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Tahmoor Coal Pty Ltd

WATER MANAGEMENT PLAN

Tahmoor North - Western Domain
Longwalls West 3 and West 4

September 2021

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Document Control

APPLICANT:	Tahmoor Coal Pty Ltd
MINE:	Tahmoor Coal Mine
DEVELOPMENT APPROVAL:	DA 57/93 (as modified) and DA 67/98 (as modified)
MINING LEASES:	ML 1376 and ML 1539
DOCUMENT TITLE:	Tahmoor North - Western Domain Longwalls West 3 and West 4 Water Management Plan
DOCUMENT NUMBER:	TAH-HSEC-328
PUBLICATION DATE:	September 2021
DOCUMENT STATUS:	Final (Version 4)
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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 34 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 and was completed on 17 June 2021.

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**.

Tahmoor Coal received conditional approval from DPIE of the Extraction Plan for LW W3-W4 on 13 September 2021.

1.2 Purpose

This Water Management Plan (WMP) has been prepared to support an Extraction Plan for the secondary extraction of coal from LW W3-W4. This WMP has been designed to identify the monitoring and management measures for surface water and groundwater resources 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 WMP consists of a combination of the predicted 20 millimetre (mm) Total Subsidence Contour and the 35° 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.

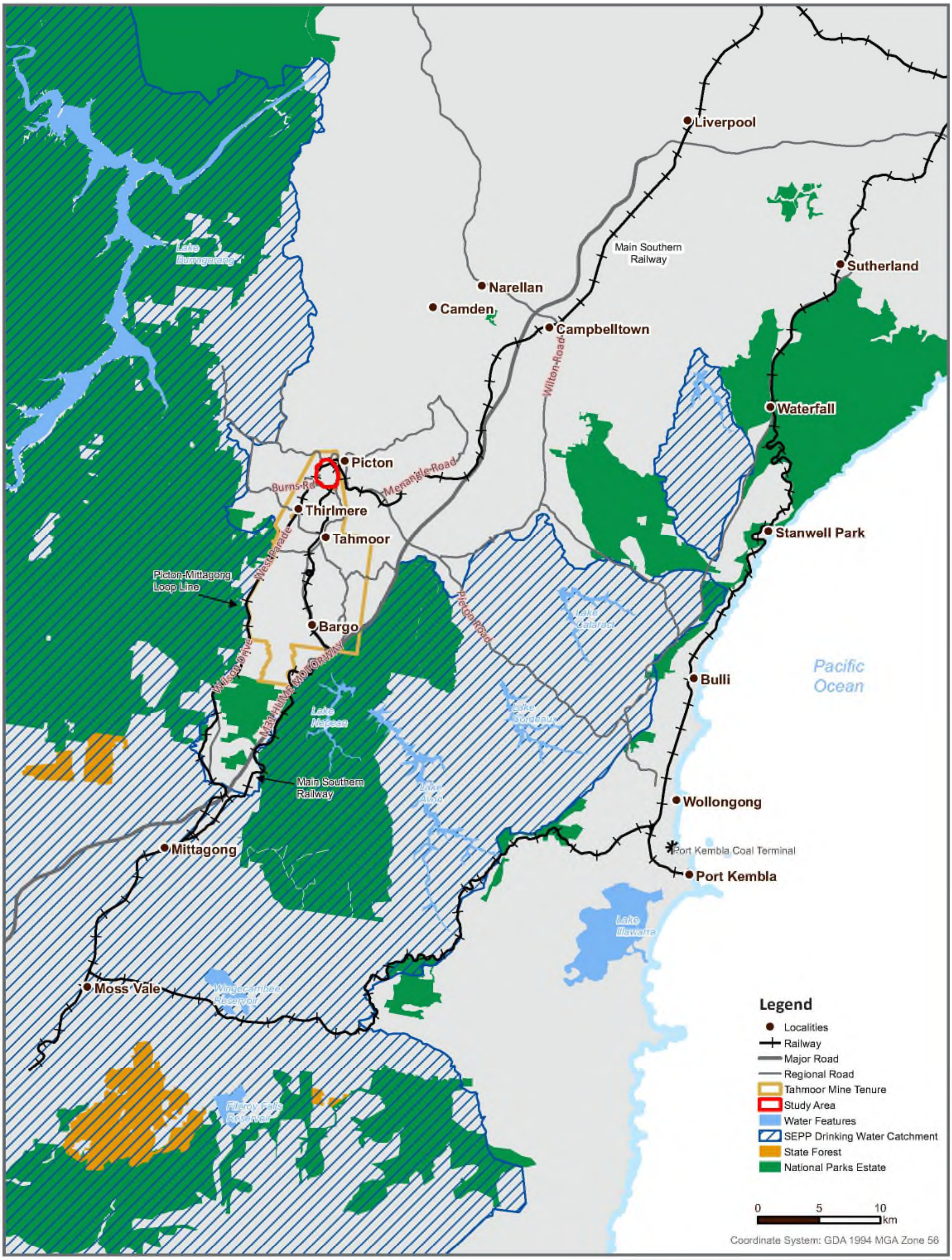
This WMP:

- Addresses specific requirements set by DA 67/98 Condition 13H(vii)(c) (refer to **Section 2.1**);
- Addresses related regulatory requirements (refer to **Section 2.1.2**);
- Addresses the monitoring and management of potential subsidence-related impacts to surface water and groundwater resources (refer to **Section 4.2.5**); and
- Provides an updated Trigger Action Response Plan (TARP) to be implemented to manage and protect surface water and groundwater resources within the Study Area (refer to **Appendix A**).

This WMP has been updated to address the conditions of LW W3-W4 Extraction Plan approval granted by DPIE on 13 September 2021.

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

- Surface Water Technical Report (SWTR) (HEC, 2021a) (**Appendix B**);
- Flood Impact Study (WRM, 2020) (**Appendix C)**;
- Groundwater Technical Report (GTR) (SLR, 2021a) (**Appendix D**);
- Baseline Private Bore Assessment (GeoTerra, 2021) (**Appendix E**);
- Memorandum in response to IAPUM Advice (SLR, 2021c) (**Appendix G**);
- Geotechnical Assessment (Douglas Partners, 2021) (**Volume 2**);
- Nepean Fault and SR17 Report (SCT, 2021) (**Volume 1**);
- Picton Rail Tunnel Report (SCT, 2020) (**Volume 1**); and
- Subsidence Predictions and Impact Assessments Report (MSEC, 2021) (**Volume 1**).



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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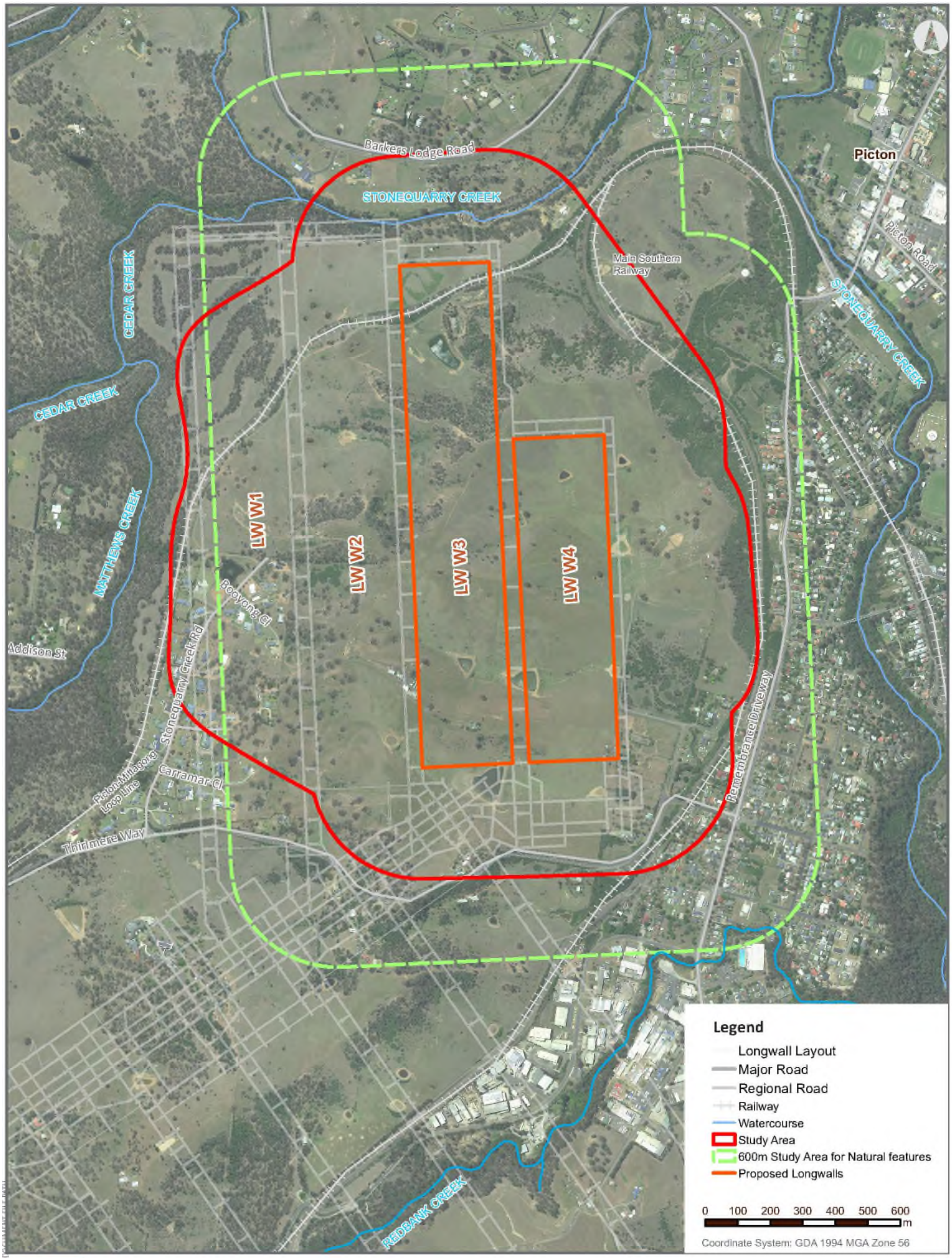

EXTRACTION PLAN STUDY AREA

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.

LW W3-W4 will be extracted 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 WMP from DA 67/98 are detailed in **Table 2-1**.

Table 2-1 Key Conditions from DA 67/98 regarding Surface Water and Groundwater 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, 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>• Public Safety</td></tr>
<tr><td colspan="4">Extraction Plan</td></tr>
<tr><td>13H(vi)</td><td colspan="2">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;</td><td>Section 5.1, Section 5.2 and Section 6</td></tr>
<tr><td>13H(vii)(c)</td><td colspan="2">Water Management Plan which has been prepared in consultation with EPA, DPIE Water, Resources Regulator and WaterNSW, which provides for the management of potential impacts and environmental consequences of the proposed underground workings on watercourses and aquifers, including:</td><td>This document, Section 2.3</td></tr>
</table>

Condition	Condition Requirement	Section(s) Addressed
	• detailed baseline data on: - surface water flows and quality in watercourses and/or water bodies that could be affected by subsidence; and • groundwater levels, yield and quality in the region, including for privately-owned licensed bores.	Section 3
	• surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality.	Section 5.1, Section 6.3, Appendix A
	• a surface water monitoring program to monitor and report on: • stream flows and quality; • stream and riparian vegetation health; and • channel and bank stability.	Section 5.2
	• a groundwater monitoring program to monitor and report on: • springs, their discharge quantity and quality, as well as associated groundwater dependent ecosystems; • groundwater inflows to the underground mining operations; • the height of groundwater depressurization; • background changes in groundwater yield/quality against mine-induced changes, in particular, on groundwater bore users in the vicinity of the site; and • permeability, hydraulic gradient, flow direction and connectivity of the deep and shallow groundwater aquifers.	Section 5.2 It is noted that monitoring of springs is not required.
	• a flood management protocol to: • identify secondary access routes for those properties that could potentially be adversely impacted by 1% AEP flood events; • regularly consult with landowners that would not have either a primary or secondary access route during 1% AEP flood events; • provide up-to-date information (including subsidence and flooding predictions) to the State Emergency Service and Council regarding privately-owned residences that could be adversely affected by lack of access during 1% AEP flood events; and • work with landowners, State Emergency Service and Council to develop evacuation plans to ensure landowners know what to do in the event of emergency as a result of a 1% AEP flood event.	Section 6.2.1
	• a description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on aquatic habitat.	Section 6.5
	• a program to validate the surface water and groundwater models for the development, and compare monitoring results with modelled predictions; and	Section 6.2.5, Section 6.3, Appendix A Not applicable for surface water
	• a plan to respond to any exceedances of the surface water and groundwater assessment criteria;	Section 6.4, Appendix A
13H(vii)(h)	Trigger Action Response Plan/s addressing all features in Table 1 and Table 2, which contain: • appropriate triggers to warn of increased risk of exceedance of any performance measure; and	Section 6.3, Section 6.5, Appendix A

Condition	Condition Requirement	Section(s) Addressed
	• 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 WMP has been prepared in accordance with the DPIE *Draft Guidelines for the Preparation of Extraction Plans V5* (DPE, 2015), as detailed 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, Section 5.1
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 5.1, Section 6
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, Appendix A
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, Section 5.2
Fully describing the proposed monitoring of subsidence impacts and environmental consequences.	Section 5.2

Extraction Plan Guideline Content Requirements for Key Component Plans	Section(s) Addressed
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

2.1.3 Extraction Plan Conditions of Approval

DPIE approved the LW W3-W4 Extraction Plan on 13 September 2021, and conditions relevant to this WMP and where they are addressed in this document are outlined in **Table 2-3**.

