.

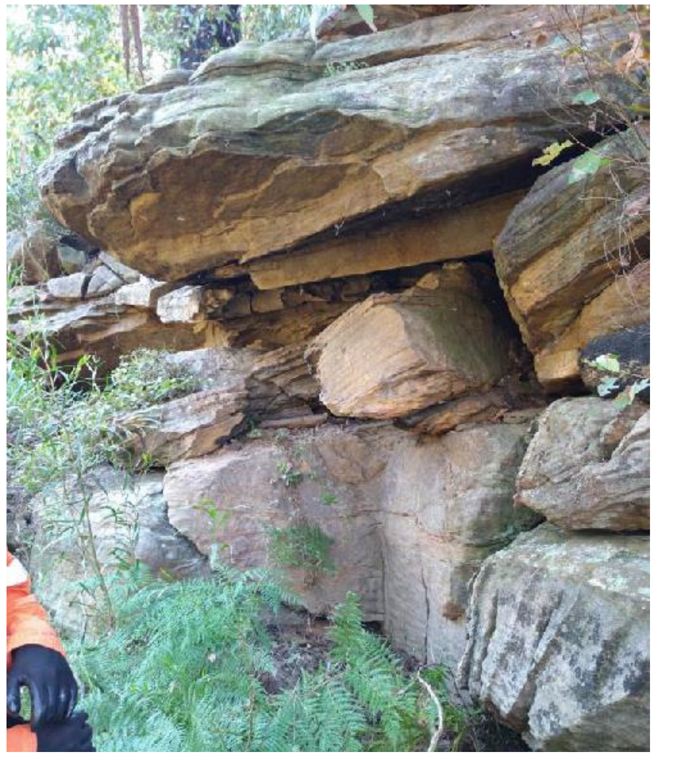


Photo 18: View looking open jointing and dislodged joint blocks near the 'Big Pool' (WC1) in Wirrimbirra Creek.

Photo 19: View looking west at rocky outcrop about Dekenden Pool (WC2) in Wirrimbirra Creek.

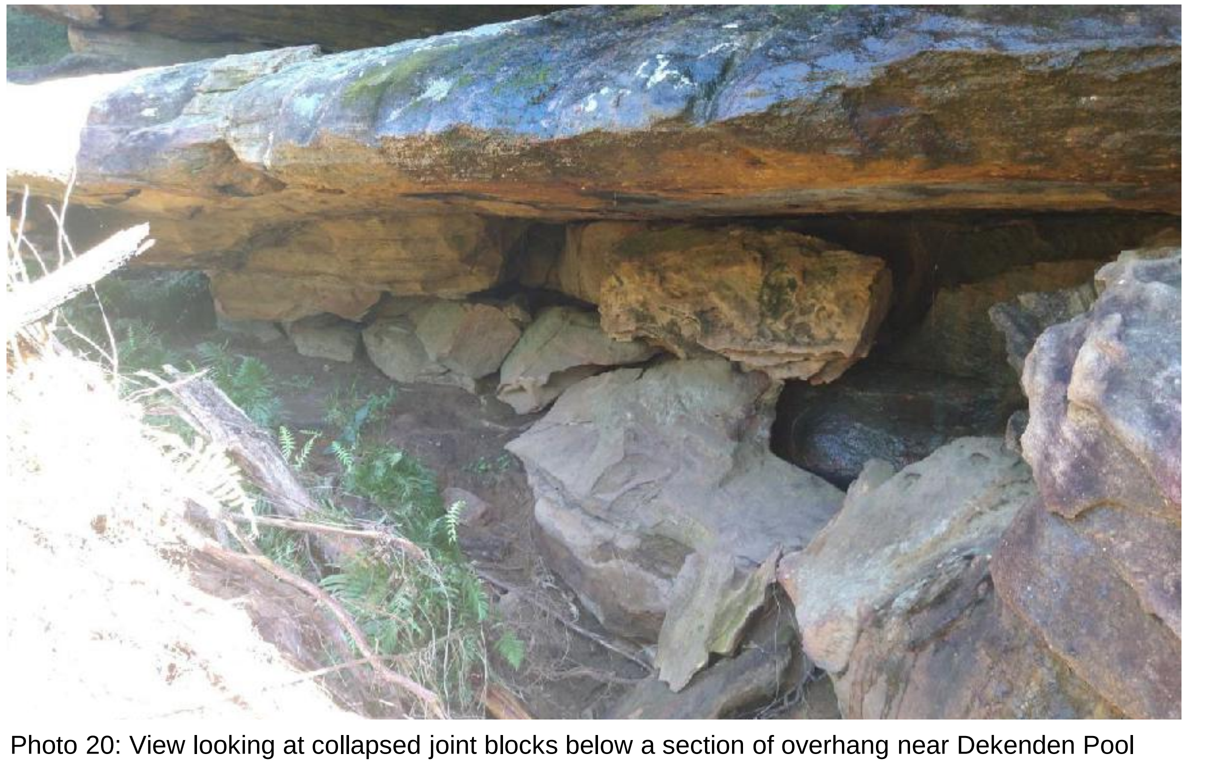


Photo 20: View looking at collapsed joint blocks below a section of overhang near Dekenden Pool (WC2).

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 17 to 20**	PROJECT No: 210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No: 5
	SCALE: NTS	DATE: 12 Apr 2022	**Longwall S1A to S6A, Bargo**	REVISION: 0

Photo 21: View looking at overhanging rocky outcrops near 'Petroph Pass' (WC3) in Wirrimbirra Creek.

Photo 22: View looking at a wide section of overhang near 'Petroph Pass' (WC3) in Wirrimbirra Creek.

Photo 23: View looking south downslope at WC4. Note: the sandstone blocks and slabs of sandstone resting on the surface.

Photo 24: View looking west across the upper slope above the Bargo River at WC4. Note: the sandstone blocks and slabs of sandstone resting on the surface and burnt/dead trees.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 21 to 24**	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No:	6
	SCALE: NTS	DATE: Feb - Apr 2022	**Longwall S1A to S6A, Bargo**	REVISION:	0

Photo 25: View looking west along the crest of the farm dam at 4 Olive Lane (ie outside SA). Note: the erosion and scour following overtopping during a heavy rainfall event in early April 2022.

Photo 26: View looking west along the downstream toe of the farm dam at 4 Olive Lane (outside the SA). Note: the erosion and scour following overtopping during a heavy rainfall event in early April 2022.

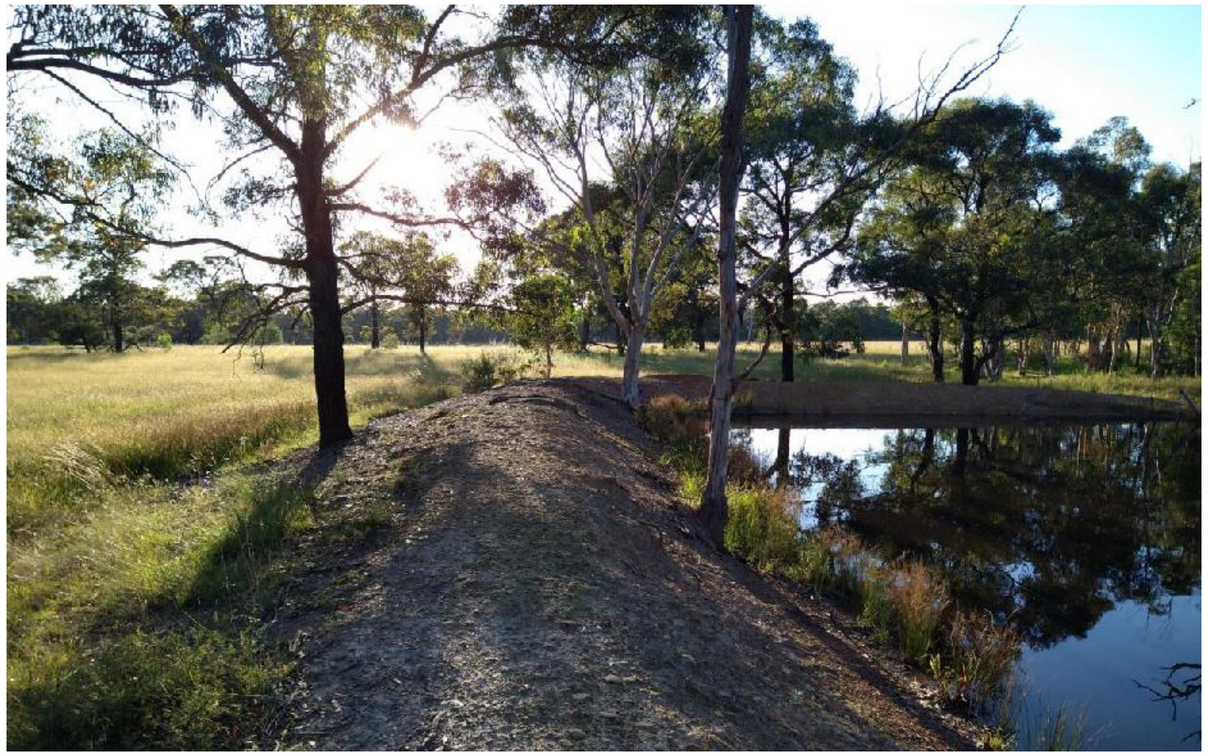


Photo 27: View looking east along the crest for FD1.

Photo 28: View looking south east across the crest of FD2.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		Site Photographs 25 to 28	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	Land Management Plan	PLATE No:	7
	SCALE: NTS	DATE: Jan - Apr 2022	Longwall S1A to S6A, Bargo	REVISION:	0

Photo 29: View looking north along the downstream embankment face of FD2.

Photo 30: View looking north across FD3.

Photo 31: View looking south along the crest of FD5.

Photo 32: View looking north along the crest and upstream embankment face for FD8. Note: the large sandstone boulders placed over the crest.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd			**Site Photographs 29 to 32**	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY:	RJH	**Land Management Plan**	PLATE No:	8
	SCALE: NTS	DATE:	Feb 2022	**Longwall S1A to S6A, Bargo**	REVISION:	0

Photo 33: View looking south along the crest for FD9. Note: the sandstone cobbles and boulders placed embedded in the crest.

Photo 34: View looking west across the downstream embankment of FD15.

Photo 35: View looking along the spillway for FD15. Note: the embankment along the western side of the pond in the left of the photo.

Photo 36: View looking east across the upstream embankment face of FD22.

Photo 37: View looking north west towards the embankment for FD27.

Photo 38: View looking at erosion and scour in the downstream face of FD27. Note the spillway channel at the toe of the embankment in the upper photo.

Photo 39: View looking north along the crest of FD31.

Photo 40: View looking at erosion in the downstream embankment face of FD31. Note: the saplings growing in the downstream face.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 37 to 40**	PROJECT No: 210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No: 10
	SCALE: NTS	DATE: Feb 2022	**Longwall S1A to S6A, Bargo**	REVISION: 0

Photo 39: View looking east across the crest of FD39.

Photo 42: View looking northwest across FD40.

Photo 43: View looking south east across FD41. Note: the crest in the left of the photo.

Photo 44: View looking along the eastern wall of FD45.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Tahmoor Coal Pty Ltd		**Site Photographs 41 to 44**	PROJECT No:	210597.00
	OFFICE: Wollongong	DRAWN BY: RJH	**Land Management Plan**	PLATE No:	11
	SCALE: NTS	DATE: Feb 2022	**Longwall S1A to S6A, Bargo**	REVISION:	0

Appendix D

Land and Agricultural Resource Assessment Report

TAHMOOR EXTRACTION PLAN LW S1A-S6A

Land and Agricultural Resource Assessment

Prepared for:

Tahmoor Coal
2975 Remembrance Drive
Bargo NSW 2573 Australia

SLR Ref: 630.12732.002
Version No: -v0.1
April 2022

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
10 Kings Road
New Lambton NSW 2305 Australia
(PO Box 447 New Lambton NSW 2305)
T: +61 2 4037 3200
E: newcastleau@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Tahmoor Coal (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.12732.002	April 2022	Murray Fraser	Rod Masters	Rod Masters

CONTENTS

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

PHOTOS

APPENDICES

1 Introduction

Tahmoor Coal Pty Ltd, (Tahmoor Coal), owns and operates Tahmoor Mine, an existing underground coal mine that is located approximately 80 km south-west of Sydney in the Southern Coalfield of New South Wales (NSW). Tahmoor Mine surface facilities are situated between the towns of Tahmoor and Bargo within the Wollondilly Local Government Area (LGA). The mine has previously extracted longwalls to the north and west of the surface facilities and has been operating continuously since 1979 when coal was first mined using bord and pillar mining methods, followed by longwall mining methods since 1987.

Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Extracted coal is processed on site at the coal handling and preparation plant (CHPP) and coal clearance facilities prior to transportation via rail to Port Kembla and Newcastle for Australian domestic and export customers.

An Environmental Impact Statement (EIS) was exhibited in early 2019 to gain approval for the Tahmoor South Coal Project, which involves use of the existing surface infrastructure and the expansion of underground longwall mining to the south of the existing workings (referred to as the Tahmoor South Domain). Tahmoor Coal subsequently revised the proposed mine design and submitted amended development applications on two occasions (in February and August 2020). In April 2021, Tahmoor Coal received Development Application Approval (SSD 8445) for the extraction of up to 4 Mtpa of ROM coal, with a total of up to around 33 Mt of ROM coal proposed to be extracted over a 10-year period.

The Tahmoor South Domain is located south of the Bargo River and east of Remembrance Driveway and the township of Bargo. Longwall mining would be used to extract coal from the Bulli coal seam within the bounds of Consolidated Coal Lease (CCL) 716 and CCL 747. Twelve longwalls are proposed in this domain which are divided into a series of six northern (A series) and six southern (B series) longwalls. The A series, Longwalls South 1A to South 6A (LW S1A-S6A), are the focus of the current Extraction Plan application.

The locations of LW S1A-S6A, along with the Study Area and regional locality, are shown in **Figure 1**. The Study Area for this assessment comprises the total combined area of the predicted limit of vertical subsidence, taken as the 20 millimetre subsidence contour (resulting from the extraction of LW S1A-S6A), and the 35 degree angle of draw.

The proposed mine layout for LW S1A-S6A lies within the approved Extent of Longwalls. Minor changes have been made to the mine layout since development consent was received (EIS Layout), as foreshadowed by Tahmoor Coal when it applied for development consent. These changes are all within the predicted extent of the longwall boundaries and are detailed in the Extraction Plan Main Document and the Land Management Plan.

1.1 Assessment Objective

The objective of this Land and Agricultural Resource Assessment is to outline the monitoring and management measures to be implemented to manage these potential subsidence related impacts on agricultural resources, specifically from the extraction of LW S1A-S6A.

This assessment will form part of an Extraction Plan being prepared by Tahmoor Coal for LW S1A-S6A for submission to the NSW Department of Planning and Environment (DPE), formerly the Department of Planning, Industry and Environment (DPIE).

1.1.1 Consultation with Department of Primary Industries

Tahmoor Coal received correspondence from DPI on the 3rd February 2022 which noted:

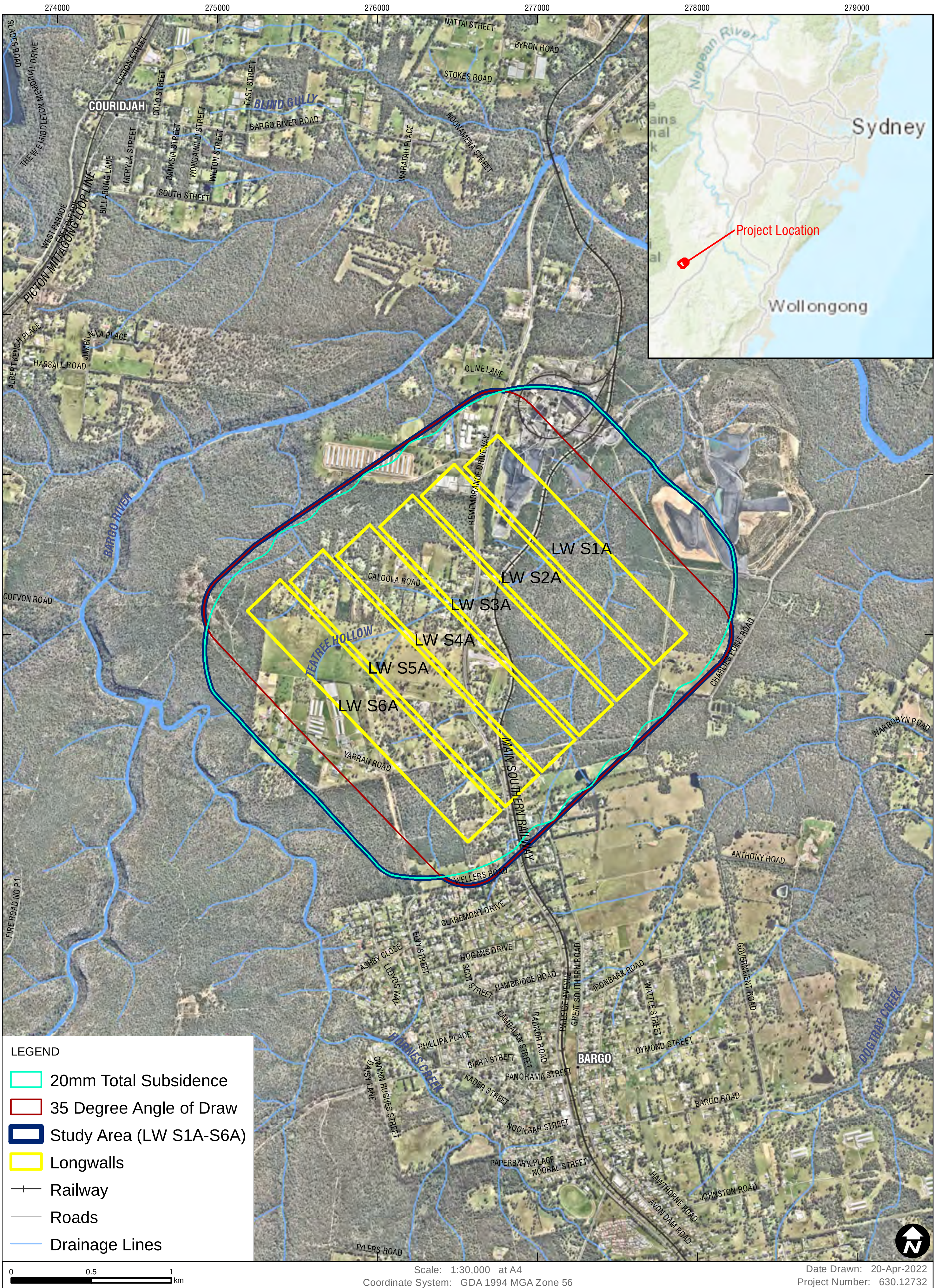
"DPI understands that the company is seeking advice with respect to matters it should consider in the development of the extraction plan. While the DPI does not have any regulatory involvement in this project, we have undertaken a brief review of the agricultural industries in the area and recommend that the company consider the following comments related to agricultural landuses when developing the plan", shown below in **Table 1**:

Table 1 DPI General Comment Register

DPI General Comments	Tahmoor Coal Response	Specific Section Where Addressed
A full assessment of the agricultural landuses in the area that may be potentially impacted so any agricultural developments and associated enterprises in the area are considered in terms of identified risks and economic disruption particularly with subsidence.	An Agricultural Impact Statement was prepared for the first Amendment Report for SSD 8445 approval. For this Extraction Plan, this document has been prepared to complement the information from the Agricultural Impact Statement, and provide any updates on agricultural impacts from the proposed longwalls.	2.8 & 4
Consult with the owners/ managers of affected and adjoining neighbours and agricultural operations in a timely and appropriate manner about; the proposal, the likely impacts and suitable mitigation measures or compensation	Consultation with owners of agricultural businesses in the Study Area has commenced. Tahmoor Coal will continue to consult with the owners during the preparation of the management plans for each individual agricultural business, and will monitor and manage potential impacts to the properties in accordance with these management plans. Further information on management plans to be prepared for infrastructure and structures is provided in the Extraction Plan Main Document. In addition, all landowners in the Study Area have been informed by an information packaged delivered by mail of the proposed development and the subsidence impact claims process in the event that their property is damaged by mining.	6
Consider possible cumulative effects to agricultural enterprises and landholders from subsidence/ other impacting events.	Given the described impacts are of a minor nature and readily managed through application of appropriate mitigation measures and management strategies, any resulting cumulative impacts on agricultural resources and enterprises are also expected to be minor and readily mitigated.	4.4.18

DPI General Comments	Tahmoor Coal Response	Specific Section Where Addressed
An assessment of the monitoring regime that will identify any changes as a result of the effects of the long wall mining, especially subsidence, this may include impacts of farm infrastructure i.e. buildings, fences, slope changes, water supply infrastructure. (This may overlap with the other documents noted in your letter).	Tahmoor Coal will consult with the agricultural business owners during the preparation of management plans for each individual agricultural business, and will monitor and manage potential impacts to the properties in accordance with these management plans.	6
DPI Poultry Comment		
In relation to the poultry enterprises that exist in the area, that these owner/ managers as well as the processors/owners of the birds be consulted to ensure that production plans can be adjusted if required. This should have at least for 12 month periods of mining activity.	Tahmoor Coal will consult with the agricultural business owners during the preparation of management plans for each individual agricultural business, and will monitor and manage potential impacts to the properties in accordance with these management plans.	6
DPI Horticulture Comments		
For protected cropping enterprises (glasshouses) located in the impacted area, the slope of the glasshouses is critical for efficient irrigation so subsidence may be a potential issue. This may also be an issue for other open horticultural enterprises e.g. olives if they are irrigated with a dripper system.	Tahmoor Coal will consult with the agricultural business owners during the preparation of management plans for each individual agricultural business, and will monitor and manage potential impacts to the properties (including hothouses and greenhouses) in accordance with these management plans.	4.4.16
Dust can also be an issue for greenhouse/glasshouse light transmission so this needs to be addressed if dust levels are an issue above ground.	The extraction of LW S1A-S6A involves the extraction of six underground longwall panels and as such there will be no impact to air quality resulting from this extraction activity. All other activities associated with the Tahmoor South Project that have the potential to create dust will be undertaken in accordance with the approved Air and Greenhouse Gas Management Plan for any onsite construction as well as the ongoing operation of Tahmoor Mine.	4.4.4
With water quality any increase in the total dissolved salts (TDS) or an increase in sodium level will be a limitation to any horticultural system relying on hydroponics or fertigation.	There is no predicted increase in total dissolved salts or sodium in groundwater bores associated with LW S1A-S6A.	4.2.4

Addressing these comments from DPI on consultation, potential impacts and mitigation measures also forms part of this Land and Agricultural Resource Assessment.



Scale: 1:30,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 20-Apr-2022

Project Number: 630.12732

SLR

Site Locality

FIGURE 1

\\au.slr.local\Corporate\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 Site Locality 23032022.mxd

2 Agricultural and Water Resources

2.1 Climate

Representative climate data for the Study Area has been obtained from the nearest Bureau of Meteorology (BOM) weather station located at Picton, approximately one kilometre to the north-west of the Study Area (Picton Council Depot, BOM Station 068052, Monthly Climate Statistics).

Picton BOM Station has recorded an average annual rainfall of 801 millimetres, of which approximately 475 millimetres (60%) falls between November and April, with an average of 70.8 rain days in any given year (**Table 2**). Mean monthly maximum temperatures range between 29.3°C and 16.8°C, with January being the warmest month. Mean monthly minimum temperatures range between 15.4°C and 1.7°C, with July being the coldest month.

Table 2 Picton Climate Data

Temperature	Average (Mean)	Annual Range
Minimum temperature	8.8°C	1.7°C – 15.4°C
Maximum temperature	23.5°C	16.8°C – 29.3°C
Rainfall	**Average (Mean)**	**Average Rain Days**
Annual Rainfall	800.9 mm	70.8
Wettest month	February 91.0 mm	6.8
Driest month	September 43.5 mm	5.1

Source: *Bureau of Meteorology (2020)*

The BOM classifies this as a temperate climate zone. The area can be susceptible to occasional heavy showers and thunderstorms due to easterly troughs during warmer months. Summer winds are generally from the south or south-east, with a tendency for afternoon north-easterly winds. During winter, winds are predominantly from the south or south-west.

