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Tahmoor Coal Pty Ltd

LAND MANAGEMENT PLAN

Tahmoor North - Western Domain
Longwalls West 3 and West 4

May 2021

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Document Control

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1 Introduction

1.1 Background

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to **Figure 1-1**). Tahmoor Mine produces up to three million tonnes of Run of Mine coal per annum from the Bulli Coal Seam. 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. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

Tahmoor Coal has previously mined 33 longwalls to the north and west of Tahmoor Mine's current pit top location. The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton. The Western Domain is within the Tahmoor North mining area and is within Mining Lease (ML) 1376 and ML 1539.

The mine plan for the Western Domain includes four longwalls - Longwalls West 1 to West 4. An Extraction Plan for the first two longwalls in the Western Domain, Longwalls West 1 and West 2 (LW W1-W2), was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Longwalls West 1 (LW W1) was the first longwall to be extracted in the Western Domain and was completed on 6 November 2020. The extraction of Longwalls West 2 (LW W2) commenced on 7 December 2020.

The proposed Longwalls West 3 and West 4 (LW W3-W4) are an extension of LW W1-W2 and will be the focus of the current Extraction Plan. LW W3-W4 are illustrated in **Figure 1-2**.

1.2 Purpose

This Land Management Plan (LMP) has been prepared to support an Extraction Plan for the secondary extraction of coal from LW W3-W4. This LMP has been designed to identify the monitoring and management measures for landscape features, with specific focus on cliffs, minor cliffs, rock outcrops, steep slopes, and agricultural land within the Extraction Plan Study Area that are required to be implemented to demonstrate that the relevant performance measures are achieved.

1.3 Scope

The Study Area applicable to this LMP consists of a combination of the Predicted 20 millimetre (mm) Total Subsidence Contour and the 35^{o} Angle of Draw Line as shown on **Figure 1-2**. Relevant environmental features within a 600 metre (m) buffer from extraction that could be susceptible to far-field or valley related movements have also been included for consideration.

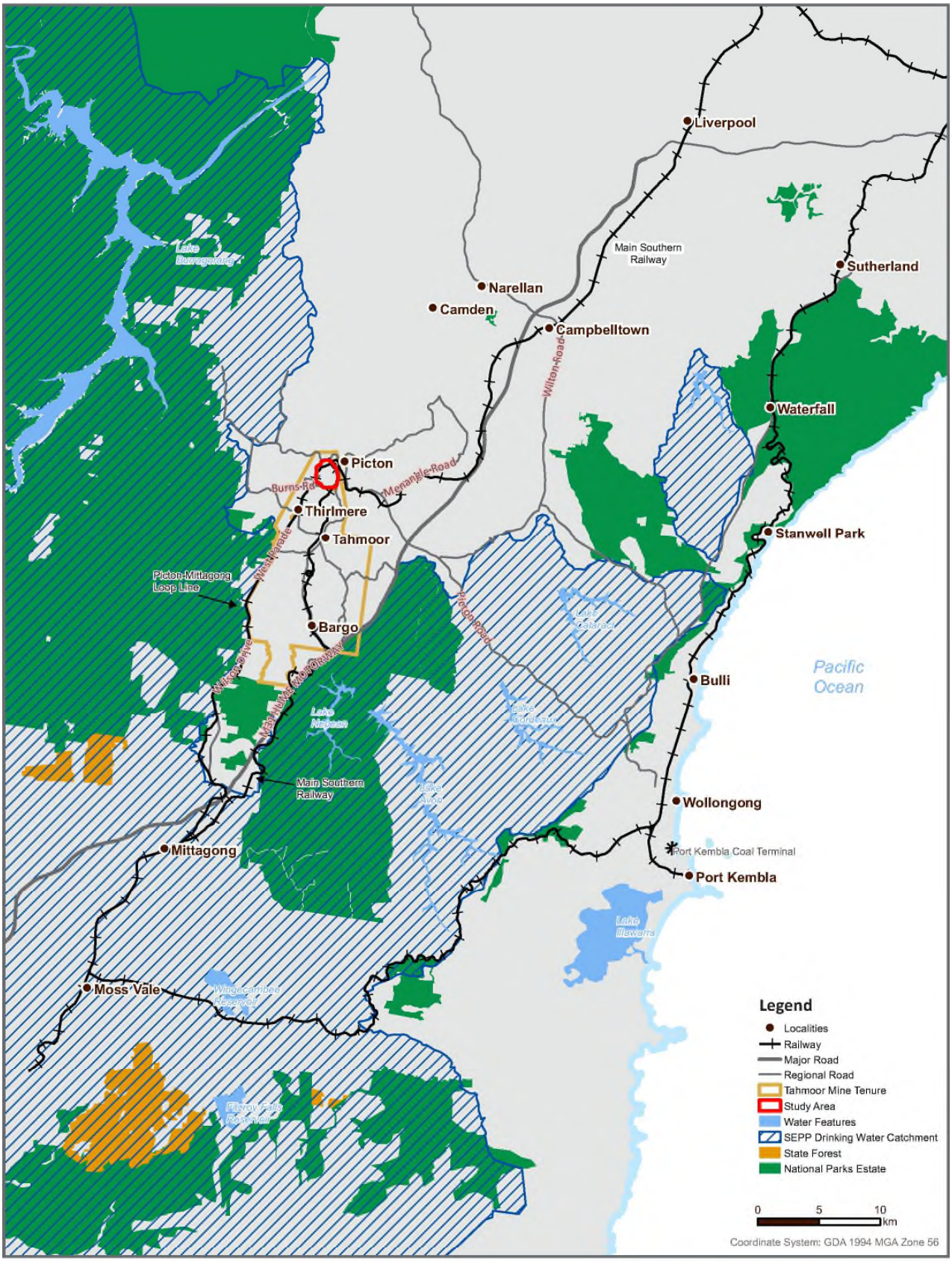
This LMP:

- Addresses specific requirements set by DA 67/98 Condition 13H(vii)(e) (refer to **Section 2.1**);
- Addresses related regulatory requirements (refer to **Section 2.2**);
- Addresses the monitoring and management of potential subsidence-related impacts to landscape features and agricultural resources (refer to **Section 5**); and
- Provides a Trigger Action Response Plan (TARP) to be implemented to manage and protect landscape features and agricultural resources within the Study Area (refer to **Appendix A**).

This LMP has been prepared based on the contents of the following technical reports:

- Geotechnical Assessment (Douglas Partners, 2021) (**Appendix B**);
- Land and Agricultural Resource Assessment (SLR, 2021) (**Appendix C**); and
- Subsidence Predictions and Impact Assessment (MSEC, 2021) (**Volume 1**).

This LMP considers the management of landscape features, such as steep slopes, cliffs, rockface features, and agricultural land. Consideration of waterways, flooding risks, dams and groundwater is provided in the LW W3-W4 Water Management Plan.



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REGIONAL CONTEXT

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-1

Date: 22/12/2020

Data Sources:
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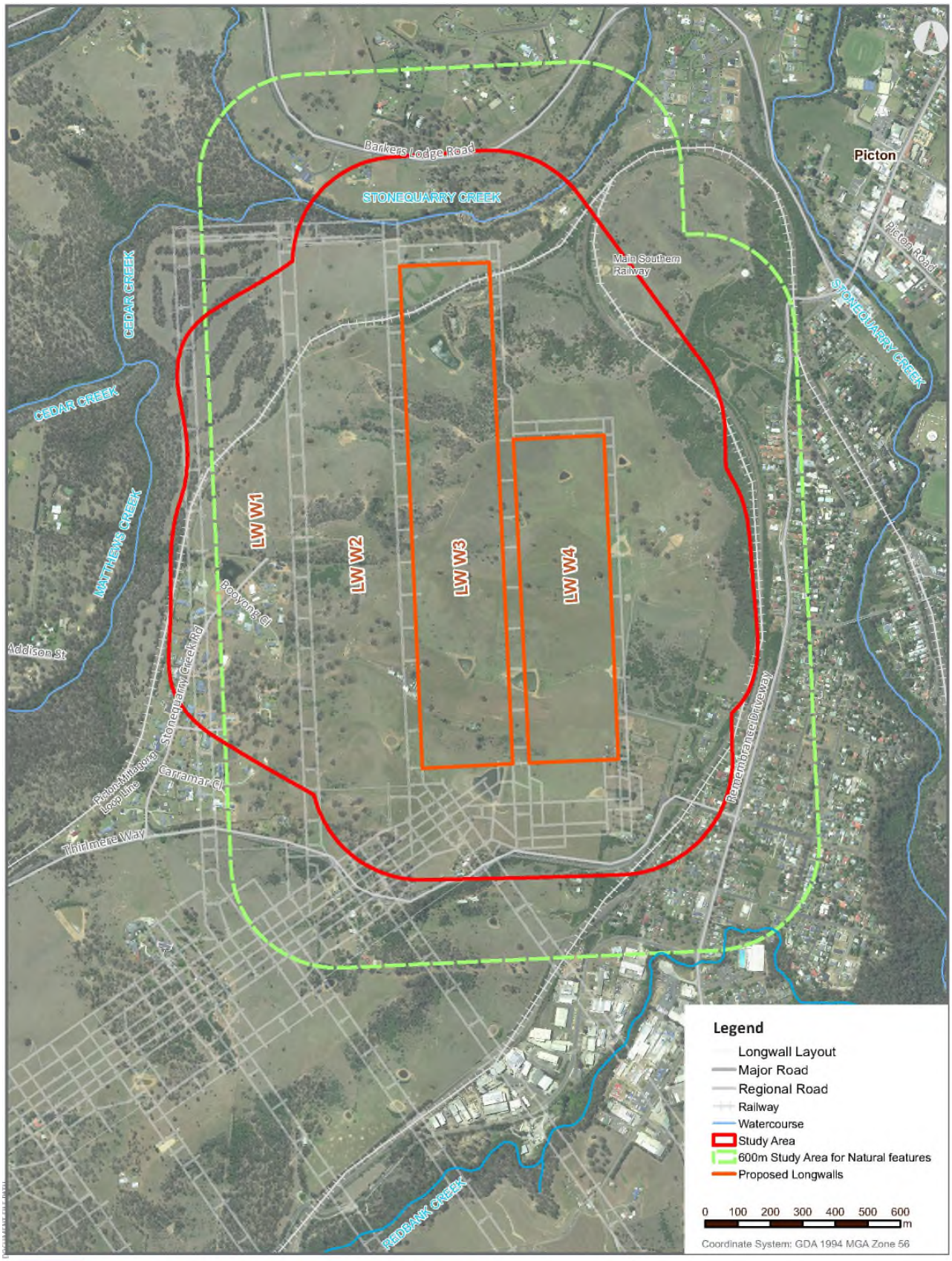

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EXTRACTION PLAN STUDY AREA

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-2

Date: 10/05/2021

Data Sources:
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Aerial Imagery: © Photomapping Services (November 2018)

2 Regulatory Requirements

2.1 Project Approval

2.1.1 Development Consent

Tahmoor Coal's operations are conducted in accordance with applicable Commonwealth and State environmental, planning, mining safety, and natural resource legislation. A register of relevant environmental legislative and regulatory requirements is maintained by Tahmoor Coal in a compliance database.

The proposed LW W3-W4 will be operating in the Tahmoor North mining area under Development Consents DA 57/93 and DA 67/93, as discussed further in **Section 3.2.1** of the Extraction Plan Main Document.

DA 67/98 provides the conditional planning approval framework for mining activities in the Western Domain to be addressed within an Extraction Plan and supporting management plans. Conditions relevant to this LMP from DA 67/98 are detailed in **Table 2-1**.

Table 2-1 Key Conditions from DA 67/98 regarding Landscape Features and Agricultural Resources

<table>
<tr><th>Condition</th><th colspan="2">Condition Requirement</th><th>Section(s) Addressed</th></tr>
<tr><td colspan="4">Performance Measures – Built Features</td></tr>
<tr><td>13E</td><td colspan="2">The Applicant must ensure that extraction of Longwall 33 and subsequent longwalls does not cause any exceedances of the performance measures in Table 2.
Notes
• The Applicant will be required to define more detailed performance measures in the Built Features Management Plans or Public Safety Management Plan.
• Requirements regarding safety or serviceability do not prevent preventative or mitigatory actions being taken prior to or during mining in order to achieve or maintain these outcomes.
• Requirements under this condition may be met by measures undertaken in accordance with the Coal Mine Subsidence Compensation Act 2017.</td><td rowspan="4">Section 5.1, Section 6, Appendix A</td></tr>
<tr><td rowspan="3">Excerpt from Table 2</td><td>Feature</td><td>Performance Measure</td></tr>
<tr><td colspan="2">Public Safety</td></tr>
<tr><td>• Public Safety</td><td>• Negligible additional risk.</td></tr>
<tr><td>13F</td><td colspan="2">Any dispute between the Applicant and the owner of any built feature over the interpretation, application or implementation of the performance measures in Table 2 is to be settled by the Secretary, following consultation with the Resources Regulator. Any decision by the Secretary shall be final.</td><td>Noted.</td></tr>
</table>

Condition	Condition Requirement	Section(s) Addressed
Extraction Plan		
13H(vi)	Describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 1 and Table 2, and manage or remediate any impacts and/or environmental consequences;	Section 5.1, Section 5.2 and Section 6
13H(vii)(e)	Land Management Plan which has been prepared in consultation with any affected public authorities, which provides for the management of potential impacts and/or environmental consequences of the proposed underground workings on land in general, with a specific focus on cliffs, minor cliffs, rock face features, steep slopes and agricultural land.	Section 2.3, Section 6 It is noted that there are no cliffs, minor cliffs or rock face features in the LW W3-W4 Study Area.
13H(vii)(h)	Trigger Action Response Plan/s addressing all features in Table 1 and Table 2, which contain:	Section 6.3, Section 6.5, Appendix A
	• appropriate triggers to warn of increased risk of exceedance of any performance measure; and	
	• specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded;	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures; and	
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 or Table 2, or where any such exceedance appears likely; an	
13H(vii)(i)	Contingency Plan that expressly provides for:	Section 5.3, Section 6.4, Section 6.5, Appendix A
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 and Table 2, or where any such exceedance appears likely; and	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures; and	
	• includes a program to collect sufficient baseline data for future Extraction Plans.	

2.1.2 Extraction Plan Guideline

This LMP has been prepared in accordance with the DPIE *Draft Guidelines for the Preparation of Extraction Plans V5* (DPE, 2015), as illustrated in **Table 2-2**.

Table 2-2 Extraction Plan Guideline Requirements for Key Component Plans

Extraction Plan Guideline Content Requirements for Key Component Plans	Section(s) Addressed
An overview of all landscape features, heritage sites, environmental values, built features or other values to be managed under the component plan.	Section 3
Setting out all performance measures included in the development consent relevant to the features or values to be managed under the component plan.	Section 2.1.1
Setting out clear objectives to ensure the delivery of the performance measures and all other relevant statutory requirements (including relevant safety legislation).	Section 2, Section 5, Section 6

Extraction Plan Guideline Content Requirements for Key Component Plans	Section(s) Addressed
Proposing performance indicators to establish compliance with these performance measures and statutory requirements.	Section 5.1
Describe the landscape features, heritage sites and environmental values to be managed under the component plan, and their significance.	Section 3
Describe all currently-predicted subsidence impacts and environmental consequences relevant to the features, sites and values to be managed under the component plan.	Section 4
Describe all measures planned to remediate these impacts and/or consequences, including any measures proposed to ensure that impacts and/or consequences comply with performance measures and/or the Applicant's commitments.	Section 6
Describe the existing baseline monitoring network and the current baseline monitoring results, including pre-subsidence photographic surveys of key landscape features and key heritage sites which may be subject to significant subsidence impacts (such as significant watercourses, swamps and Aboriginalheritage sites).	Section 3
Fully describing the proposed monitoring of subsidence impacts and environmental consequences.	Section 5.2
Describe the proposed monitoring of the success of remediation measures following implementation.	Section 6.4, Appendix A
Describe adaptive management proposed to avoid repetition of unpredicted subsidence impacts and/or environmental consequences.	Section 6.5
Describe contingency plans proposed to prevent, mitigate or remediate subsidence impacts and/or environmental consequences which substantially exceed predictions or which exceed performance measures.	Section 6.4, Appendix A
Listing responsibilities for implementation of the plan.	Section 7.3
An attached Trigger, Action, Response Plan (effectively a tabular summary of most of the above).	Appendix A

2.2 Relevant Legislation

For legislation that regulates health and safety during mining subsidence and obligations to remediate (which includes environmental consequences to cliffs, minor cliffs, rock face features, steep slopes, or agricultural land), refer to the Extraction Plan Main Document and specific Infrastructure Management Plans.

2.3 Risk Management

Tahmoor Coal manages risks by following a risk management process, which involves the four steps:

- Identify hazards – find out what could cause harm;
- Assess risks if necessary – understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening;
- Control risks – eliminate the risk or, if this is not possible, minimise the risk through risk control measures; and
- Review – review control measures to ensure they are working as planned.

The framework utilised for the risk assessment is the risk management process outlined within AS/NZS ISO 31000.

A LW W3-W4 Risk Assessment was held on 23 September 2020 and considered all built and natural features in the Study Area. The outcomes of the risk assessment are outlined further in the Public Safety Management Plan.

Landscape features that could be at risk from the development of mine subsidence in the Study Area include:

- Steep slopes;
- Agricultural land.

Waterways, flooding risks, dams and groundwater are considered further in the LW W3-W4 Water Management Plan.

Potential hazards to steep slopes from mine subsidence can include:

- Potential for surface cracking; and
- Potential for movement of overhang rock boulders/landslide.

Potential hazards from the impact of mine subsidence on agricultural land can include:

- Potential impact to land use from flooding;
- Potential for remnant ponding reducing available land;
- Potential impact on water resources - surface water and ground water;
- Potential change in grade of drainage lines; and
- Potential increase in erosion / tunnel erosion on earthworks.

It is noted that there are no cliffs, minor cliffs and rock outcrops within the LW W3-W4 Study Area.

2.4 Consultation

The NSW Department of Primary Industries – Agriculture (DPI Agriculture) and DPIE Crown Lands were consulted during the preparation of this LMP. A summary of consultation undertaken is provided in **Section 2.1.2** of the Extraction Plan Main Document, and a copy of the incoming correspondence is also provided in **Appendix C** of the Extraction Plan Main Document.

During consultation with DPI Agriculture, it was requested that the following information is included in the Land and Agricultural Resource Assessment:

- Describe the current Important Agriculture Land on the proposed development site and surrounding locality including the land capability, and soil landscapes. We note that the site verification is previous work indicates no presence of biophysical strategic agricultural land. This work provides a baseline evaluation of the current land resource for any impact assessment;
- A description of the agricultural landuses in the area and associated enterprises and agricultural productivity of these again to provide a current status of agriculture in the area;
- Detail the expected life span of the proposed development;
- Consider possible cumulative effects to agricultural enterprises and landholders from subsidence / other impacting events;
- 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, water supply infrastructure. (This may overlap with the other informing plans); and

- 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.

A Land and Agricultural Resource Assessment (SLR, 2021) has been prepared and includes information to address the list of inclusions in the DPI Agriculture letter. This report is included in **Appendix B**.

In accordance with Condition 15(ii) of DA 67/98, Tahmoor Coal have notified relevant landowners / occupiers within the 20 mm subsidence area and 35 degree angle of draw of the intention to extract LW W3-W4. This consultation was completed on 15 September 2020 and included an overview of the proposal, likely subsidence impacts, and information about the services offered by Tahmoor Coal (Pre-Mining Inspections and Hazard Identification), and the subsidence claims process under the *Coal Mine Subsidence Compensation Act 2017*.

Tahmoor Coal has an established compliance register into which complaints are registered and tracking of consequent investigative actions. In addition, Tahmoor Coal records correspondence with landowners in a correspondence register.

3 Existing Environment

3.1 Climate

Climate data for the Study Area has been obtained from the nearest Bureau of Meteorology (BOM) weather station located at Picton, approximately one (1) km 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 mm, of which approximately 475 mm (60%) falls between November and April, with an average of 70.8 rain days in any given year, as outlined within **Table 3-1**. 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 3-1 Picton Climate Data (BoM, 2020)

Climate Data	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
Annual rainfall	800.9 mm	70.8
Wettest month - February	91.0 mm	6.8
Driest month – September	43.5 mm	5.1

The BOM classifies the region as a temperate climate zone. The region 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.

3.2 Topography

Topography in the region 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 (SLR, 2021).

The Study Area is bounded by Matthews Creek, Cedar Creek and Stonequarry Creek. The highest point of topography within the Study Area is at about 272 m Australian Height Datum (AHD) in the ridge line near the central western part of LW W3. Surface levels on relatively flat land to the north of the Study Area are the location of vegetated creek lines running from the wet to the north-east. Surface elevations of the low points are approximately 180 m AHD (SLR, 2021; Douglas Partners, 2021).

3.3 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 Coal Seam. Overlying the Bulli Coal 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 m thick (SLR, 2021).

Overlying the Narrabeen Group is the Hawkesbury Sandstone which is comprised of a series of bedded sandstones up to 185 m thick. The Wianamatta Group overlies the Hawkesbury Sandstone, and is comprised of shales and siltstones and is relatively thin in comparison (SLR, 2021).

3.4 Cliffs and Steep Slopes

Tahmoor Coal has extensive experience directly mining beneath or adjacent to cliffs and steep slopes. Tahmoor Coal has implemented extensive subsidence and mitigation measures prior to, during and after mining to ensure that the health and safety of people have not been put at risk due to mine subsidence.

Douglas Partners (2021) define cliffs and steep slopes as:

- Cliff – slope appears vertical and ranges between 64° and 84°;
- Extreme Slope – need rope access to climb slope and ranges between 45° and 64°;
- Very Steep Slope – can climb by clutching at vegetation and ranges between 27° and 45°;
- Steep Slope – walkable with effort and ranges between 18° and 27°;
- Moderate Slope – walkable and ranges between 10° and 18°; and
- Gentle Slope - easy walking and ranges between 0° and 10°.