Table 2-3 Conditions for LW W3-W4 Extraction Plan approval relevant to WMP

<table>
<tr><th>Condition</th><th>Condition Requirement</th><th>Section(s) Addressed</th></tr>
<tr><td colspan="3">Performance Measures</td></tr>
<tr><td>1</td><td>The Applicant must ensure that the development does not cause any exceedances of the performance measures in Table 1.</td><td>Section 5.1</td></tr>
<tr><td>2</td><td>Table 1: Subsidence impact performance measures – natural features
<table><tr><th>Feature</th><th>Performance Measure</th></tr><tr><td>Stonequarry Creek, Cedar Creek and Matthews Creek</td><td>No subsidence impact or environmental consequence greater than minor*
No connective cracking between the surface, or the base of the alluvium, and the underground workings.</td></tr></table>*minor is defined as not very large, important or serious</td><td>Section 5.1</td></tr>
<tr><td>3</td><td>These performance measures apply to all mining taking place after the date of this Extraction Plan approval.</td><td>Section 5.1</td></tr>
<tr><td>4</td><td>If the Applicant exceeds the performance measures in Table 1 and the Secretary determines that:
a) it is not reasonable or feasible to remediate the subsidence impact or environmental consequence; or
b) remediation measures implemented by the Applicant have failed to satisfactorily remediate the subsidence impact or environmental consequence,
then the Applicant must provide a suitable offset to compensate for the subsidence impact or environmental consequence, to the satisfaction of the Secretary.</td><td>Noted</td></tr>
<tr><td colspan="3">Water Management Plan</td></tr>
</table>

Condition	Condition Requirement	Section(s) Addressed
10	The Applicant must undertake a review of the Water Management Plan groundwater level TARP triggers and, if necessary following this review, revise the TARP to address the matters raised by the Panel in Section 4.2 of its advice dated September 2021 on the "Tahmoor Coal North Western Domain Longwalls W3 and W4 Extraction Plan." This review and any subsequent revisions must be undertaken to the satisfaction of the Secretary, prior to the extraction of LW W3 retreating more than 150m from its starting position.	Review completed and TARP triggers updated. Refer to Section 6.3.1.

2.2 Relevant Legislation

The relevant acts and regulations protecting and managing surface water and groundwater resources in New South Wales are detailed in the subsections below.

2.2.1 Water Management Act 2000

The NSW DPIE Water develops, assesses and recommends changes to water sharing / water resources plans and water management rules for regional water in NSW in accordance with the *Water Management Act 2000*. A primary objective of DPIE Water is the sustainable management and use of water resources, balancing environmental, social and economic considerations. DPIE Water has developed Water Sharing Plans (WSPs) for much of the State and these establish rules for sharing and trading water between the environment, town water supplies, basic landholder rights and commercial uses (HEC, 2021a).

NSW Industry – Natural Resources Access Regulator (NRAR) is an independent regulatory body established by DPIE Water and is responsible for compliance with and enforcement of the regulatory framework. The Study Area is located within the Upper Nepean River Water Source which is regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources*, which specifically addresses the Stonequarry Creek Management Zone of the Upper Nepean and Upstream Warragamba Water Source (HEC, 2021a).

Groundwater is regulated under the Greater Metropolitan Region Groundwater Sources (NOW, 2011b) with the Study Area positioned within Nepean Management Zone 2 of the Sydney Basin Nepean Groundwater Source. The Nepean Sandstone Groundwater Source has an annualised limit on entitlement of 99,568 megalitres (NOW, 2011a), while current entitlement is 31,346 megalitres (based on the WaterNSW Water Register 2020-2021 water year)[1].

The NSW Water Register indicates that there are 22 Water Access Licence (WAL) - Water Supply Works and Water Use Approvals for the Stonequarry Creek Management Zone with a total share component of 680.3 ML for the period July 2020 to June 2021 (inclusive). Seven WALs, associated with fourteen lots, are located in the vicinity of the Study Area. The WALs pertain to diversion works from the Stonequarry Creek Management Zone via direct extraction (pumping) and / or through collection and storage for irrigation and / or farming purposes (HEC, 2021a). A discussion regarding the predicted incidental water loss and required surface water WALs is provided in **Section 4.1.2**.

[1] See: https://waterregister.waternsw.com.au/

Water used in existing and on-going mining and coal processing operations will continue to be sourced from the underground operations (groundwater ingress and recycling of supply for mining operations) and from water captured within the existing pit top water management system – principally at the coal handling and processing plant and rejects emplacement area, which are located approximately eight km south of the Study Area. Some water is also supplied under agreement with Sydney Water.

NSW Aquifer Interference Policy

Underground mining generally requires the dewatering of the geological strata. In accordance with the NSW Aquifer Interference Policy 2012 (AIP), such activity is classified as an 'Aquifer Interference'. In order to meet the requirements of the 'minimal impact considerations', outlined within the AIP, a groundwater assessment is conducted (SLR, 2021a).

The AIP requires an estimation of "all quantities of water that are likely to be taken from any water source during and following cessation of the activity and all predicted impacts associated with that activity...". Water 'take' and impact estimation is to be based on a "complex modelling platform", where the model makes use of the "available baseline data that has been collected at an appropriate frequency and scale and over a sufficient period of time to incorporate typical temporal variations" (SLR, 2021a).

The AIP was developed to provide a framework to guide the assessment of impacts that may result following the 'take' of water from an aquifer. It outlines the requirements for obtaining licences for approved aquifer interference activities, as well as considerations for the assessment of impacts (NSW Government, 2012). The AIP specifies 'minimal harm considerations' for highly and less productive aquifers, while also defining thresholds for water table and groundwater pressure drawdown, and changes in groundwater and surface water quality (SLR, 2021a).

The AIP categorises groundwater source productivity (highly productive or less productive) based on characteristics of salinity and aquifer yield. Tahmoor Mine is located within the 'Highly Productive' Hawkesbury Sandstone aquifer, which is the most ulitilised aquifer in this region. Water sourced from the Narrabeen Group and Permian Coal Measures comprises the remaining portion of water sourced around the Tahmoor Mine (SLR, 2021a).

It should be noted that the categorisation of groundwater source productivity does not make any vertical distinction of aquifer productivity. This is pertinent as the high yielding Hawkesbury Sandstone aquifer overlies the lower yielding Narrabeen Group/Permian Coal Measures groundwater systems which are present at greater depths (SLR, 2021a).

Water Licensing

Water Access Licences (WAL) held by Tahmoor Coal under the authority of the *Water Management Act 2000* are listed in **Table 2-3**.

Table 2-4 Water Access Licence Details

Works Approval	WAL Title	Issued	Purpose	Share
10WAI18745	WAL 36442	6/12/2013	Mining dewatering (groundwater) – Nepean Sandstone Groundwater MZ2	1642 ML
10AL103025	WAL 25777	27/10/2014	Surface Water Take – Maldon Weir MZ	5 ML
10MW119329	WAL 43572	13/04/2021	Incidental Surface Water Take – Stonequarry Creek MZ	16 ML

Tahmoor Coal also holds a discharge licence, issued by the NSW Environment Protection Authority (EPA). This licence, Environment Protection Licence (EPL) 1389, permits the discharge of wastewater and 'made water' from the underground mine to surface water. The extraction of longwalls within the Western Domain will not affect the licence conditions of this EPL (HEC, 2021a).

2.2.2 Protection of the Environment Operations Act 1997

EPL 1389 includes licensed discharge points for surface water. The conditions of EPL 1389 are concerned with the management of water at the pit top location and the mining and coal processing operations related to LW W1 and subsequent longwalls in the Western Domain will not impact these conditions.

2.3 Consultation

2.3.1 Consultation during Extraction Plan Preparation

The following stakeholders were consulted during the preparation of this WMP:

- Department of Regional NSW – Resources Regulator (Resources Regulator);
- DPIE - Environment, Energy and Science (EES) Group;
- DPIE Water;
- Dams Safety Committee;
- NRAR;
- NSW Environment Protection Authority;
- WaterNSW;
- Wollondilly Shire Council; and
- NSW State Emergency Services.

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.

In response to preliminary comments from EES, Tahmoor Coal notes that this WMP provides further information to address EES's primary concerns relating to subsidence impact (**Section 4**), monitoring (**Section 5**) and remediation of waterways (**Section 6**).

Tahmoor Coal will complete further consultation with EES following the submission of the Extraction Plan. This will include the provision of the Myrtle Creek Rehabilitation Report (**Appendix E** of the Extraction Plan Main Document), Nepean Fault and SR17 Report (**Appendix F** of the Extraction Plan Main Document), Surface Water Technical Report (**Appendix B**), Groundwater Technical Report (**Appendix C**), updated Subsidence Predictions and Impact Assessment Report (**Appendix A** of the Extraction Plan Main Document). During the consultation, Tahmoor Coal will also provide a presentation regarding an overview of progress for Myrtle Creek and Redbank Creek rehabilitation, which will include discussion of results as reported in the Myrtle Creek Rehabilitation Report (**Appendix E** of the Extraction Plan Main Document).

In response to NRAR correspondence, Tahmoor Coal notes that details of water take and water licencing is included in **Section 4.1.2** of this document.

During consultation with Wollondilly Shire Council, a number of requests were made regarding the following information is included in the WMP. These comments and Tahmoor Coal's response is provided in **Table 2-4**.

Table 2-5 Wollondilly Shire Council Comments and Tahmoor Coal Responses

Wollondilly Shire Council Comment	Tahmoor Coal Response
Modelling and data analysis to obtain an accurate scientific based assessment of the setbacks required for the longwalls to avoid impacts to third order water streams or above (in a catchment context.	The current mine plan is a revision of the 2014 SMP Application mine plan, which was reviewed based on feedback received from the community and NSW Government agencies, as well as updated knowledge on geotechnical, operational and mining conditions. The updated mine design was re-orientated to avoid mining directly under high order streams (Matthews Creek, Cedar Creek and Stonequarry Creek). Tahmoor Coal considers that the current subsidence predictions for the current mine plan to be acceptable, and that the current mine plan appropriately balances the requirements of resource recovery, minimisation of environmental impact, and consideration of community and Government agency concern. An Adaptive Management Strategy has been developed to respond to any observed impacts to creeks from subsidence as a result of LW W2 and, if required, will inform the modification of the commencing end of LW W3 to potentially avoid impacts to Stonequarry Creek. This strategy will be implemented after 1,000 metres of LW W2 extraction. The Water Management Plan includes an assessment of the potential impacts to ephemeral drainage lines and surface water systems within the Study Area based on subsidence and baseflow loss predictions and with consideration of surface water impacts associated with mining previously undertaken in the region. This is provided in **Section 4** of the WMP.
A detailed assessment of potential impacts mining operations on the ecological health of waterways in a catchment context that includes aquatic ecology.	Potential impacts to aquatic ecology from the mining of LW W3-W4 are discussed in **Section 4.1** of the Biodiversity Management Plan and **Section 4.1.8** of the Water Management Plan.
A detailed groundwater and geological model that would allow for an accurate scientific based understanding of identification of potential impacts associated with the proposal on both surface and groundwaters.	The detailed groundwater model and potential impacts associated with the mining of LW W3-W4 are discussed in **Section 4.2** of the Water Management Plan.
A Water Management Plan detailing intended water quality monitoring that includes triggers based on ecological health parameters and monitoring for the presence of any re-emergence of water to the surface from mine induced fractures.	A detailed water quality monitoring plan and associated TARP is documented in the Water Management Plan. This is provided in **Section 5** and Appendix A of the WMP. The water quality monitoring plan and TARP incorporate learnings from monitoring and TARP assessments undertaken for LW W1-W2, and have been developed with consideration to ecological health parameters as guided by the Biodiversity Management Plan.

Wollondilly Shire Council Comment	Tahmoor Coal Response
	The 'Impact to pool level, natural drainage behaviour or overland connected flow' TARP includes a trigger stating that if impacts are observed at the monitoring sites, a visual inspection of downstream reaches will be undertaken, and if re-emergence is identified a water quality monitoring program will be implemented at the re-emergence location/s.
Any first or second other order watercourse be subject to a detailed assessment of likely subsidence induced impacts prior to the commencement of any extraction activity.	The Water Management Plan includes an assessment of the potential impacts to ephemeral drainage lines within the Study Area based on subsidence and baseflow loss predictions, and with consideration to surface water impacts associated with mining previously undertaken in the region. This assessment is included in Section **4.1** of the Water Management Plan and **Section 5.4.1** of the Subsidence Predictions and Impact Assessment Report (**Appendix A** of the Extraction Plan Main Document).

3 Existing Environment

3.1 Surface Water

3.1.1 Natural Waterways in the Study Area

The Study Area is located in the Upper Hawkesbury-Nepean Catchment with the natural waterway features comprising Matthews Creek, Cedar Creek, Stonequarry Creek, and Redbank Creek (refer to **Figure 3-1**). The south-west portion of the Study Area drains to Matthews Creek, while the north-northwest portion of the area drains 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 (HEC, 2021a).