2.2 Topography

Topography in the region (Wollondilly LGA) is varied, ranging from gently undulating plateaus, ridges and low hills in the upland areas, to a rugged landscape of deeply dissected valleys and gorges within the Hawkesbury Sandstone.

Topography within the Subsidence Study is generally undulating with a fall from the south-west to the north-east (**Figure 2**). The major topographical feature within the Study Area is Teatree Hollow. The major topographical feature nearby the Study Area is the Bargo River valley, which is located to the north.

Elevation near the Study Area varies from a low point of approximately 265 metres AHD, in the base of Teatree Hollow, downstream from of the proposed LW S1A, to a high point of approximately 345 metres AHD, at the south-western end of the Study Area to the south-west of the proposed LW S6A.

Scale: 1:30,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-Mar-2022
Project Number: 630.12732

H:\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 Topography and Hydrology 23032022.mxd

SLR

Topography and Hydrology

FIGURE 2

2.3 Hydrology

2.3.1 Surface Water

The Study Area is located in the catchment of the Hawkesbury-Nepean River, within the sub-catchment of the Nepean River (**Table 2**). The Nepean River rises in the Great Dividing Range to the west of the Study Area. Flows in the upper reaches of the Nepean River are highly regulated by the Upper Nepean Water Supply Scheme, operated by the Water NSW, incorporating four major water supply dams on the Cataract, Cordeaux, Avon and Nepean Rivers. There are no catchment areas or declared special areas within the Study Area. The nearest catchment area is the Metropolitan Special Area, which is located approximately 4.5 kilometres southeast of the proposed longwalls.

There are two dominant drainage channels associated with the Study Area, Teatree Hollow and Wirrimbirra Creek, which is a tributary to Teatree Hollow (**Table 3**). The streams have flow controlling features along their alignments that include rockbars, riffles, knick points and debris accumulations (MSEC, 2022).

In addition to these drainage channels there are a number of intermitted watercourses and numerous small farm dams. All drainage channels within the Study Area are considered low flow or intermittent channels suggesting that the number of users dependent on flows from these watercourses is limited.

Table 3 Streams within the Study Area

Location	Stream Order	Description
Teatree Hollow	3rd Order	Located directly above the proposed LW S1A-S6A, with a total length of 2.1 kilometres directly mined beneath.
Wirrimbirra Creek	3rd Order	Located directly above the proposed LW S1A-S4A, with a total length of 1.3 kilometres directly mined beneath

2.3.2 Licenced Surface Water Users

The Study Area is located within the Maldon Weir Management Zone of the Upper Nepean and Upstream Warragamba Water Source which is regulated in accordance with the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011. The NSW Water Register indicates there is one WAL is associated with a property located within the Study Area and one WAL is associated with a property located adjacent to the Bargo River downstream of the Study Area (Tahmoor Coal, 2022).

2.3.3 Groundwater

The Study Area is located within the Sydney Basin porous rock groundwater system (Nepean Groundwater Source, Management Zone 2) which is classed as highly productive. The recognised aquifers/water bearing zones within the area are the:

- Alluvium/sediment aquifers;
- Hawkesbury Sandstone aquifers;
- Narrabeen Group sandstone aquifers; and
- Illawarra Coal Measures water bearing seams.

Alluvium/Sediment Aquifers

Alluvial sediments within the plateau gullies and river bed are too shallow to be used as aquifers for groundwater supply (Geoterra, 2013).

Hawkesbury Sandstone

The Hawkesbury Sandstone aquifers are the principal groundwater source used within the region due to their significantly higher yields and quality in comparison to other water bearing strata. Due to the lack of fracturing and fault lines within the Hawkesbury Sandstone, the associated aquifers are generally primary permeability aquifers. As a result, yields and quality are highest in recharge areas south of the Nepean River. Groundwater monitored in the Hawkesbury Sandstone piezometers within the Study Area is considered low to brackish salinity (less than 6,895 µS/cm) with acid to circum-neutral pH (3.52 to 7.72). Recorded bore yields in the Hawkesbury Sandstone in the Study Area ranged from 0.22 litres per second to 4.5 litres per second (Geoterra, 2013).

Narrabeen Group and Associated Aquitards

The Narrabeen Group is the other major aquifer within the region, however, the quality and yield is significantly lower than the Hawkesbury Sandstone. The major aquifers are separated by aquitards associated with the Bald Hill Claystone, Stanwell Park Claystone and the Wombarra Claystone. These aquitards are exhibit low permeability and limit vertical groundwater flow between the aquifers (Geoterra, 2013).

Illawarra Coal Measures

The Illawarra Coal Measures exhibit low permeability due to their depth and fine-grained associated rock. Water quality within the water bearing coal seams is considered brackish to moderately saline (Geoterra, 2013).

2.3.4 Licenced Groundwater Users

The Study Area is covered by the Greater Metropolitan Groundwater Sources Water Sharing Plan. Five Department of Industry (Water) registered bores are located within the Study Area, with a further three bores located within the vicinity of the Study Area (**Table 4**). The majority of bores are registered for stock and/or domestic use. Groundwater for these bores is sourced from the Hawkesbury Sandstone Aquifer (SLR, 2022).

Table 4 Registered Groundwater Users

Identifier	Depth (m)	Purpose	Current Use	In Study Area
GW105883	Unknown	Domestic	Water feature & garden irrigation	Outside
GW104323	109	Stock & Domestic	On timer for crop irrigation	Yes
GW032443	130.1	Irrigation	Not currently used	Yes
GW109257	120	Stock & Domestic	Not used, previously used to fill dam	Yes
GW014262	48.8	Stock	Unknown	Yes
GW104659	132	Irrigation	Replenish adjacent dam by timer	Yes
GW111810	142	Stock & Domestic	Used for irrigation via holding tanks	Outside
GW105847	Unknown	Stock & Domestic	Unknown	Outside

2.4 Geology

The Study Area is located within the southern area of the Permo-Triassic Sydney Basin. The main coal bearing sequence is the Illawarra Coal Measures, which contains four workable seams. The upper most seam, located in the north-western part of the Illawarra Coalfield, is the Bulli Seam. Overlying the Bulli Seam is the Hawkesbury Tectonic Stage which is comprised of three stratigraphic units, namely the Narrabeen Group, Hawkesbury Sandstone Group and the Wianamatta Group. The Narrabeen Group overlies the Illawarra Coal Measures and is comprised of interbedded sandstones and claystone units up to 310 metres thick. Overlying the Narrabeen Group is the Hawkesbury Sandstone which is comprised of a series of bedded sandstones up to 185 metres thick. The Wianamatta Group overlies the Hawkesbury Sandstone, and is comprised of shales and siltstones and is relatively thin in comparison.

Another major geological feature is the Bald Hill Claystone which lies at the base of the Hawkesbury Sandstone. The Bald Hill Claystone varies in width to over 25 metres, which tends to act as an aquitard.

2.5 Soil Landscape Units

Soil Landscapes Units (SLU) within the Study Area have been mapped by the former NSW Department of Land and Water Conservation, incorporating the NSW Soil Conservation Service (now part of NSW Department of Primary Industries (DPI)), on the *Wollongong – Port Hacking 1:100,000 Sheet* (Hazelton & Tille, 1990) as shown in **Figure 3**. four soil landscapes occur in the Study Area and are summarised in **Table 5.**

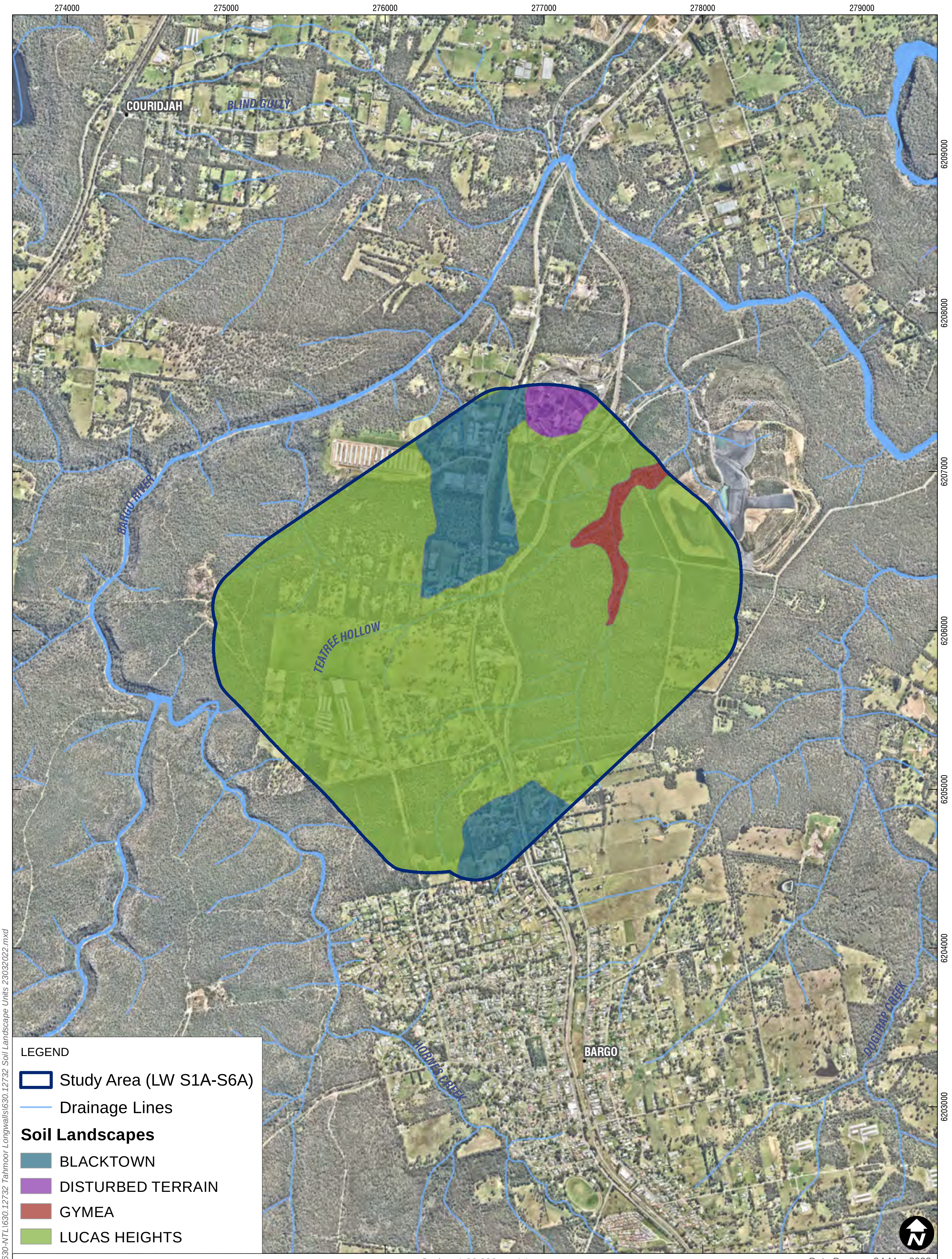
Below is a summary of the key agricultural features of each SLU:

- The majority of the Study Area (88%) is highly constrained for cultivation.
- The Gymea and Disturbed Terrain SLU are highly to severely constrained for any agricultural enterprises, which covers 4% of the Study Area.
- Agricultural land best suited to grazing enterprises is the Blacktown, SLU which covers 12% of the Study Area.
- Lucas Heights SLU has moderate limitations for grazing and high limitations for cultivation and covers the majority (84%) of the Study Area.