The LW W3-W4 Study Area consists of steep slopes and is devoid of any cliffs, terraces, rock outcrops and very steep slopes. Steep slopes are located on the flanks of ridges and also along the banks of Stonequarry Creek and the unnamed tributary of Redbank Creek. Steep slopes such as dam walls, embankments and cut batters are also located in the Study Area, and 25 properties have been identified as containing structures close to steep slopes (Douglas Partners, 2021).

The location of steep slopes within the Study Area is illustrated in **Figure 3-1**.

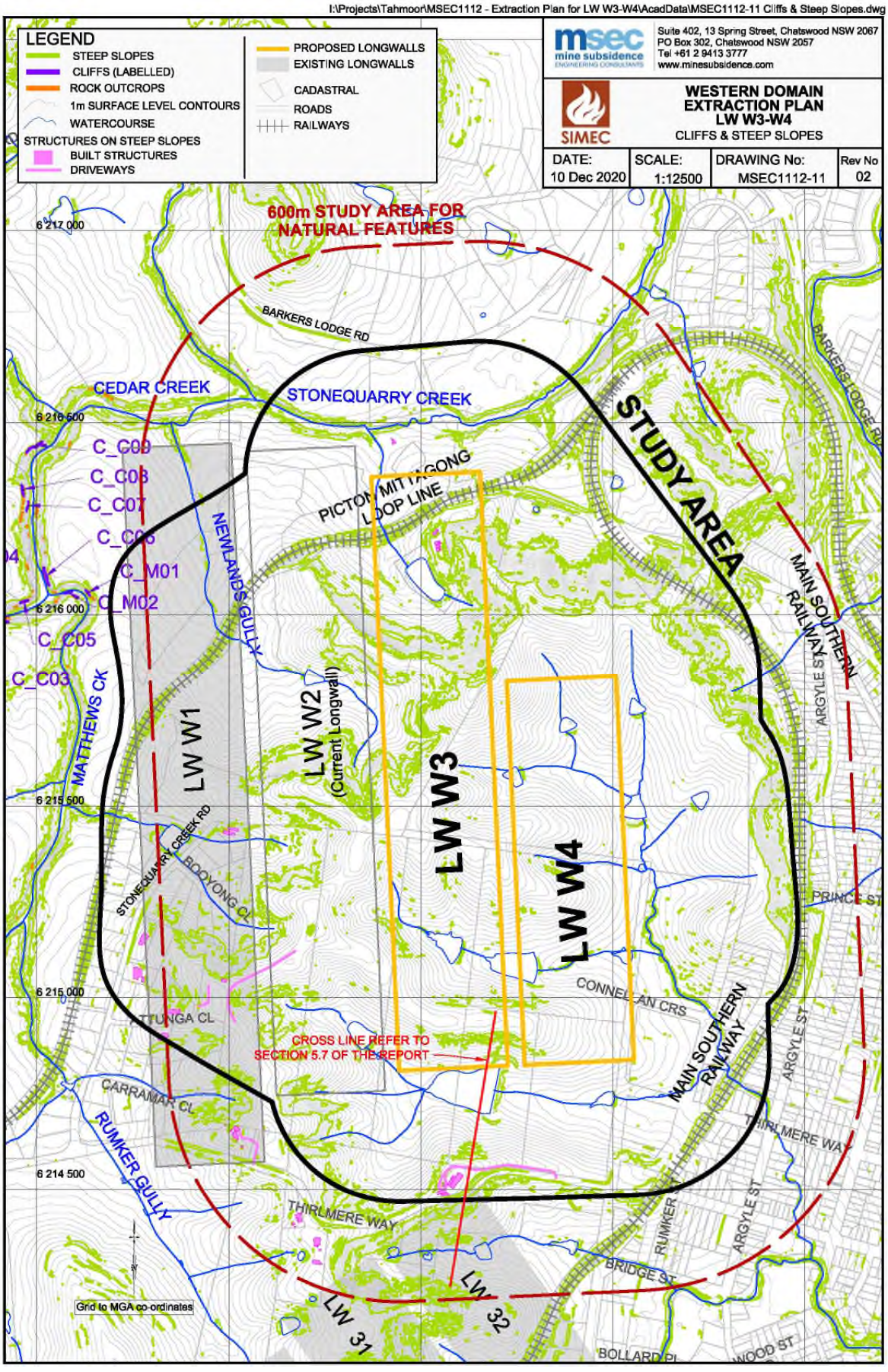

Figure 3-1 Cliffs and Steep Slopes in the Study Area (MSEC, 2021)

3.5 Soils

The soils within the Study Area consist of six Soil Landscape Units and are summarised in **Table 3-2**.

Agricultural land best suited to grazing land covers 90% of the Study Area, and about 4% of the soils within the Study Area are moderately limited for grazing and highly limited for cultivation (SLR, 2021).

Table 3-2 Soil Landscape Units (SLR, 2021)

Soil Landscape	Study Area		Agricultural Limitation Rating	
Unit	Hectares	%	Unit	Hectares
Hawkesbury	<1	<1	High – Severe	High – Severe
Picton	16	6		
Sub Total	**16**	**6**		
Lucas Height	11	4	Moderate	High
Sub Total	**11**	**4**		
Blacktown	155	55	Low	Moderate
Luddenham	72	25		
Monkey Creek	28	10		
Sub Total	**255**	**90**		

Full descriptions of the six Soil Landscape Units within the Study Area are presented in **Appendix C**.

Two Australia Soil Classification soil types are present in the Study Area:

- Dermosols - moderately high inherent fertility comprising 82% of the Study Area; and
- Kurosols – moderately low inherent fertility comprising 18% of the Study Area.

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 (SLR, 2021).

3.6 Land Use

The majority of the Study Area comprises of cleared pastoral land (approximately 64%) with the remaining land comprised of thick native vegetation along riparian zones and steep slopes, and small areas used as rural residential land (SLR, 2021).

The agricultural use of the land is small scale cattle and horse grazing of improved native grass species (refer **Figure 3-2**). Overall farm size is considered small and many would be classified as hobby farms with a very low potential to produce significant agricultural income. A small number of poultry farms, orchards and commercial vegetable gardens exist within or adjacent to the Study Area. No poultry farms or intensive cropping activities exist within the Study Area, however, least three protected cropping businesses exist to the south of the Study Area (SLR, 2021).

3.7 Biophysical Strategic Agricultural Land

No Biophysical Strategic Agricultural Land exists within the Study Area. The nearest Biophysical Strategic Agricultural Land is located between Douglas Park and Camden, approximately 20 km to the north-east of the Study Area (SLR, 2021).

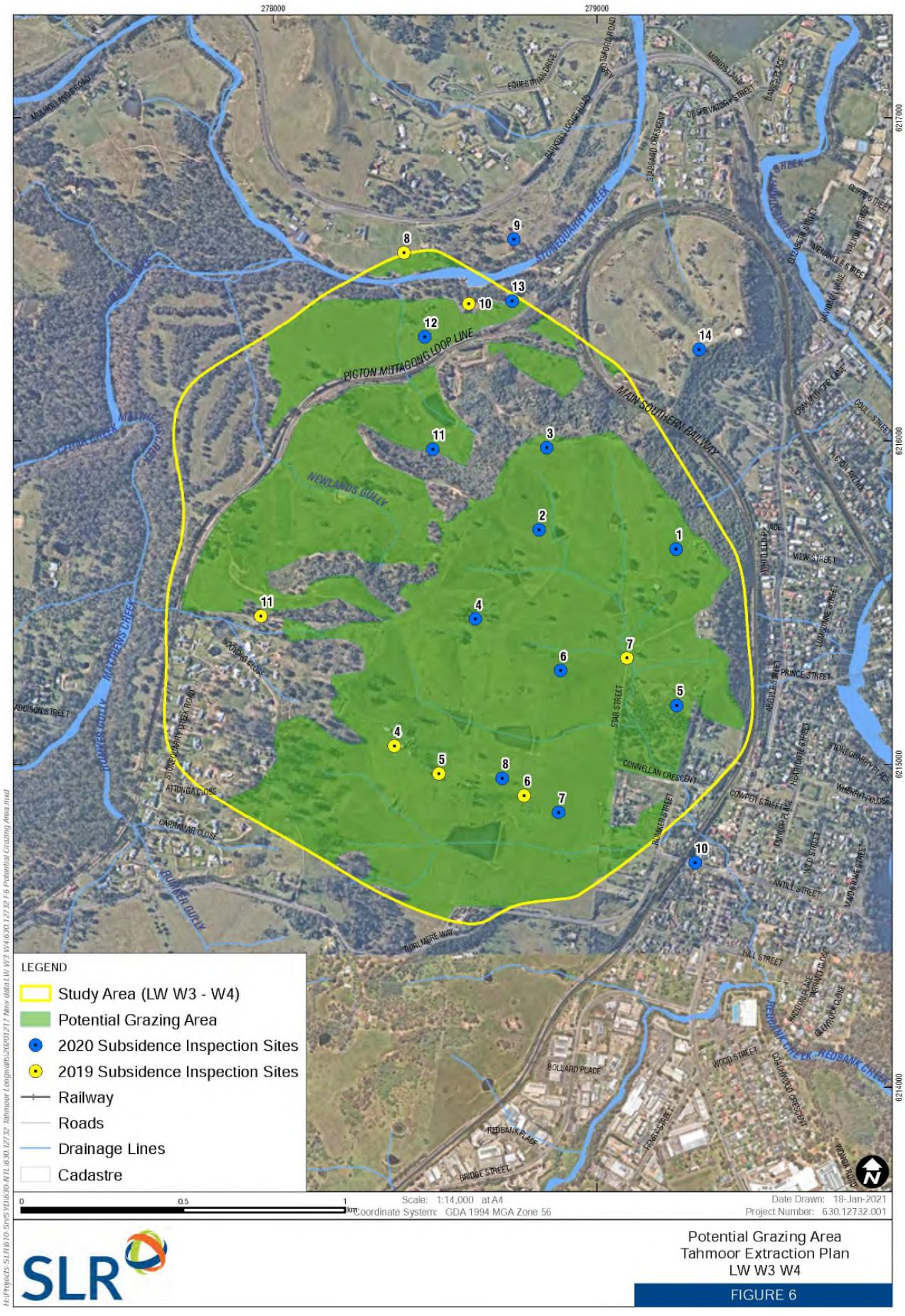

Figure 3-2 Agricultural Land in the Study Area (SLR, 2021)

4 Predicted Subsidence Impacts and Environmental Consequences

4.1 Steep Slopes

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

- Tilting (anticipated to be up to about 5 mm/m in the Study Area);
- Reduced shear strength; and
- Water concentration.

Mine subsidence movements can reduce shear strength of a slope or rock mass by introducing cracking. The anticipated mean compressive and tensile strains are expected to be up to about 1.5 mm/m within the Study Area which are considered minor and are not expected to produce significant cracking or differential lateral movement (Douglas Partners, 2021).

Water can ingress into a slope due to the development of cracks. This can potentially trigger instability due to saturation and/or piping, as well as increasing porewater pressures in the soil and rock.

Subsidence will take place over a broad subsidence bowl, and coupled with the depth of overburden and localised changes in slope, the changes in relief across the Study Area will be minor. The landform directly above the longwall excavation could experience cracking and damage. The assessed risk levels to property due to slope instability was *Very Low to Moderate* during and following longwall mining, provided that management and monitoring is carried out during active mine subsidence (Douglas Partners, 2021).

Monthly geotechnical inspection of cliff lines and steep slopes were carried out by Douglas Partners within the zone of active subsidence during the extraction of LW W1, and at three-monthly intervals following the completion of active subsidence. No discernible changes that could be attributed to mine subsidence were observed and TARP levels remained within thin the 'normal' range (Level 1) during the prior of monitoring (Douglas Partners, 2021).

4.2 Agricultural Land

The majority of agricultural land use is for grazing and no intensive cropping activities are conducted. Based on the natural landscape contours and the predicted subsidence contours, there is unlikely to be any remnant ponding in the landscape. Therefore, there is no land which will be temporarily removed from agriculture as a result of LW W3-W4 (SLR, 2021).

The majority of rural structures within the Study Area are of lightweight construction and are anticipated to tolerate mining induced tilt. It is noted that there are only a few rural structures in the Study Area (refer Figure 3-2; LW W3-W4 Built Features Management Plan). It has been found from past longwall mining experience that tilts of the magnitudes predicted for LW W3-W4 generally do not result in 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, 2021).

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 (MSEC, 2021).

Monthly inspection of agricultural land within the zone of active subsidence during the extraction of LW W1, and at three-monthly intervals following the completion of active subsidence. No impacts to agricultural resources or enterprises have been observed during the extraction of LW W1.

5 Subsidence Monitoring Program

5.1 Performance Measures and Indicators

Performance measures referring directly to the management of land resources were not specified in DA 67/98. However, the performance measure for public safety from Table 2 of DA 67/98 Condition 13E is relevant to steep slopes and is listed in **Table 5-1**.

Table 5-1 Subsidence Performance Measures and Performance Indicators for Landscape Features

Feature	Subsidence Performance Measures	Subsidence Performance Indicator and Triggers
Public safety	Negligible additional risk	This performance indicator will be considered to be triggered if: • Subsidence impacts to landscape features result in the collapse of steep slopes in proximity to members of the public.

For the purpose of this Extraction Plan and associated documents, 'negligible' is defined as being 'so small and insignificant as to not be worth considering'. A negligible impact is viewed with regards to a long term context, causing little or no impact. If a short term impact causes a greater than negligible impact, the impact can still be considered negligible if the impacts are of a limited duration and are considered negligible when considered over the long term.

It is anticipated that the above performance measures will be achieved during and after mining of LW W3-W4.

5.2 Monitoring Program

A monitoring program for steep slopes and agricultural land has been compiled in **Table 5-2**.

The aim of the monitoring program is to identify where there is a risk of impact to steep slopes and agricultural land as a result of mining activities. The monitoring program provides for the opportunity to record the condition of the site during the following three phases:

- Prior to Mining – baseline survey of the condition of the site before the commencement of mining, also referred to as the baseline check;
- During Mining – monitoring of the condition of the site during active subsidence to establish whether there has been any change to the site or if changes have occurred from the effects of subsidence; and
- Post Mining – monitoring of the condition of the site after mining to identify whether there has been any change to the site in the period since mining, and to determine if the conditions have stabilised.

If an impact is identified to have occurred or is likely to occur, the TARP (refer to **Appendix A**) should then be referred to for the identification of appropriate mitigation strategies.

Table 5-2 Monitoring Program for Landscape Features (Douglas Partners, 2021; SLR, 2021)

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Steep Slopes	Identified steep slopes within the Study Area.	Visual Inspection baseline one month before active subsidence period by a geotechnical engineer.	Monthly visual inspection during active subsidence period by a geotechnical engineer.	Quarterly visual inspection for 12 month following active subsidence period by a geotechnical engineer.
Agricultural Land	Identified agricultural land within the Study Area	Visual Inspection baseline one month before active subsidence period.	Monthly visual inspection during active subsidence period.	Quarterly visual inspection for 12 month following active subsidence period.

5.3 Baseline Monitoring for Future Extraction Plans

To assist in the preparation of future Extraction Plans, monitoring of steep slopes and agricultural land as outlined in **Table 5-2** would provide sufficient baseline data to assist the preparation of future extraction plans.

6 Subsidence Management Strategies

6.1 Mine Design Considerations

Tahmoor Coal submitted a Subsidence Management Plan Application (SMP Application) for Longwalls 31 to 37 in the Bulli Coal Seam in December 2014, which included longwalls in the Western Domain. The current mine plan has been modified since the 2014 SMP Application to consider feedback received following submission of the SMP Application in 2014, and additional information gathered from underground conditions. The revision of the mine plan has been redesigned specifically to avoid significant impact to the sensitive surface features of the environment, particularly avoiding mining directly under streams of third order or above. The revision of the mine plan also resulted in the re-orientation of longwalls in the Western Domain. Further discussion of mine design considerations is provided in **Section 3.6.1** of the Extraction Plan Main Document.

The current mine plan proposes to continue underground mining operations by the underground mining operations through the extraction of LW W3-W4 in the Western Domain, which will continue on from the active longwall series (LW W1-W2). The proposed LW W3-W4 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the previous longwall series (refer to **Figure 1-2**).

6.2 Management and Mitigation Measures

6.2.1 Agricultural Land

Tahmoor Coal will implement the following management and mitigation measures for agricultural land features if impacted during the extraction of LW W3-W4:

- Whilst there are no earthworks proposed during the extraction of LW W3-W4, 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.
- In the unlikely event of damage to fence tensioning or farm gate levels, Tahmoor Coal will remediate any damage in consultation with relevant landowner stakeholders.
- If impacts to tanks occur, the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017* and the LW W3-W4 Built Features Management Plan
- Tahmoor Coal has committed to “make good” provisions for any groundwater users shown to be adversely affected by mine operations and associated impacts (discussed in further detail in the LW W3-W4 Water Management Plan).
- 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, the mine would provide an alterative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

6.2.2 Surface Deformation or Surface Cracking

In response to observed subsidence impacts causing surface deformations or surface cracking, Tahmoor Coal will implement the following management measures:

- Install warning signs and/or danger tape in the immediate area if the cracking is consider a public safety risk;
- Plan and undertake site rehabilitation as soon as practical to remove any ongoing public safety risks. Site rehabilitation measures could include:
  - Backfilling or grout filling of surface cracking;
  - Re-profiling of compression humps;
  - Infilling of pot holes or subsidence related undulations developed; and
  - Securing of unstable structures or natural features, such as rock masses.

6.3 Trigger Action Response Plan

A TARP has been developed using the performance indicators for management of landscape features and agricultural land as a result of LW W3-W4 mining (refer to **Appendix A**). Level 1 of the TARP indicates that, based on monitoring results, the environment is performing within normal levels. Where performance indicators indicate that a level of risk has been triggered greater than a normal level (Levels 2 or higher with escalating corresponding risk), a response in the form of management / corrective actions is required to be implemented as outlined in the TARP.

6.4 Contingency Plan

In the event that performance measures are considered to have been exceeded or are likely to be exceeded, a response will be undertaken in accordance with the TARP provided in **Appendix A**. This response is a contingency plan that describes the management / corrective actions which can be implemented where required to remedy the exceedance.

If the event that a Corrective Action Management Plan is required in accordance with the TARP, this plan will be prepared in accordance with **Section 3.6.3** of the Extraction Plan Main Document. The success of remediation measures that has been implemented for any TARP exceedance would be reviewed as part of any Corrective Action Management Plan, the Annual Review and Six Monthly Subsidence Impact Reports (refer to **Section 6.1** of the Extraction Plan Main Document).

6.5 Adaptive Management Strategy

An Adaptive Management Strategy has been proposed to review mining-induced ground movement and impacts on the streams in proximity to LW W2 (Cedar Creek and Stonequarry Creek, particularly Pool SR17) to inform considerations for the amendment of the commencing position of LW W3. This strategy is discussed in more detail in **Section 3.6.4** and **Section 3.6.5** of the Extraction Plan Main Document.

While impacts to landscape features will be considered as part of the overall Adaptive Management Strategy, there are no adaptive management strategies proposed specifically to manage impacts to landscape features or agricultural land.

7 Review and Improvement

This section of the LMP describes the key elements of implementation relevant to the management of landscape features and agricultural land. A description of general reporting requirements, reviews and key responsibilities that are applicable to extraction of LW W3-W4 are discussed in the Extraction Plan Main Document.

7.1 Reporting Requirements

Generic reporting requirements for the LW W3-W4 Extraction Plan are discussed in **Section 6.1** of the Extraction Plan Main Document. There are no reporting requirements specific to the management of landscape features and agricultural resources identified for the extraction of LW W3-W4.

7.2 Review and Auditing

Generic review and auditing requirements for the LW W3-W4 Extraction Plan are discussed in **Section 6.2** of the Extraction Plan Main Document. There are no review or auditing requirements specific to the management of landscape features and agricultural resources identified for the extraction of LW W3-W4.

7.3 Roles and Responsibilities

Generic roles and responsibilities applicable for the implementation of the LW W3-W4 Extraction Plan are discussed in **Section 6.3** of the Extraction Plan Main Document. There are no roles and responsibilities specific to the implementation of landscape features and agricultural resources management measures identified for the extraction of LW W3-W4.

8 Document Information

This section provides a compiled list of references, related documents, terms, and abbreviations used in this document. In addition, this section provides the change information for this document.

8.1 References

Bureau of Meteorology (2020), BoM Website accessed November 2020, www.bom.gov.au

Department of Planning and Environment (DPE) (2015), Draft Guidelines for the Preparation of Extraction Plans V5.

Douglas Partners (2021), Report on Geotechnical Assessment, Extraction Plan Longwall West 3 and West 4, prepared for Tahmoor Coal, March 2021, document 89541.03.R.001.Rev1.

SLR (2021), Tahmoor Extraction Plan LW W3-W4 Land and Agricultural Resource Assessment, prepared for Tahmoor Coal, document 630.12732-R01-v1.0.

Mine Subsidence Engineering Consultants (2021), Tahmoor Coal – Longwalls W3 and W4, Subsidence Predictions and Impact Assessments for Natural and Built Features due to the Extraction of the Proposed Longwalls W3 and W4 in Support of the Extraction Plan Application. Prepared for Tahmoor Coal, March 2021, document MSEC1112.

8.2 Glossary of Terms

The Extraction Plan Main Document provides a compiles Glossary of Terms in **Section 8.3**.

8.3 Abbreviations

Abbreviations used in this document are provided below in **Table 8-1**.

Table 8-1 Abbreviations

Abbreviation	Definition
AHD	Australian Height Datum
BOM	Bureau of Meteorology
DPE	NSW Department of Planning and Environment (now DPIE)
DPIE	NSW Department of Planning, Industry and Environment (formerly DPE)
DPI Agriculture	NSW Department of Primary Industries – Agriculture
km	Kilometre/s
LMP	Land Management Plan
LW	Longwall
LW W1	Longwall West 1
LW W1-W2	Longwalls West 1 to West 2
LW W2	Longwall West 2
LW W3-W4	Longwalls West 3 to West 4
LW W4	Longwall West 4

Abbreviation	Definition
m	Metre/s
mm	Millimetre/s
ML	Mining Lease
Resources Regulator	Department of Regional NSW – Resources Regulator
SMP Application	Subsidence Management Plan
Tahmoor Coal	Tahmoor Coal Pty Ltd
Tahmoor Mine	Tahmoor Coal Mine
TARP	Trigger Action Response Plan

8.4 Change Information

Table 8-2 provides the details of document history of this Extraction Plan.