Matthews Creek and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 850 m west of LW W3. These creeks are fourth order streams within the vicinity of the Study Area, with Cedar Creek becoming a fifth order stream downstream of the confluence with Matthews Creek. Stonequarry Creek also rises to the west and flows to the east, and is joined by Cedar Creek approximately 370 m north west of LW W3 before flowing east and south through the town of Picton. The creek is a fifth order stream within the Study Area.

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 m south of the edge of LW W4 at its closest point (refer to **Figure 3-1**) and is a fourth order stream within the vicinity of the Study Area.

The proposed LW W3-W4 Study Area includes several minor tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek (HEC, 2021a).

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 near and downstream of the Study Area are not part of a WaterNSW Drinking Water Catchment Area (HEC, 2021a).

Further details of the waterways in the Study Area and surrounding regions is provided in the SWTR (HEC, 2021a; **Appendix B**).

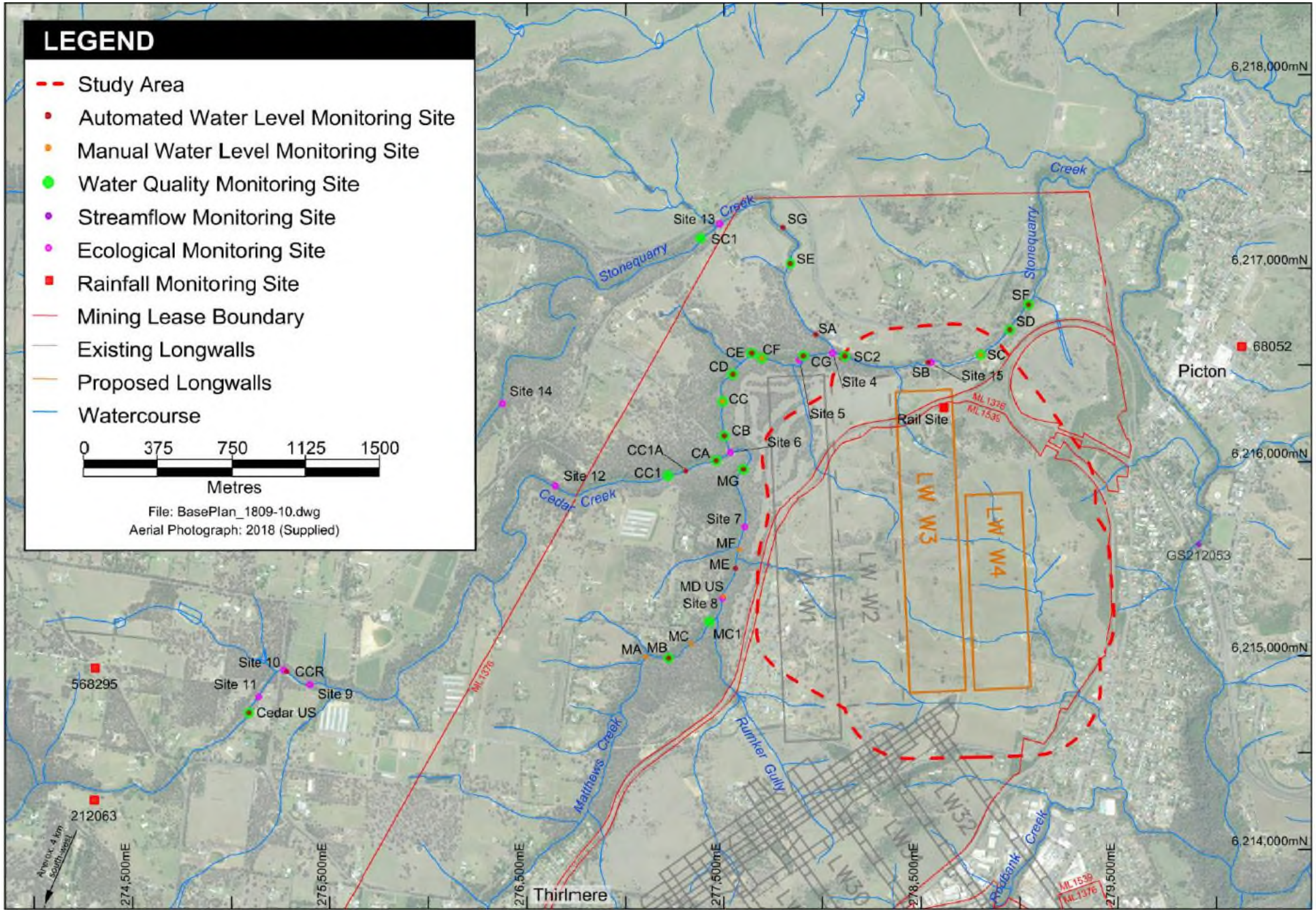

Figure 3-1 Rainfall, Surface Water and Ecological Monitoring Locations (HEC, 2021a)

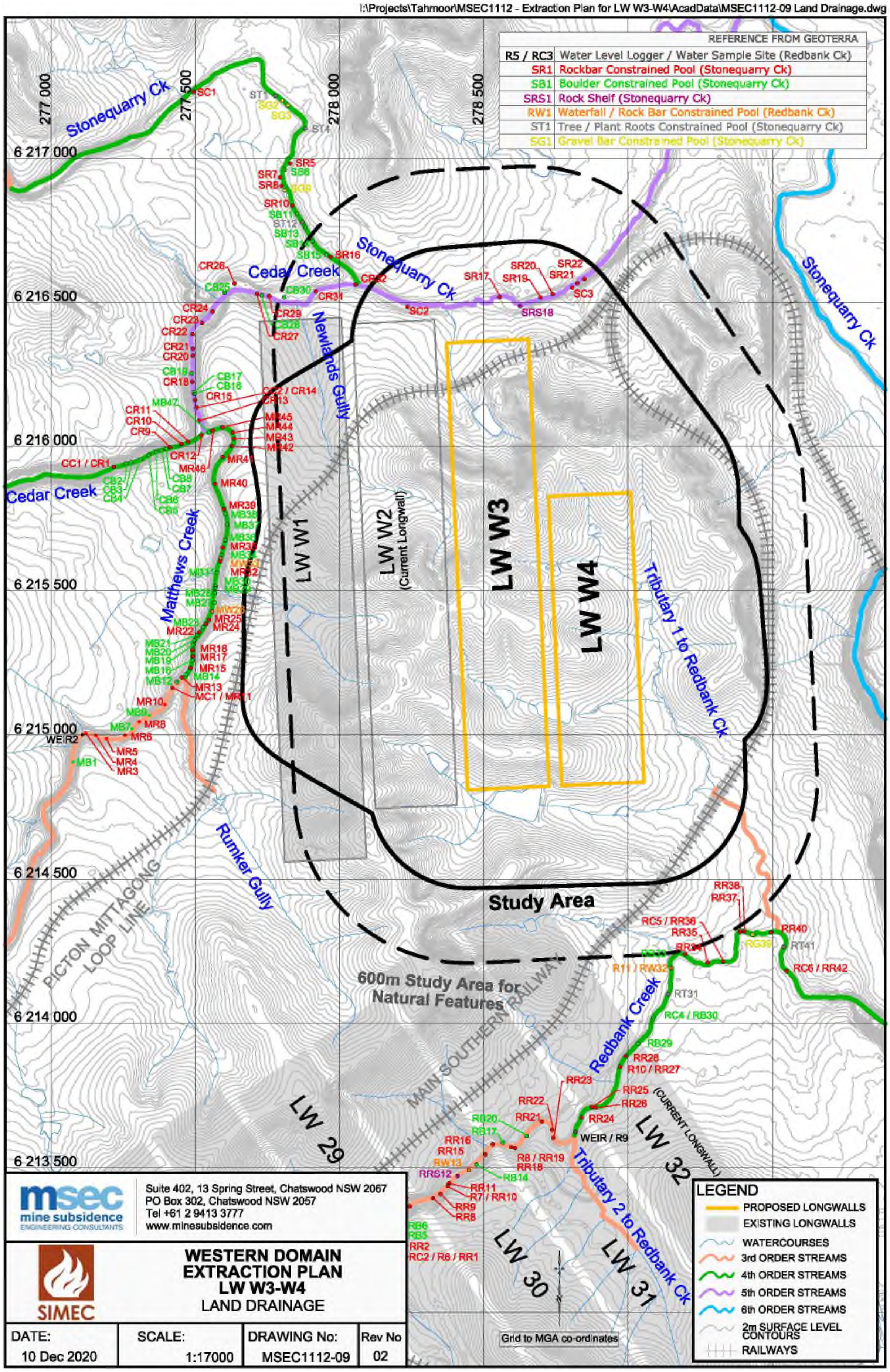

Figure 3-2 Waterways within the LW W3-W4 Study Area and Rockbar SR17 (MSEC, 2021)

3.1.2 Pool Water Levels and Flow

Continuous (automated) surface water level data has been collected by Tahmoor Coal at three monitoring sites on Matthews Creek, eight monitoring sites on Cedar Creek, and seven monitoring sites on Stonequarry Creek (refer to **Figure 3-1** and **Appendix F**). The surface water level data are recorded hourly using a water level sensor. Flow rating relationships have been derived from the continuous surface water level data for the relevant sites.

In addition to the above, pool and surface water levels are measured manually at an additional four sites on Matthews Creek, two sites on Cedar Creek and one site on Stonequarry Creek (refer to **Figure 3-1** and **Appendix F**). Water levels are measured on a monthly basis at these sites.

SLR (2021) state that the reach of Matthews Creek within the Study Area prior to mining LW W1 – W2 was inferred to be losing to the groundwater system at upstream monitoring sites (MA and MB) and gaining from the groundwater system at sites further downstream in Matthews Creek.

Prior to the commencement of mining LW W1 and LW W2, the reach of Cedar Creek from monitoring sites CA to CG was inferred to be dominantly gaining from the groundwater system, although losing conditions were predominant at monitoring site CC1A and CF (SLR, 2021a). These inferences are supported by the water level records for Cedar Creek and estimated streamflow rates at monitoring sites CC1A, CE and CG (HEC, 2021a).

In the LW W3-W4 Study Area, the Stonequarry Creek bed has a low gradient and predominately consists of a long pool, SR17, which extends from monitoring site SC2 (upstream) to monitoring site SB (downstream) (refer to **Figure 3-1**). The pool is approximately 670 m long and flow appears to be perennial in nature, with trickle flow observed over the rockbar during a period of prolonged low rainfall in 2019. The deepest section of pool SR17 is approximately 4 metres below the surface of rockbar SR17 (refer **Figure 3-2**; MSEC, 2021).

Prior to the commencement of mining LW W1 and W2, the upstream reach of Stonequarry Creek from monitoring site SG to SE (refer **Figure 3-1**) was inferred to be spatially varying between gaining and losing conditions from the groundwater system (SLR, 2021a). Further downstream at pool SR17 (monitoring site SB), there is potential that the base of the pool is in connection with the Hawkesbury Sandstone, with the Hawkesbury Sandstone supporting baseflow to Stonequarry Creek. However, the relative influence of the shallow colluvium present at this location in comparison with the contribution of baseflow from the Hawkesbury Sandstone is uncertain (SLR, 2021a). Losing conditions are inferred to prevail at monitoring sites SC, SD and SF further downstream in Stonequarry Creek (SLR, 2021a). These inferences are supported by water level records for Stonequarry Creek and estimated streamflow rates at monitoring site SA and SD.

The tributaries of Redbank Creek within the Study Area, including the main tributary of Redbank Creek, are ephemeral and likely only flow during periods of extended, moderate or high rainfall. SLR (2021) indicate that there is limited baseflow contribution from the outcropping Wianamatta Group to the main tributary of Redbank Creek. Two large farm dams and a number of smaller farm dams are located within the catchment area. Surface water runoff from the headwaters of the tributaries is predominately captured by these farm dams with runoff from the tributaries likely to contribute to flow in Redbank Creek during periods of extended or significant rainfall only.

In addition to the monitoring within the Study Area undertaken by Tahmoor Coal, recorded streamflow data is available from a WaterNSW gauging station located on Stonequarry Creek at Picton (GS 212053), approximately 5 km downstream of the confluence of Stonequarry Creek and Cedar Creek (refer **Figure 3-1**). The estimated catchment area to the streamflow gauging station is 83 km^2. It is noteworthy that a significant tributary (Racecourse Creek) contributes additional flow to the creek at this point, downstream of the Study Area.

Detailed information on water level and streamflow is provided in the SWTR (HEC, 2021a; **Appendix B**).

3.1.3 Surface Water Quality

Water quality monitoring has been undertaken at sites on Matthews Creek, Cedar Creek and Stonequarry Creek since 2014. Water quality monitoring was undertaken by GeoTerra in November 2014 (GeoTerra, 2014) and by Niche in October 2014, November 2017, May 2018, November 2018, May 2019 and December 2019 (Niche, 2014; Niche, 2019; Niche, 2021). The location of the monitoring sites is shown in **Figure 3-1**.

Water quality monitoring of Redbank Creek has been undertaken by Tahmoor Coal since 2005 at some sites. During this time LW24B to LW32 were mined. Monitoring sites RB2/RC1 to RB10 were progressively influenced by mining-induced subsidence, with subsidence induced cracking of site flow controls (e.g. rock bars) leading to leakage, underflow and re-emergence of flow further downstream of impacted sites.

In NSW, the level of protection applied to most waterways is that for 'slightly to moderately disturbed' ecosystems, for which ANZG (2018) recommends adoption of the default guideline values for aquatic ecosystems at the 95% protection level. The water quality data for physicochemical constituents has been assessed against the ANZECC & ARMCANZ (2000) default guideline values for the protection of slightly disturbed aquatic ecosystems in south-east Australian Upland Rivers (HEC, 2021a).