Table 5 Soil Landscape Units

Soil Landscape	Study Area		Agricultural Limitation Rating	
Unit	Hectares	%	Grazing	Cultivation
Gymea	14	2	High – Severe	High – Severe
Disturbed Terrain	12	2		
Sub Total	**26**	**4**		
Lucas Heights	572	84	Moderate	High
Blacktown	85	12	Low	Moderate
Total	**682**	**100**		

Source: *Soil Landscapes of the Wollongong – Port Hacking 1:100,000 Sheet* (Hazelton & Tille, 1990)



0 0.5 1 km

Scale: 1:30,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-Mar-2022
Project Number: 630.12732

H:\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 Soil Landscape Units 23032022.mxd

SLR

Soil Landscape Units

FIGURE 3

2.6 Dominant Soil Types and Inherent Fertility

The two dominant Australia Soil Classification (ASC) soil types were digitally mapped by the Office of Environment & Heritage (now NSW Heritage) and are shown on **Figure 4**. Three soil types are present in the Study Area, dominated by Kurosols with some smaller areas of Dermosols and Rudosols & Tenosols (**Table 6**). These soil types are summarised in the major points listed below:

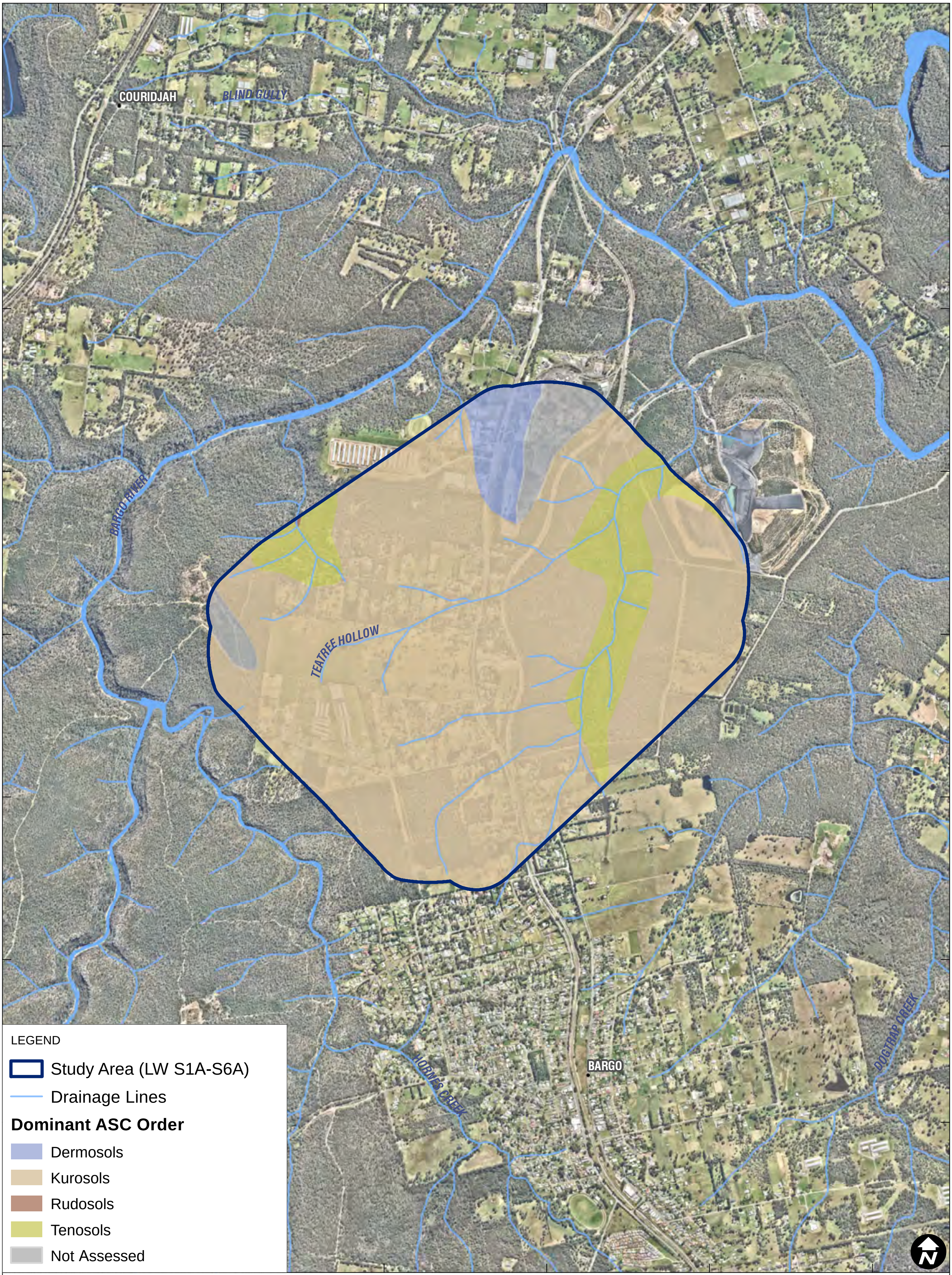
- Kurosols are the main soil type within the Study Area. Kurosols are soils with a strong texture contrast between the A horizons and strongly acidic B horizons and often have unusual subsoil chemical attributes such as high magnesium, sodium and aluminium. Kurosols generally have moderately low inherent fertility and comprise 80% of the Study Area.
- Tenosols are a minor soil type within the Study Area comprising 12% of the total area. Tenosols are soils with weak pedologic organisation apart from the A horizons. Tenosols comprise three major soil horizons and the profile is characterised by a sandy to sandy loam texture throughout, generally with moderately low inherent fertility.
- Rudosols comprise <1% of the Study Area and are soils with negligible pedologic organisation, often characterised by a very sandy texture. They are generally young soils which have not had time form structurally with low inherent fertility.
- Dermosols are the remaining soil type within the Study Area comprising 4% of the total area. Dermosols are soils with structured B horizons which lack strong texture contrast between the A and B horizons. Dermosols generally have moderately high inherent fertility and high agricultural potential with good structure and water-holding capacity.
- Areas of mine disturbance are not allocated an ASC soil type and comprise 4% of the Study Area.

Table 6 Dominant Soil Types and Inherent Fertility

Australian Soil Classification	Inherent Fertility	Hectares	%
Kurosol	Moderately Low	547	80
Tenosol	Moderately Low	82	12
Dermosol	Moderately High	25	4
Rudosol	Low	<1	<1
Not Assessed (Mine Disturbance)	N/A	28	4
	Total	**682**	**100**

2.7 Acid Sulfate Soils

The likelihood of acid sulfate soils occurring within the Study Area is very low due to its position away from the coast and potential acid sulfate landform type. Furthermore, none of the Soil Landscape Units mapped within the Study Area have acid sulfate soil potential.



0 0.5 1 km

Scale: 1:30,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-Mar-2022
Project Number: 630.12732

H:\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 ASC Soil Type 23032022.mxd

SLR

ASC Soil Type

FIGURE 4

2.8 Vegetation and Land Use

Review of recent aerial images shows only a minor portion of the Study Area comprises of cleared pastoral land (approximately 27%) that may be suitable for agricultural enterprises, as shown in **Figure 5**. The remainder comprises thick native vegetation along riparian zones and steep slopes, along with mine disturbance areas and small holdings used as rural residential land.

Site inspections in June 2013 and December 2017 by SLR's Principal Agronomist showed several differing agricultural land uses within and adjacent to the Study Area, with poultry production being the main agricultural enterprise. The various land uses at each site were recorded and are shown on **Figure 5** and described in **Table 7**. Plates for each inspection site are shown in **Appendix A**.

Changes in observed land use between the 2013 and 2017 site inspections are highlighted in red. The changes in land use over the four years indicate a shift away from agriculture and an increase toward rural residential areas. No intensive cropping activities were observed at the time of the inspection and assessment.

Table 7 Observed Land Uses

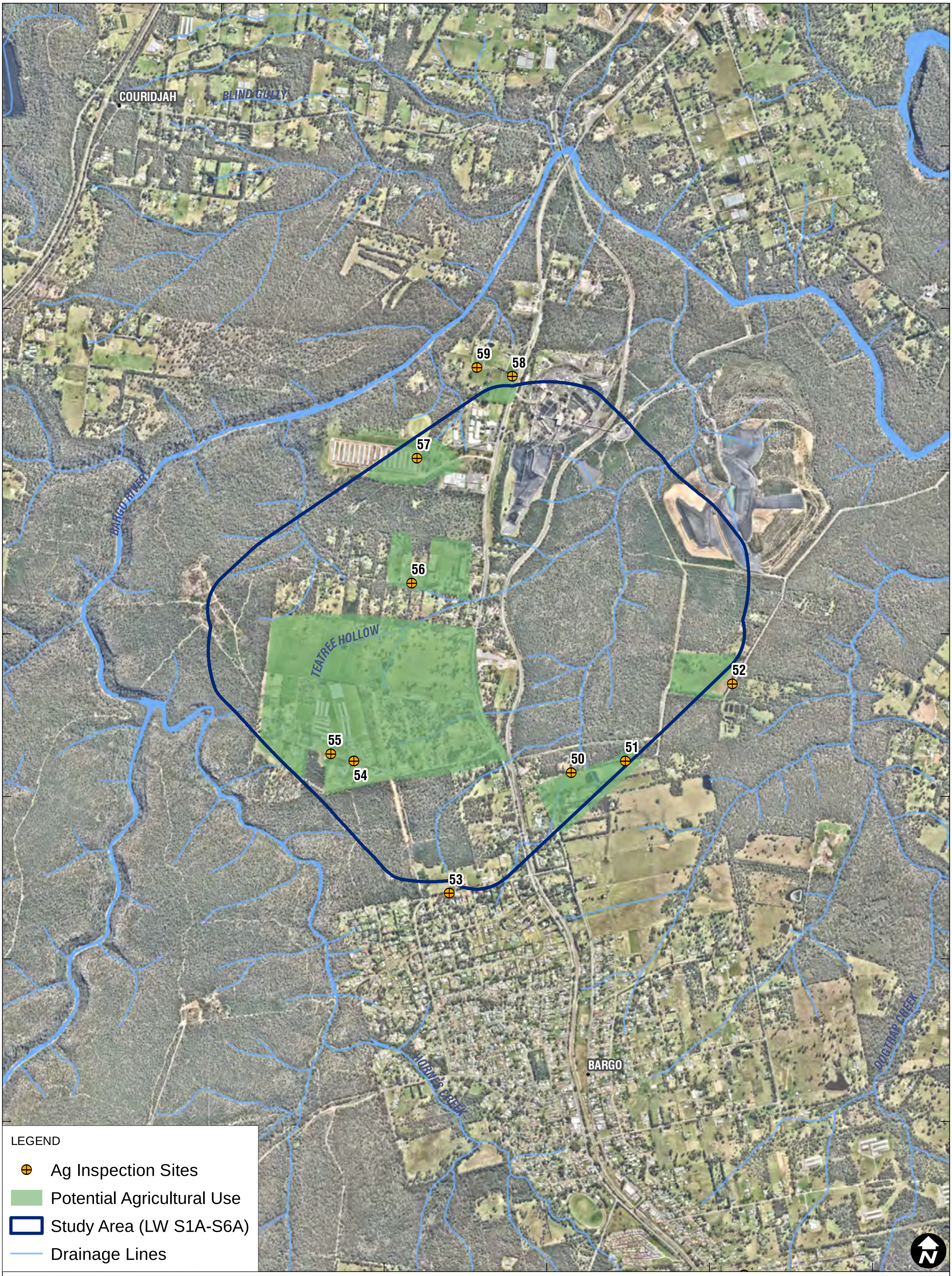
Inspection Site	Land Use
49	Pleasure horses
50	Cattle grazing
51	Cattle feedlot 2013, disused cattle feedlot 2017
52	Pleasure horses
53	Rural residential
54	Hydroponic lettuce and poultry sheds
55	Poultry sheds
56	Cut flower greenhouse 2013, disused cut flower greenhouses 2017
57	Poultry sheds
58	Olives & sheep grazing
59	Irrigated olives & alpaca stud

Grazing is the major agricultural land use within the Study Area (by area) appears to be commonly used as a grass and vegetation management tool rather than an income generating agricultural enterprise. Overall farm size is considered small and many would be classified as hobby farms with a very low potential to produce significant agricultural income. Approximately 182 hectares of potential grazing land is currently available for agricultural use. As previously described in correspondence received from DPI, poultry farms are a significant industry in the area, with three located within and adjacent to the Study Area (**Figure 5**). **Plate 1** and **Plate 2** show two of the intensive agricultural land uses within the area.

Native vegetation, present predominantly in riparian zones within the Study Area, was mapped during the Native Vegetation of Southeast NSW mapping project (Tozer et al., 2006). It includes the Cumberland Shale Sandstone Transition Forest which is listed as an Endangered Ecological community (EEC) under the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act), and a small area of Cumberland River Flat Forest which is listed as an EEC on the BC Act.