Table 8-2 Document History

Version	Date Reviewed	Reviewed By	Change Summary
1.0	May 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	New document

Appendix A – Trigger Action Response Plan

Trigger Action Response Plan – Land Management Plan

Feature	Management		
	Trigger	Action	Response
Steep slope damage or instability	Level 1		
	• Surface cracking < 10 mm wide on slope	• Continue monitoring in accordance with the monitoring program.	• No response required.
	Level 2		
	• Surface cracking 10 – 20 mm wide on slope	• Continue monitoring in accordance with the monitoring program. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs and restrict access to areas where necessary.	• As defined by the Tahmoor Coal Environmental Response Group. • Repair cracks at the completion of the active subsidence period.
	Level 3		
	• Surface cracking > 20 mm wide, tree fall.	• Increase frequency of monitoring by geotechnical consultant to weekly during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs and restrict access to areas where necessary. • Geotechnical engineer inspection to determine need for further action/investigation.	• Notify relevant Government Agencies and other stakeholders. • Repair cracks at the completion of the active subsidence period.

Feature	Management		
	Trigger	Action	Response
Surface cracking of landform	Level 1		
	• Surface cracking < 10 mm wide.	• Continue monitoring in accordance with the monitoring program.	• No response required.
	Level 2		
	• Surface cracking 10 – 20 mm wide.	• Continue monitoring in accordance with the monitoring program. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs and restrict access to areas where necessary.	• As defined by Tahmoor Coal Environmental Response Group. • Repair cracks at the completion of the active subsidence period.
	Level 3		
	• Surface cracking > 20 mm wide.	• Increase frequency of monitoring by geotechnical engineer to weekly during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs and restrict access to areas where necessary. • Geotechnical engineer inspection to determine need for further action/investigation.	• Notify relevant Government Agencies and other stakeholders. • Repair cracks > 20 mm in width with excavation, grouting and re-compaction where practical.

Feature	Management		
	Trigger	Action	Response
Agricultural land	Level 1		
	• Vertical subsidence within predicted range. • Negligible impact to agricultural productivity or use of the land. • Negligible change to ponding. • No or minor impact to buildings or improvements. • Negligible increase in soil or tunnel erosion.	• Continue monitoring in accordance with the monitoring program.	• No response required.
	Level 2		
	• Impact to agricultural land from subsidence or increased flooding or ponding within predicted impacts. • Minor increase in ponding or changes to drainage systems that can be remediated.	• Continue monitoring in accordance with the monitoring program. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Tahmoor Coal Environmental Response Group. • Repair any subsidence impacts at the completion of the active subsidence period.
	Level 3		
	• Significant impact and change to agricultural land functionality or agricultural productivity greater than predicted.	• Increase frequency of monitoring to weekly during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs and restrict access to areas where necessary.	• Notify relevant Government Agencies and other stakeholders. • Repair any subsidence impacts at the completion of the active subsidence period with excavation, re-levelling and re-compaction where required.

Appendix B – Geotechnical Assessment

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Assessment
Longwalls W3 and W4, Picton

Prepared for
Tahmoor Coal Pty Ltd

Project 89541.06
March 2021

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	89541.06	Document No.	R.001.Rev1
Document title	Report on Geotechnical Assessment		
Site address	Longwalls W3 and W4, Picton		
Report prepared for	Tahmoor Coal Pty Ltd		
File name	89541.06.R.001.Rev1		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Rev0	Roderick Haselden	John Braybrooke	17 March 2021
Rev1	Roderick Haselden	John Braybrooke	22 March 2021

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			22 March 2021
Reviewer		for: John Braybrooke	22 March 2021

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Douglas Partners
Geotechnics / Environment / Groundwater

Table of Contents

Report on Geotechnical Assessment
Geotechnical Land Management Plan
Longwalls W3 and W4, Picton

1. Introduction

This report presents the results of a geotechnical assessment for landscape features within the Subsidence Study Area (SSA) of Longwalls (LW) West 3 (W3) and West 4 (W4). The assessment was commissioned in an email dated 22 September 2020 by Ms April Hudson of Tahmoor Coal Pty Ltd (TC) and was undertaken in accordance with Douglas Partners' proposal WOL200362.P.001.Rev1 dated 3 September 2020.

It is understood that TC plans to mine a further two panels, LW W3 and W4, in the Western Domain of Tahmoor Mine using longwall extraction methods. The aim of this geotechnical assessment was to:

Review the provided information and studies related to subsidence to provide context to the impact on surface features for LW W3 and W4;

Identify the potential risks to land features, namely cliffs, rock face features, steep slopes and farm dams within the SSA due to mine subsidence;

Risk assess these features to identify the likely consequence of subsidence-induced instability; 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 an experienced engineering geologist. The details of the assessment are presented in this report, together with comments and recommendations for the items list 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 SSA were unavailable for site inspections. Inspections may be required in the future to evaluate the impact of subsidence on those features.

2. Project Definitions

The Landslide Risk Management Guidelines prepared by the Australian Geomechanics Society (AGS, 2007), provide the following definitions for cliffs and steep slopes:

Cliff – Slope appears vertical and ranges between 64° and 84°;
Extreme Slope – need rope access to climb slope and ranges between 45° and 64°;
Very Steep Slope – Can climb by clutching at vegetation, rocks, etc and ranges between 27° and 45°;
Steep Slope – Walkable with effort and ranges between 18° and 27°;

Moderate Slope – Walkable and ranges between 10° and 18°; and
Gentle Slope – Easy walking and ranges between 0° and 10°.

In order to incorporate the predicted effects of mine subsidence on the landscape features and to maintain consistency with the impact assessment methodology used on cliffs and slopes, the definitions provided in Table 1 have been adopted in this report. The details given in Table 1 are based on the precedents in other coal fields with similar mining and surface conditions.

Table 1: Definition of Terminology used to describe Surface Features

Feature	Definition by geometry	Impacts due to subsidence
Cliff	A continuous rock face, including overhangs, greater than 20 m in length, a minimum height of 10 m and a minimum slope of 0.5:1 (H:V, ie > 63.4°)	Tilting and cracking resulting in collapse of overhangs, wedge and toppling failures; rock fall roll outs, felling trees and creating public safety hazards. Permanent landscape changes.
Minor Cliff	A continuous rock face, having a minimum length of 20 m, heights between 5 m and 10 m and a slope greater than 0.5:1 (H:V, ie >63.4°) or a rock face having a maximum length of 20 m and a height between 10 m and 20 m.	Tilting and cracking resulting in collapse of overhangs, wedge and toppling failures; rock fall rollouts, felling trees and creating public safety hazards. Temporary to permanent landscape changes.
Cliff Terrace	A combination of two to five minor cliffs in close proximity, which results in a stepped surface profile. The average slopes between upper and lower cliffs range between 50° and 60° with a total cliff height of between 10 m and 25 m.	Tilting and cracking resulting in collapse of overhangs, wedge and toppling failures: rockfall roll outs, felling trees and creating public safety hazards. Temporary to permanent landscape changes.
Rock Outcrop	A discontinuous rock face (<20 m in length) having heights < 5 m and slope > 63.4°	Tilting and cracking resulting in collapse of overhangs, wedge and toppling failures: rock fallouts, felling trees and creating public safety hazards. Temporary landscape changes.
Very Steep Slopes*	An area of land having a gradient of between 1:1 (H:V, ie 45°) and 0.5:1 (H:V, ie 63.4°). This includes precariously located boulders fallen from cliffs.	Tilting and cracking resulting in landslip failures; felling trees and creating public safety hazards, Permanent to temporary landscape changes.
Steep Slopes+	An area of land having a natural gradient ranging between 3:1 to 1:1 (H:V, ie 18.4° to 45°). This includes precariously located boulders fallen from cliffs.	Tilting and cracking resulting in landslip failures; felling trees and creating public safety hazards. Permanent to temporary landscape changes.

* Very steep slopes are generally located within cliff line terraces.
+ Steep slopes generally exist below the cliff terraces, minor cliffs and rock outcrops and can extend for 100 m or more.

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, New South Wales (NSW). LW W3 and W4 are located in the 'Western Domain', which is located northwest of the Main Southern Rail (MSR) between the townships of Thirlmere and Picton (refer Figure 1).

Tahmoor Mine is operated by Tahmoor Coal and 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 33 longwall panels to the north and west of Tahmoor Mine's current pit top location, and is currently extracting LW W2, which commenced on 7 December 2020. It is anticipated that LW W3 will commence in late 2021.

This study covers the surface area located within the 20 mm predicted subsidence contour and the 35 degree angle of draw from the extents of LW W3 and W4 (refer Figure 1 and Drawing 1 in Appendix B). The proposed extraction of LW W3 and W4 will extend underground coal mining to the west of the Main Southern Railway and to the south east of the Picton Mittagong Loop Line in the Western Domain (refer Figure 1). The surface footprint of these longwall panels is located to the south and east of Stonequarry Creek and Matthews Creek and Cedar Creek, respectively.

Both of the longwalls (LW W3 – W4) are planned to be 283 m and 285 m wide, respectively, with tailgate chain pillar widths in between the longwalls of 39 m and 44 m, respectively (refer Figure 1). The total lengths for LW W3 and W4 are about 1550 m and 1005 m, respectively. The panels will extract the Bulli Seam from north to south. The extraction height is proposed to be constant at 2.15 m. The Bulli Seam dips towards the north east with an average gradient of 5% across the mining area. Based on the information provided by the client, the lowest level of the seam floor is about RL-295 m relative to Australian Height Datum (AHD). The depth of cover directly above the proposed longwall varies between a minimum of 470 m above the commencing end of LW W3 and a maximum of 540 m on the western edge of LW W3.

The surface level contours within the Subsidence Study Area (SSA) indicate that the highest point of topography is about 272 m AHD in the ridge line near the central western part of LW W3. The surface topography is hilly with valleys and ridges with the lowest level being about 160 m AHD in Stonequarry Creek in the north of the SSA. The surface area primarily comprises rural residential and low-density residential developments with properties used for housing, hobby farms, stock grazing and orchards. 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 SSA for LW W3 and W4 consists of steep slopes and is devoid of any cliffs, terraces, rock outcrops and very steep slopes. Steep slopes are indicated on the flanks of ridges in the SSA and also located along the banks of Stonequarry Creek and an unnamed tributary of Redbank Creek. Steep slopes such as dam walls, embankments and cut batters were also identified by the LiDAR survey. 25 properties have been identified as containing structures close to steep slopes (refer Drawing 1).

A total of 17 dams are located within the SSA for LW W3 and W4, of which, 5 dams are located directly over the longwall (refer Drawing 1).

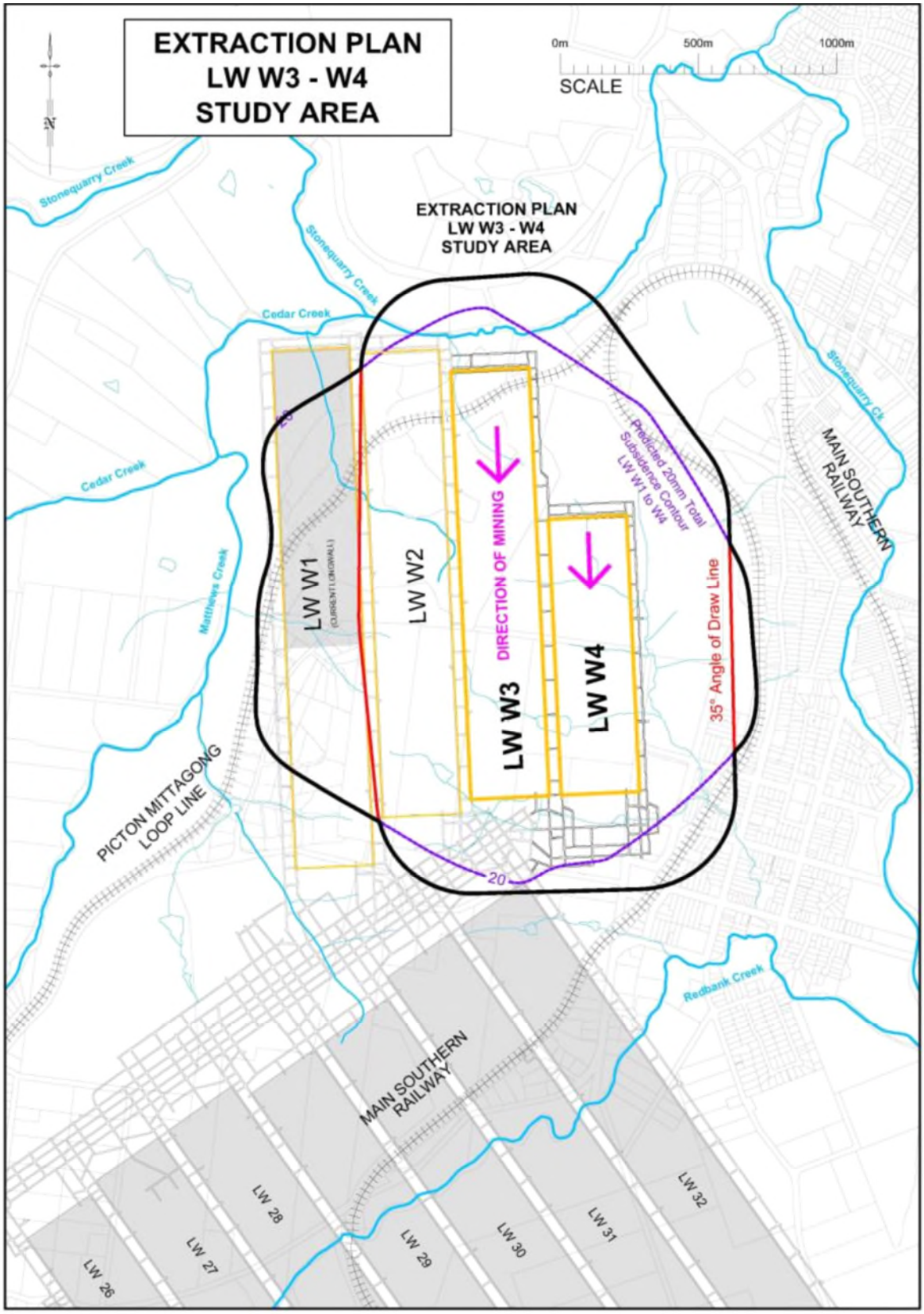

Figure 1: Study Area for Subsidence Effect on Land Features (Courtesy TC)

The SSA also contains sections of the Picton to Mittagong Loop Line heritage railway and the Main Southern Line. It is understood that both of these features, which include cuttings, embankments and tunnels, will be subject of separate geotechnical assessments and are therefore not included in this report.

4. Information Review

4.1 Information Provided by TC

TC previously 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:

GeoTerra report titled "Longwall Panels 31 to 37 – Streams, Dams & Groundwater Assessment";

GHD report titled "Landslide Risk Assessment of Identified 'Steep Slopes' Principally Affected by Retreat of LW 28";

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 "Tahmoor Colliery Subsidence Impact Upon 'Steep Slopes' over LW 24 to LW26";

SCT report titled "Tahmoor Coal – Investigation into the Potential Impact on the Nepean Fault on Subsidence Adjacent to LW 32;

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;

MSEC report MSEC1073 Rev34 titled "Tahmoor LW W1 Subsidence Monitoring Report"; and

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".

4.2 Geological Setting

The study area lies within the Southern Coalfield, part 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 four 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 forms the immediate and main roof. 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 which has a thickness of up to 185 m, and Ashfield Shale. Much of the surface in the SSA is mapped as being underlain by Ashfield Shale of the Wianamatta Group having a thickness of a few tens of metres. The Mittagong Formation is a transitionary unit between the Ashfield Shale and Hawkesbury Sandstone, which consists of interbedded shale, laminite and fine grained sandstone. The Hawkesbury Sandstone and Mittagong Formation crop out along the incised and downstream sections of the local creeks and watercourses. The typical stratigraphic section in the SSA is shown in Figure 2.

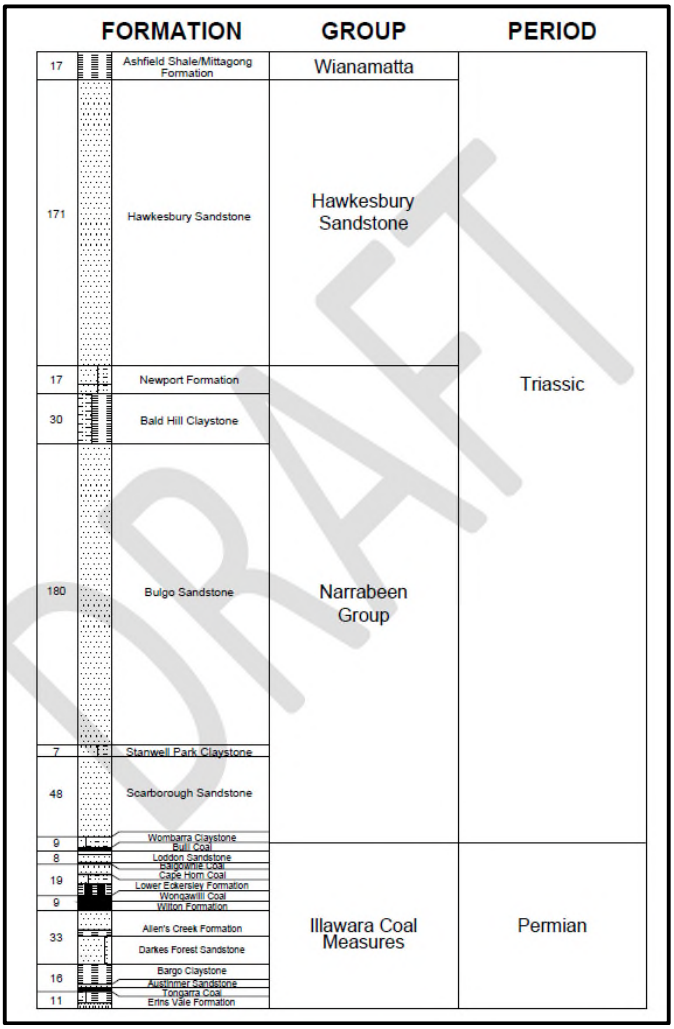

Figure 2: Typical Geological Stratification at Tahmoor (Courtesy MSEC, 2019)

The Ashfield Shale forms the upper surface of the SSA, which is deeply dissected by numerous streams exposing sandstone of Hawkesbury Sandstone formation. Incision tends to follow the dominant joint directions in the rock (ie northwest and northeast) and it is possible that this influences the orientation of the long axis of the valley in which the creeks are formed. The sandstone rocks tend to break up into large blocks due to weathering along the joint planes and near-horizontal bedding planes.

The Nepean Fault Zone is located within the eastern section of the SSA and passes close to the north eastern corner of LW W4. The fault zone is described as a first order fault zone and comprises a number of faults.

4.3 Previous Impacts of Mine Subsidence

No slope instability has been reported in the hillsides in nearby mining areas with similar topography. 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.

Mine subsidence during the extraction of LW W1 has been reported by MSEC as currently being about 50% of mine subsidence predictions (ie a maximum subsidence of 212 mm at the completion of LW W1), which has been similar to mine subsidence behaviour observed during the extraction of LW 901 at Appin Colliery, which was also the first panel in a new series of long walls. Discussions with MSEC have indicated that the subsidence predictions may be closer to predictions following the completion of additional longwalls as the overall span of the across the longwall panels increases.

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 LW W1 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 W3 and W4

Based on the MSEC's 2021 report for LW W3 and W4:

The maximum predicted incremental subsidence results due to extraction of LW W3 and W4 (studies on calibrated numerical model by MSEC1112) are reported in Table 2.

Table 2: Predicted incremental subsidence details for LW W3 and W4 (MSEC1112, 2021)

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 W3	650	4.5	0.05	0.09
LW W4	600	4.5	0.05	0.08

The maximum predicted total subsidence results due to extraction of LW W3 and W4 (studies on calibrated numerical model by MSEC1112) are reported in Table 3.