Detailed information on water quality is provided in the SWTR (HEC, 2020). **Table 3-1** provides a summary of water quality trends for pH, electrical conductivity (EC) and heavy metals as observed from the available data for Matthews Creek, Cedar Creek, Stonequarry Creek, and Redbank Creek.

To date, there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Matthews Creek, Cedar Creek or Stonequarry Creek. The water quality characteristics of potential impact sites in the three waterways following commencement of mining LW W1 and LW W2 have been consistent with baseline conditions and / or consistent with reference site conditions (HEC, 2021a).

Table 3-1 Summary of Water Quality Observations

Waterway	Parameter Trends
pH	
All sites	• The pH (laboratory and field) records for all monitoring sites in Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek indicate slightly acidic to near neutral conditions for the majority of the monitoring period. • Substantially higher field pH values, inconsistent with baseline (pre-mining) conditions, were recorded between February and April 2020 at monitoring sites on Matthews Creek, Cedar Creek, and Redbank Creek. The field pH values recorded during this period were identified as potentially erroneous and the field pH meter replaced. Following replacement of the field pH meter, the recorded values have been consistent with baseline values. • Some field pH measurements recorded at Redbank Creek monitoring site RB6/RC2 prior to the commencement of mining LW24B and at RC3 during the period of mining indicated increasing acidic conditions (less than pH 5), however, these pH values were not persistent.
Electrical Conductivity	
Matthews Creek	• The EC values recorded at monitoring sites in Matthews Creek indicate that EC is naturally elevated in Matthews Creek with a declining trend in EC values occurring from upstream (monitoring site MB) to downstream (monitoring site MG) on Matthews Creek. • An increasing trend in EC values was recorded at monitoring site MB between April and November 2019 during an extended period of low rainfall. Following considerable rainfall in February 2020, the EC level reduced at all sites and has remained below 500 µS/cm for the remainder of the monitoring period.
Cedar Creek	• The monthly field EC values recorded at monitoring sites in Cedar Creek between January 2019 and January 2021 indicate that EC is naturally elevated in Cedar Creek (maximum 1,086 µS/cm recorded at monitoring site CC1 in August 2019) with generally consistent EC values recorded for upstream (monitoring site CC1) and downstream sites (monitoring site CG). • From August 2019 to January 2020 during an extended period of low rainfall, EC values exceeded 1,000 µS/cm at some sites. Following substantial rainfall in early 2020, the EC levels reduced at all sites and records were less than 1,000 µS/cm for the remainder of the monitoring period.
Stonequarry Creek	• The EC values recorded at monitoring sites in Stonequarry Creek indicate that EC in Stonequarry Creek is naturally elevated (generally less than 1,100 µS/cm). • An increasing trend in EC values was recorded at SC, SC2 and SD between October and January 2020. During this time EC recordings at monitoring site SC were historically high with a measurement of 3,240 µS/cm recorded in January 2020. Following substantial rainfall in February 2020, EC levels reduced at all sites and remained below 900 µS/cm for the remainder of the monitoring period.
Redbank Creek	• The EC values recorded at monitoring site RB6/RC2 increased between 2013 and 2015 as mining progressed, with elevated EC values also recorded at monitoring sites RB9/RC3 and RC6 (downstream of LW32) between late 2014 and early 2018. • Recorded EC values generally declined in 2018 and increased in 2019 during an extended low rainfall period. Recorded EC levels have since declined at all sites during and following the cessation of mining LW32.
Metals – arsenic, barium, lead, and selenium	
Matthews Creek, Cedar Creek, Stonequarry Creek	• Concentrations of total arsenic, barium, lead and selenium recorded at all monitoring sites in Matthews Creek, Cedar Creek and Stonequarry Creek have been consistently below the ANZG (2018) default guideline values for the duration of monitoring.
Redbank Creek	• Concentrations of total arsenic and barium recorded at all sites have been consistently below the ANZG (2018) default guideline values for the duration of monitoring with low concentrations of dissolved lead recorded at all sites for the duration of monitoring.

Waterway	Parameter Trends
Metal - Aluminium	
Matthews Creek	• Dissolved aluminium at each monitoring site was generally low for the period post-commencement of mining of LW W1 and W2 (equal to or less than 0.05 mg/L) and lower than or consistent with baseline values. • Some elevated concentrations were recorded in periods prior to or during rainfall events although no clear trend in dissolved aluminium concentrations is evident in the record and concentrations were also elevated at the reference site upstream of mining influences (monitoring site MB in Matthews Creek).
Cedar Creek	• At monitoring site CC1 (reference site) dissolved aluminium concentrations ranged between 0.1 mg/L and 0.32 mg/L from January to November 2019, indicating that dissolved aluminium concentrations are naturally elevated in Cedar Creek. • From April 2020 to March 2021, dissolved aluminium concentrations recorded at all monitoring sites in Cedar Creek were typically low (equal to or below 0.06 mg/L) relative to previous records.
Stonequarry Creek	• Dissolved aluminium concentrations recorded in Stonequarry Creek have typically been low (below 0.03 mg/L) except following substantial rainfall events where spikes in aluminium concentrations have been recorded. • Nevertheless, aluminium concentrations are relatively low in Stonequarry Creek, with the median total aluminium concentrations exceeding the ANZG (2018) default guideline value (0.055 mg/L) at only one monitoring site – SC1 (reference site).
Redbank Creek	• Dissolved aluminium concentrations recorded in Redbank Creek have typically been low (below 0.05 mg/L) except following substantial rainfall events where spikes in aluminium concentrations have been recorded.
Metal - Copper	
Matthews Creek	• Copper concentrations are also naturally elevated in Matthews Creek at times with exceedances of the ANZG (2018) default guideline value for total copper. However, the median concentration of total copper recorded at all sites was less than the limit of detection (0.001 mg/L).
Cedar Creek	• Total copper concentrations have predominately been recorded below the limit of detection (0.001 mg/L) at monitoring sites in Cedar Creek. • The ANZG (2018) default guideline value for total copper (0.0014 mg/L) was exceeded in 19% of samples recorded at monitoring site CC1 (reference site), 15% of samples recorded at monitoring site CB and 11% of samples recorded at monitoring site CG.
Stonequarry Creek	• Copper concentrations are naturally low in Stonequarry Creek with the median concentration recorded at all sites equal to or less than the limit of detection (0.001 mg/L).
Redbank Creek	• The data records indicate that copper concentrations may be naturally elevated in Redbank Creek with elevated dissolved copper concentrations recorded at monitoring site RC5 (downstream of LW32) in 2007 and early 2008, during mining of LW24B, although prior to the occurrence of mining impacts in Redbank Creek.
Metal - Iron	
Matthews Creek	• Dissolved iron concentrations have been variable at all sites, with an elevated concentration of 13.7 mg/L dissolved iron recorded at monitoring site MB (reference site) following the onset of rainfall in early 2020 after a low rainfall period. • An elevated dissolved iron concentration was also recorded at monitoring site MG (3.5 mg/L) and MC1 (4.54 mg/L) in February 2020 following the onset of substantial rainfall. High iron hydroxide precipitation has been recorded historically at monitoring site MG (Niche, 2019).
Cedar Creek	• Iron concentration records for each site have been variable with the highest concentrations generally recorded immediately prior to or following the onset of substantial rainfall in early 2020 which occurred after an extended low rainfall period.

Waterway	Parameter Trends
	• The high concentrations of dissolved and total iron recorded at monitoring sites CA and CB in January 2020 were likely due to groundwater seepage which has been observed historically at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (GeoTerra, 2019).
Stonequarry Creek	• Iron concentration records for each site have been variable with the highest concentrations generally recorded immediately prior to or following the onset of substantial rainfall in early 2020 which occurred after an extended low rainfall period.
Redbank Creek	• Iron concentrations recorded at monitoring site RB6/RC2 significantly increased during the mining of LW26 to LW32 (2012 to 2016), with isolated elevated concentrations also recorded at monitoring site RC4, RC5 and RC6 (downstream of LW32) between 2015 and 2019. • The elevated dissolved iron concentrations recorded at monitoring sites RB6/RC2 and RC4, RC5 and RC6 (downstream of LW32) during the period of mining suggest that longwall mining and the reported cracking of bedrock resulted in periodic increases in iron, however, the effects at downstream monitoring sites were largely isolated and appear to have diminished with time. • Elevated dissolved iron concentrations were recorded at monitoring site RB1 (upstream of LW24B) in early to mid-2020 following substantial rainfall which occurred after a prolonged low rainfall period. The same trend was recorded at monitoring site RC5 downstream of LW32, however, the dissolved iron concentrations recorded at monitoring site RC5 were less elevated than at monitoring site RB1. • From mid-2020, dissolved iron concentrations have substantially declined at all sites.
Metal - Manganese	
Matthews Creek, Cedar Creek	• An increasing trend in dissolved manganese concentration was recorded at all monitoring sites in Matthews Creek and Cedar Creek during an extended low rainfall period from April 2019 to January 2020. Following substantial rainfall from mid-January to February 2020, the dissolved manganese concentrations reduced at all sites since this time.
Stonequarry Creek	• Prior to commencement of mining LW W1 in November 2019, an elevated dissolved manganese concentration of 20.7 mg/L, 5.56 mg/L dissolved iron and 0.03 mg/L dissolved nickel were recorded at monitoring site SD. The sulphate concentration recorded on the same day was also elevated at 87 mg/L.
Redbank Creek	• Elevated dissolved manganese concentrations were recorded at monitoring site RB6/RC2 prior to and during the period of mining. Elevated dissolved manganese concentrations were also recorded periodically at monitoring sites RB9/RC3, RC4 and RC5 over the period of mining, however, only slight increases in dissolved manganese concentrations were recorded further downstream at monitoring site RC6 during corresponding periods. • Towards the end of and following completion of mining LW32, the dissolved manganese concentrations were generally below the ANZG (2018) default guideline value of 1.9 mg/L except at monitoring site RB10 and RC6 following substantial rainfall in early 2020.
Metal - Zinc	
Matthews Creek, Cedar Creek, Stonequarry Creek	• Zinc concentrations are naturally elevated in Matthews Creek, Cedar Creek and Stonequarry Creek at times, with multiple exceedances of the ANZG (2018) default guideline value noted, particularly during the extended low rainfall period of April 2019 to January 2020. • Following substantial rainfall in early 2020, the total zinc concentrations recorded in Matthews Creek and Cedar Creek have been generally less variable and have remained relatively low since this period.
Redbank Creek	• Slightly elevated dissolved zinc concentrations were recorded at monitoring site RB6/RC2 and monitoring site RC5 during the period of mining although concentrations have declined following cessation of mining. • The pattern in recorded zinc concentrations is similar to the pattern in iron concentrations and suggests that longwall mining and the reported cracking of bedrock has resulted in periodic increases in zinc concentrations, although this has decreased with time.

Waterway	Parameter Trends
Metal - Nickel	
Matthews Creek	• Concentrations of total nickel recorded at all monitoring sites in Matthews Creek have been consistently below the ANZG (2018) default guideline values for the duration of monitoring.
Cedar Creek	• An increasing trend in nickel concentrations was recorded at sites CC1 and CB during an extended low rainfall period from April 2019 to January 2020. Following substantial rainfall in early 2020, the dissolved and total nickel concentrations reduced to below the ANZG (2018) default guideline value (0.011 mg/L) at all sites in Cedar Creek.
Stonequarry Creek	• Nickel concentrations have generally been low at all sites in Stonequarry Creek, with a higher median concentration of total nickel recorded the reference site SC1 in comparison with potential impact sites. • Following substantial rainfall in early 2020, the dissolved and total nickel concentrations at all sites reduced to below the ANZG (2018) default guideline value (0.011 mg/L) and have remained below this level since.
Redbank Creek	• Periodic elevated dissolved nickel concentrations were recorded at monitoring sites RB6/RC2, RB9/RC3, RB10, RC4 and RC5 during the period of mining, particularly from 2014 to 2018. Following the cessation of mining, dissolved nickel concentrations remained below the ANZG (2018) default guideline value of 0.011 mg/L at all sites except monitoring site RC6 where isolated elevated concentrations of dissolved nickel were recorded following substantial rainfall in early 2020. This suggests a temporary increase in dissolved nickel concentrations during the period of mining.

3.1.4 Aquatic Habitat and Stream Health

Baseline monitoring of aquatic ecology within the Study Area was undertaken in October 2014, November 2017, April 2018, November 2018 and May 2019 (Niche, 2014; Niche, 2019).

The baseline monitoring identified that Matthews Creek, Stonequarry Creek and Cedar Creek were in moderate to good condition with the best habitat located within gorges along Matthews Creek and Cedar Creek. Aquatic habitat within the Study Area and at control sites consisted predominately of pools with little to no riffles present. The streams were found to be controlled by the sandstone geology, with bedrock present in numerous locations and stream benthos dominated by finer sand/silt sized sediment where bedrock does not occur. Most sites had moderate to good riparian and channel health (Niche, 2019).

Macrophyte occurrence varied between sites with generally low abundance and diversity recorded at upstream sites in Matthews Creek and Cedar Creek, and more diverse and abundant further downstream in Stonequarry Creek. Pollution sensitive macroinvertebrates were present in Cedar Creek, Matthews Creek and Stonequarry Creek indicating that the streams are unlikely to be severely affected by pollution (Niche, 2019).