Plate 1 Poultry sheds at Site 55

Plate 2 Hydroponic Lettuce at Site 54



H:\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 Potential Agricultural Use 23032022.mxd

Scale: 1:30,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-Mar-2022
Project Number: 630.12732

SLR

Potential Agricultural Use

FIGURE 5

2.9 Land and Soil Capability Classification

2.9.1 Land and Soil Capability Methodology

The Land and Soil Capability (LSC) classification applied to the Study Area was in accordance with the OEH guideline *The Land and Soil Capability Assessment Scheme; Second Approximation* (OEH, 2013). This scheme uses the biophysical features of the land and soil to derive detailed rating tables for a range of land and soil hazards. The scheme consists of eight classes, which classify the land based on the severity of long-term limitations. The LSC classes are described in **Table 8** and their definition has been based on two considerations:

- The biophysical features of the land to derive the LSC classes associated with various hazards.
- The management of the hazards including the level of inputs, expertise and investment required to manage the land sustainably.

Table 8 Land and Soil Capability Classification

Class	Land and Soil Capability
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, conservation)	
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)	
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

2.9.2 Determining LSC Classes

The LSC for the Study Area has been digitally mapped by the OEH and is summarised in **Table 9** and shown in **Figure 6**. The limitations associated with each LSC Class are discussed below.

Table 9 Land and Soil Capability Areas

LSC Class	Agricultural Capability Rating	Hectares	%
4	Moderate	572	84
6	Low	82	12
7	Very Low	<1	<1
Mine Disturbed	Nil	28	4
	Total	**682**	**100**

LSC Class 4 Land

Class 4 land is associated with Dermosols and Kurosols. This classification indicates a moderate land capability, with moderate to serve limitations for some land uses that need to be consciously managed to prevent soil and land degradation. This land is capable of pasture improvement and can be tilled for an occasional crop. LSC Class 4 land comprises the majority (84%) of the Study Area.

LSC Class 6 Land

Class 6 land is associated with Kurosols. The classification indicates low land capability, with very high limitations for high impact land management uses such as cropping. The land is generally more suitable to low impact land uses such as grazing with limitations. LSC Class 6 land comprises 12% of the Study Area.

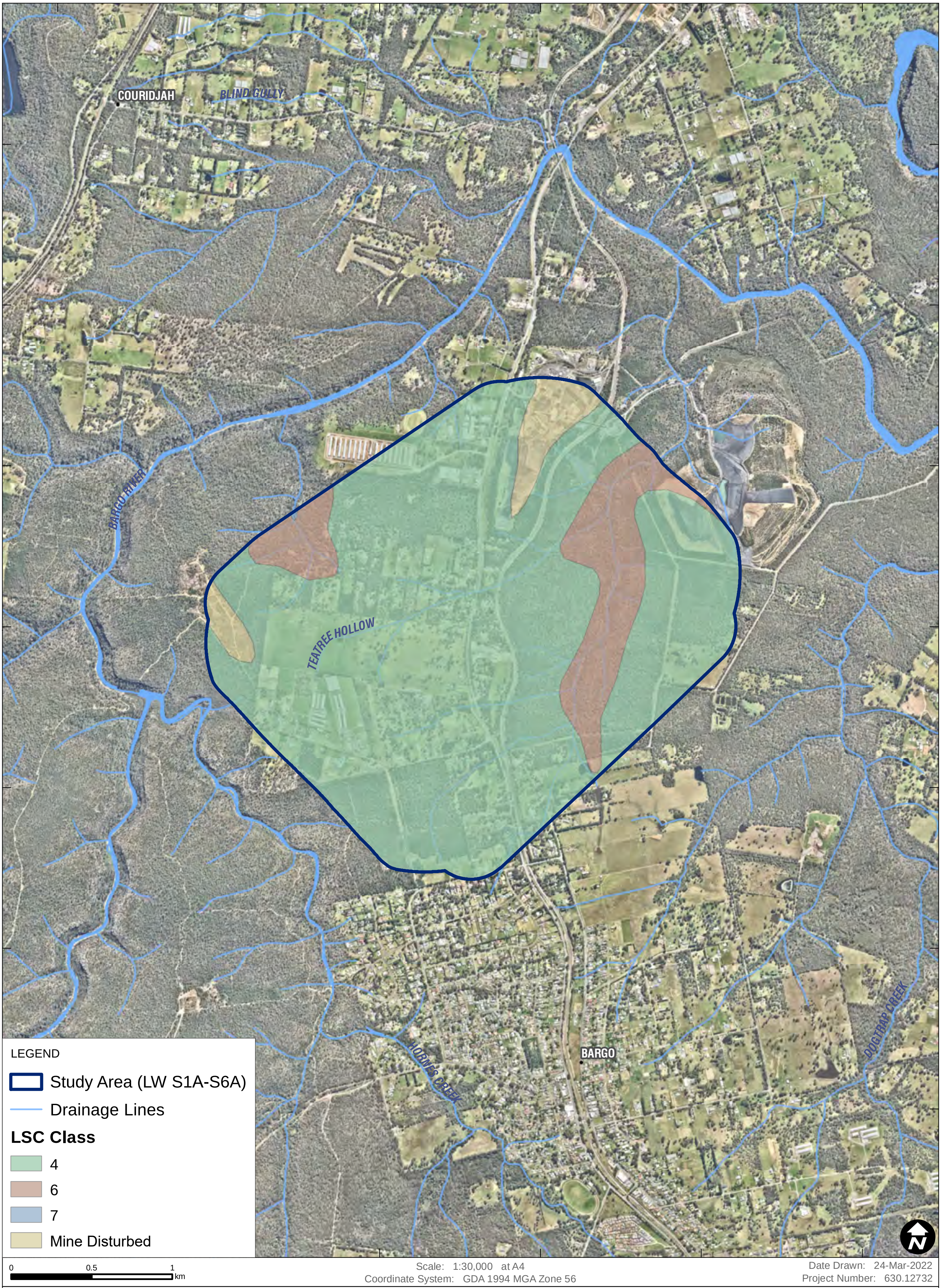
LSC Class 7 Land

Class 7 land indicates very low capability land, with severe limitations for most land uses. It is generally unsuitable for any type of cropping or grazing due to its limitations. It covers a minor portion of the Study Area (<1%).

Within the Study Area, 16% of the land area is considered to have low to very low agricultural capability according to definitions given in *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH, 2013), whilst the remainder has moderate to moderately low agricultural capability.

2.10 Biophysical Strategic Agricultural Land

The nearest mapped Biophysical Strategic Agricultural Land (BSAL) according to the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 – Strategic Agricultural Land Map – Sheet STA_41* (DPI, 2013) is between Douglas Park and Camden, approximately 20 kilometres to the north-east of the Study Area.



Scale: 1:30,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-Mar-2022
Project Number: 630.12732

H:\Projects-SLR\610-SrvSYD\630-NTL\630.12732 Tahmoor Longwalls\630.12732 LSC 23032022.mxd

SLR

Land and Soil Capability

FIGURE 6

3 Local and Regional Agricultural Enterprises

3.1 Regional Agricultural History

Agriculture within the Wollondilly LGA is based on a foundation of market gardens, orchards, dairy and poultry. Early European settlement saw the establishment of small villages including Picton, Menangle, Thirlmere, Tahmoor, Bargo, and Appin.

Picton is one of the earliest European settlements in the area. Agriculture dates back to when a number of cattle went missing in the early days of the colony and were later found in 1795 by a convict near the Nepean River. This area became known as Cowpastures and then Stonequarry until gaining its current name, Picton, in 1841.

In the 1860's the railway system came to Picton and created a building explosion. The area was proclaimed a municipality in 1895, and in 1939 Wollondilly Shire Council and Picton Municipality amalgamated to create today's LGA (Wollondilly Shire Council, 2020).

Poultry farming was established in in the Wollondilly region during the 1930's. Many Estonian families fled political upheaval in their homeland between 1924 and 1939. Australia offered cheap land and a new life, with many of these people settling at Thirlmere and established poultry farms.

In the late 1940's many Estonians who were caught in European Displaced Persons camps after World War II also chose to come to Australia, and were sponsored and supported by the Thirlmere community. They built on their national connections and helped each other to start poultry farming. By the 1960's there were over 60 families from Estonia involved in poultry farming in Thirlmere. Most farms comprised of 2,000 to 4,000 hens.

Estonians pioneered the Cooperative movement in 1912. The Thirlmere Estonians started "KUNGLA", the Thirlmere farmers' Cooperative in 1939 and was continued by the new settlers after the war. This considerably increased the viability and efficiency of the poultry industry until Thirlmere became the largest producer of eggs in Australia by the 1960's (Migration Heritage Centre, 2020).

Today, Wollondilly LGA is predominantly rural area with several national parks, whilst there are urban areas in 15 towns and villages. Two-thirds of the population live in the urban centres, and one-third in the rural areas. There are five large towns, the largest of which is Tahmoor, whilst Picton is the administrative centre. The LGA encompasses a land area of nearly 260,000 hectares, of which approximately 90% is national park, bushland, water catchment or rural land, including gorges, ranges and plains. Most of the rural land is used for agricultural purposes, including market gardens, orchards, dairy farms, poultry farms and grazing (profile.id, 2020).

3.2 Agricultural Enterprises and Associated Industries

3.2.1 Regional Land Use

Agriculture is a minor land use for the regional area (Wollondilly LGA), accounting for 11% of land use. (Australian Bureau of Statistics (ABS), 2011 [2011 is the latest regional agricultural data available from ABS]). The agricultural land use is outlined in **Table 10**. It details the area of land used for agriculture in the region and the specific uses of the land. The major points are summarised below:

- Agricultural land is almost exclusively used for grazing, utilising 98% of all agricultural land. The primary enterprise is meat cattle farming, which accounts for 60% of livestock numbers, followed by milk cattle (25%) and sheep farming (15%).
- Cropping enterprises comprise a minor portion of agricultural activities. The primary crops grown are vegetables for human consumption along with fruit and nuts. No cereals for grain are grown in the region.
- Minor irrigation cropping is carried out, comprising only 7% of the agricultural land in the region. Agriculture accounts for 5,513 megalitres of volume to irrigate approximately 2,000 ha of agricultural area, while 981 megalitres is utilised for other agricultural uses, such as poultry production and hydroponic vegetables.
- Poultry comprise a large portion of livestock numbers within the Wollondilly LGA, with 2.3 million birds were recorded at the last census of these 2.1 million were being raised for poultry meat production. The region also produced 2.4 million dozen eggs.

Table 10 Wollondilly LGA Agricultural Land Use

Agricultural Land Area	Units	Total
Total land area within LGA	Hectare	255,593
Area of National Parks, nature reserves & other protected lands	Hectare	160,555
Area of agricultural land	Hectare	28,058
Proportion of agricultural land	**%**	**11**
Agricultural Enterprise		
Land under cropping activities	Hectare	598
Land under grazing activities	Hectare	27,460
Proportion of agricultural land used for grazing	**%**	**98**
Grazing Enterprises	**Total**	**%**
Sheep and lambs	2,315	15
Meat cattle	9,553	60
Dairy cattle (excluding house cows)	3,943	25
Pigs	55	<1
Total	**15,866**	**100**
Cropping Enterprises		
Cereals for grain	Hectare	Nil
Vegetables for human consumption	Hectare	461

Agricultural Land Area	Units	Total
All fruit and nuts	Hectare	142
Total land cropped	**Hectare**	**603**
Irrigation		
Area irrigated	Hectare	2,000
Irrigation volume applied	Megalitre	5,513
Other agricultural uses	Megalitre	981
Total water use	**Megalitre**	**6,494**
Proportion of agricultural land irrigated	**%**	**7**

Source: *ABS* (2011) - 2011 is the latest regional agricultural data available from ABS

3.2.2 Regional Employment

A summary of the total regional employment and the proportion of agriculture related employment is shown in **Table 11.** The regional employment in the agriculture related sectors is shown in **Table 12.** The major points are summarised below:

- Agriculture is not a major employer within the region; the total of 1,911 persons employed in the direct and indirect agricultural sectors is only 10% of the total employed population.
- Agriculture-related wholesaling and retailing is responsible for 48% of agricultural employment, followed by processing and manufacturing (26%), and agricultural production (26%).
- The major agricultural production employers are beef cattle farming, poultry farming and vegetable growing, which account for 13% employment in agriculture. Horse farming, dairying and floriculture and nursery production comprise another 6% of employment in agriculture. All other sectors are minor agricultural employers in the region.
- The main agriculture-related processing and manufacturing is poultry processing, comprising 12% of agricultural related employment.
- Supermarkets and grocery stores account for the vast majority of agricultural related wholesaling and retailing employment, comprising 27% of the agricultural related employment.