Table 3: Predicted total subsidence details for LW W3 and W4 (MSEC1112, 2021)

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 W3	950	5.0	0.06	0.10
LW W4	1025	5.0	0.06	0.10

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

Table 4: Predicted maximum strains during extraction of LW W1 and W2 (MSEC1112, 2021)

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	1.7	1.0	0.5	0.6
99% confidence level	3.3	1.5	0.8	1.0

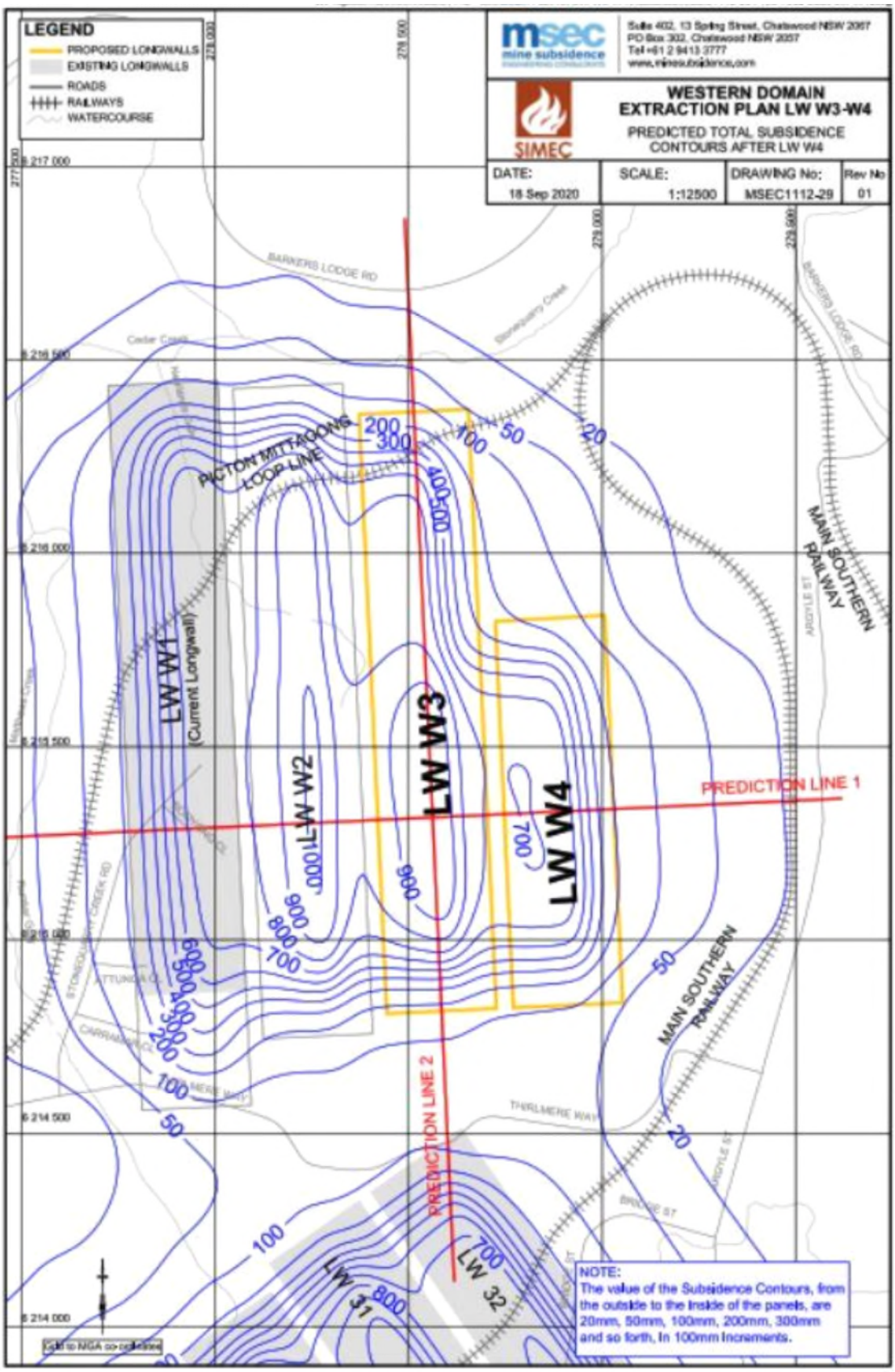

Figure 3: Total mine subsidence following extraction of LW W4 (courtesy MSEC).

5. Field Work

Site inspections of the landscape features within the SSA were undertaken by an experienced engineering geologist on 15, 16 and 26 October 2020, 30 November 2020 and 1 December 2020. In addition to these inspections, DP carries out monthly inspection of surface features within the active subsidence zone for LW W1 and W2, which includes an area of overlap with the SSA discussed in this report. 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.

DP carries out inspections of Stonequarry Creek as part of the monitoring program for LW W1 and W2. Within the SSA the creek comprises a meandering watercourse flowing from west to east along the northern side of the LW W3 and W4 SSA. The creek includes shallow and deep ponds and rock bars and is ephemeral during extended periods of low rainfall.

Areas with steep slopes in the LW W3 and W4 SSA are shown on Drawing 1. The areas of steep slopes with a structure or group of structures located within or adjacent to these areas were identified from LiDAR data and aerial photography, which includes several dwellings that have been constructed at the crest or near the toe of steep slopes. It is understood that as part of the subsidence management for LW W3 and W4, building inspections are carried out for all structures within the SSA. Inspections for steep slopes within the SSA were limited to accessible slopes adjacent to identified structures where permission to enter properties was granted.

The locations of farm dams were identified from surface topography contours and LIDAR data (refer Drawing 1 in Appendix B). The farm dams within the SSA are man-made structures and rely on rainfall for their impoundment. These farm dams are generally up to about 4 m high, although a few dams (FD1, FD3, FD7 and FD12) were up to about 7 m high, and appear to have been constructed by forming shallow embankments across dry valleys. During the previous assessment for LW W1 and W2, which was carried out during an extended period of below average rainfall, some of the farm were observed to be dry.

The following observations were made during inspections of steep slopes and farm dams within the SSA:

Spillways had been excavated into the steep hillside abutments for both FD1 and FD3.

Spillways had also been constructed around the edges of FD4, FD5, FD7, FD8, FD12 – FD16 and FD18. FD5 also included a culvert to discharge overflow.

FD6 has a large slot through the centre of the embankment from a previous failure. The slot is estimated to be up to 2.5 m high and up to 1.5 m wide. While there is still limited water storage capacity in the dam, its capacity has been drastically reduced. Anecdotal information provided by a farmer that runs cattle on the site indicates a wombat hole was previously located in the embankment. There were no signs of a wombat hole during the current inspection. Review of historic aerial photography on Metromap.com.au indicates that the slot in the embankment was present in July 2018 (ie prior to the mining of Longwall W1) and the embankment was intact in December 2016, however, there are signs of erosion of the embankment in the vicinity of the slot, probably from overtopping. In its current state the damage to the existing farm dam is not considered to increase the risk to the Picton Mittagong Loop Line downslope. It is expected that erosion of the embankment will continue, over time, that will result in the total loss of storage capacity.

There has been no access to FD9 for the current assessment or for monthly geotechnical inspections for LW W1 and W2.

Two wombat holes have been observed through the FD11 embankment. The wombat holes could provide a preferential pathway for water through the embankment resulting in piping (ie internal erosion) and possibly failure of the embankment. As FD11 has a relatively small storage capacity (estimated to be approximately 0.4 ML by MSEC) and there are no structures between it and Rumker Gully, if failure of this farm dam were to occur the consequence category remains unchanged (ie at *Very Low*) from DP's November 2019 report.

Loose material has been placed in front of the face of FD13. The grass in the loose material was lush and green, indicating potential seepage through the face. The material may also indicate buttressing of a previous failure in the downstream face.

Recent remedial works had been carried out in the downstream face of FD15 including the clearing of vegetation, re-grading and possibly the construction of a new spillway. The works may be indicative of repairs to recent damage to the downstream face.

Erosion rills up to 0.4 m deep were observed on the downstream face of FD17 and a sheet of sediment had been deposited below the downstream face, which indicates that the dam has previously been overtopped.

The steep slope to the east of 36 Star Street has a dense cover of shrubs and is generally inaccessible.

6. Comments

6.1 General

Incremental and total subsidence due to longwall mining of LW W3 and W4 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 features within the mining lease before subsidence occurs. Out of the various features mentioned in DOP (2008), this study focusses on cliff lines, steep slopes and farm dams. 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 SSA are assessed in the following sections of this report.

Due to the nature of 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. The procedure recommended by Australian Geomechanics Society publication *Practice Note Guidelines for Landslide Risk Management 2007* (AGS, 2007) was used to evaluate the steep slopes. The farm dams are evaluated using the Small Dam Consequence Screening tool (VIC DEPI, 2014). As noted earlier in the report, no cliff line features were identified within the SSA.

6.2 Assessment of Steep Slopes

6.2.1 General

As discussed in Section 2, steep slopes are defined as an area of land having a natural slope angle of between 18.4° and 45°. The 1 m surface level contours, generated from the LIDAR survey of the area, provided information regarding the steep slopes in the SSA. The SSA above LW W3 and W4 consists of numerous steep slopes (slope angles typically between 20^0 to 40^0) with shallow residual soil cover underlain by Ashfield Shale. In this section, assessment of steep slopes is discussed with reference to the presence of structures and human life near the slopes. Residential and other structures constructed on or adjacent to steep slopes or within the run-out distance of potential landslides were identified by aerial photography and LiDAR data. The steep slopes are evaluated by considering the likelihood of failure and the impact on structures in the vicinity. Assessment of individual residential structures are beyond the scope of this work. However, field inspection was carried out to ascertain the vulnerability of identified structures. Steep slopes were also located along the banks of Stonequarry Creeks and an unnamed tributary of Redbank Creek. Accessibility to the creeks banks was also limited to properties where access arrangements were in place at the time of the assessment. Some of these steep slopes are directly above LW W3 and W4 and will be affected by the predicted mine subsidence.

The soils in the SSA may be differentiated in terms of the parent material from which they are derived. On the one hand are the residual soils developed on the Wianamatta Shale ridge-tops and on the other, potentially weakly developed soils in the colluvial material of the lower slopes and the alluvial material within the creeks. The ridge-top soils appear to be generally shallow (0.3 – 1.5 m) and undifferentiated into horizons, except for the accumulation of organic matter at the surface.

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 W3 and W4; 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. Future changes to the surface profile due to building development and site excavations are not considered in this risk assessment. Each of the sites was assessed on the basis of the estimated likelihood and extent of landsliding in relation to infrastructure that was able to be identified from aerial photographs and 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 structures considered in the assessment includes those identified on MSEC draft plans.

6.2.2 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 a landslide 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 landslides.

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 landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides 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.

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. 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.

Landslide Susceptibility – A quantitative or qualitative assessment of the classification, volume (or area) and spatial distribution of landslides 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 landslide.

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 landslide 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 the landslide.

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 5 to 7.

Table 5: 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	> 10	> 10	> 10	10^{-1}
High	1 to 10	1 to 10	1 to 10	10^{-2}
Moderate	0.1 to 1	0.1 to 1	0.1 to 1	10^{-2} to 10^{-4}
Low	0.01 to 0.1	0.01 to 0.1	0.01 to 0.1	10^{-5}
Very Low	<0.01	<0.01	<0.01	10^{-8}

Table 6: Descriptor for Risk Zoning using Life Loss Criteria

Annual probability of death of the person most at risk in the zone	Risk zoning descriptors
> 10^{-3}/annum	Very High
10^{-4} to10^{-3}/annum	High
10^{-5} to 10^{-4}/annum	Moderate
10^{-6} to 10^{-5}/annum	Low
< 10^{-6}/annum	Very Low

Table 7: 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 life for the person most at risk from instability of existing slopes of 10^{-4}. This level has been adopted for the purposes of risk calculations in this study.

6.2.3 Structures at Risk

A review of aerial photography together with the site inspections indicates 24 dwellings and a total of 29 structures or groups of structures are present in the vicinity of steep slopes, although no structures are located on the steep slopes. Many of these structures are located on the eastern side of Stonequarry Creek Road or associated with the ridgelines with the SSA. The structures have been separated into six regions with similar characteristics for the purpose of the slope stability assessment (refer Drawing 2 in Appendix B). The details of the topography in these regions are presented in Table 8. Based on the site inspections, a few structures were identified to be close to steep slopes and may be affected by slope instability. The structures are tabulated in Table 9.

6.2.4 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 W3 and W4 SSA may occur in a variety of forms and incorporate varying proportions of soil, rock, and water. Based on the field observation and understanding of the area, the types of slope instability that the identified steep slopes may undergo is described as follows:

Type 1 – Extremely slow soil creep in steep slopes and accumulated colluvium, typically within the upper 1.5 m to 2.0 m of the soil profile. While soil creep may not occur on many of the sites above and below the steep slopes, it may be a precursor for landsliding.

Type 2 – Very rapid, shallow soil slumping and rotational failures through colluvial and residual soils on steep slopes with the low potential to run-out into downslope properties.

Type 3 – Slow to rapid, intermediate-depth failures through colluvial and residual soil and potentially into the extremely to highly weathered bedrock on steep slopes with the moderate potential for slope regression into sites on the ridgeline or run-out into downslope properties.

Type 4 – Very slow, deep-seated landslide extending through the soil and upper rock profile with a high potential for slope regression into sites on the ridgeline or run-out into downslope properties.

Type 5 – Moderate to rapid, shallow and intermediate depth soil failures triggered by creek bank erosion with a moderate potential for regression of the creek banks into the site.

Structures in Regions 1 – 5 (refer Drawing 2 in Appendix B) have the potential slope instability Types 1 – 4. Region 6 has the potential for Type 5 slope instability. The trigger for such failures can include major storms, extended periods of rainfall and earthquake events. Poor development practices in adjacent areas can also increase the risk of slope instability.

Table 8: Details of Areas containing Structures at Risk in the SSA

Region	Details of the slope		Slope Height (m)	Horizontal Extent of the Slope (m)
	Maximum Elevation of Slope (m ADH)	Minimum Elevation of Slope (m AHD)		
1	270 – 286	230 – 250	30 – 40	30 – 220
2	270 – 286	220 – 250	30 – 40	30 – 210
3	225 – 240	210 – 220	15 – 20	100 – 150
4	240 – 250	200 – 205	35 – 50	100 – 160
5	225	200	25	50 – 90
6	169	174	5	10 – 20

Table 9: Inspected Structures near the Steep Slopes in the SSA

Region	Remarks	Reference	Constructed on Slope	Distance from Steep Slope (m)	Relative to Steep Slope
Region 1	Inspected	14SCR	GS – MS	50	downslope
		18SCR*	MS	< 5	downslope
		26SCR	MS	< 5	downslope
		3BC	GS	15	downslope
		5BC	MS	< 5	downslope
		7BC	MS	25	downslope
		5AC	GS – MS	40	downslope
		6AC	MS	5	upslope
		7AC	MS	<5	downslope
	Not inspected	16SCR	MS	<5	upslope
		2BC	GS	20	downslope
		4BC	GS – MS	15	downslope
		6BC	GS – MS	30	downslope
		8BC	GS – MS	35	downslope
Region 2	Inspected	664TW/1 – /2	GS	20	upslope
		700TW/1 – d/2	GS – MS	< 5	upslope
	Not inspected	10AC	GS	20	upslope
Region 3	Inspected	34SS	GS – MS	20	upslope
		2-10CCr	GS – MS	15	downslope
	Not inspected	786TW	GS – MS	10	downslope
Region 4	Inspected	36SS/1 – /2	GS	10	upslope
		36SS/3 – /4	GS	<10	upslope
Region 5	Not inspected	WTP	GS – MS	<10	downslope
Region 6	Not inspected	3SC/1 – /2	GS	<10	upslope

where:
AC = Attunga Close
BC = Booyong Close
CC = Connellan Crescent
SC = Stargard Crescent
GS = gentle slope (5 – 10°)
SS = Star Street
SCR = Stonequarry Creek Road
TW = Thirlmere Way
WTP = Water Treatment Plant
MS = moderately steep slope (10 – 18°)

6.2.5 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 SSA. These tilt movements are not expected to be sufficient to trigger soil movement or a landslide, 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;

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 1.5 mm/m within this SSA 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. The estimated subsidence movements on the surface within the SSA are unlikely to produce cracking of significant dimension in the identified regions except in Region 1. In the case of non-systematic (downslope) movements, there is potential for increased tension and cracking at the tops of slopes which could potentially lead to landslips. The steep slopes in Regions 1 – 5 are well drained and ponding of water on the crest or slopes is not anticipated.

Maximum incremental and total mine subsidence predictions for LW W3 and W4 SSA are order of 650 mm and 1025 mm, respectively. Subsidence will take place over a broad subsidence bowl, due to the depth of mining (greater than 470 m), such that incrementally the changes in relief across the area will generally be minor. Slope instability incidents may occur in the areas where large subsidence gradients (ie in the areas above the eastern sides of LW W3 and W4). 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 landslide risk due to mine subsidence such as curvature, stress and strains, however tilt (or slope change) was considered more likely to influence landslide risk rather than these other mechanisms. The structures directly above the longwall excavation could experience cracking and damage. The assessed risk levels to property due to slope instability are provided in Table 10. The assessment indicates that the risk of slope instability for the assessed hazards prior to mining is in the range of *Very Low to Moderate*, which is within the *Acceptable* to *Tolerable* risk ranges when assessed in accordance with AGS (2007). The assessed level of risk was unchanged during and following longwall mining (ie due to mine subsidence) of LW W3 and W4 provide management and monitoring of the regions is carried out during active mine subsidence through the Trigger Action Response Plan (TARP).

Table 10: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures

Regions	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
1 and 5	Periodic soil creep for structures located on moderately steep slopes	Minor for dwellings not designed for soil creep	Possible to Likely	Moderate	Possible to Likely	Moderate
		Insignificant for dwellings designed for soil creep	Possible to Likely	Very Low to Low	Possible to Likely	Very Low to Low
	Very rapid, shallow soil slumping and rotational failures	Insignificant to Minor (little damage, tidy and repair)	Possible to extend to structures located 15 m from steep slopes	Very Low to Low	Possible to extend to structures located 15 m from steep slopes	Low
			Unlikely to extend to structures in excess of 15 m from steep slopes	Very Low	Unlikely to extend to structures in excess of 15 m from steep slopes	Very Low
	Slow to rapid, intermediate-depth failures	Minor to Medium (damage to structure, part of the site requiring stabilisation)	Unlikely	Low	Unlikely	Low
	Very slow, deep-seated landslide	Major to Catastrophic (extensive damage and significant stabilisation works)	Rare	Low to Moderate	Rare	Low to Moderate

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

Table 10: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures (cont'd)

Regions	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
2 and 4	Soil Creep	Minor for dwellings not designed for soil creep	Possible to Likely	Moderate	Possible to Likely	Moderate
		Insignificant for dwellings designed for soil creep	Possible to Likely	Moderate	Possible to Likely	Moderate
	Very rapid, shallow soil slumping and rotational failures	Insignificant (little damage)	Unlikely to regress >5 m into upslope properties	Very Low	Unlikely to regress >5 m into upslope properties	Very Low
	Slow to rapid, intermediate-depth failures	Minor to Medium (damage to structure, part of the site requiring stabilisation)	Unlikely to regress >10 m into upslope properties	Low	Unlikely to regress >10 m into upslope properties	Low
	Very slow, deep-seated landslide	Major to Catastrophic (extensive damage and significant stabilisation works)	Rare	Low to Moderate	Rare	Low to Moderate

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

Table 10: Assessment of Slope Instability Hazards Due to Mine Subsidence Affecting Structures (cont'd)

Regions	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
3	Soil Creep	Insignificant for dwellings located on gentle slopes.	Barely Credible	Very Low	Barely Credible	Very Low
	Very rapid, shallow soil slumping and rotational failures	Insignificant (little damage)	Unlikely	Very Low	Unlikely	Very Low
	Slow to rapid, intermediate-depth failures	Minor to Medium (damage to structure, part of the site requiring stabilisation)	Rare	Very Low to Low	Rare	Very Low to Low
	Very slow, deep-seated landslide	Major to Catastrophic (extensive damage and significant stabilisation works)	Barely Credible	Very Low to Low	Barely Credible	Very Low to Low
6	Moderate to rapid, shallow and intermediate depth failure of creek banks	Minor (part of the site requiring stabilisation)	Possible	Moderate	Possible	Moderate

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

6.3 Assessment of Farm Dams

Site inspection of the farm dams were carried out with the exception of FD19, where permission to access was not granted. It is further noted that FD9 and FD10 are outside the current study area. The following information was obtained by the site inspection, the LiDAR survey, aerial photography, contour and topographic maps.

In total, 17 small farm dams are located within the SSA of LW W3 and W4 (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 11. The farm dam capacities vary from about 0.2 ML to 30 ML. The topography around the identified farm dams can be classified as steep, however, most of the dams are situated at the toe of the slope. The predicted subsidence that the farm dams located above the longwall panels will be subjected to is in the order of 650 mm incremental subsidence (ie during extraction of a single longwall) and 1025 mm total subsidence. The dams are of earth fill construction and have been established by localised cut and fill operations within valley floors. The farm dams are generally shallow with the maximum wall heights for 13 of the farm dams estimated to up to about 4 m and up to 7.5 m for the remaining four farm dams.

Table 11: Details of Farm Dams

Farm Dam No.	Northing (MGA)	Easting (MGA)	Estimate Maximum Wall Height (m)	Approximate Surface area (m^2)	Estimated Volume (ML)
FD1	278660	6214760	6.0	15000	30
FD2	278390	6214850	1.0	130	0.15
FD3	278770	6215080	5.0	7250	14.5
FD4	278580	6215130	2.7	3850	7.7
FD5	277850	6215420	3.0	3550	7.1
FD6	278210	6215830	2.5	900*	0.6*
FD7	278490	6216120	7.5	5100	10.2
FD8	278750	6215580	4.0	1480	3.0
FD12	278350	6214890	4.5	3100	6.2
FD13	279050	6215480	3.0	2750	5.5
FD14	279040	6215110	2.0	1200	2.4
FD15	279060	6215750	3.0	1200	2.4
FD16	278880	6215700	3.2	1250	2.5
FD17	279220	6215510	4.0	1300	2.6
FD18	278990	6214740	1.5	1580	3.2
FD19	279010	6216350	1.7	750	1.5
FD20	278800	6216270	2.0	260	0.5

Notes: * Reduced estimated dam capacity (ie considering slot in dam embankment).

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 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.

In the present study, farm dams having capacity of 1 ML or more have been considered for analysis based on the volume that could have a significant impact (Table 9). It is noted that DP carried out detailed assessments for FD5 and FD7 including dam break analyses as part of the assessment for LW W1 and W2 (DP, 2020). There are dwellings located between Rumker Street North and a rail embankment for MSL located to the east of Rumker Street North, which are downstream of a number of the farm dams. Farm Dams FD3 – FD8, and FD12 lie directly above the longwall panels where the predicted total subsidence varies between 650 mm to 1025 mm after the extraction of LW W3 and W4. Farm Dams FD5, 7, 12 and 16 will also be subject to total differential subsidence in excess of 100 mm. Cracking of the top surface may cause loss of water pondage and eventually breaching of the dam. Based on the DEPI Consequence Screening Tool for Small Dams, it is assessed that structures located between Rumker Street North and a rail embankment for MSL are at risk of inundation due to dam break if a dam break were to occur. As per the ANCOLD Consequence Categories for small dams, the consequence of farm dam break have been various categorised as Very Low to High C (refer Table 12). It is noted that higher consequence categories (ie Significant and High C) would be applicable for the farm dams upstream of Rumker Street North when cascading failure (ie if the farm dams failed in series, one after another) is considered.