All creeks were mapped as ‘key fish habitat’ and classed as either having highly sensitive or moderately sensitive aquatic habitat in 2014. Few fish were observed as part of the fish surveys in 2017 - 2019, with introduced Mosquito Fish (*Gambusia holbrooki*) observed in Cedar Creek, Matthews Creek and Stonequarry Creek, Mountain Galaxid (*Galaxias olidus*) observed in upstream Cedar Creek on one occasion, and Cox’s Gudgeon (*Gobiomorphus coxii*) in Matthews Creek on one occasion. No aquatic threatened species were found to occur or have habitat within the Study Area (Niche, 2019b).

3.1.5 Surface Water Related Infrastructure

A number of small farm dams and stormwater culverts overlie the predicted subsidence impact area (refer to **Figure 3-3**). This includes 23 farm dams within the Study Area (MSEC, 2021). Of these water features, seven farm dams are located directly above LW W3-W4 (FD3-FD8, and FD-12). The dams have been inspected by geotechnical engineers (Douglas Partners) and found to be typically of earthen 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 generally up to four metres high, although four dams are up to 7.5 m high (Douglas Partners, 2021).Water Access Licences and Pumping of Water

The closest property lots with a WAL for direct extraction (pumping) from Cedar Creek and Matthews Creek are located upstream of the Study Area. One WAL for extraction from the Stonequarry Creek Management Zone is allocated to two property lots which are located within the Study Area and overlie a portion of LW W1, W2 and W3. Although the property bounds sections of Matthews Creek and Cedar Creek, it is inferred, based on reports from visual inspections that direct extraction (pumping) is undertaken from Stonequarry Creek. A landholder pump is located in pool SR17 on Stonequarry Creek within the bounds of the property assigned a WAL (HEC, 2021a).

Three lots, with one WAL, overlie a portion of LW W3 and W4 with the WAL associated with collection and storage of runoff in farm dams which are located on minor tributaries of Redbank Creek. Downstream of the Study Area, two lots with two WALs are located on Stonequarry Creek adjacent to the confluence with Redbank Creek. The WAL for these lots is associated with direct extraction (pumping) from Stonequarry Creek (HEC, 2021a).

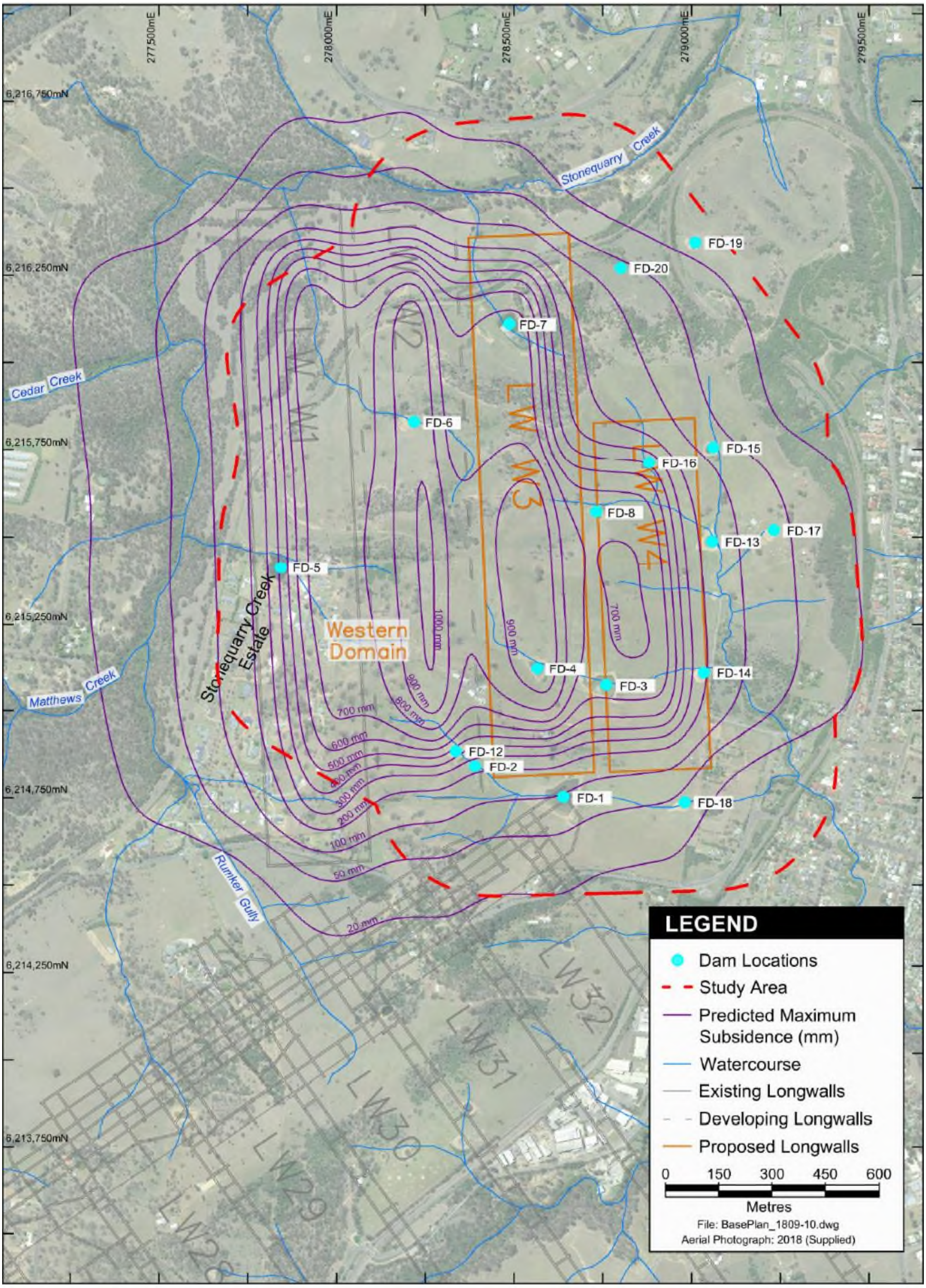

Figure 3-3 Locations of Farm Dams and Predicted Maximum Subsidence (HEC, 2021a)

3.2 Groundwater

3.2.1 Hydrogeological Units

The major hydrostratigraphic units that characterise the area around the Tahmoor Mine are the Sydney Basin Triassic and Permian rock units, with the Hawkesbury Sandstone being the primary aquifer. These aquifers fall within the Nepean Sandstone Groundwater Source and have been classified as being 'Highly Productive' by the NSW Government based on considerations of bore yield and groundwater quality. The Bulgo Sandstone and Illawarra Coal Measures of the Narrabeen Group supply additional water to this system; however, contributions are substantially lower (SLR, 2021a).

The key hydrogeological units relevant to the Study Area is summarised below (SLR, 2021a):

- Alluvium – composed of two main units (the Thirlmere Lakes alluvium and the Quaternary to modern alluvium), within which groundwater conditions are likely to be unconfined. Recharged is expected be predominantly from rainfall, rainfall runoff and peak streamflow events. Alluvial units occur to the north and east of LW W3-W4 along the lower reaches of Stonequarry Creek and do not intersect the LW W3-W4 mine footprint, except for an area of approximately 75 m^3 in the north-eastern corner of LW W3;
- Wianamatta Formation – composed of shales with poor permeability and water quality, however can lead to the development of springs in areas in contact with the Hawkesbury Sandstone. This formation is present over the all the surface area of LW W3;
- Hawkesbury Sandstone – a porous rock aquifer of moderate resource potential, with potential for surface drainage contributions to baseflow in proximity to surface drainage lines. Over the mine, groundwater in this aquifer generally flows in an east to north-easterly direction in the area of Tahmoor Mine. The water table is approximately 20 m below the ground surface in proximity to surface drainage lines, and 40 to 50 m below the ground surface in areas not associated with surface drainage lines. Groundwater extracted from the latest bore census for the Western Domain (GeoTerra, 2021) indicates a freshening in the shallow Hawkesbury Sandstone aquifer near Stonequarry Creek; and
- Illawarra Coal Measures – interbedded shales, mudstones, lithic sandstones and coals including the Bulli Coal seam (2-3 m thick), Eckersley Foundation (which includes the Balgownie Seam, Loddon Sandstone and Lawrence Sandstone), Wongawilli Coal seam (7-9 m thick), and the Kembla Sandstone. An average Total Dissolved Solids (TDS) of 11,000 mg/L and a range 3,200-27,500 mg/L was reported for groundwater from the Illawarra Coal Measures, which includes the Bulli Coal Seam.

3.2.2 Nepean Fault

The major structural feature of interest in the vicinity of the Study Area is the Nepean Fault. At the north-eastern corner of the panel, LW W3 is located 250 m west of the nearest mapped fault trace and in the south-eastern corner of the panel, LW W3 is located 570 m west of the nearest mapped fault trace. LW W4, in the north-eastern corner of the panel, is located 20 m west of the nearest mapped surface trace and 245 m in the south-eastern corner of the panel (SCT, 2020).

A figure showing the indicative location of the Nepean Fault Complex and its located adjacent to the LW W3-W4 Study Area is provided in **Figure 3-4**.

SLR (2021) note that the significant high angle structural feature is known to be transmissive and, as such, mine workings that intersect this zone may produce more water and increased groundwater depressurisation in overlying strata may occur. The permeability within the Nepean Fault zone in the vicinity of LW W4 would govern the longitudinal movement of groundwater along the fault zone, however, the permeability along the Nepean Fault zone is uncertain (HEC, 2021a).

3.2.3 Historic Groundwater Inflows

Since 2009, inflows to the Tahmoor Mine have been within the range of 2 Megalitres per day (ML/d) to 6 ML/d. The average inflow to the mine for current water year (July-2020 to date) is 4.9 ML/d, was 4.0 ML/d for the previous water year (July 2019 to June 2020), and was 3.7ML/d for the water year 2018-19 (SLR, 2021a).

The period between mid-2020 shows an increase in inflows to greater than 5 ML/day at the end of July 2020 likely due to the extraction of LW W1. Inflows declined in late 2020, before rising in February 2021 (early in LW W2), with the recent peak at just over 6 ML/d in March and April 2021. Inflows to the Western Domain are not metered in isolation from other parts of Tahmoor North (they are metered along with all other pump-out) but are estimated to be greater than 2.5 ML/d in recent months. Other than the minor fault observed in the southern 'half' of LW W1 and LW2, no other obvious geological structures have been noted as intersecting current workings. Further advice from underground staff has been sought on where in the workings higher inflows can be observed (SLR, 2021a).

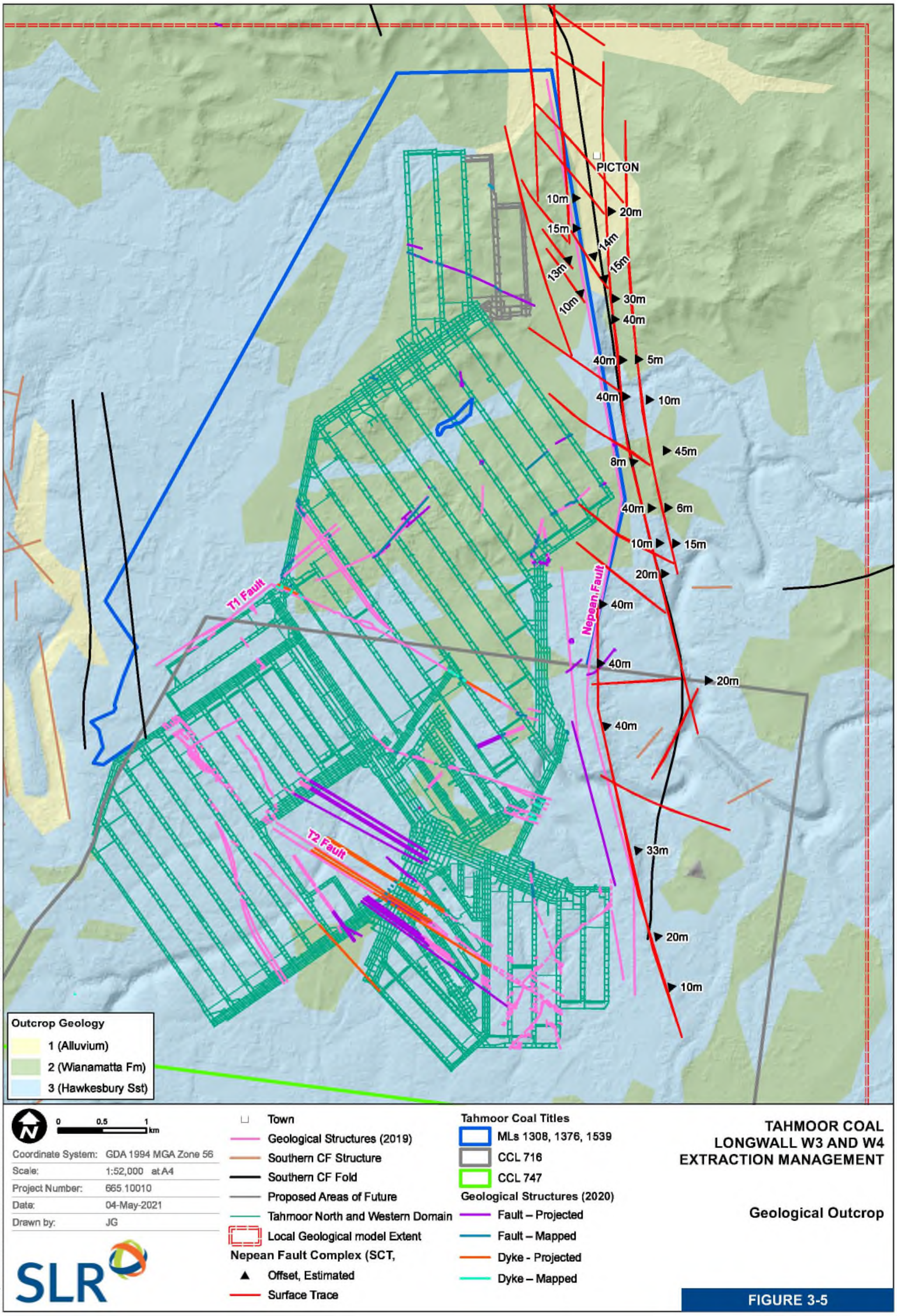

Figure 3-4 Geological Outcrop and Nepean Fault Structures (SLR, 2021a)

3.2.4 Groundwater Levels

For the purpose of monitoring the subsidence related impacts that may result following the extraction of LW W3-W4, a monitoring network consisting of bores established as illustrated in **Figure 3-5** (SLR, 2021a). The following sections discuss key bores within or near the LW W3-W4 Study Area and baseline corresponding groundwater levels. Further detail is provided in the GTR (SLR, 2021a).