Detailed agricultural employment figures are not available for the Study Area; however the main agricultural activities generating income within and adjacent to the Study Area observed during the site inspection were small scale horse and cattle grazing along with a number of poultry farms and orchards.

Table 11 Wollondilly LGA Employment Related to Agriculture

Employment Sector	No. of persons	%
Total Regional Employment	**19,417**	**100**
Direct Regional Agricultural Employment	497	3
Indirect Regional Agricultural Employment	1,414	7
Total Regional Employment Related to Agriculture	**1,911**	**10**

Source: *ABS* (2011) - 2011 is the latest regional agricultural data available from ABS

Table 12 Wollondilly LGA Agricultural Related Employment by Sector

Agricultural Production	Number of People	%
Beef Cattle Farming (Specialised)	103	5
Poultry Farming	84	4
Horse Farming	41	2
Dairy Cattle Farming	47	2
Other Livestock Farming and Beekeeping	24	1
Vegetable Growing (Outdoors)	80	4
Floriculture and Nursery Production	44	2
Turf Growing	12	1
Other Crop Growing (Grains, fruit and tree nuts, mushrooms etc.)	33	2
Agriculture (Not further defined)	29	2
Subtotal	**497**	**26**
Agriculture Related Processing and Manufacturing	**Number of People**	**%**
Poultry Processing	229	12
Cereal, Pasta and Baking Mix Manufacturing	56	3
Factory Based Manufacturing Bread, Biscuit, Cake, Pastry	50	3
Meat Processing and Manufacturing (Inc. Cured Meat and Smallgoods)	26	1
Log Sawmilling, Timber Re-sawing and Dressing	25	1
Cheese, Ice-cream, Milk and Other Dairy Product Manufacturing	25	1
Fruit and Vegetable Processing	20	1
Bakery Product Manufacturing (Non-factory based)	17	1
Potato, Corn and Other Crisp Manufacturing	11	1
Food Product Manufacturing (Not further defined)	46	2
Subtotal	**505**	**26**
Agricultural Related Wholesaling and Retailing	**Number of People**	**%**
Supermarket and Grocery Stores	509	27
Fresh Meat, Fish, Poultry, Smallgoods Retailing and Wholesaling	76	4
Fruit and Vegetable Retailing and Wholesaling	63	3
Grocery, Liquor and Tobacco Product Retailing and Wholesaling	113	5
Food Retailing (Not further defined)	25	1
Timber Wholesaling	20	1
Flower Retailing	14	1
Other Agricultural Product Wholesaling	89	4
Sub total	**909**	**48**
Total Agricultural Related Employment	**1,911**	**100**

Source: *ABS* (2011) - 2011 is the latest regional agricultural data available from ABS

3.3 Regional Agricultural Production Value

Agricultural production values for the Wollondilly LGA totals $61.3 M, detailed in **Table 13.** The main agricultural production by value is from poultry production, both for meat and eggs (livestock slaughtering and livestock products), and vegetables for human consumption (crops) accounting for almost 90% of the value of agricultural commodities produced (ABS, 2011 [2011 is the latest regional agricultural data available from ABS]).

Table 13 Regional Agricultural Production

Agricultural Production Gross Value	Value (M)	%
Crops	$21.7	35
Livestock slaughtering	$33.0	54
Livestock products	$6.6	11
Total gross agricultural production	**$61.3**	**100**

Source: *ABS* (2011) - 2011 is the latest regional agricultural data available from ABS

3.4 Potential Agricultural Production Value of the Study Area

Potential agricultural productivity was determined using NSW DPI agricultural gross margin productivity data for agricultural enterprises suitable for each of the LSC classes (see **Section 2.9**) that are present within the Study Area. This analysis has been undertaken on the potential capability of the land rather than current land use. If potential agricultural production values were to be pursued, significant investment in land management and agricultural infrastructure would be required. However, this information can be used to approximate potential farm incomes.

The *Beef Cattle Gross Margin Budget Inland Store Weaners* (DPI, 2019) has been applied to this assessment to determine potential agricultural income for the Study Area. The *NSW Department of Primary Industries Beef Stocking Rates & Farm Size* (DPI, 2006) was used to determine stocking rates in Dry Sheep Equivalents (DSE) for the three LSC's mapped within the Study Area. Full agricultural gross margin information is contained in **Appendix B**.

Table 14 summarises the potential gross margins for each applicable agricultural enterprise per LSC Class. The major points are listed below:

- Class 4 land has the potential to generate approximately $227 per hectare from beef cattle grazing enterprises (yearling beef production).
- Class 6 land has the potential to generate approximately $116 per hectare from beef cattle grazing.
- Class 7 land has the potential to generate approximately $58 per hectare from beef cattle grazing.
- Mine Disturbed land has no agricultural rating and no potential to generate income in its current guise.

Table 14 Gross Margin per LSC Class

LSC	Stocking Rate	Cow & Calf Equivalent	Revenue	Variable Costs	Gross Margin
Class	DSE	Per Hectare	Per Hectare	Per Hectare	Per Hectare
4	8	0.47	$282	$55	$227
6	4	0.24	$144	$28	$116
7	2	0.12	$72	$14	$58

Based on the nominated gross margins, and assuming the required agricultural capital costs and fixed costs are outlaid (not included in the calculations in **Table 14**), the Study Area has the capacity to generate an estimated gross margin of $139,412 per annum (**Table 15**). It is important to note that these figures are derived from the optimum potential uses and are likely to be higher than the actual incomes being achieved from the area under actual production.

Table 15 Annual Gross Margins per LSC Class

LSC	Gross Margin	Study Area	
Class	Per Hectare	Hectares	Gross Margin
4	$227	572	$129,939
6	$116	28	$9,473
7	$58	<1	Nil
	Total	**682**	**$139,412**

It is expected that income generated from agricultural enterprises within the Study Area would be less than that presented in **Table 13**, due to the small area (182 hectares) available for actual agricultural production (**Figure 5**). The majority of this cleared area is LSC Class 4 and using the gross margin information presented in **Table 14**, beef cattle grazing 182 hectares of LSC Class 4 land has a potential gross margin of $41,347 per annum.

3.5 Regional Agricultural Support Infrastructure

Agricultural support infrastructure within the Wollondilly LGA includes the Hume Highway as the major arterial road, and rail infrastructure providing transport from agricultural areas in the west, south and north of the state.

The main purpose-built agricultural support infrastructure within the Study Area is a number of large farm dams which are used for cattle and horse grazing areas.

There are two abattoirs located nearby in Tahmoor. Poultry processing is carried out at the Inghams processing facility whilst the Wollondilly Co-op abattoir processes pigs. The closest livestock selling centre is located at Moss Vale, approximately 50 kilometres south-west of the Study Area.

There are a number of small retail agricultural suppliers that service the numerous small hobby farms in the region. Other purpose built agricultural infrastructure is generally for intensive agricultural enterprises and includes greenhouses and hothouses for cut flower and vegetable production, poultry laying and growing sheds, farm dams and groundwater extraction bores.

4 Assessment of Potential Impacts

The primary potential impact to agricultural resources is from subsidence. MSEC (2022) predicts maximum vertical subsidence to be 1,350 millimetres over LW S5A-6SA. Maximum predicted tilt is 9.5 millimetres per metres over LW S6A which is very small when compared to the natural surface grade of slopes within the Study Area.

4.1 Land Resources

4.1.1 Land Temporarily Removed from Agriculture

Based on the natural landscape contours and the predicted subsidence contours, there is unlikely to be any remnant ponding in the agricultural landscape (Tahmoor Coal, 2022). Therefore, there is no land which will be temporarily removed from agriculture as a result of LW S1A-S6A.

4.1.2 Land Permanently Removed From Agriculture

There is no land which will be permanently removed from agriculture as a result of LW S1A-S6A.

4.1.3 Acid Sulfate Soils

As outlined in **Section 2.7** there are no Soil Landscape Units associated with the Study Area with acid sulfate potential. LW S1A-S6A will not impact upon acid sulfate soils.

4.1.4 Impact on Biophysical Strategic Agricultural Land

There is no Biophysical Strategic Agricultural Land within or adjacent to the Study Area. LW S1A-S6A will not impact any Biophysical Strategic Agricultural Land.

4.2 Water Resources

4.2.1 Surface Water

Based on the previous experience of mining beneath streams at Tahmoor Mine, it is likely that fracturing and surface flow diversions will occur in the sandstone bedrock along the streams over LW S1A-S6A, particularly for streams that are located directly above the proposed longwalls. In some of these locations, the fracturing could impact the holding capacity of the standing pools, particularly those located directly above the proposed longwalls. It is unlikely, however, that there would be any net loss of water from the catchment (MSEC, 2022).

Given that drainage channels within the Study Area are considered low flow or intermittent channels, the impact on agricultural users dependent on flows from these watercourses is negligible.

4.2.2 Groundwater

The NSW Aquifer Interference (AI) Policy 2012 established a 2 metre threshold as the maximum allowable drawdown for 'water supply works' in order to satisfy the considerations for 'minimal harm'.

As shown in **Table 16,** all assessed bores will have a predicted drawdown of greater than 2 metres, however all have a greater available drawdown than the predicted drawdown, allowing continued access to groundwater for irrigation and stock & domestic purposes (SLR, 2022).

Table 16 Predicted Impacts to Private Bores

Identifier	Purpose	Condition	Potential Drawdown (m)	Available Drawdown (m)
GW105883	Domestic	Operational	N/A	N/A
GW104323	Stock & Domestic	Operational	14.8	40.4
GW032443	Irrigation	Not currently used	80.1	129.4
GW109257	Stock & Domestic	Not currently used	75.1	82.9
GW014262	Stock	Unknown	5.9	N/A
GW104659	Irrigation	Operational	10.2	88.2
GW111810	Stock & Domestic	Operational	14.8	82.0
GW105847	Stock & Domestic	Unknown	N/A	N/A

N/A = not available

4.2.3 Water Reallocation

Tahmoor Mine currently holds three groundwater extraction licences for a total of 1,642 megalitres, utilised for mine dewatering. However, this water would not be considered as being taken from potential agricultural use as Licence Condition 16 of all three groundwater extraction licences states '*this is a special purpose (mine de-watering) licence; as such, the licence is including the volumetric groundwater allocation not transferrable, and the licence will be lapsed at the conclusion of mining operations*'.

Therefore, whilst Tahmoor Coal currently holds groundwater extraction licences for 1,642 megalitres, this water would not be considered as being taken from potential agricultural production as the licences are restricted to mine de-watering only. There will be no impact on agricultural users through water reallocation.

4.2.4 Water Resource Impacts on Agricultural Productivity

Given the impacts described previously, longwall subsidence will result in limited impacts on water resources relied upon by agricultural enterprises and should not result in impacts on agricultural productivity. There is no predicted increase in total dissolved salts or sodium in groundwater bores associated with LW S1A-S6A (SLR, 2022).

4.3 Impact on Agricultural Resources from Biodiversity Offsets

A regional Biodiversity Offset Strategy (BOS) has been proposed by Tahmoor Coal to offset the loss of vegetation from clearing associated with the construction of the new surface facilities required to support the Tahmoor South Project. The Biodiversity Assessment Report (Niche, 2020) identifies five proposed biodiversity offset sites comprising 381 hectares, for the BOS:

- Rockford Road
- Pit Top
- 185 Charlies Point Road
- Bargo Colliery Land

- 220 Charlies Point Road

None of the identified sites are on potentially agriculturally productive land, and all are heavily timbered with native bushland. Therefore, the BOS will have negligible impact on agricultural resources, enterprises or BSAL.

The extraction of LW S1A-S6A is not expected to result in the establishment of any further biodiversity offsets; therefore there will be no impact to agricultural resources resulting from biodiversity offsets.