Table 12: Assessment of Farm Dams

Dam ID	Volume (ML)	Downstream Topography	Population at Risk (PAR)	Consequence
FD1	30	Hilly	> 10	High C
FD2	0.15	Hilly	< 1	Very Low
FD3	14.5	Hilly	> 10	High C
FD4	7.7	Hilly	1 – 10	Significant
FD5	7.1	Hilly	< 1	Low
FD6	2.4	Hilly	< 1	Very Low
FD7	10.2	Hilly	< 1	Low
FD8	3.0	Hilly	< 1	Very Low
FD12	6.2	Hilly	1 – 10	Significant
FD13	5.5	Hilly	1 – 10	Significant
FD14	2.4	Hilly	< 1	Very Low
FD15	2.4	Hilly	< 1	Very Low
FD16	2.5	Hilly	< 1	Very Low
FD17	2.6	Hilly	< 1	Very Low
FD18	3.2	Hilly	< 1	Very Low
FD19	1.5	Hilly	< 1	Very Low
FD20	0.5	Hilly	< 1	Very Low

While the farm dams are constructed with clay material, which can absorb conventional cracking, localised cracking and deformations may occur which may require remediation. Farm dams FD1 – FD8, FD12 and FD16 could potentially experience cracking due to mining induced subsidence, which may cause loss of water storage capacity. To assess the quality of construction of the larger farm dams upstream of Rumker Street and the potential extent of downstream of these dams, it is recommended that a geotechnical investigation including dam break analyses are carried out to assess the likelihood and extent of the assessed risk and to provide recommendations on remedial and precautionary works, if required.

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 to its pre-mining condition. 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

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

Slope instability of steep slopes resulting in the regression of steep slopes into properties and/or the run-out of landslide debris downslope; and

Cracking and piping (ie internal erosion) of dam walls potentially resulting in dam failure.

Management of the identified hazards will require the following:

Baseline monitoring prior to active subsidence;

Regular monitoring and reporting on changes which have the potential to develop into 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 13 has been developed to assess the subsidence impacts on steep slopes and farm dams that can occur due to subsidence during and following the extraction of LW W3 and W4. The monitoring plan includes the following components:

Steep slope monitoring; and

Farm dam monitoring.

8. Trigger Action Response Plan

A contingency plan has been developed in the form of a Trigger Action Response Plan (TARP), as outlined on Tables 14 – 16. The actions developed within the TARP are to address any potential significant subsidence related impacts and include steep slopes, surface cracking and farm dams.

Table 13: Monitoring Program for Geotechnical Features

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Steep Slopes	Identified steep slopes within the SSA.	Visual Inspection baseline 1 month before active subsidence period by a geotechnical consultant.	Monthly visual inspection during active subsidence period by a geotechnical consultant .	Quarterly visual inspection for 12 month following active subsidence period by a geotechnical consultant .
Farm Dams	Identified farm dams within the SSA.	Dam embankment integrity and water level observation by a geotechnical consultant every month for at least two months immediately prior to undermining using fixed location photo points.	Dam embankment integrity and water level observation every week during active subsidence period using fixed location photo points by TC and every month during the active subsidence period using fixed photo points by a geotechnical consultant.	Dam embankment integrity and water level observation using fixed location photo points on a 3-monthly basis for 12 months following completion of LW W4. This period may be extended by the Tahmoor Coal Environmental Response Group.

Table 14: Trigger Action Response Plan for Steep Slopes

Feature	Management		
	Trigger	Action	Response
Steep Slope Damage or Instability	Level 1		
	Surface cracking < 10 mm wide on slope	– Continue monitoring in accordance with the monitoring program.	– No response required.
	Level 2		
	Surface cracking 10 – 20 mm wide on slope	– Continue monitoring in accordance with the monitoring program. – Convene Tahmoor Coal Environmental Response Group (TC ERG) to review response. – Erect warning signs and restrict access to areas where necessary.	– As defined by TC ERG. – Repair cracks at the completion of the active subsidence period.
	Level 3		
	Surface cracking > 20 mm wide, tree fall	– Increase frequency of monitoring by geotechnical consultant to weekly during active subsidence period. – Convene TC ERG to review response. – Erect warning signs and restrict access to areas where necessary. – Geotechnical consultant inspection to determine need for further action/investigation.	– Notify relevant Government Agencies and other stakeholders. – Repair cracks at the completion of the active subsidence period.

Table 15: Trigger Action Response Plan for Surface Cracking

Feature	Management		
	Trigger	Action	Response
Surface cracking	Level 1		
	Surface cracking < 10 mm wide	– Continue monitoring in accordance with the monitoring program.	– No response required.
	Level 2		
	Surface cracking 10 – 20 mm wide	– Continue monitoring in accordance with the monitoring program. – Convene Tahmoor Coal Environmental Response Group (TC ERG) to review response. – Erect warning signs and restrict access to areas where necessary.	– As defined by TC ERG. – Repair cracks at the completion of the active subsidence period.
	Level 3	–	
	Surface cracking > 20 mm wide	– Increase frequency of monitoring by geotechnical consultant to weekly during active subsidence period. – Convene TC ERG to review response. – Erect warning signs and restrict access to areas where necessary. – Geotechnical consultant inspection to determine need for further action/investigation.	– Notify relevant Government Agencies and other stakeholders – Repair cracks > 20 mm in width with excavation, grouting and re-compaction where practical.

Table 16: Trigger Action Response Plan for Farm Dams

Feature	Management		
	Trigger	**Action**	**Response**
Farm dams	Level 1		
	No cracks develop within dam embankment (ie other than natural desiccation cracking).	– Continue monitoring in accordance with the monitoring program.	– No response required.
	Level 2		
	Development of isolated cracks (<10 mm wide) within dam wall (ie other than natural desiccation cracking).	– Continue monitoring in accordance with the monitoring program. – Continue monthly review of data	– No response required.
	Level 3		
	Development of isolated cracks (> 10 mm wide) within the dam wall (ie other than natural desiccation cracking); AND/OR Development of isolated seepage from the face or toe of the farm dam embankment.	– Increase frequency of monitoring by geotechnical consultant to weekly during active subsidence period. – Convene Tahmoor Coal Environmental Response Group (TC ERG) to review response.	– As defined by TC ERG.
	Level 4		
	Development of persistent longitudinal or arcuate cracking within dam wall > 10 mm; AND/OR Development of seepage from the face or toe of the farm dam embankment.	– Increase frequency of monitoring by geotechnical consultant to weekly during active subsidence period. – Convene TC ERG to review response. – Erect warning signs where necessary – Reduce dam water level by at least half dam volume. – Geotechnical consultant inspection to determine need for further action/investigation.	– Notify relevant Government Agencies and other stakeholders – Repair cracks and embankment instability at the completion of the active subsidence period by excavation, grouting and re-compaction where practical.

9. Comments

A high-level geotechnical assessment was conducted on the land features within the SSA of LW W3 and W4. The geotechnical assessment included risk based assessments of steep slopes 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 steep slopes and farm dams within the SSA.

The risk assessment of the steep slopes were evaluated by the procedure recommended by Australian Geomechanics Society publication "Practice Note Guidelines for Landslide Risk Management 2007" (AGS 2007). The Small Dam Consequence Screening Tool (DEPI, 2014) was used to analyse farm dams.

The risk assessment of steep slopes indicated that the risk of slope instability prior to mining was within the range of Very *Low* to *Moderate* and within the *Tolerate* risk range defined by AGS (2007). The risk levels were considered to be unchanged following the propose extraction of LW W3 and W4.

The consequence of farm dam failure to property or human lives was assessed to be in the *Significant* to *High C* ranges for farm dams in excess of 5 ML in the tributaries of Redbank Creek in the SSA (ie typically in the eastern and southern parts of the SSA) due the properties located downstream of Rumker Street North, which are expected to be affected if a dam break occurred. When considering cascading failure for farm dams in the tributaries of Redbank Creek, they are all assessed in the *Significant* to *High C* ranges. The remaining farm dams (ie in the western and northern parts of the SSA) were assessed to be in the *Very Low* to *Low* ranges. It is recommended that a detailed assessment is carried out for farms dams located in the tributaries of Redbank Creek and within the SSA to assess the quality of construction of the larger farm dams and a dam break analyses to assess the extent of the flooding impact downstream.

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 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 with tolerable levels.

10. References

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.

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

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

11. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Longwalls W3 and W4 at Picton in accordance with DP's proposal WOL200362.P.001.Rev1 dated 3 September 2020 and email acceptance received from Tahmoor Coal dated 22 September 2020. 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

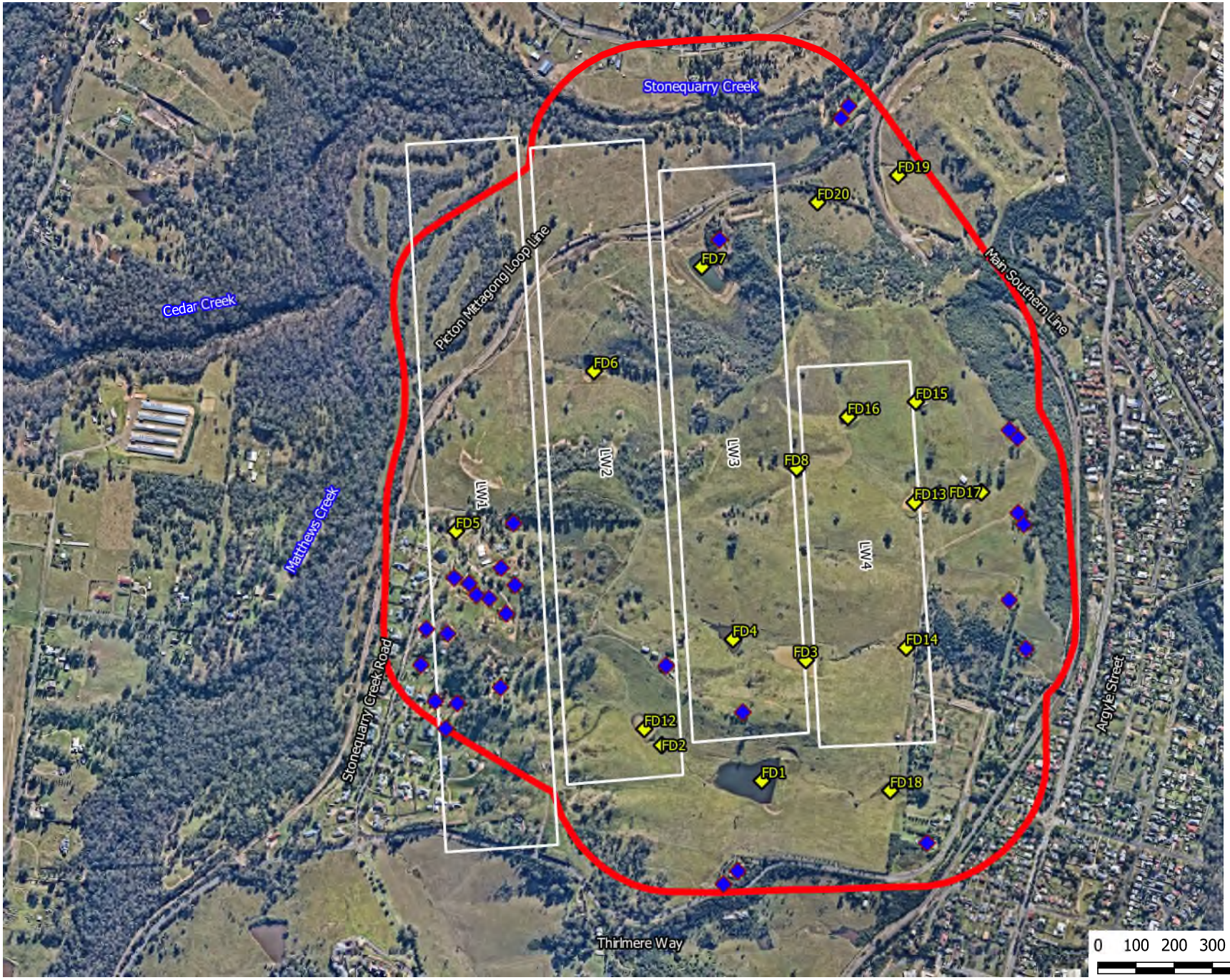
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate 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
Site Photographs



Locality Plan

Notes: Aerial photography from Nearmap.com

Legend

- Structures Near Steep Slopes
- Farm Dams
- Longwalls
- Subsidence Study Area (SSA)

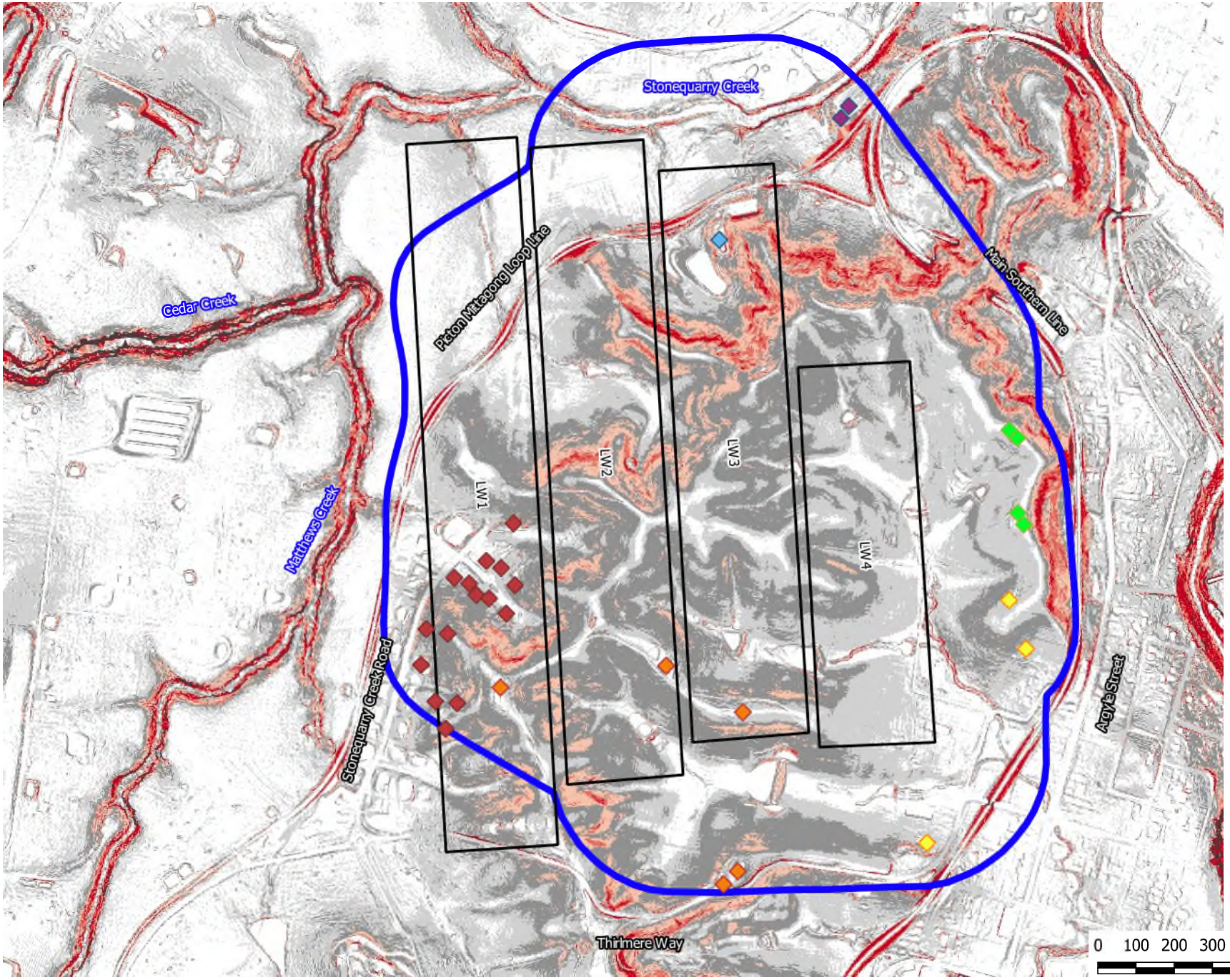
0 100 200 300 400 500 600 700 800 900 1000 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Tahmoor Coal Pty Ltd		
OFFICE:	Wollongong	DRAWN BY:	RJH
SCALE:	1:10,000 @ A3	DATE:	20 Nov 2020

TITLE: **Subsidence Study Area and Landscape Features**
Geotechnical Land Management Plan
Longwalls W3 and W4, Picton

PROJECT No:	89541.06
DRAWING No:	1
REVISION:	0



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

Legend

Structures

- Region 1
- Region 2
- Region 3
- Region 4
- Region 5
- Region 6
- Longwalls
- Subsidence Study Area (SSA)

Slopes

- 0 - 5 Degrees
- 5 - 10 Degrees
- 10 - 18 Degrees
- 18 - 25 Degrees
- 25 - 32 Degrees
- 32 - 45 Degrees
- >45 Degrees

0 100 200 300 400 500 600 700 800 900 1000 m

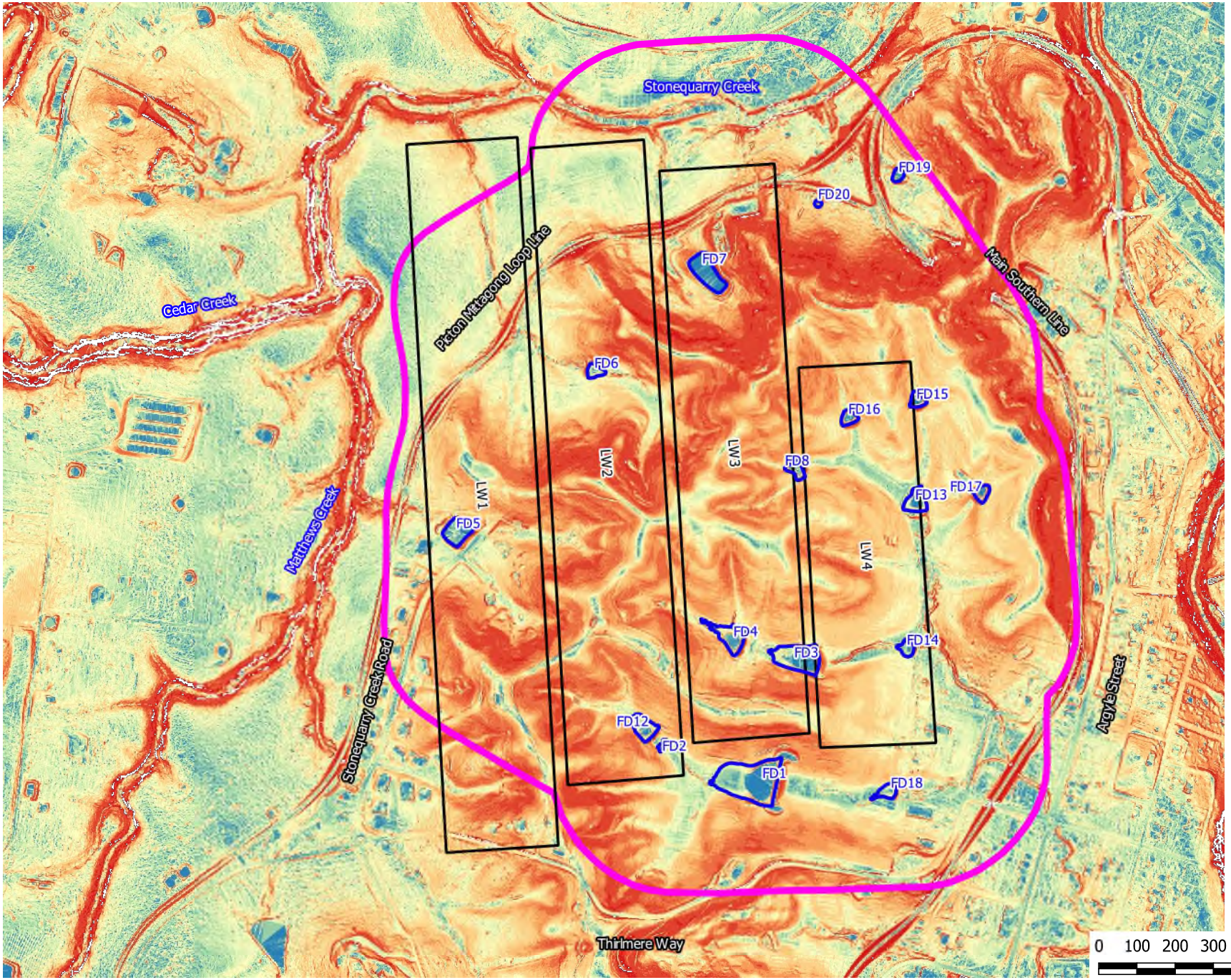
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Tahmoor Coal Pty Ltd		
OFFICE:	Wollongong	DRAWN BY:	RJH
SCALE:	1:10,000 @ A3	DATE:	20 Nov 2020

TITLE: **Structures Near Steep Slopes**
Geotechnical Land Management Plan
Longwalls W3 and W4, Picton

N

PROJECT No:	89541.06
DRAWING No:	2
REVISION:	0



Notes: Grades derived from LiDAR data available in the public domain.

Legend

- Farm Dams
- Longwalls
- Subsidence Study Area (SSA)

Surface Grades (H:V)

- 100:1
- 50:1
- 40:1
- 25:1
- 20:1
- 16:1
- 12.5:1
- 10:1
- 8:1
- 6:1
- 5:1
- 4:1
- 3:1
- 2:1
- 1:1

0 100 200 300 400 500 600 700 800 900 1000 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Tahmoor Coal Pty Ltd		
OFFICE:	Wollongong	DRAWN BY:	RJH
SCALE:	1:10,000 @ A3	DATE:	20 Nov 2020

TITLE: **Farm Dams Locations and Regional Topography**
Geotechnical Land Management Plan
Longwalls W3 and W4, Picton

N

PROJECT No:	89541.06
DRAWING No:	3
REVISION:	0

Appendix C

Excerpts of AGS 2007
Excerpts of DEPI 2014

Rate of Movement

Figure B3 shows the velocity scale proposed by Cruden & Varnes (1996) which rationalises previous scales. The term "creep" has been omitted due to the many definitions and interpretations in the literature.