P9

P9 monitoring sites are located on the northern bank of Redbank Creek and overlie the pillar between LW31 and LW32, where extraction commenced in November 2018 (refer **Figure 3-5**). These bores are not directly relevant to the Western Domain, but show behaviours that would be expected above or near to Western Domain longwalls. Groundwater data has been recorded at P9 since October 2017. The open standpipe bores are screened at 22-24 m (P9A), 37-40 m (P9C) and 65-68 m (P9D), all within the Hawkesbury Sandstone. There were also three VWPs installed in a single P9 bore at 28 m, 40 m and 68 m depths, corresponding to some of the open standpipe intervals. One of the standpipe bores P9D (65-68m) and all three VWP sensors at P9 have failed (SLR, 2021a).

An investigation of shallow groundwater in boreholes (including P9) around Redbank Creek was conducted by SCT in late 2018 (SCT, 2018). This report identified increases in hydraulic conductivity at bore P9 in the presence of subsidence-induced "surface cracking". This hydrograph indicates that water drains from shallowest horizons and recharges deeper horizons. From December 2018 to April 2019, as LW32 advanced toward the P9 bores, water levels in P9_V2 and in standpipe bore P9D (65-68m) decline by 2 m, followed by a sharp drawdown of 6 m in May 2019 due to the extraction of LW32, noting that this monitoring site lies above the chain pillar of LW32 (SLR, 2021a).

P12

P12 is a cluster of open standpipe bores screening three depths in Hawkesbury Sandstone, located 50 m north of LW W1 (refer **Figure 3-5**). The hydrograph for this bore is presented in **Figure 3-6**.

The minimum groundwater level elevation recorded at P12C between June and November 2019, prior to LW W1, was 176.3 m AHD, with evidence of groundwater pumping by nearby users, causing drawdown over a short periods (less than 2 months) in the range of 1 m to 3 m (SLR, 2021a).

Groundwater levels at P12C shows a mild response to rainfall in mid-January and February 2020 and started to decline significantly from 180 mAHD in March 2020 to 167 mAHD in November 2020, falling below the baseline level. From mid / late October 2020, groundwater levels at P12C start to stabilise at 167 mAHD following rainfall events and recover to 168.7 mAHD in December 2020. P12C groundwater levels have stabilised to some degree since November 2020, but during that time there have been variations of 1-2 m, possibly in response to rainfall or to the commencement of LW W2 (SLR, 2021a).

These groundwater level trends at P12C resulted initially in a Level 3 TARP trigger from June 2020 and followed in a Level 4 TARP trigger from December 2020, attributed to mining induced depressurisation of deeper groundwater aquifer but also correlated to a reduction in rainfall recharge events. As of March 2021, groundwater levels have slightly recovered to 167.5 mAHD but a Level 4 TARP still applies at P12C (SLR, 2021a).

Prior to the mining of LW W1, there was an upward hydraulic or pressure gradient from P12C to P12B, and from P12B to P12A consistent with the inferred ‘gaining’ condition from Matthews Creek. Since the commencement of mining, the gradients have altered so that there is a stronger downward hydraulic gradient from surface water to P12A and then to P12B and P12C (SLR, 2021a).

P13

P13 is a cluster of open standpipe bores screening three depths in Hawkesbury Sandstone, located 130 m north of LW W1 (refer **Figure 3-5**). The hydrograph for this bore is presented in **Figure 3-6**.

The minimum groundwater elevation recorded at P13C between June and November 2019, prior to LW W1 mining, was 169.8 m AHD, with a similar minimum of 170.2 m AHD on 6 January 2020, that are reflective of the drought conditions at the time (SLR, 2021a).

The groundwater level at P13C recovered by 2 m following substantial rainfall in mid-January and February 2020, and then began to decline in March 2020, declining consistently through much of 2020. Groundwater levels were recorded at 165.4 m AHD in late October 2020, almost 5 m below the baseline minimum. A Level 4 TARP significance was triggered in relation to groundwater level decline at P13C in November 2020. The decline in groundwater level was attributed to mining induced regional depressurisation of deeper aquifers. P13C groundwater levels have stabilised to some degree since November 2020, but during that time there have been variations of 0.5-1 m, possibly in response to rainfall or to the commencement of LW W2. As of 15 March 2021 (end of the available data period), groundwater levels are at 165.8 mAHD, 0.4 m above the post-mining minimum (SLR, 2021a).

Groundwater trends at P13B and P13A have been much more subdued than those in the deeper P13C horizon (mid-Hawkesbury Sandstone). Both piezometers showed relatively stable levels though 2019, declines in late 2019 and early 2020 (severe drought) and recovery due to rainfall in January and February 2020. Post February 2020 there was a consistent decline to October 2020. At that time, P13B groundwater levels declined by 0.6 m below the baseline minimum to 165.3 m AHD and has stabilised to 165.8 mAHD in March 2021. P13A exhibited drawdown through 2020 to 166.9 m in October 2020, which is similar to the previous minimum. Despite some mild variation, it remains close to this level (167.1 mAHD) on 15 March 2021 (SLR, 2021a).

Prior to LW W1, there was an upward hydraulic or pressure gradient from P13C to P13B, and a downward gradient from P13A to P13B, which is consistent with the inferred ‘losing’ condition from the Stonequarry Creek, based on the shallow groundwater level (P16A) being below creek bed elevation. Since the commencement of LW W1 mining, the hydraulic gradients have altered so that there is a stronger downward hydraulic gradient from surface water to P13A and then to P13B, and the former upward gradient from P13C to P13B has become effectively neutral (SLR, 2021a).

P14

P14 is a cluster of open standpipe bores screening four depths in Hawkesbury Sandstone, located 350 m east of LW W1 (refer **Figure 3-5**). The hydrograph for this bore is presented in **Figure 3-6**.

Since the start of monitoring in June 2019 each of the open standpipes show a continual and relatively linear decline in water levels which correlate with a reduction in rainfall until February 2020. Water levels respond to the wetter condition from January-February 2020. From March 2020, there is an on-going reduction in the groundwater trends at P14B (approximately 1 m), P14C (approximately 1.5 m) and P14D (approximately 1.2 m) which is likely induced by the extraction of LW W1. Following rainfall events mid-October 2020, water levels at P14B, P14C and P14D start to stabilise and recover by approximately 0.5 m. These groundwater trends are observable until January 2021 and then begin to decline from mid-January 2021 by approximately 0.3-0.5 m, to below the baseline level (SLR, 2021a).

The minimum groundwater elevation recorded at P14D between June and November 2019, prior to LW W1, was 164.8 m AHD. In March 2021, groundwater levels at P14D were recorded at 163.2 mAHD and shows the greatest depressurisation at P14 site with an approximate 1.6 m drawdown since the start of mining. The shallow piezometer P14A (colluvium/alluvium) has shown stable groundwater levels between June and November 2019 with water levels at around 168.6 mAHD, recovery in mid-January and February 2020 and consistent water levels though 2020 with mild responses to rainfall. P14A groundwater levels sit at 170 mAHD in March 2021 (SLR, 2021a).

P15

P15 is a cluster of open standpipe bores screening four depths in Hawkesbury Sandstone, located 60 m north of LW W3 (refer **Figure 3-5**). The top three bores were completed in March 2021, while the deepest bore (P15D) is yet to be completed at the time of this report. No groundwater level has been included in this section due to lack of data.

P16

P16 is a cluster of open standpipe bores screening three depths in Hawkesbury Sandstone, located 430 m north of LW W1 (refer **Figure 3-5**). The hydrograph for this bore is presented in **Figure 3-6**.

The minimum groundwater level recorded between June and November 2019, prior to LW W1 at P16B and P16 was 206.4 mAHD and 199.6 mAHD respectively with evidence of groundwater pumping by nearby users, causing drawdown over a short periods (less than 2 months) in the range of 1 m to 2.5 m (SLR, 2021a).

A mild decline less than 1 m is observed from December 2019 to December 2020 with water levels declining just below the creek bed level in August 2020 which could cause mild reductions in baseflow. An apparent downward vertical head gradient is observed at P16, with fluctuations in water levels closely related and a head separation of 4 m between the two lower strata, suggesting the HBSS aquifer is not confined at this location. In the two deeper strata, water levels correlate with rainfall trends until a sharper decline occurs during December 2019, likely due to a severe rainfall deficit followed by the start of LW W1 extraction which exacerbates drawdown (SLR, 2021a).

From January 2020, following wetter conditions, water levels at P16 begin to recover and reach baseline levels in March 2020. Post March 2020 there is a gradual reduction in groundwater levels in P16B and P16C with water level declining to 201.3 mAHD and 187.4 mAHD respectively. Following rainfall in mid-October 2020, water levels at P16B and P16C stabilise and recover by approximately 1 m in December 2020. P16B and P16C exhibited some mild drawdown in the range of 2 m over short periods after the commencement of LW W2 and stabilised in March 2021 to similar level as December 2020 (SLR, 2021a).

As of March 2020, these groundwater trends at P16B and P16C result in the triggering of Level 4 TARP triggers, likely to be influenced by a reduction in rainfall between March and October 2020 and mining effects from LW W1 and commencement of LW W2 (SLR, 2021a).

P17

P17 is an open standpipe bore in the Hawkesbury Sandstone, located 600 m north of LW W1 (refer **Figure 3-5**). The hydrograph for this bore is presented in **Figure 3-6**.

A slight reduction in water levels to 170.8 mAHD (approximately 0.2 m) in December 2019 is attributed to the extraction of LW W1. From March 2020, water levels have recovered to 171.8 mAHD, approximately 0.7 m above the baseline level, and no further response to LW W1 is observed in this hydrograph. Following the completion of LW W1 and commencement of LW W2, groundwater levels at P17 begin to decline by 1 m. In March 2021, groundwater levels at P17 have stabilised at 171 mAHD, a similar level as recorded in December 2020 (SLR, 2021a).

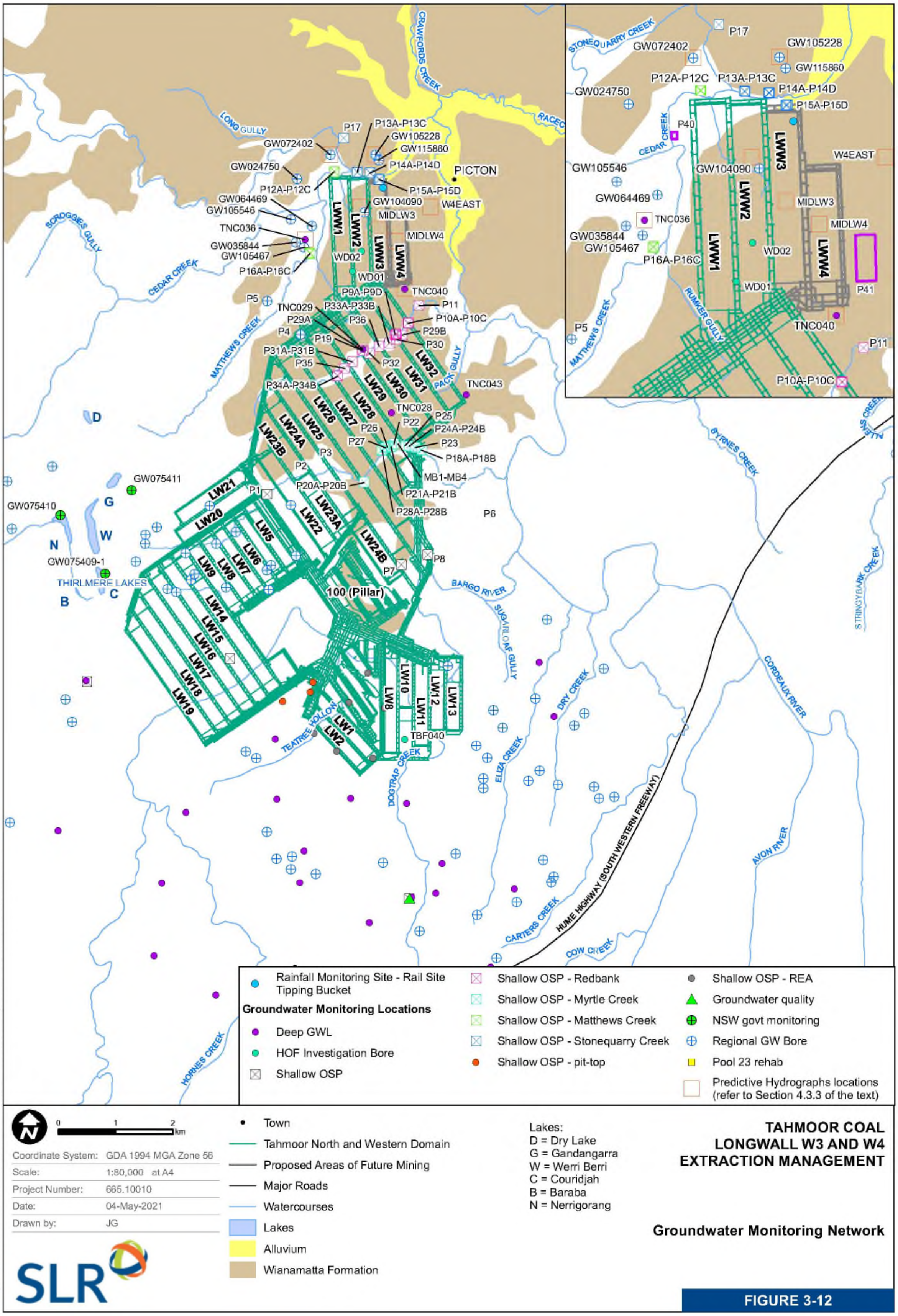

Figure 3-5 Groundwater Monitoring Locations (SLR, 2021a)