4.4 Other Impacts

4.4.1 Visual Amenity and Landscape Values

Site inspection during 2013 and 2017 by SLR's Principal Agronomist did not identify any agricultural enterprises which were reliant upon visual amenity or landscape values as component of their operations. On this basis, the extraction of LW S1A-S6A is considered to have negligible impact on visual amenity and landscape value relied upon by local and regional agricultural enterprises.

4.4.2 Tourism

The assessment has not identified any tourism infrastructure within the local area upon which agricultural enterprises are reliant. Therefore, LW S1A-S6A is not anticipated to impact on agriculture-related tourism.

4.4.3 Weed Management and Biosecurity

There is no risk from weed infestation during the extraction of LW S1A-S6A through vehicle movements on and off site. Weeds are currently managed within the frameworks of the Tahmoor Coal Environmental Management System.

Biosecurity is defined in the *NSW Biosecurity Strategy 2013 – 2021* (NSW DPI, 2013) as 'protecting the economy, environment and community from the negative impacts of pests, diseases and weeds'. It includes measures to prevent new pests, diseases and weeds from entering our country and becoming established. On a regional level, appropriate weed management will reduce biosecurity risks.

The vast majority of equipment used at Tahmoor Mine is site-dedicated and poses no biosecurity risk. Any import of equipment or machinery from interstate or overseas will follow the standard procurement safeguards and quarantine procedures as per NSW and Australian requirements.

Given the processes above, it is considered the extraction of LW S1A-S6A has negligible risk to the biosecurity of agricultural resources and enterprises within the region.

4.4.4 Air Quality

The extraction of LW S1A-S6A involves the extraction of six underground longwall panels and as such there will be no impact to air quality resulting from LW S1A-S6A.

All other activities associated with the Tahmoor South Project that have the potential to create dust will be undertaken in accordance with the approved Air and Greenhouse Gas Management Plan for any onsite construction as well as the ongoing operation of Tahmoor Mine.

4.4.5 Noise

The extraction of LW S1A-S6A involves the extraction of six underground longwall panels and as such there will be no impacts to agricultural production from noise generated during the extraction of LW S1A-S6A.

All other activities associated with the Tahmoor South Project that have the potential to generate noise will be undertaken in accordance with the approved Noise Management Plan for any onsite construction as well as the ongoing operation of Tahmoor Mine.

4.4.6 Blasting

The extraction of LW S1A-S6A does not involve any blasting on the surface and as such there will be no impact to agricultural resources from blasting.

All other activities associated with the Tahmoor South Project that have the potential to generate noise will be undertaken in accordance with the approved Noise Management Plan for any onsite construction as well as the ongoing operation of Tahmoor Mine.

4.4.7 Traffic

The extraction of LW S1A-S6A involves the extraction of six underground longwall panels with no increased surface traffic movements, and as such the impact to agricultural resources as a result of increased traffic movements is considered negligible.

All other activities associated with the Tahmoor South Project that have the potential to increase surface traffic movements will be undertaken in accordance with the approved Traffic Management Plan for any onsite construction as well as the ongoing operation of Tahmoor Mine.

4.4.8 Rural Structures

The majority of rural structures within the Study Area are of lightweight construction and are expected to tolerate mining induced tilt. It has been found from past longwall mining experience that tilts of the magnitudes predicted for LW S1A-S6A generally have limited adverse impacts on rural structures. Some minor serviceability impacts could occur at the higher levels of tilt, including door swing and issues with roof and pavement drainage. These serviceability impacts can generally be remediated using normal building maintenance techniques (MSEC, 2022).

Impacts on the rural structures that occur as the result of the extraction of the proposed longwalls are expected to be remediated using well established building techniques and it is unlikely that there would be long term impacts on rural structures resulting from the extraction LW S1A-S6A. It is considered that rural structures can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred (MSEC, 2022).

4.4.9 Tanks

There are water, gas and fuel storage tanks on some of the properties within the Study Area. There are 74 tanks which have been identified within MSEC's Subsidence Study Area, just less than half of which are not directly above LW S1A-S6A (MSEC, 2022).

Storage tanks are typically constructed above ground level, and therefore are unlikely to experience the full ground movements resulting from the proposed mining. It is possible, that any buried water pipelines associated with the tanks within the Study Area could be impacted by the ground strains, if they are anchored by the tanks, or by other structures in the ground. Any impacts are expected to be of minor nature and easily repaired (MSEC, 2022).

4.4.10 Farm Fencing

Farm fences are generally flexible in construction and can usually tolerate mine subsidence movements. Impacts to fences may include tension loss and changes to post alignment. The most vulnerable section of farm fences are gates, particularly long gates, or those with latches as they are less tolerant to differential horizontal movements and tilts between the gate posts and the ground. Any impacts on the wire fences or gates are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing (MSEC, 2022).

4.4.11 Farm Dams

There are 45 farm dams which have been identified within the MSEC Subsidence Study Area. The length of farm dams within the MSEC Subsidence Study Area vary between 8 metres and 99 metres and the plan areas vary between 26 m^2 and 5,047 m^2. The dams are typically of earthen construction and have been established by localised cut and fill operations within the natural watercourses. The farm dams are generally shallow, with the dam wall heights generally being less than 3 metres (MSEC, 2022).

The maximum predicted final tilt for the farm dams is 0.75 %, which represents a change in grade of 1 in 133. Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side, and decreasing on the other. The predicted changes in freeboard at the farm dams within the Study Area is less than 300 millimetres at 41 dams, and it is unlikely that the majority of the farm dams within the would experience adverse impacts on the storage capacities due to these small changes in freeboard (MSEC, 2022).

The predicted changes in freeboard are greater than 500 millimetres at one 1 dam within the Study Area (i.e. < 1 % of the total). It is possible, that this dam could experience a reduced storage level, however, this could be remediated by increasing the height of the affected dam wall.

The maximum predicted conventional curvatures and strains for farm dams could be sufficient to result in cracking in the bases and walls of some farm dams within the Study Area.

4.4.12 Surface Water Extraction

At locations of minimum natural gradient, the predicted subsidence may result in a very slight reduction in surface grade (i.e. less than 1%). This level of change is not expected to result in impacts to overland flow and therefore impacts to registered surface water extraction will be negligible (Tahmoor Coal, 2022).

4.4.13 Groundwater Wells and Bores

Temporary lowering of the regional piezometric surface over the subsidence area due to extraction of LW S1A-S6A may occur, with impacts more notable directly over extracted panels. Groundwater levels may reduce up to 80 metres at GW032443 and GW109257, which are located directly over LW S1A and S4A, however neither of these bores are in use. The remaining four assessed private bores are anticipated have a drawdown of between six and 15 metres, with all bores having an available drawdown greater than the predicted drawdown (**Table 16**), meaning there will still be water available for extraction (SLR, 2022).

It is anticipated that groundwater levels will recover over a few months to two to three years. However, it must be noted the rate of groundwater level recovery is significantly affected by climatic conditions at the time. There is no predicted permanent post mining reduction in the Hawkesbury Sandstone Aquifer groundwater levels (SLR, 2022).

4.4.14 Impact on State Forest

There are no State forests or conservation areas present within the Study Area. The extraction of LW S1A-S6A is not expected to impact the State Forest.

4.4.15 Poultry Sheds

There are 21 poultry sheds within the Study Area. The poultry sheds are lightweight structures up to 113 metres in length. The Inghams Bargo Chicken Breeder Complex Production Complex is located on Remembrance Drive, beyond the finishing ends of LW S2A-S3A. The Inghams Turkey Farm and Bargo Valley Produce poultry sheds are located on Yarran Road, to the west of LW S6A. Part of one shed at Bargo Valley Produce is located directly above LW S6A.

The poultry sheds are predicted to experience relatively mild conventional subsidence, tilt, curvatures and strains. Tilt can potentially affect the serviceability of poultry sheds by altering the watering and drainage systems in the sheds. The predicted changes in grade are small and unlikely, therefore, to result in any adverse impacts on the serviceability of the tanks. Mining-induced curvature and ground strain can result in the opening of gaps or cracks in the wall linings of the poultry sheds. The potential for impacts are, however, considered low as only one shed at Bargo Valley Produce is above the proposed LW S6A.

It is expected that the predicted mine subsidence movements on the poultry sheds and ancillary building structures can be managed by the implementation of suitable management strategies, including visual monitoring during active subsidence (MSEC, 2022).

4.4.16 Horticulture & Permaculture

Irrigation Systems

Irrigation systems are used on commercial and private properties for production of olives, lettuce and other horticultural applications. Elevated troughs are located on Bargo Valley Produce on Yarran Road, to the west of LW S6A. Irrigation systems are usually constructed from polyethylene pipes which can tolerate ground movements much larger than the predicted mine subsidence movements within the Study Area. Elevated strains can occur in the pipelines where they are anchored to the ground, or where they are subjected to non-systematic ground movements. Impacts are expected to be minor, including leaking joints, which could be readily remediated (MSEC, 2022).

Glass Houses

No glass houses have been identified within the Study Area, though there are a number of greenhouses and hothouses. As these structures are relatively lightweight in construction, they are usually able to tolerate differential subsidence movements. Impacts can occur, e.g., if the roof materials are designed to be slid open or closed to ventilate the greenhouse or hothouse, differential horizontal movements can cause the frames to crack and prevent sliding of the materials. It is expected that the predicted mine subsidence movements on the greenhouses and hothouses can be managed by the implementation of suitable management strategies, including visual monitoring during active subsidence (MSEC, 2022).

Hydroponic Systems

There are no known hydroponic systems within the Study Area. However, there are a number of greenhouses and hothouses. These buildings may have hydroponic systems. While the water pipes are usually flexible and able to tolerate differential subsidence movements, the drainage of the systems may require monitoring and adjustment, if necessary. It is expected that the predicted mine subsidence movements on the hydroponic systems can be managed by the implementation of suitable management strategies, including visual monitoring during active subsidence (MSEC, 2022).

4.4.17 Agricultural Regional Community Impacts

No other impacts which may affect the regional agricultural community, resources or enterprises have been identified in this assessment.

4.4.18 Cumulative Impacts

Given the previously described impacts are of a minor nature and readily managed through application of appropriate mitigation measures and management strategies, any cumulative impacts on agricultural resources and enterprises are also expected to be minor and readily mitigated.

5 Mitigation Measures and Management Strategies

This section describes the proposed mitigation measures and management strategies recommended to minimise potential agricultural impacts. Whilst the majority of impacts on agricultural enterprises and resources have been assessed as negligible, as a matter of best practice, Tahmoor Coal has adopted a number of mitigation measures to further minimise these impacts. A summary of key measures specifically in relation to potential agricultural impact is provided below.

5.1 Soil Resources

Whilst there are no earthworks proposed during the extraction of LW S1A-S6A, in the unlikely event they would be required, gypsum will be applied for any remediation earthworks where sodic subsoils (exchangeable sodium is greater than 5%) are exposed. The application of gypsum will minimise the potential for tunnel erosion to occur on disturbed subsoil. The recommended application rates are shown in **Table 17**.

Table 17 Gypsum Application Rates

Exchangeable Sodium (ESP)	Gypsum Rate per Hectare	Gypsum Rate per Square Metre
5 to 10%	2 to 5 tonnes	0.2 to 0.5 kilograms
Greater than 10%	5 tonnes	0.5 kilograms

It is noted that there are no soil stripping or stockpiling activities anticipated within the Study Area associated with the extraction of LW S1A-S6A.

5.2 Surface Water Resources

Where impacted watercourses have sediment accumulations upstream, it is expected that some of the fractures would be naturally filled over time with sediment during subsequent flow events, as has previously been observed. Where little sediment is present, the impacts are likely to remain for longer periods of time and remediation may be required after the completion of mining, which could include sealing these fractures and voids with grout (MSEC, 2022).

Tahmoor Coal has previously developed Water Management Plans to manage the potential impacts on streams during the mining of longwalls. The management plans include ground monitoring, water quality and pool level monitoring and visual inspections. The plans also commit to remediation of aquatic ecosystems if impacts occur. A Water Management Plan has been prepared as part of the Extraction Plan for LW S1A-S6A.

5.3 Groundwater Resources

All currently operating private bores are predicted to be impacted by a maximum incremental drawdown of greater than two metres, however all impacted bores have a greater available drawdown than the predicted drawdown. Tahmoor Coal have committed to “make good” provisions for any groundwater users shown to be adversely affected by mine operations and associated impacts. These commitments are detailed in the Water Management Plan, which has been prepared as part of the Extraction Plan for LW S1A-S6A.