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
		5×10^{3}	5 m/sec	
6	Very Rapid			Some lives lost; velocity too great to permit all persons to escape
		5×10^{1}	3 m/min	
5	Rapid			Escape evaluation possible; structures; possessions, and equipment destroyed
		5×10^{-1}	1.8 m/hr	
4	Moderate			Some temporary and insensitive structures can be temporarily maintained
		5×10^{-3}	13 m/month	
3	Slow			Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
		5×10^{-5}	1.6 m/year	
2	Very Slow			Some permanent structures undamaged by movement
		5×10^{-7}	15 mm/year	
	Extremely **SLOW**			Imperceptible without instruments; construction **POSSIBLE WITH PRECAUTIONS**

Figure B3: Proposed Landslide Velocity Scale and Probable Destructive Significance.

REFERENCES AND ACKNOWLEDGEMENT

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PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	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** (5)
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**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		**Example Implications** (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Appendix C – Land and Agricultural Resource Assessment

TAHMOOR EXTRACTION PLAN LW W3-W4

Land and Agricultural Resource Assessment

Prepared for:

Tahmoor Coal
2975 Remembrance Drive
Bargo NSW 2573 Australia

SLR Ref: 630.12732.001
Version: -v1.0
May 2021

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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
630.12732.001	May 2021	Murray Fraser	Rod Masters	Rod Masters

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APPENDICES

1 Introduction

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to **Figure 1**). Tahmoor Mine produces up to three million tonnes of Run of Mine coal per annum from the Bulli Coal Seam. 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. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (**Tahmoor Coal**) since Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a wholly owned entity within the SIMEC Mining Division of the GFG Alliance group.

Tahmoor Coal has previously mined 33 longwalls to the north and west of the Tahmoor Mine's current pit top location. The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton.

The mine plan for the Western Domain includes four longwalls - Longwalls West 1 to West 4. An Extraction Plan for the first two longwalls in the Western Domain, Longwalls West 1 and West 2 (**LW W1-W2**), was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Longwall West 1 (**LW W1)** was the first longwall to be extracted in the Western Domain and was completed on 6 November 2020. The extraction of Longwall West 2 (**LW W2**) commenced on 7 December 2020. The further two longwalls to be mined are Longwall West 3 and LW W4 (collectively referred to as LW W3-W4).

Extraction of LW W4 is estimated to be completed by approximately August 2022, and visual monitoring of agricultural land will continue for 12 months following active subsidence (estimated August 2023).

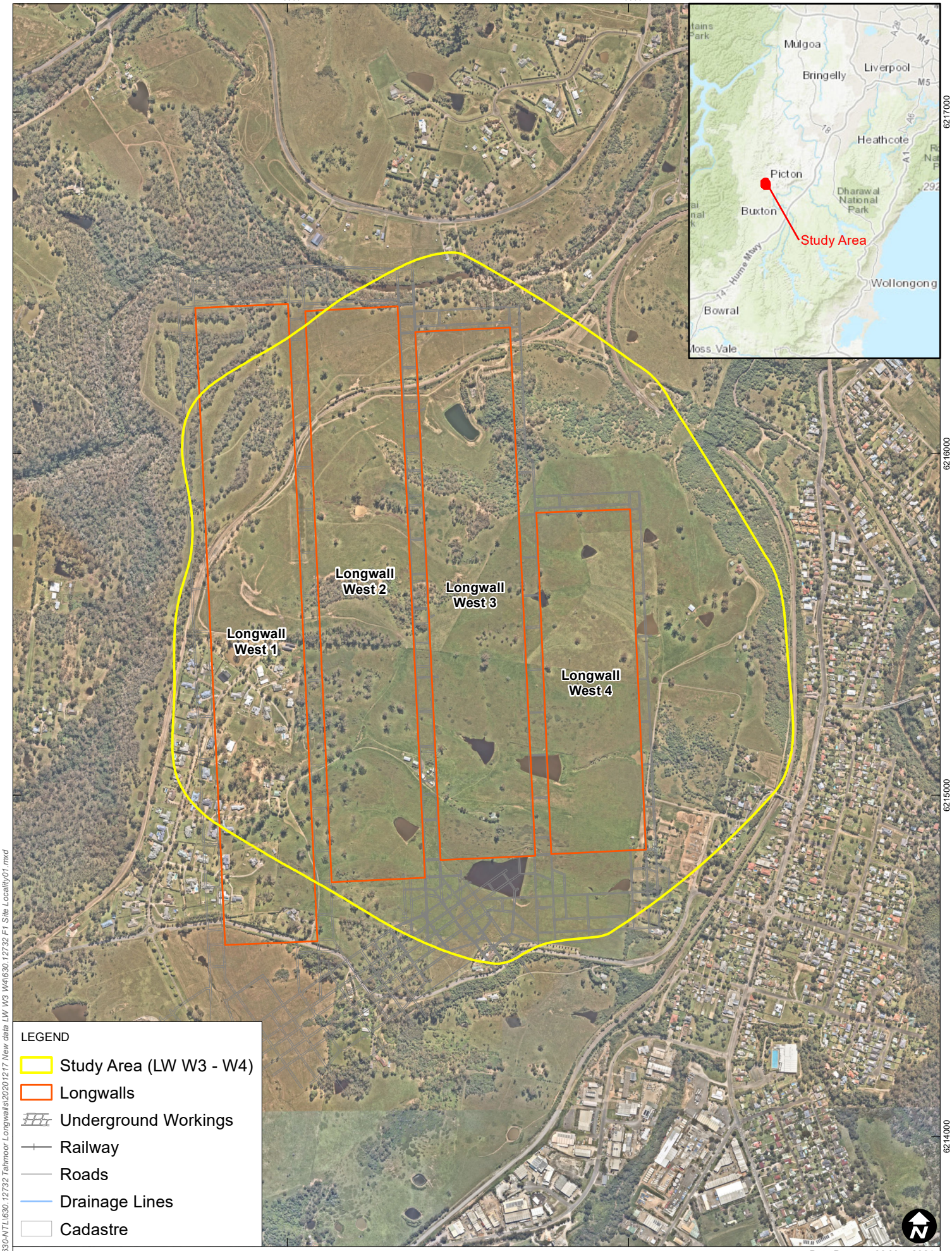
SLR has been commissioned by Tahmoor Coal to complete a Land and Agricultural Resource Assessment for the extraction of LW W3-W4. The purpose of this assessment is to form part of an Extraction Plan for LW W3-W4.

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 W3-W4. This assessment will form part of an Extraction Plan being prepared by Tahmoor Coal for LW W3-W4 for submission to DPIE.

The Extraction Plan Study Area (the Study Area), as shown on **Figure 1**, is defined as the surface area that is likely to be affected by the extraction of LW W3-W4 from the Bulli Coal Seam. This Study Area has been calculated by combining the areas bound by the following limits:

- The predicted limit of vertical subsidence, taken as the 20 millimetre (mm) subsidence contour resulting from the extraction of LW W3-W4; and
- A 35^{o} angle of draw line from the limit of proposed extraction for LW W3-W4.



SLR

Study Area
Tahmoor Extraction Plan
LW W3 W4

FIGURE 1

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 1**). 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 1 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 Study Area is generally undulating with rises in the south-east falling to lower slopes in the north. High points on rises have surface elevations up to 280 metres Australian Height Datum (**AHD**) and are generally cleared for small scale rural production, as shown in **Figure 2**, Surface levels on relatively flat land to the north of the Study Area are the location of vegetated creek lines running from the west to the north-east. Surface elevations of the low points are approximately 180 metres AHD. The slope analysis (**Figure 3**) further highlights the undulating rises and creek valleys, shown in red.

2.3 Hydrology

2.3.1 Surface Water

The Study Area is located in the Stonequarry Creek Catchment with the relevant natural waterway features comprising Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek, as shown on **Figure 2**. Redbank Creek flows from west to east adjacent to, though outside of, the southern boundary of the Study Area. A topographic ridgeline straddles the Study Area, with the south-east portion of the area discharging via tributaries to Redbank Creek. The south-west portion of the area discharges to Matthews Creek, while the north-northwest portion of the area discharges to Cedar Creek and Stonequarry Creek. A portion of Stonequarry Creek traverses the northern boundary of the Study Area, while Matthews Creek, Cedar Creek and Redbank Creek are located outside of the Study Area.

Matthews Creek and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 850 metres west of LW W3. Stonequarry Creek also rises to the west and flows to the east, joining Cedar Creek approximately 370 metres north west of LW W3, before flowing east and south through the town of Picton. Redbank Creek rises to the west and flows into Stonequarry Creek towards the south-east of the Study Area. Redbank Creek is located approximately 600 metres south of the edge of LW W4 at its closest point. Downstream of the confluence with Redbank Creek, Stonequarry Creek continues to flow south-east, joining the Nepean River near Maldon.

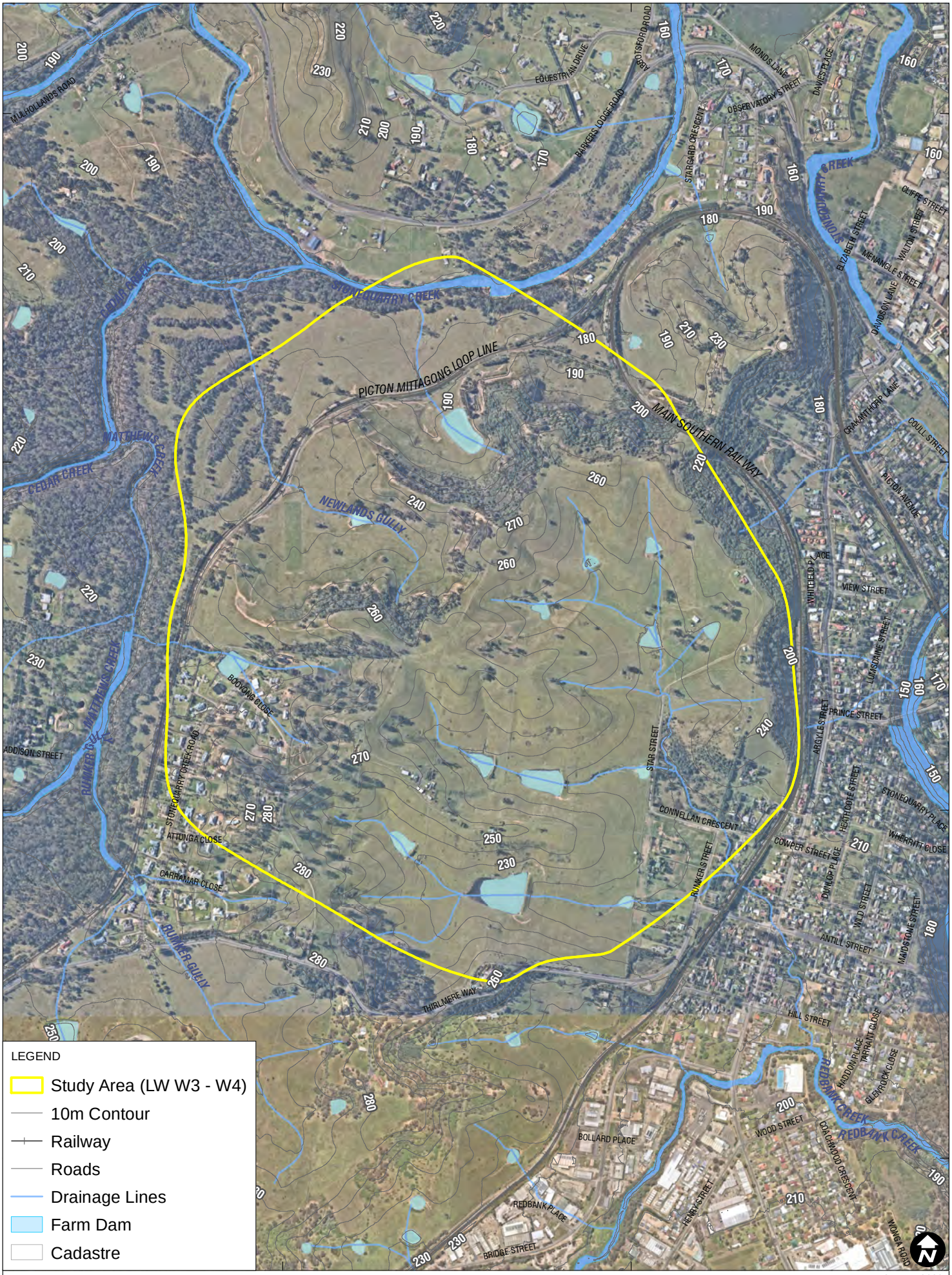
The Nepean River rises in the Great Dividing Range to the west of the Study Area, although its headwaters also lie in the coastal ranges to the east of the Study Area. Flows in the upper reaches of the Nepean River are highly regulated by the Upper Nepean Water Supply Scheme, operated by WaterNSW, which incorporates four major water supply dams on the Cataract, Cordeaux, Avon and Nepean Rivers. Flows in the Nepean River near and downstream of the Study Area are not part of a WaterNSW Drinking Water Catchment Area (HEC, 2021).

Table 2 Drainage Channels

Catchment	Sub Catchment	Associated Watercourses	Flow Direction
Stonequarry Creek Catchment	Nepean River	Matthews Creek	North
		Cedar Creek	North-East
		Stonequarry Creek	East
		Redbank Creek	South-East

2.3.2 Licenced Surface Water Users

A search of the WaterNSW Register for surface water licenses found six properties within the Study Area with a Water Supply Works and Water Use Approval (HEC, 2021).



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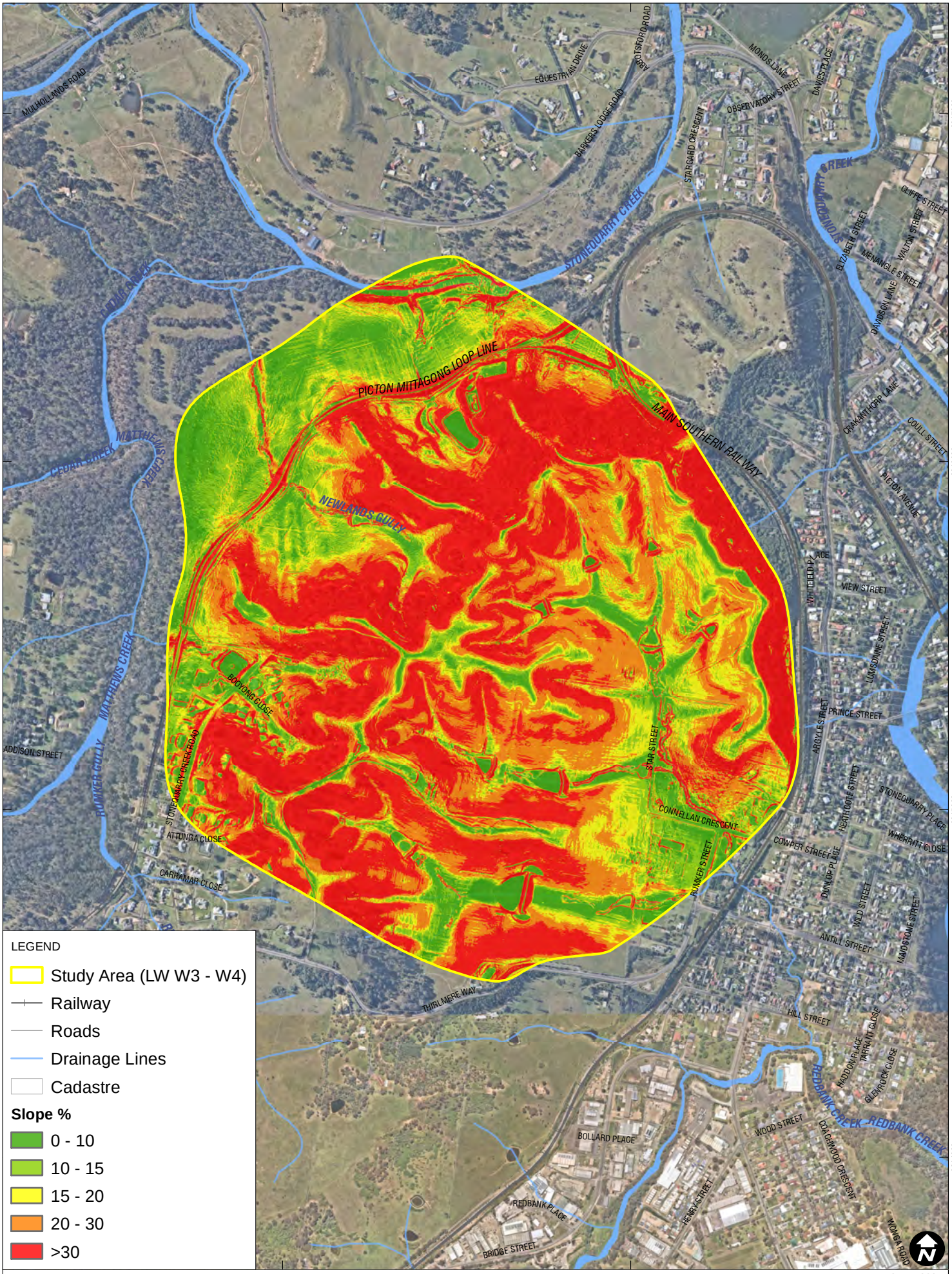
SLR

Topography and Hydrology
Tahmoor Extraction Plan
LW W3 W4

FIGURE 2



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Project Number: 630.12732.001

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SLR

Slope Analysis
Tahmoor Extraction Plan
LW W3 W4

FIGURE 3

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.

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. One bores registered by DPIE Water is located within the Study Area (GW104090), with a further eight bores located within the vicinity of the Study Area (**Table 3**). The majority of bores are registered for stock and/or domestic use. Groundwater for these bores is sourced from the Hawkesbury Sandstone Aquifer, with low yields ranging up to 2.67 litres per second (GeoTerra, 2021).

Table 3 Registered Groundwater Users

Identifier	Depth (m)	Yield (L/s)	Purpose	Currently Used	In Study Area
GW24750	11.9	N/A	Stock & Domestic	Bore Collapsed	No
GW35844	45.7	N/A	Irrigation	Not Inspected (property access not obtained)	No
GW64469	91	N/A	Domestic	Not Inspected (property access not obtained)	No
GW72402	72	N/A	Stock & Domestic	Pump Removed	No
GW104090	150.5	N/A	Recreation	Pump Disabled	Yes
GW105228	63	1.82	Stock & Domestic	Pump Installed, bore operational	No
GW105467	120	0.47	Stock & Domestic	Pump Installed, bore operational	No
GW105546	163	1.60	Irrigation	Pump Installed, bore operational	No
GW115860	60	2.28	Domestic	Pump Installed, bore operational	No

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 4**. Six soil landscapes occur in the Study Area and are summarised in **Table 4.**

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

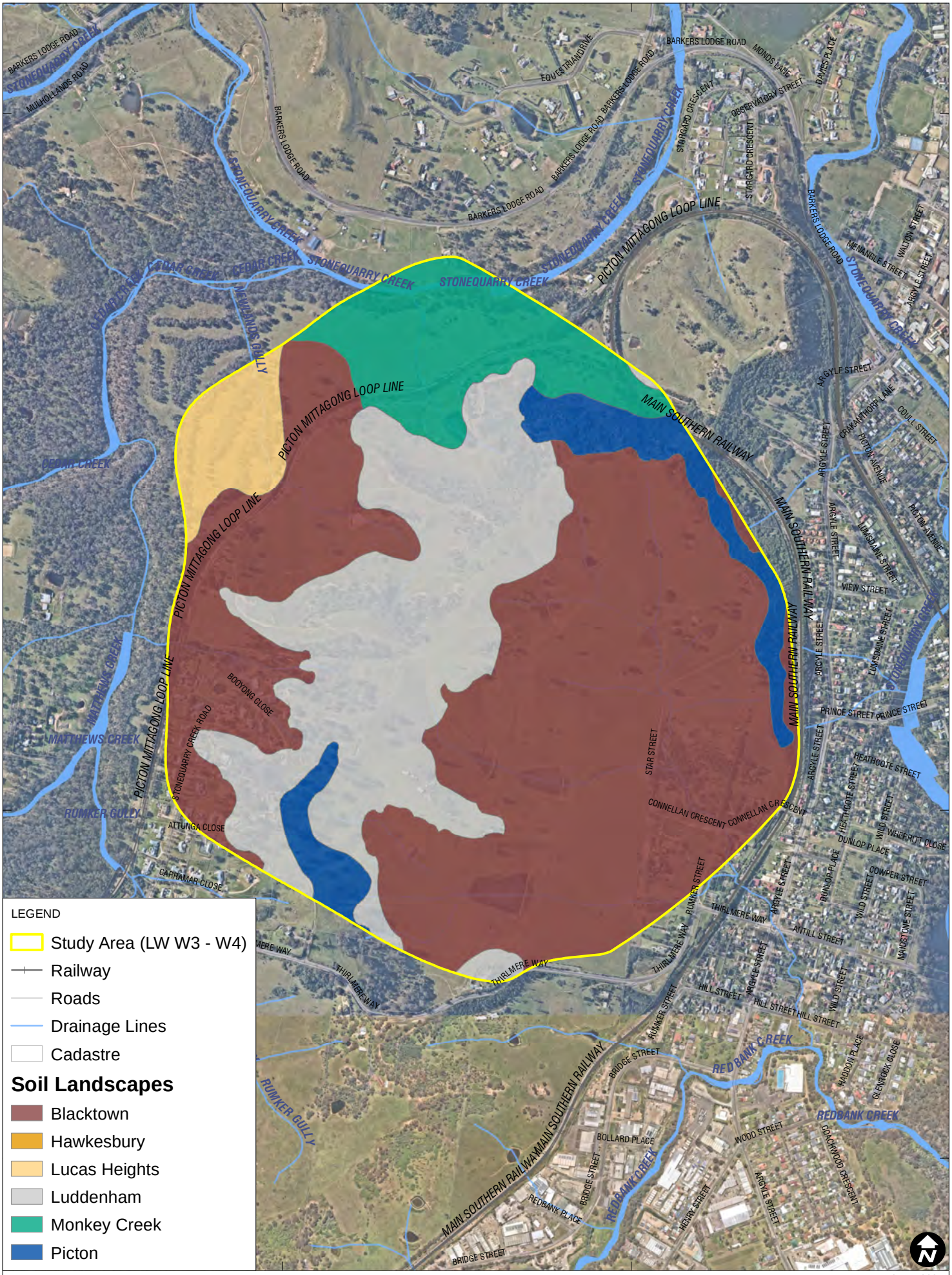
- The majority of the Study Area (90%) is moderately constrained for cultivation:
- The Hawkesbury and Picton SLU are highly to severely constrained for any agricultural enterprises, which covers 6% of the Study Area:
- Agricultural land best suited to grazing enterprises includes the Blacktown, Luddenham, and Monkey Creek SLU which covers 90% of the Study Area: and
- Lucas Heights SLU has moderate limitations for grazing and high limitation for cultivation and covers 4% of the Study Area.