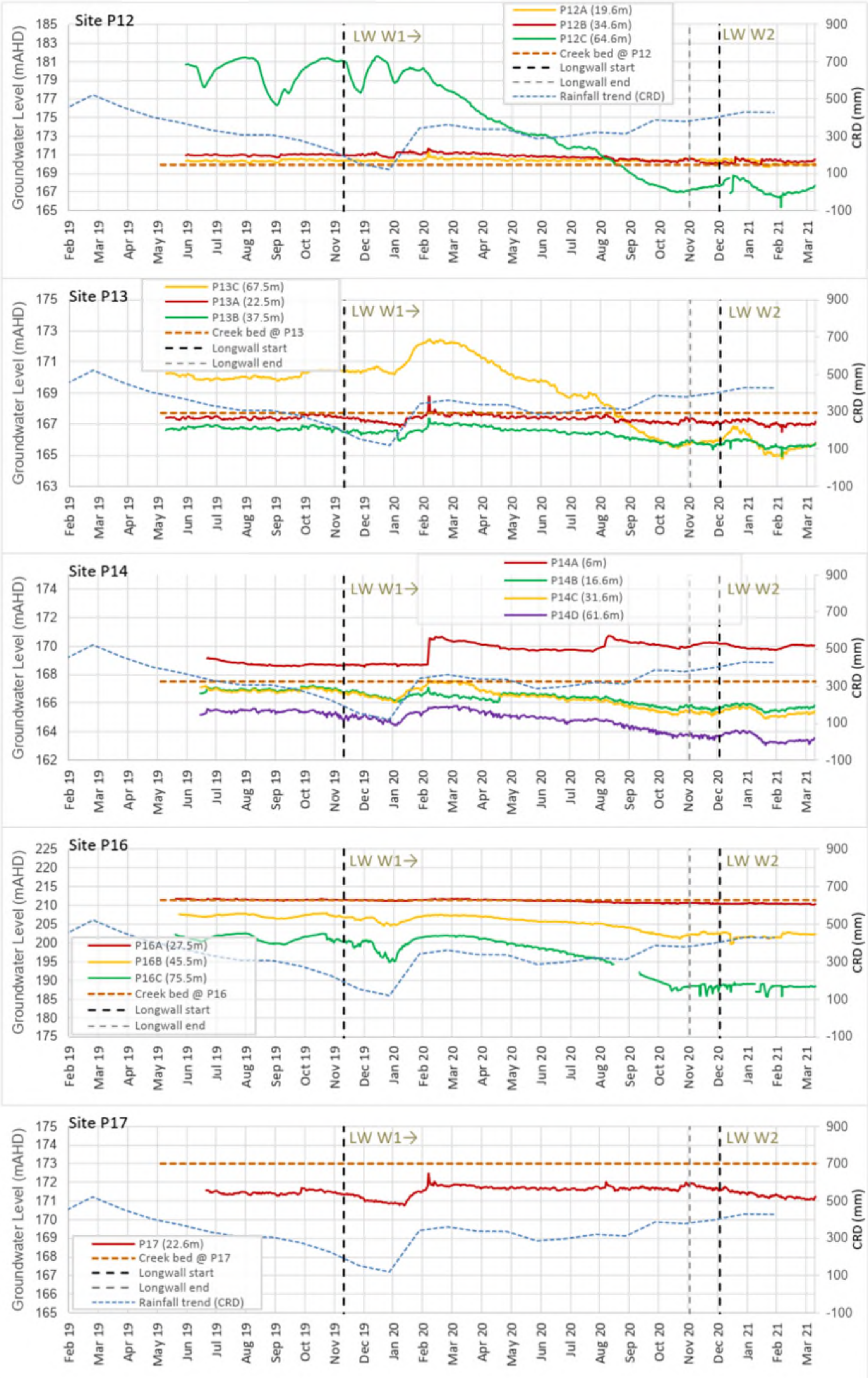

Figure 3-6 Western Domain Bore Hydrographs (bores P12-P17) (SLR, 2021a)

TNC36

TNC36 monitoring bore has multi-level Vibrating Wire Piezometers (VWP) and is located about 500 m west of LW W1 and just west of Matthews Creek (refer **Figure 3-5**). It has a number of sensors placed in the Hawkesbury and Bulgo Sandstones at various depths, as well as one in the Bulli Coal seam. The hydrograph for this bore is presented in **Figure 3-7**.

Data from TNC36 has been collected since 2010. Depressurisation is apparent in the Bulli Coal Seam and the lower Bulgo Sandstone (BGSS 412.5) for the period from February 2016 to August 2019, likely due to regional drawdown of deeper aquifers due to the cumulative effect of longwalls 29-32 at Tahmoor Mine. After February 2020, declines are observed in water levels which are considered to be due to LW W1 extraction. By December 2020, these groundwater trends triggered a Level 4 TARP category (SLR, 2021a).

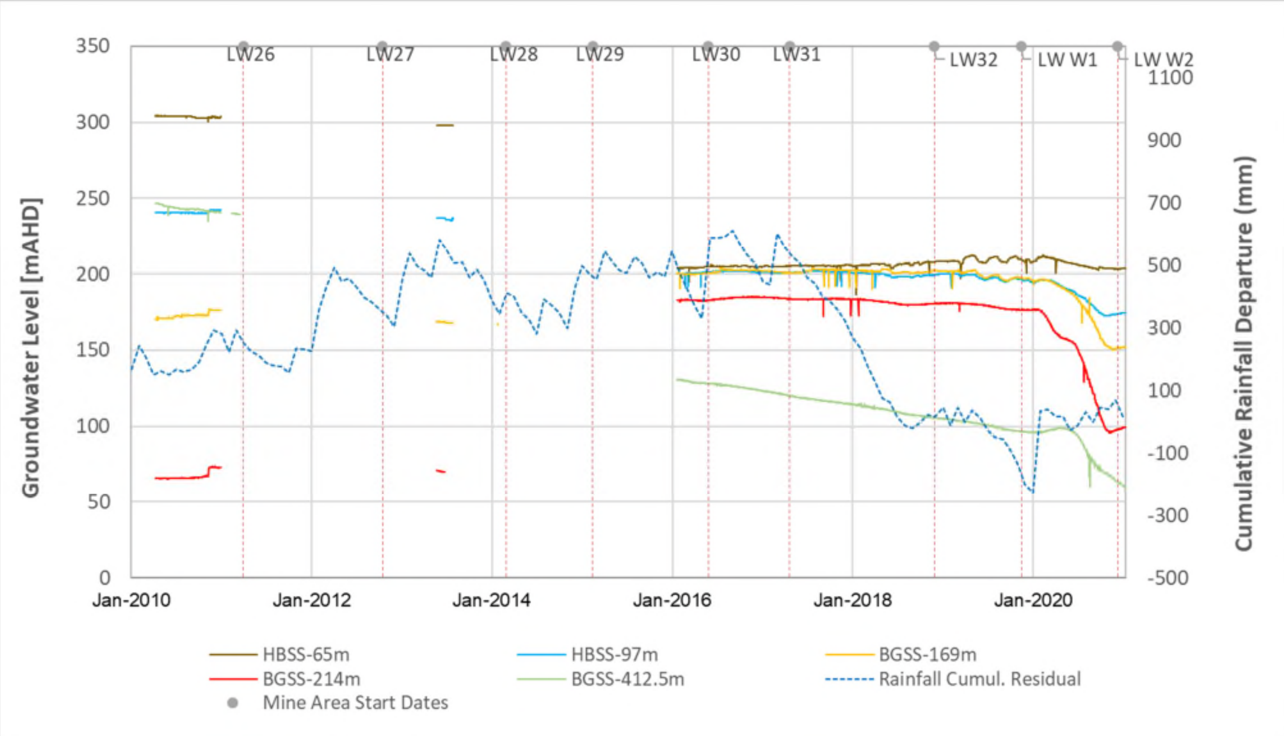

Figure 3-7 **Groundwater level trends at TNC036 (SLR, 2021a)**

TNC40

TNC40 monitoring bore has multi-level VWPs and is located about 650 m south-east of LW W3 and 430 m south of LW W4 (refer **Figure 3-5**). This piezometer originally had eight data sensors positioned within the Wianamatta Group, Hawkesbury Sandstone, Bald Hill Claystone, Bulgo Sandstone, Scarborough Sandstone and Bulli Coal seam. However only the upper two sensors remain active. The hydrograph for this bore is presented in **Figure 3-8**.

Data from TNC40 has been collected since late 2009. The data that was obtained between early 2014 and 2016 was inconsistent with data being collected intermittently by the four lower sensors in 2014 (BHCS 252, BGSS 352, SCSS 482, and BUCO 501.9), and no data collected at any loggers throughout 2015. A gradual decline in water levels at sensors BHCS 252, BGSS 352, SCSS 482 and BUCO 501.9 is apparent over this period as mining approached from the south. The greatest declines are observed in the Bulli Coal seam, with water levels falling by approx. 110 m from May 2016 until February 2019. More than half of this decline (60 m) occurred from June 2018, in response to nearby mine workings (roadways), until it ceased operating in September 2018. The BHCS-252 piezometer showed a drawdown of approx. 10 m in 2019 as LW32 approached (SLR, 2021a).

A vertical profile showing potentiometric head for bore TNC040 to illustrate groundwater level trends in response to mining in an alternative format to hydrographs (refer **Figure 3-8**). Potentiometric heads for the deeper strata in the more recent profiles (2017 to 2019) do not show the same behaviour as the earlier data, reflecting depressurisation due to the approach of Tahmoor North longwalls.

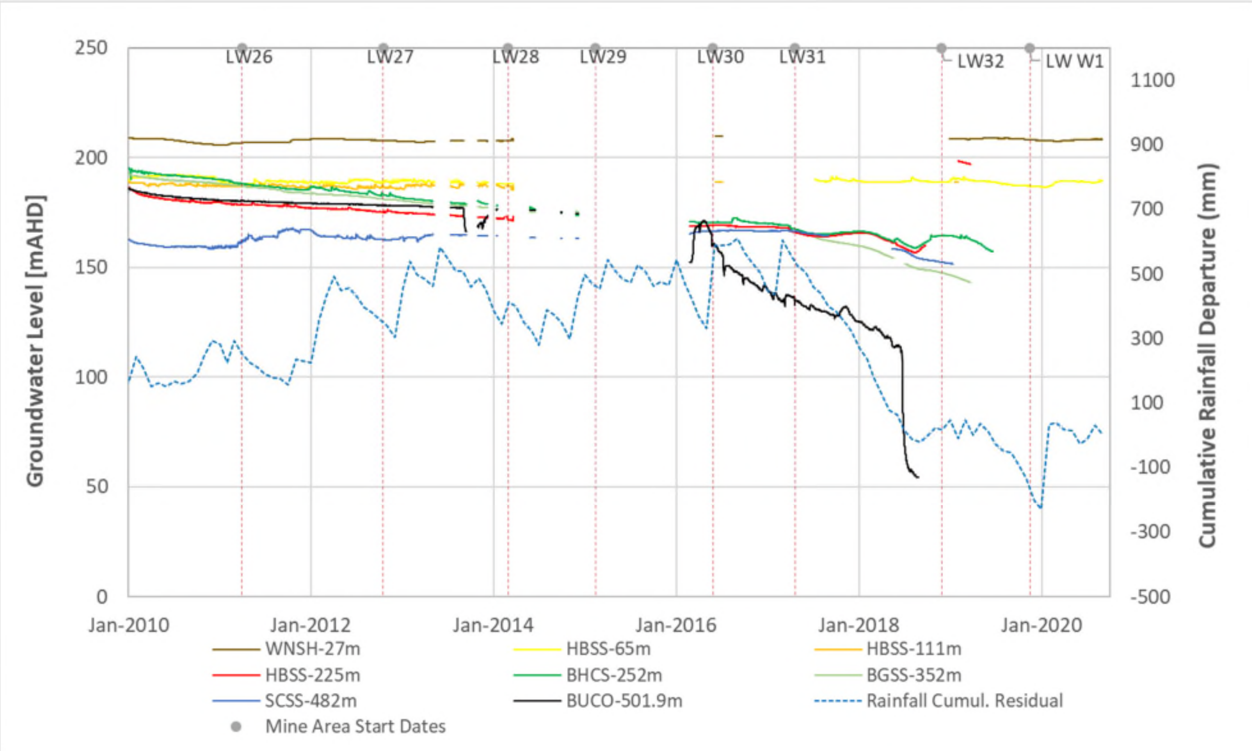

Figure 3-8 **Groundwater level trends at TNC040 (SLR, 2021a)**

TNC43

TNC43 monitoring bore has multi-level VWPs and is located south-east of LW W3-W4, about 140 m east of the southern end of LW 32 (refer **Figure 3-5**). This piezometer originally had seven data sensor, however only manual readings of the upper two sensors are able to be currently obtained. The hydrograph for this bore is presented in **Figure 3-9**.