Although, groundwater quality is not predicted to adversely change, it will continue to be monitored and compared to groundwater quality triggers in the Trigger Action Response Plans which are prescribed to act as early warning measures for any changes in groundwater quality

5.4 Tanks

Only minor impacts to tanks are expected, if impacts occur the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

5.5 Farm Fencing

In the unlikely event of damage to fence tensioning or farm gates, Tahmoor Coal will remediate the damage in consultation with relevant stakeholders.

5.6 Farm Dams

It is expected that all farm dams in the Study Area can be maintained during the extraction of the proposed longwalls, even if impacts were greater than the predictions or substantial non-conventional movements occurred. Any substantial cracking in the dam bases or walls within the Study Area could be repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, Tahmoor Coal would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017* (MSEC, 2022).

6 Monitoring & Consultation

Tahmoor Coal notifies all residents and/or businesses within the 20 millimetre subsidence area and 35 degree angle of draw prior to commencement of all first and second workings. Comprehensive monitoring of all potentially impacted properties within these areas is undertaken from the commencement of extraction, and continues regularly until extraction is completed. Further monitoring is completed during the post-extraction phase in accordance with the relevant management plan for the residence / business (refer to the Extraction Plan for further details).

Agricultural reports completed during the extraction of Longwalls West 1, West 2 and West 3 in the Western Domain show that no impacts to agricultural resources or enterprises have been observed during the extraction of these longwalls. These inspections are based on baseline reporting undertaken by SLR prior to the commencement of extraction. An example of this reporting, the *Tahmoor Coal LW W1-W2 Agricultural Inspection Report*, is given in **Appendix C**.

In relation to the poultry enterprises that exist in the area, that the owner/manager as well as the processor/owner of the birds will be consulted during the preparation of the relevant management plan for each agricultural business to ensure that production plans can be adjusted if required. Monitoring will also be detailed in the relevant management plan, as agreed during consultation with the poultry enterprises.

Tahmoor Coal keeps a complaints register for any public matters resulting from aspects of mine operation. The complaints register is tracked using the compliance program Cority, which allows Tahmoor Coal to enter the details of complaints, as well as details of investigation procedures and outcomes as required. Tahmoor Coal also employs a Consultation Manager to track and undertake consultation with landowners.

7 Findings

This Land and Agricultural Resource Assessment has been prepared to be included in Tahmoor Coal's Extraction Plan LW S1A-S6A. The purpose of this Land and Agricultural Resource Assessment is to assess and report on the potential impacts on agricultural resources within and adjacent to the Study Area and recommend mitigation measures to alleviate any identified impacts. The key findings are listed below:

- The majority agricultural land use by area within the Study Area is for small scale cattle and horse grazing areas, which are not major contributors to agricultural income generation. This small scale grazing is mostly carried out as a land and vegetation management tool. Land available for agricultural land use comprises 27% of the Study Area.
- There are three poultry enterprises within the Study Area, and impacts are expected to be minor and readily remediated using well accepted techniques.
- Post-mining agricultural economic potential in the Study Area is expected to be very similar to pre-mining potential.
- The longwall mining will have minor impacts on surface and groundwater resources relied upon by agriculture, comprising two WALs and six private bores. Any surface or groundwater impacts will be "made good" by Tahmoor Coal.
- Any impacts resulting from longwall mining are expected to be minor and temporary, and can be managed through application of appropriate mitigation measures and management strategies.
- As a result of any impacts being minor, any cumulative impacts on agricultural resources and enterprises are also expected to be minor, and can be managed through application of appropriate mitigation measures and management strategies.
- Continuation of longwall mining by Tahmoor Coal will provide considerable positive economic benefits to the local and broader communities. These benefits are far greater than any potential income lost by existing or potential agricultural enterprises.

In summary, the extraction of LW S1A-S6A will provide considerable economic benefits to the region whilst having negligible impact on agricultural resources, enterprises or related industries.

8 References

Australian Bureau of Statistics website accessed March 2022 www.abs.gov.au

Bureau of Meteorology website accessed March 2022 www.bom.gov.au

Geoterra (2013), *Tahmoor South Project Shallow Groundwater Baseline Monitoring*

MSEC (2022), *Tahmoor South Project – Extraction Plan for Longwalls S1A to S6A*

Migration Heritage Centre (2020), website accessed March 2022 www.migrationheritage.nsw.gov.au

NSW Department of Planning and Infrastructure (2013), *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 Strategic Agricultural Land Map – Sheet STA_41_20130910*

NSW Department of Primary Industries (2019), *Beef Cattle Gross Margin Budget Inland Store Weaners*

NSW Department of Primary Industries (2013), *NSW Biosecurity Strategy 2013 – 2021*

NSW Department of Primary Industries (2006), *Beef Stocking Rates& Farm Size – Hunter Region 2006*

NSW Office of Environment & Heritage (2013) *Land and Soil Capability Assessment Scheme 2nd Approximation*

NSW Office of Water (2012), *Aquifer Interference Policy*

Profile.id (2020), website accessed March 2022 www.profile.id.com.au

SLR (2022), *Tahmoor Coal Pty Ltd LW S1A-S6A Baseline Private Bore Assessment*

SLR (2022), *Tahmoor Coal LW S1A-S6A Extraction Management Plan: Groundwater Technical Report*

Tahmoor Coal (2020) *Tahmoor Coal Pty Ltd Subsidence Monitoring Program Tahmoor North Western Domain Longwalls West 1 and West 2*

Tahmoor Coal (2022), *Tahmoor South Domain Longwalls South 1A – South 6A Water Management Plan*

Wollondilly Shire Council (2020), website accessed March 2022 www.wollondillyshire.com.au

Appendix A

Site Inspection Plates

Site 50 – Cattle grazing

Site 51 – Cattle feedlot 2013, disused cattle feedlot 2017

Site 52 – Pleasure horses

Site 53 – Rural residential

Site 54 – Hydroponic lettuce and poultry sheds

Site 55 – Poultry sheds

Site 56 – Cut flower greenhouse 2013, disused cut flower greenhouses 2017

Site 57 – Poultry sheds

Site 58 – Olives & sheep grazing

Site 59 – Irrigated olives & alpaca stud

Appendix B

Agricultural Productivity Gross Margin Data

Department of Primary Industries

BEEF CATTLE GROSS MARGIN BUDGET

Farm enterprise Budget Series: April 2019

Enterprise: **Inland store weaners**

Enterprise Unit: **100 cows**

Pasture: **Native pasture**

INCOME:				Standard Budget	Your Budget
	42	steer weaners @	$725 /hd	$30,467	
	21	heifer weaners @	$463 /hd	$9,727	
	1	CFA Bull @	$1,554 /hd	$1,554	
	6	CFA cows @	$963 /hd	$5,779	
	0	Dry cows @	$963 /hd	$0	
	13	Other culls @	$963 /hd	$12,522	
	83				
		A. Total Income:		**$60,049**	

VARIABLE COSTS:		
Replacements 1 Bull @ $3,500 /hd	$3,500	
Livestock and vet costs: see section titled beef health costs for details.	$1,244	
Hay & Grain or silage. Low level supplementary feeding for 3 months	$2,250	
Drought feeding costs.	$0	
Pasture maintenence (372 Ha of native pasture)	$0	
Livestock selling cost (see assumptions on next page)	$4,776	
B. Total Variable Costs:	**$11,770**	
GROSS MARGIN (A-B)	**$48,279**	
GROSS MARGIN/COW	**$482.79**	
GROSS MARGIN/DSE*	**$32.45**	
GROSS MARGIN/HA	**$129.78**	

Change in gross margin ($/cow) for change in price &/or the weight of sale stock

(Note: Table assumes that the price and weight of other stock changes in the same proportion as steers. As an example if steer sale price falls to 269c/kg and steer weight to 240 kg, gross margin would fall to $419 per cow. This assumes that price and weight of all other sale stock falls by the same percentage.

Liveweight (kg's) of Stock sold		Steer sale price cents/kg live				
		259	269	279	289	299
	Steer wt.					
-40 kgs	**220**	358	375	393	411	429
-20 kgs	**240**	399	419	438	457	477
0	**260**	441	462	483	504	525
+20 kgs	**280**	483	505	528	550	572
+40 kgs	**300**	524	548	572	596	620

GM $ per Cow

An increase of 5% in weaning percentage increases gross margin per cow by $27.08

Assumptions **Inland store weaners**

Enterprise unit is 100 cows weighing on average 480 kg
Weaning rate: 84% - conception rate 90%

Sales

Steers sold at 9 months	260 kg	@279c/kg	live weight
Heifers sold at 9 months	230 kg	@201c/kg	live weight
21 heifers retained for replacement.			
Cull cows cast for age at 10 years	240 kg	@401c/kg	dressed weight
100% of preg tested empty cows culled	"	"	"
4% cows culled for other reasons	"	"	"
Bulls run at 3% & sold after 4 years use	420 kg	@370c/kg	dressed weight

Selling costs include: Commission 4%; yard dues $8.00/hd; MLA levy $5/hd; average freight cost to saleyards $12/hd; NLIS tags $3.60

Cows: age at first calf : 24 months

Mortality rate of adult stock: 2%

The average feed requirement of a cow + followers is rated at 2.21 LSU or 15.25 dse's. This is an average figure and will vary during the year.
.
.

Age structure

Age	**Number**
2	21
3	18
4	15
5	13
6	11
7	9
8	7
9	6
Total Joined	**100**
10	6

84 calves → 42 heifers → 21 sold; 21 retained for breeding
84 calves → 42 steers → 42 sold
10-year-olds: 6 → 6 sold cfa

Marketing Information:
Mainly sold to grass back-grounders for growing out.
Steers likely to end up in feedlots after further weight gain on grass.
Following sale, heifers either grown out to become breeders or fattened for the local trade market.

Production Information:
Mixed sex weaners sold from March to June from lighter country or at heavier stocking rates than for vealers. Common on unimproved areas with some supplementary feed in normal years.
This enterprise is the most drought susceptible.

NSW Department of Primary Industries Farm Enterprise Budget Series

Appendix C

Example Tahmoor Coal LW W1-W2 Agricultural Inspection Report

Table 1 Property Owner

Tahmoor Coal LW W1 – W2 Agricultural Inspections			20/07/2020
Mining Sequence	**During Mining Inspection**	Property & Site	**XXXXX**
Easting & Northing	XXXXX		
Current Land Use	Sheep grazing grass pasture		
Dominant Landform	Lower slope to creek flat		
Soil Surface Condition	Uneven surface +/- 150 millimetres in places		
Rainfall Since Last Inspection	15.24 mm		
Baseline Property Condition			
Erosion Presence	Nil	Minor	Widespread
Boundary Fence Condition	Good	Stock proof	Not stock proof
Boundary Fence Posts	Straight	Minor lean	Major lean
Boundary Fence Wire	Full Tension	Minor sag	Major sag
Internal Fence Condition	Good	Stock proof	Not stock proof
Internal Fence Posts	Straight	Minor lean	Major lean
Internal Fence Wire	Full Tension	Minor sag	Major sag
Paddock Gate Condition	Good	Stock proof	Not stock proof
Out-Building Condition	Useable	Unusable	N/A
Paddock Dams	Holding Water	No Water	N/A
Surface Slumping	Nil	Yes	*If yes, depth and width*
Surface Cracking	Nil	Yes	*If yes, depth and width*
Vegetation Dieback	Nil	Yes	Eucalypt
Additional Comments	February Comments (02/03/2020): No observed changes since January report Significant rainfall has however resulted in grass and shrub growth March Comments (27/03/2020): No observed changes since February report Increased vegetation growth April Comments (24/04/20): No observed changes since March report May Comments (21/05/20): Increased vegetation growth along riverbank due to recent rain. Dieback of paddock vegetation has begun as the change of season approaches. June Comments (30/06/20): Seasonal changes corresponding with mid-winter timing		


Property Owner east towards sheds (left: June 20; right: current)

Property Owner south towards Stonequarry Creek (left: June 20; right: current)


Property Owner ground surface (left: June 20, right: current)

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

GOLD COAST
Ground Floor, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628