Table 4 Soil Landscape Units

Soil Landscape	Study Area		Agricultural Limitation Rating	
Unit	Hectares	%	Grazing	Cultivation
Hawkesbury	<1	<1	High – Severe	High – Severe
Picton	16	6		
Sub Total	**16**	**6**		
Lucas Height	11	4	Moderate	High
Sub Total	**11**	**4**		
Blacktown	155	55	Low	Moderate
Luddenham	72	25		
Monkey Creek	28	10		
Sub Total	**255**	**90**		
Total	**282**	**100**		

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

Full descriptions of the six Soil Landscape Units within the Study Area are presented in **Appendix A**.



SLR

Soil Landscape Units
Tahmoor Extraction Plan
LW W3 W4

FIGURE 4

2.6 Dominant Soil Types and Inherent Fertility

The two dominant Australia Soil Classification (ASC) soil types were digitally mapped by the DPIE and are shown on **Figure 5**. Two soil types are present in the Study Area, dominated by Dermosols and Kurosols (**Table 5**). These soil types are summarised in the major points listed below.

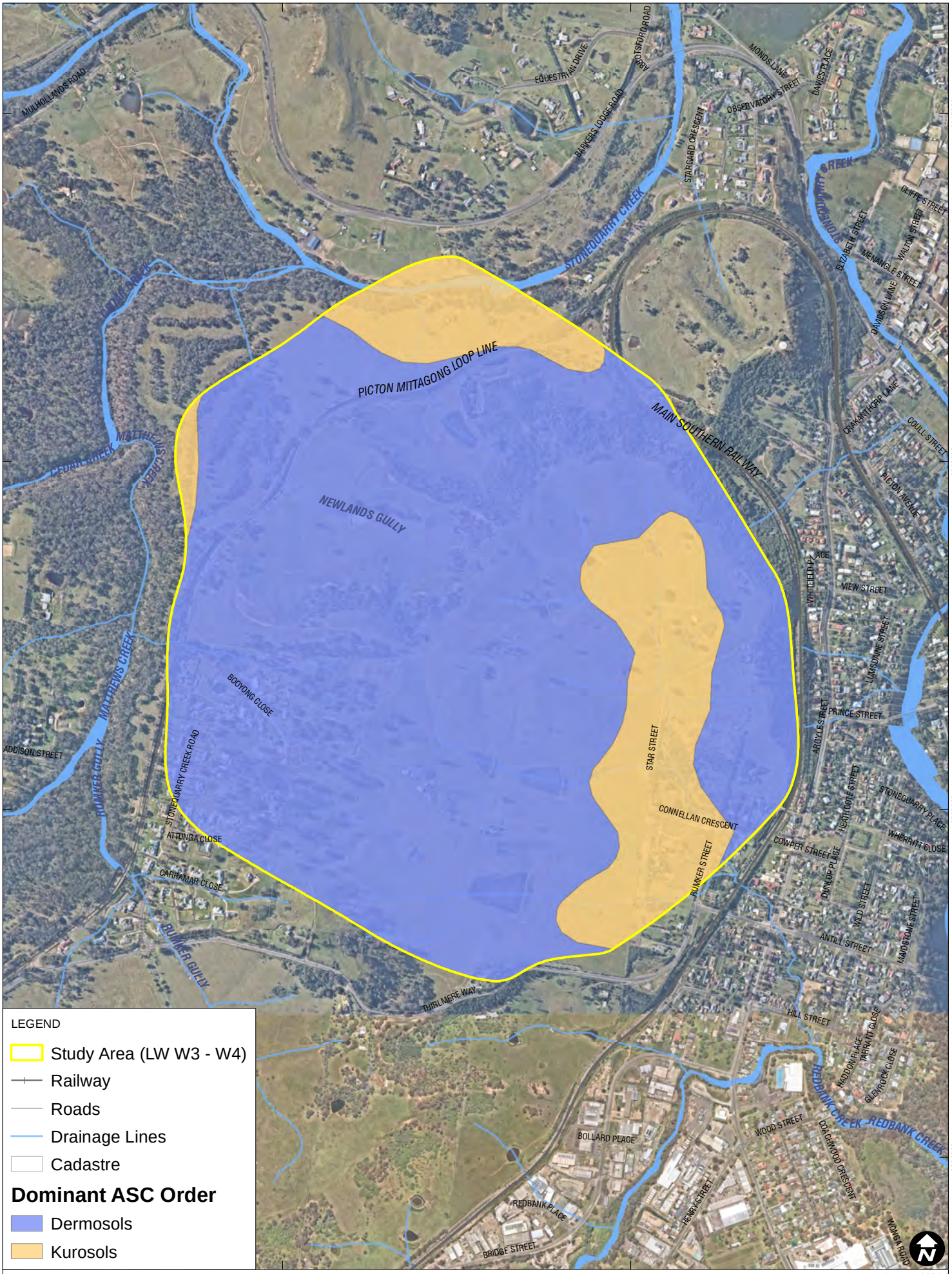
- Dermosols are the major soil type within the Study Area comprising 82% of the total area. Dermosols are soils with structured B horizons which lack strong texture contrast between the A and B horizons. Dermosols generally have moderately high inherent fertility.
- Kurosols are soils with a strong texture contrast between the A horizons and a strongly acidic B horizon. Kurosols generally have moderate inherent low fertility and comprise 18% of the Study Area.

Table 5 Dominant Soil Types and Inherent Fertility

Australian Soil Classification	Inherent Fertility	Hectares	%
Dermosol	Moderately High	230	82
Kurosol	Moderately Low	52	18
	Total	**282**	**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.



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SLR

ASC Soil Units
Tahmoor Extraction Plan
LW W3 W4

FIGURE 5

2.8 Vegetation and Land Use

Review of recent aerial images shows that the majority of the Study Area comprises of cleared pastoral land (approximately 64%) that may be suitable for agricultural enterprise, as shown in **Figure 6**. The remainder is comprised of thick native vegetation along riparian zones and steep slopes, along with small areas used as rural residential land. Site inspections in March 2019 and September 2020 by SLR's Associate Agronomist, in conjunction with a desktop assessment, has shown that small scale cattle and horse grazing of improved along with native grass species such as Kangaroo Grass (*Themeda australis*), Poa Tussock (*Poa labillardierei*), Red Grass (*Bothriochloa* spp.), Paspalum (*Paspalum dilatatum*) and Kikuyu (*Pennisetum clandestinum*) is the dominant agricultural enterprise. A small number of poultry farms, orchards and commercial vegetable gardens also exist within or adjacent to the Study Area. No intensive cropping activities were observed at the time of the inspection and assessment. The various land uses at each inspection site were recorded and are shown on **Figure 6** and described in **Table 6**. Plates for each inspection site are shown in **Appendix B**.

Table 6 Observed Land Uses

2019 Inspection Site	Land Use
4	Rural residential
5	Rural residential
6	Cattle grazing
7	Pleasure horses
8	Ungrazed pasture
10	Pleasure horses
11	Orchards
2020 Inspection Site	**Land Use**
1	Cattle grazing
2	Cattle grazing
3	Cattle grazing
4	Cattle grazing
5	Ungrazed pasture
6	Cattle & pleasure horse grazing
7	Cattle & pleasure horse grazing
8	Cattle & pleasure horse grazing
9	Ungrazed pasture
10	Residential & rural residential
11	Cattle & pleasure horse grazing
12	Cattle & pleasure horse grazing
13	Cattle & pleasure horse grazing
14	Cattle grazing

Grazing within the Study 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 206 hectares of potential grazing land is currently available for agricultural use. As described in correspondence received from the NSW DPI (30 April, 2019) poultry farms are a significant industry in the area, with two located to the west of the Study Area (**Figure 6**). DPI has also identified at least three protected cropping businesses to the south of the Study Area.

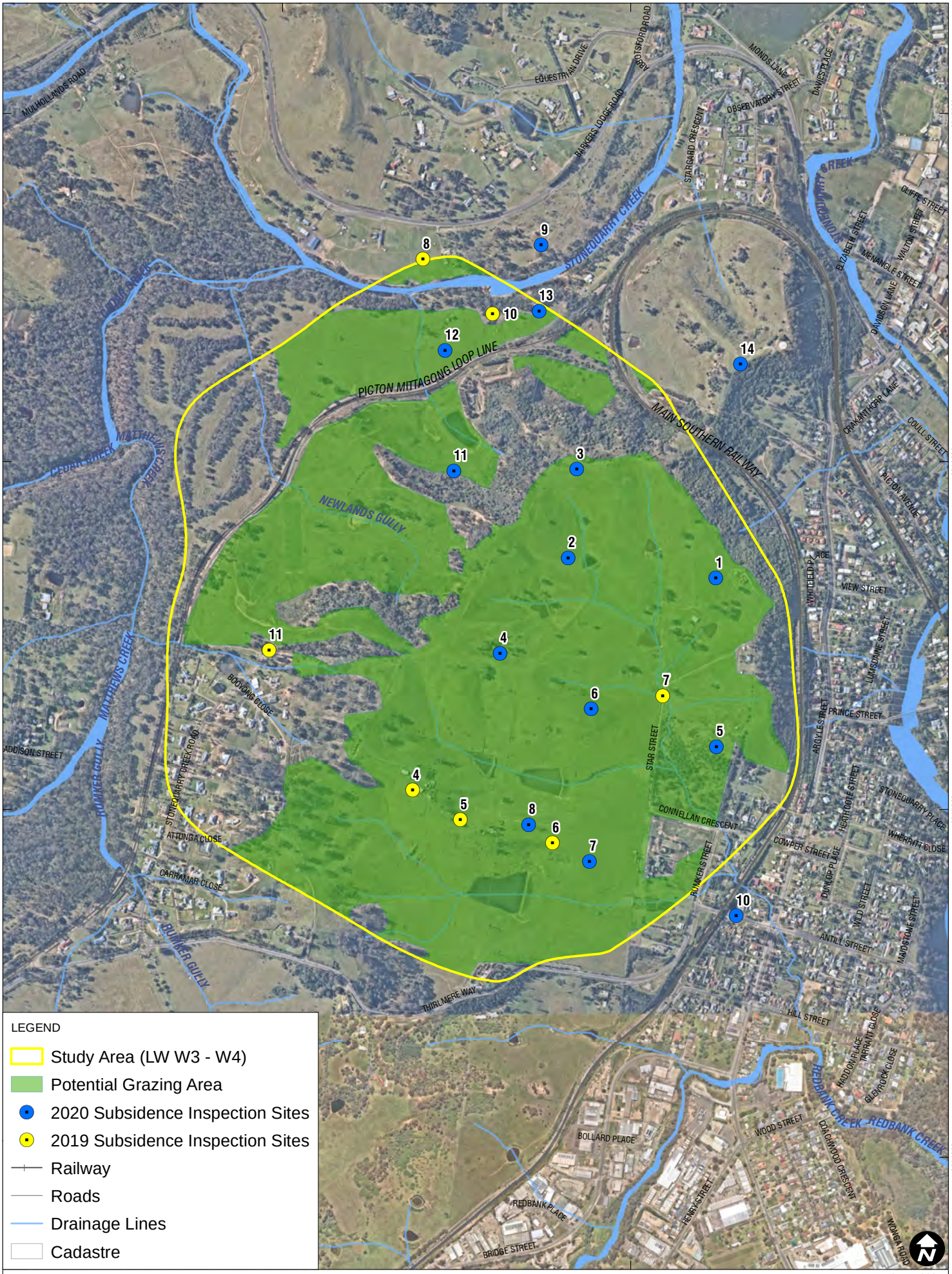
Site inspection revealed no poultry farms or protected cropping businesses in the Study Area.

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** to **Plate 3** shows some of the typical land uses within the area.

Plate 1 Cattle grazing grass pasture area on cleared hills within the Study Area

Plate 2 Grass pasture on rolling hills within the Study Area

Plate 3 Non-agricultural land adjacent to the Study Area



LEGEND

- Study Area (LW W3 - W4)
- Potential Grazing Area
- 2020 Subsidence Inspection Sites
- 2019 Subsidence Inspection Sites
- Railway
- Roads
- Drainage Lines
- Cadastre

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Scale: 1:14,000 at A4

Coordinate System: GDA 1994 MGA Zone 56

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Potential Grazing Area
Tahmoor Extraction Plan
LW W3 W4

FIGURE 6

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 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 7** and their definition has been based on two considerations:

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

Table 7 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 DPIE and is summarised in **Table 8** and shown in **Figure 7**. The limitations associated with each LSC Class are discussed below.

Table 8 Land and Soil Capability Areas

LSC Class	Agricultural Capability Rating	Hectares	%
4	Moderate	40	14
5	Moderately Low	15	5
6	Low	35	13
7	Very Low	192	68
	Total	**282**	**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 14% of the Study Area.

LSC Class 5 Land

Class 5 land is associated with Kurosols and Sodosols. This classification indicates a moderate to low land capability, with severe limitations to high impact land management uses such as cropping. This land is generally more suitable for grazing with some limitations, or very occasional cultivation for pasture establishment. LSC Class 5 land comprises 5% 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 13% of the Study Area.

LSC Class 7 Land

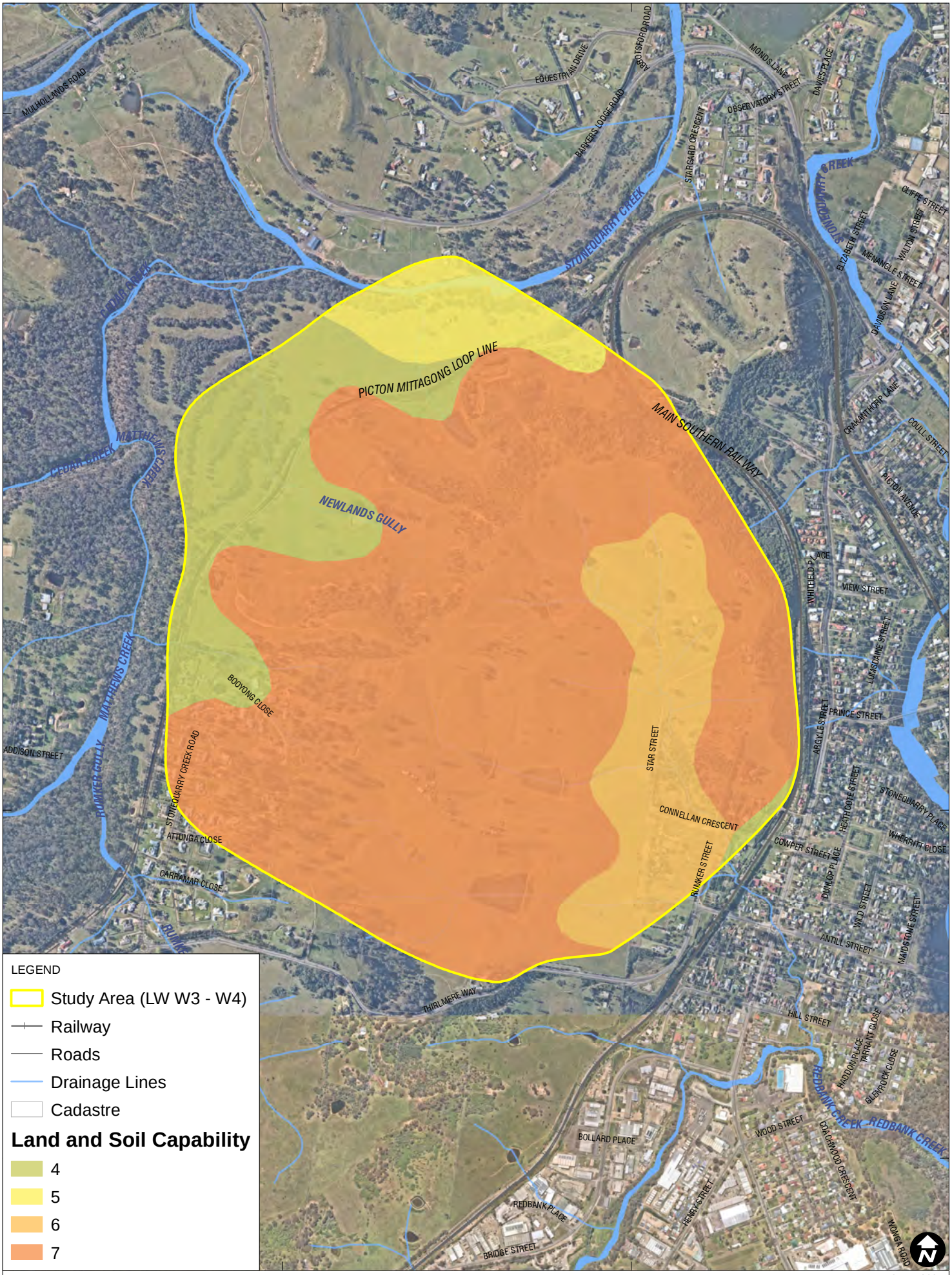
Class 7 land is represented by Dermosols, Rudosols and Tenosols. This classification indicates very low capability land, with severe limitations for most land uses. It is generally unsuitable for any type of cropping or grazing due to its limitations. It covers the major portion of the Study Area (68%).

Within the Study Area, 68% of the land area is considered to have 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.

There is no LSC Class 1, 2 or 3 land within or adjacent to the Study Area. These three LSC Classes are generally considered DPI Agriculture as 'Important Agriculture Land", given their agricultural capability is rated as high (LSC Class 3) to extremely high (LSC Class 1). As such, there will be no impact to "Important Agricultural Land".

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* (DP&I, 2013) is between Douglas Park and Camden, approximately 20 kilometres to the north-east of the Study Area.



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SLR

Land ans Soil Capability
Tahmoor Extraction Plan
LW W3 W4

FIGURE 7

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*). The agricultural land use is outlined in **Table 9**. 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; and
- 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 9 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 10.** The regional employment in the agriculture related sectors is shown in **Table 10.** 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; and
- 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 10 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*)

Table 11 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*)

3.3 Regional Agricultural Production Value

Agricultural production values for the Wollondilly LGA totals $61.3 M as detailed in **Table 12.** 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*).

Table 12 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*)

3.4 Potential Agricultural Production Value of the Study Area

Potential agricultural productivity was determined using 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* (NSW Department of Primary Industries, 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 C.**

Table 13 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 5 land has the potential to generate approximately $174 per hectare from beef cattle grazing;
- Class 6 land has the potential to generate approximately $116 per hectare from beef cattle grazing; and
- Class 7 land has the potential to generate approximately $58 per hectare from beef cattle grazing.

Table 13 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
5	6	0.36	$216	$42	$174
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 13**), the Study Area has the capacity to generate an estimated gross margin of $26,886 per annum (**Table 14**). 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 14 Annual Gross Margins per LSC Class

LSC	Gross Margin	Study Area	
Class	Per Hectare	Hectares	Gross Margin
4	$227	40	$9,080
5	$174	15	$2,610
6	$116	35	$4,060
7	$58	192	$11,136
	Total	**282**	**$26,886**

It is expected that income generated from agricultural enterprises within the Study Area would be minimal due to the small area (191 hectares) available for actual agricultural production (**Figure 6**). The majority of this cleared area is LSC Class 7 and using the gross margin information presented in **Table 14**, 191 hectares of LSC Class 7 land has a potential gross margin of $11,078 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 55 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 (2021) predicts maximum vertical subsidence over LW W3 to be 950 millimetres and for LW W4 to be 1,025 millimetres. Maximum predicted tilt for both longwalls is 5 millimetres per metre which is very small when compared to the natural surface grades of steep slopes within the Study Area. However, steep slopes are likely affected by curvature and strain that result in tension cracks appearing at the tops and sides of steep slopes with compression ridges forming at the bottom of the steep slopes (MSEC, 2021).

4.1 Land Resources

Within the Study Area, 68% of the land area is considered to have very low agricultural capability, whilst the remainder has moderate to moderately low agricultural capability. There is no LSC Class 1, 2 or 3 land within or adjacent to the Study Area. These three LSC Classes are generally considered by DPI Agriculture as 'Important Agriculture Land", given their agricultural capability is rated as high (LSC Class 3) to extremely high (LSC Class 1). As such, there will be no impact to "Important Agricultural Land" as a result of the extraction of LW W3-W4.

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 landscape (HEC, 2021). Therefore, there is no land which will be temporarily removed from agriculture as a result of LW W3-W4.

4.1.2 Land Permanently Removed From Agriculture

There is no land which will be permanently removed from agriculture as a result of the extraction of LW W3-W4.

4.1.3 Impact on Biophysical Strategic Agricultural Land

There is no Biophysical Strategic Agricultural Land within the Study Area. LW W3-W4 will not impact any Biophysical Strategic Agricultural Land.

4.1.4 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 W3-W4 will not impact upon Acid Sulfate Soils.

4.2 Water Resources

4.2.1 Surface Water

The Matthews Creek, Cedar Creek and Stonequarry Creek system is partly located within the Study Area. The proposed extraction of LW W3-W4 is predicted to result in minor additional increases in subsidence, valley closure and upsidence along Matthews and Cedar Creeks. This is in addition to movements that will have occurred previously due to the extraction of LW W1 (completed) and LW W2 (currently being extracted) (MSEC, 2021).

The majority of the movements for these creeks are predicted to occur during the mining of LW W1-W2. The predicted maximum additional movements due to the extraction of LW W3-W4 represent approximately 10 to 15% of the total maximum predicted movements due to LW W1-W4 (MSEC, 2021).

Should impacts develop within these creeks during the extraction of LW W1-W2, it is likely that further impacts will be experienced during the mining of LW W3. At the time of MSEC reporting, gas bubbles were observed in Pool MR45 in Matthews Creek between February and June 2020. If the gas bubbles were discharged due to mine subsidence movements, it is likely that further emissions will occur during the mining of LW W2 and further emissions could possibly occur during the mining of LW W3. No reduction in pool water levels have been observed during the mining of LW W1, taking into account variations due to rainfall and temperature (MSEC, 2021).

The proposed extraction of LW W3-W4 is predicted to result in minor additional increases in subsidence, valley closure and upsidence along Stonequarry Creek. The predicted movements are in addition to movements that will have occurred previously due to the extraction of LW W1 (completed) and LW W2 (currently being extracted) (MSEC, 2021).

Cedar Creek and Stonequarry Creek are predicted to experience 70 millimetre maximum vertical subsidence after mining LW W3-W4, while Matthews Creek is predicted to experience 100 millimetre maximum vertical subsidence. Matthews Creek and Cedar Creek are predicted to experience maximum total valley-related closure of 200 millimetre after mining LW W3-W4, while Stonequarry Creek is predicted to experience 80 millimetre maximum total valley-related closure. The majority of the predicted movements along Matthews Creek and Cedar Creek are expected to occur due to extraction of LW W1-W2 (MSEC, 2021).

Regarding flooding and inundation, WRM (2020) found that flows are generally contained within the channels of Matthews Creek, Cedar Creek and Stonequarry Creek within the Study Area. The crest of Barkers Lodge Road may be overtopped during a Probable Maximum Flood (PMF) event. The subsidence resulting from the mining of the proposed LW W1-W4 will results in a negligible change in flood levels, flow velocities and flood extent within the catchment area.

Gas emissions from the sandstone strata have been previously observed above and adjacent to mining areas in the Southern Coalfield, and some gas emissions have also been observed in water bores. Analyses of gas compositions indicate that the Bulli Seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (MSEC, 2021).

Prior to the extraction of LW W1, all recorded examples of gas emissions have occurred in collieries located to the east and to the north-east of Tahmoor Mine. No gas emissions or consequential changes in water quality have been reported over Tahmoor Mine in the Bargo River, Redbank Creek or Myrtle Creek (MSEC, 2021).

4.2.2 Groundwater

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

The potential and available drawdowns for all private bores within the vicinity of LW W3-W4 are shown in **Table 15**. Based on observation of bores within the LW W3-W4 Study Area, the potential drawdown due to subsidence of private bores directly over the proposed workings may extend to 15 metres, however those not over the proposed workings may experience less than 5 metres, or have no impact, depending on the separation distance from the mine working to a particular bore. Based on a combination of site measurements and standing water levels, bore yields and recorded bore depths, all of the private bores have sufficient available drawdown and their pumps, where installed, are not anticipated to run dry (Geoterra, 2021).

Table 15 Predicted Impacts to Private Bores (SLR, 2021)

Identifier	Bore Use	Condition	Maximum Incremental Drawdown (m)	Maximum Cumulative Drawdown (m)	Available Drawdown (m)
GW24750	Stock & Domestic	Not Inspected	0	6.9	
GW35844	Irrigation	Not Inspected	0	0.2	21.4
GW64469	Domestic	Not Inspected	0	0.2	N/A
GW72402	Stock & Domestic	Pump Removed	0	3.1	59.8
GW104090	Recreation	Pump Disabled	7.5	30.8	111.5
GW105228	Stock & Domestic	Pump Installed	0	4.1	40.0
GW105467	Stock & Domestic	Pump Installed	0	5.6	88.0
GW105546	Irrigation	Pump Installed	0.9	12.8	131.11

One recreation bore (GW104090) will have a maximum incremental drawdown of greater than the Level 1 minimal impact considerations for the NSW AI Policy, of greater than two metres (highlighted in red). No bores with a registered agricultural use are predicted to have maximum incremental drawdown of greater than two metres (SLR, 2021).

4.2.3 Water Reallocation

Tahmoor Coal 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 are six properties within the Study Area with a Water Supply Works and Water Use Approval. For the surface water systems in which pumping would occur, MSEC (2021) has predicted that less than 10% of pools are likely to experience fracturing and associated reduction in standing water level (refer **Section 4.4.2**). As such, while minor impacts to water supply may occur, the potential impacts to water supply should be manageable through implementation of monitoring, mitigation and management measures (refer **Section 5**) and through contingency planning (HEC, 2021).

There will be minor impact on agricultural users through water reallocation.

4.2.4 Water Resource Impacts on Agricultural Productivity

Given the very limited impacts described previously, longwall subsidence will result in minor impacts on water resources relied upon by agricultural enterprises and will not result in any impact on agricultural productivity.

4.3 Impact on Agricultural Resources from Biodiversity Offsets

The extraction of LW W3-W4 is not expected to result in the establishment of any 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 by SLR's Associate 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 W3-W4 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 in the local area upon which agricultural enterprises are reliant. Therefore, LW W3 –W4 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 W3-W4 through vehicle movements on and off site. Weeds are currently managed within the frameworks of the Tahmoor 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 W3 –W4 has negligible risk to the biosecurity of agricultural resources and enterprises within the region.

4.4.4 Air Quality

The extraction of LW W3-W4 involves the extraction of two underground longwall panels and as such there will be no impact to air quality resulting from LW W3-W4.

4.4.5 Noise

The extraction of LW W3-W4 involves the extraction of two underground longwall panels and as such there will be no impacts to agricultural production from noise generated during the extraction of LW W3-W4.

4.4.6 Blasting

The extraction of LW W3-W4 does not involve any blasting on the surface and as such there will be no impact to agricultural resources from blasting.

4.4.7 Traffic

The extraction of LW W3-W4 involves the extraction of two 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.

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 W3-W4 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, 2021).

4.4.9 Tanks

There are water, gas and fuel storage tanks on some of the properties within the Study Area.

The tanks themselves 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, 2021).

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 are expected to be of minor nature and easily repaired (MSEC, 2021).

4.4.11 Farm Dams

A total of 20 medium to large sized dams are located within or adjacent to the Study Area for LW W3 and LW W4, of which, six dams are directly overlying LW W3 and LW W4. Note that FD-5 appears to be a detention basin within the Stonequarry Creek Estate. FD-9 to FD-11 were previously assessed for LW W1 – W2 (HEC, 2020), however, are outside the Study Area of LW W3 – W4 and have therefore not been included in this assessment.

Table 16 provides predictions of subsidence related impacts to these dams and the detention basin as summarised from MSEC (2021).

Table 16 Subsidence Predictions for Dams

Dam*	Predicted Total Subsidence after LW W3 (mm)	Predicted Total Subsidence after LW W4 (mm)	Predicted Total Tilt after LW W3 (mm/m)	Predicted Total Tilt after LW W4 (mm/m)	Predicted Change in Freeboard after LW W3 (mm)	Predicted Change in Freeboard after LW W4 (mm)
FD-1	150	200	1.5	2	<0 5	<0 5
FD-2	300	350	3	3.5	<0 5	<0 5
FD-3	425	775	4.5	3.5	150	300
FD-4	700	975	5	3.5	<0 5	<0 5
FD-5	675	700	4	4	150	150
FD-6	950	975	2.5	2.5	<0 5	<0 5
FD-7	725	775	5	5	50	50
FD-8	200	675	1.5	1.5	<0 5	<0 5
FD-12	700	750	4.5	5	150	150
FD-13	40	250	< 0.5	2.5	<0 5	<0 5
FD-14	50	375	< 0.5	4.5	<0 5	100

Dam*	Predicted Total Subsidence after LW W3 (mm)	Predicted Total Subsidence after LW W4 (mm)	Predicted Total Tilt after LW W3 (mm/m)	Predicted Total Tilt after LW W4 (mm/m)	Predicted Change in Freeboard after LW W3 (mm)	Predicted Change in Freeboard after LW W4 (mm)
FD-15	40	100	< 0.5	1	<0 5	<0 5
FD-16	80	500	< 0.5	3.5	<0 5	50
FD-17	< 20	80	< 0.5	< 0.5	<0 5	<0 5
FD-18	< 20	60	< 0.5	< 0.5	<0 5	<0 5
FD-19	< 20	< 20	< 0.5	< 0.5	<0 5	<0 5
FD-20	60	70	0.5	0.5	<0 5	<0 5

*FD-9 to FD-11 were previously assessed for LW W1 – W2, however, are outside the Study Area of LW W3 – W4 and have therefore not been included in this assessment.

4.4.12 Groundwater Wells and Bores

Temporary lowering of the regional piezometric surface over the subsidence area due to extraction of LW W3-W4 may occur, with impacts more notable directly over extracted panels. Groundwater levels may reduce up to 20 metres at GW104090, which is located directly over LW W2. All other private bores are not anticipated to experience adverse impacts to bore yield or serviceability (Geoterra, 2021).

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 (GeoTerra, 2021).

4.4.13 Impact on State Forest

There are no State forests or conservation areas present within the Study Area. The extraction of LW W3-W4 is not expected to impact the State Forest.

4.4.14 Cumulative Impacts

No further cumulative impacts have been identified within the various specialist impact assessments; therefore, it is anticipated there will be negligible cumulative impacts to agricultural resources as a result of the extraction of LW W3-W4.

4.5 Agricultural Regional Community Impacts

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

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 W3-W4, 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 W3-W4.

5.2 Groundwater Resources

All currently operating private bores are predicted to be impacted by a maximum incremental drawdown of greater than two metres. Tahmoor Coal have committed to “make good” provisions for any groundwater users shown to be adversely affected by mine operations and associated impacts.

5.3 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*.

5.4 Farm Fencing

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

5.5 Farm Dams

Tahmoor Coal have an extensive dam monitoring program recommended and carried out by geotechnical engineers from Douglas Partners. All farm dams in the study area are monitored by competent persons prior to, during and after mining to ensure safety and serviceability. 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, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017.*

5.6 Surface Water Extraction

The potential impact on streamflow would be mitigated by Tahmoor Coal purchasing sufficient water licences (WALs) for licensable surface water 'take' within the Stonequarry Creek Management Zone of the Upper Nepean and Upstream Warragamba Water Source. A median baseflow reduction of 51 ML/annum and a maximum baseflow reduction of 155 ML/annum are predicted for Stonequarry Creek at Picton due to mining of LW W3 – W4. A total of 680.3 share components (680.3 ML) is currently allocated as unregulated river access licences from the Stonequarry Creek Management Zone (WaterNSW, 2021). The median predicted reduction of 51 ML/annum equates to 7.5% of the total issued share component of the Stonequarry Creek Management Zone for unregulated river access while the maximum predicted reduction of 155 ML/annum equates to 22.8% of the total issued share component (HEC, 2021).

Although there may be some temporary loss of flow (diversion) from the surface water systems in the event of fracturing or dilation, connectivity between the groundwater and surface water systems is not predicted to occur (SLR, 2021). As such, the estimated baseflow reduction for Stonequarry Creek at Picton associated with mining influences is highly conservative as a portion of the diverted flow is likely to re-emerge further downstream in the event of fracturing and / or dilation.

6 Monitoring & Consultation

6.1 Agricultural Land Monitoring

Comprehensive monitoring of all potentially impacted properties within the LW W1-W2 Study Area is undertaken from the commencement of extraction, and continues monthly until extraction is completed. Further monitoring is undertaken quarterly for 12 months post-extraction, as detailed in the *Tahmoor Coal Pty Ltd Subsidence Monitoring Program Tahmoor North Western Domain Longwalls West 1 and West 2* (Tahmoor Coal, 2020).

The Tahmoor Coal LW W1–W2 Agricultural Inspection Reports show no impacts to agricultural resources or enterprises have been observed during the extraction of LW W1. These inspections are based on baseline reporting undertaken by SLR prior to the commencement of extraction. An example of the Tahmoor Coal LW W1–W2 Agricultural Inspection Report is given in **Appendix D**. The monitoring regime has enabled Tahmoor Coal to effectively monitor agricultural land during LW W1.

Similar monitoring of agricultural land will be completed for all potentially impacted properties within the LW W3-W4 Study Area, and will be document in the LW W3-W4 Extraction Plan (specifically the Land Management Plan and Subsidence Monitoring Program documents).

6.2 Community 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. This consultation was completed on 15 September 2020 and included an overview of the proposal, likely subsidence impacts, and information about the services offered by Tahmoor Coal (Pre-Mining Inspections and Hazard Identification), and the subsidence claims process under the *Coal Mine Subsidence Compensation Act 2017*.

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.

6.3 Government Agency Consultation

During the preparation of the LW W3-W4 Extraction Plan, Tahmoor Coal sent a letter of consultation to DPI Agriculture. A letter response was received, dated 7 October 2020, which provided a list of inclusions that are a guide for the development of this Land and Agricultural Resource Assessment. This list of inclusions is replicated in **Table 18** below, along with a response regarding how this inclusion has been covered by this report.

Table 18 DPI Agriculture Consultation Summary

DPI Agriculture List of Inclusions	Response
Describe the current *Important Agriculture Land* on the proposed development site and surrounding locality including the land capability, and soil landscapes. We note that the site verification is previous work indicates no presence of biophysical strategic agricultural land. This work provides a baseline evaluation of the current land resource for any impact assessment.	Section 2.9 Section 4.1 There is no *Important Agricultural Land* within or adjacent to the Study Area.
A description of the agricultural land uses in the area and associated enterprises and agricultural productivity of these again to provide a current status of agriculture in the area.	Section 3
Detail the expected life span of the proposed development.	Section 1 Extraction of LW W4 is estimated to be completed by approximately August 2022, and visual monitoring of agricultural land will continue for 12 months following active subsidence (estimated August 2023).
Consider possible cumulative effects to agricultural enterprises and landholders from subsidence / other impacting events.	Section 4.4.15 Cumulative effects are anticipated to be negligible.
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, water supply infrastructure. (This may overlap with the other informing plans).	Section 6.1 Impacts to agricultural resources is undertaken as part of the *Tahmoor Coal Pty Ltd Subsidence Monitoring Program Tahmoor North Western Domain Longwalls West 1 and West 2*.
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.	Section 6.2 In accordance with Condition 15(ii) of DA 67/98, Tahmoor Coal have notified relevant landowners / occupiers within the 20 millimetre subsidence area and 35^{o} angle of draw of the intention to extract LW W3-W4. This consultation was completed on 15 September 2020 and included an overview of the proposal, likely subsidence impacts, and information about the services offered by Tahmoor Coal (Pre-Mining Inspections and Hazard Identification), and the subsidence claims process under the *Coal Mine Subsidence Compensation Act 2017*.
Establish a complaints register that includes reporting and investigating procedures and timelines, and liaison with local government in relation to complaint issues involving agriculture.	Section 6.2 Tahmoor Coal has an established compliance register, Cority, into which complaints are registered and tracking of consequent investigative actions. In addition, Tahmoor Coal records all correspondence with landowners in Consultation Manager.

7 Findings

This Land and Agricultural Resource Assessment has been prepared to be included in Tahmoor Coal's Extraction Plan LW W3-W4. The purpose of this Land and Agricultural Resource Assessment is to assess and report on the potential impacts agricultural resources within and the Study Area and recommend mitigation measures to alleviate any identified impacts. The key findings are listed below:

- The majority of agricultural land use 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 64% of the Study Area;
- 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 one stock and domestic bore. Any 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; and
- 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 W3-W4 will provide considerable economic benefits to the region whilst having negligible impact on agricultural resources, enterprises or related industries.

8 References

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Appendix A

Soil Landscape Unit Descriptions

Blacktown Soil Landscape

The Blacktown Soil Landscape Unit consists of gently undulating rises, broad rounded crests and ridges, with slopes less than 5%, but occasionally up to 10% and local relief is up to 30 metres. It occurs on the Wianamatta Group geological unit, which is predominately comprised of shale. Vegetation is almost completely cleared eucalypt woodland, open-forest and tall open-forest. Soils are dominated by shallow to moderately deep Chromosols on crests, upper slopes and well drained areas; deep Dermosols occur on lower slopes and in drainage depressions.

Limitations of this unit include moderately reactive soil, low fertility and seasonal waterlogging. The Soil Landscape unit is suitable for cropping (requiring intensive management practices) and grazing. Much of the Blacktown Soil Landscape Unit has been urbanised or under rural residential development.

This soil landscape dominates the potential grazing areas and occurs over 170 hectares (53%) of the Study Area.

Luddenham Soil Landscape Unit

The Luddenham Soil Landscape Unit consists of undulating to rolling low hills, with slopes 5-20% and local relief is 50-80 metres. It occurs on the Wianamatta Group shales and often associated with Minchinbury Sandstone. Vegetation has been extensively cleared, consisting of open-forest. Soils are dominated by shallow Dermosols on crests; moderately deep Dermosols on upper and lower slopes and near drainage lines.

Limitations of this unit include erosion hazard, mass movement potential and moderate surface swelling potential. This soil landscape unit is suited to grazing enterprises.

This soil landscape occurs throughout 78 hectares (24%) of the Study Area.

Monkey Creek Soil Landscape Unit

The Monkey Creek Soil Landscape Unit consists of floodplains, valley flats and drainage depressions of the creeks draining the Cumberland Plain. Slopes are generally 1-2% but can locally range to up to 10%, local relief is less than 5 metres. Vegetation has been extensively cleared with isolated stands of river oaks. Dominant soils include Sodosols and Kurosols on floodplains and valley floors, with alluvial soils and Hydrosols and Rudosols on poorly drained depressions and close to recent flow lines.

Limitations of this soil landscape include flood hazards, permanently high watertable and seasonal waterlogging. This soil landscape is capable of both grazing and regular cultivation.

This soil landscape occurs throughout 44 hectares (14%) of the Study Area.

Picton Soil Landscape Unit

The Picton Soil Landscape Unit consists of steep to very steep sideslopes, with slopes greater than 20% and local relief of 90-300 metres. It occurs on Wianamatta group shales and derived colluvial materials. Vegetation consists of extensively cleared tall open-forest of blue gum and blackbutt. Dominant soils are shallow to deep Dermosols on upper slopes and Kurosols on lower slopes and benches.

Limitations of this soil landscape unit include steep slopes, mass movement hazards, seasonal waterlogging and water erosion hazards. This soil landscape is not suitable for any agricultural enterprise.

This soil landscape occurs throughout 19 hectares (6%) of the Study Area.

Lucas Heights

The Lucas Heights Soil Landscape Unit consists of gently undulating crests, ridges and plateau surfaces, with slopes less than 10% and local relief is 10-50 metres. It occurs on the Mittagong Formation geological unit consisting of shale, laminite and quartz sandstone. Vegetation is extensively to completely cleared dry sclerophyll low open-forest and low woodland. Soils are dominated by moderately deep hard setting Kurosols on ridges and plateaus with Kurosols on crests, Kandosols on shoulders of plateaus and ridges and Tenosols on valley flats.

Limitations of this unit include stoniness, low fertility and land surface movement potential. The soil landscape is predominantly suited to grazing enterprises.

This soil landscape occurs throughout 11 hectares (3%) of the Study Area.

Hawkesbury Soil Landscape Unit

The Hawkesbury Soil Landscape Unit covers rugged, rolling to very steep hills, with slopes greater than 25% and local relief of 100-200 metres. It occurs on the Hawkesbury Sandstone geological unit consisting of sandstone and some shale and laminate. Vegetation consists of mostly uncleared eucalypt woodland, open-forest (dry sclerophyll forest) and tall open forest (wet sclerophyll forest). Soils are dominated by shallow Tenosols and Rudosols associated with rock outcrops; Tenosols and Kandosols and locally deep sands occur on the inside of benches and along joints and factures. Kurosols are present on shale lenses with Tenosols on valley flats.

Limitations of this soil landscape unit include extreme soil erosion hazard, mass movement (rock fall) hazard, steep slopes, rock outcrop and shallow, stony, highly permeable soils of very low fertility. The Hawkesbury unit is not suitable for any agricultural enterprise.

This soil landscape occurs over less than 1 hectare (<1%) of the Study Area.

Appendix B

Site Inspection Plates

2019 Site Inspection Photos

Site 4 – Rural residential

Site 5 – Rural residential

Site 6 – Cattle grazing

Site 7 – Pleasure horses

Site 8 – Ungrazed pasture

Site 10 – Pleasure horses

Site 11 – Orchards

2020 Site Inspection Photos

Site 1 – Cattle grazing

Site 2 – Cattle grazing

Site 3 – Cattle grazing

Site 4 – Cattle grazing

Site 5 – Ungrazed pasture

Site 6 – Cattle & please horse grazing

Site 7 – Cattle & please horse grazing

Site 8 – Cattle & please horse grazing

Site 9 – Ungrazed pasture

Site 10 – Residential & rural residential

Site 11 – Cattle & please horse grazing

Site 12 – Cattle & please horse grazing

Site 13 – Cattle & please horse grazing

Site 14 – Looking west towards cattle grazing paddocks

Appendix C

Agricultural Productivity Gross Margin Data

NSW GOVERNMENT | 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.
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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

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.

Appendix D

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	<u>February Comments (02/03/2020):</u> No observed changes since January report Significant rainfall has however resulted in grass and shrub growth <u>March Comments (27/03/2020):</u> No observed changes since February report Increased vegetation growth <u>April Comments (24/04/20):</u> No observed changes since March report <u>May Comments (21/05/20):</u> Increased vegetation growth along riverbank due to recent rain. Dieback of paddock vegetation has begun as the change of season approaches. <u>June Comments (30/06/20):</u> 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)

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