Data from TNC043 has been collected since July 2010. The water levels at HBSS-65 m and HBSS-111.5 m present similar trends to one another and both respond clearly to rainfall. In early 2019, water levels at these sensors dropped sharply by about 5 m and recovered over the remainder of 2019 to baseline levels before sensor failure occurs. This decline may have been related to the extended period of reduced rainfall in this region, as illustrated by the rainfall residual mass curve, possibly caused by mining effects or possibly due to nearby groundwater pumping during the extended dry period (SLR, 2021a).

The lower stratigraphic sequences at this monitoring site (all sensors in the BGSS sensors and the Bulli Coal seam), contain higher groundwater heads than those in the Hawkesbury Sandstone, suggesting higher pressures that may result from aquifer confinement and proximity to the Nepean River, which is the regional drainage feature for the HBSS. Each of these sensor shows a continual and relatively linear decline in water pressure since monitoring commenced in 2010. As with other monitoring locations (above), this is likely to have occurred in response to the cumulative mining impacts of historical mining at Tahmoor and possibly due to the Bulli Seam Operations Mine in Appin (SLR, 2021a).

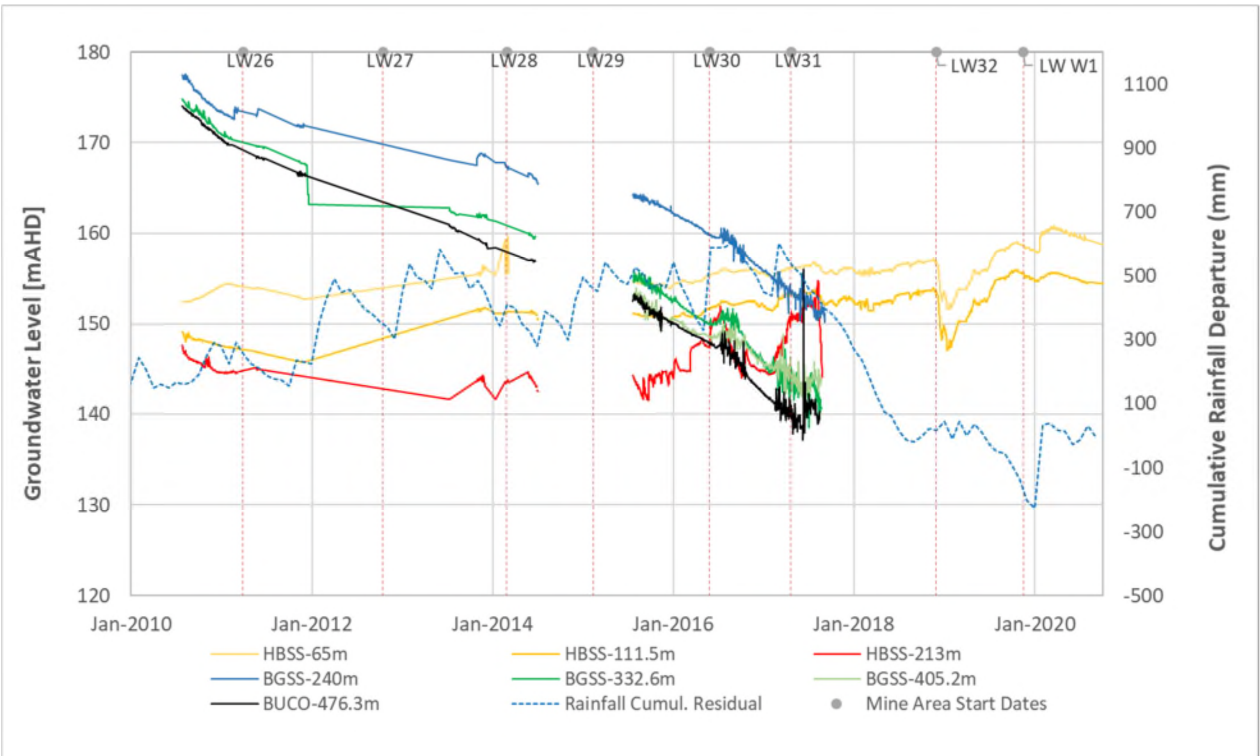

Figure 3-9 Groundwater level trends at TNC043 (SLR, 2021a)

WD01

WD01 monitoring bore has multi-level VWPs and is located above a chain pillar between the Western Domain LW W1 and LW W2 (refer **Figure 3-5**). The bore was completed while LW W1 was 400 m to the north. WD01 is instrumented with VWPs at multiple depths and has been recording groundwater pressures/heads since September 2020. The hydrograph for this bore is presented in **Figure 3-10**.

Since monitoring commenced, the two upper instruments HBSS-70 m and HBSS-90 m show stable groundwater levels at about 210 mAHD and 195 mAHD respectively and no mining effect is evident. A sharp decline in groundwater level is observed in HBSS-190 m and HBSS-210 m with a respective drawdown of 23 m and 48 m in October 2020 due to the passing of LW W1, before recovering by approximately 20 m in January 2021. Approximately 80 m of depressurisation is apparent in the Newport Formation (piezometer NPFM-230 m) between September 2020 and October 2020 with the rate of drawdown increasing in October 2020. Groundwater heads in the Newport Formation decline below the Hawkesbury groundwater heads suggesting a change in vertical head gradient from upward to downward. As of late October 2020, groundwater heads in NPFM-230 m start to recover at a similar rate to the lower HBSS following significant rainfall recharge in late October 2020 (SLR, 2021a).

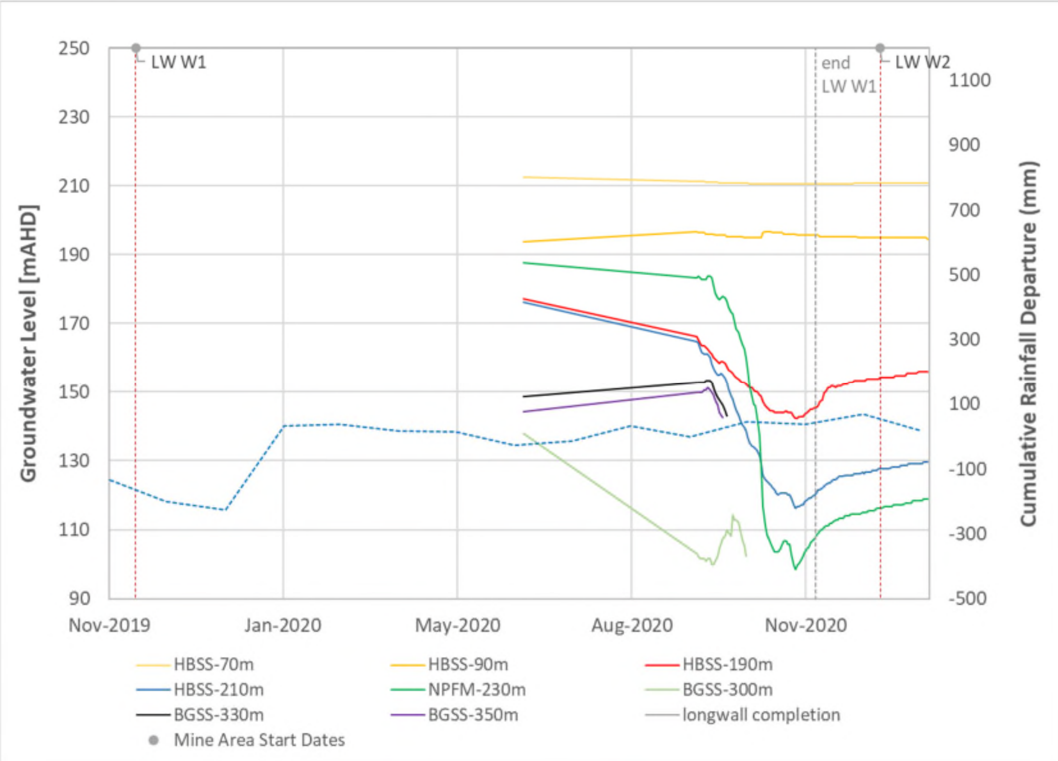

Figure 3-10 Groundwater level trends at WD01 (SLR, 2021a)

3.2.5 Hydraulic Conductivity

For the purpose of describing or quantifying how water flows through a porous or fractured medium, the term 'permeability' is used interchangeably with 'hydraulic conductivity' in this report. Horizontal permeability is abbreviated as Kh, and vertical permeability is abbreviated to Kv.

Testing of hydraulic conductivity around the Western Domain indicates that at most locations the hydraulic conductivities were 'typical' of those measured elsewhere at Tahmoor Mine, e.g. the results for WD01, located between LW W1 and LW W2, plot lie within the main population of hydraulic conductivities down to 400 m depth (SLR, 2021a).

The same is generally true for the shallower P-series bores around the Western Domain (e.g. P16, P17), but bores at P13 and P14, and to a lesser degree at P12, showed anomalous and significantly higher Kh than elsewhere at Tahmoor Mine, or, based on the experience of SLR, higher than any measurements at Dendrobium Mine. These hydraulic conductivities are generally in the range 0.1-5 m/d (median = 0.8, average = 1.9 m/d), and some are at or near the upper limit of the testing equipment (SCT, 2019). These values are 0.5 to 1 order of magnitude higher than the 90th percentile HBSS Kh at Tahmoor. The cause of this is unknown, but the consistency of the high values at neighbouring sites P13 and P14, and slightly lower values at P12, suggests that the data is reliable (SLR, 2021a).

A structural feature is a plausible reason for this occurrence, but as described earlier, no structural feature has been identified by Tahmoor Coal geologists that correlates to the location of P13 and P14. It is possible that it is related to the broader Nepean Fault Complex, although the orientation or nature of the feature that might be present at P13 and P14 is unknown (SLR, 2021a).

3.2.6 Groundwater Quality

Monitoring Bores

Tahmoor Coal has been monitoring the groundwater quality at the Western Domain bores (P12-P14, P16, P17) since May 2019. A summary of the groundwater quality is presented below, and detailed information is provided in **Appendix C**.

Tahmoor Coal conducts full laboratory water quality analysis on a monthly basis at the groundwater monitoring bores and licensed bores presented in GeoTerra. The results for the following parameters are presented:

- TDS, Dissolved Organic Carbon (DOC);
- Nutrients (Total N, Total P);
- Major Ions (Ca, Cl, K, Na, SO4, HCO3, F);
- Total Alkalinity, Bicarbonate Alkalinity, Carbonate Alkalinity, Hydroxide Alkalinity; and
- Total and dissolved metals (Fe, Mn, Cu, Pb, Zn, Ni, Al, As, Se, Li, Sr, Co).

Water quality measurements show that the Hawkesbury Sandstone across the Western Domain is generally fresh (minimum of 115 µS/cm) to slightly brackish (maximum of 1835 µS/cm) with a median EC estimated at 670 µS/cm. A median pH value of 7.1 indicates near neutral conditions, but pre-mining EC ranges from 201 µS/cm to 1716 µS/cm (SLR, 2021a).

The trend in salinity (EC) is quite stable for most of the bores at the Western Domain with small fluctuations corresponding to variation in groundwater levels and rainfall events during both the baseline and mining periods.

Bores screened across the lower Hawkesbury Sandstone (P12C, P13C, P14D) seem to have, on average, a less saline groundwater from 534 (baseline) to 487 µS/cm (post-LW W1) and slightly more alkaline groundwater with a pH of 8.1 (baseline) to 7.5 (post-LW W1) than bores screened in the upper strata for both the baseline and mining periods. Although the bores screened in the upper Hawkesbury Sandstone are more saline (1152 µS/cm to 884 µS/cm), regionally, there is no apparent correlation between depth and EC or pH at the Western Domain bores (SLR, 2021a).

The baseline data also indicates an overall reduction in the average salinity and pH between the baseline and mining period for each section of the HBSS aquifer which is likely due to severe drought conditions up to early January 2020 followed by above rainfall average conditions (with especially high rainfall in February 2020) leading to freshening groundwater conditions, rather than being due to some mining-related process (SLR, 2021a).

In terms of water type, the upper Hawkesbury Sandstone aquifer at the Western Domain is strongly dominated by sodium and chloride ions. The dominant sodium type water in the upper Hawkesbury Sandstone is characteristic of shallow groundwater, due to interactions with atmospheric waters. There is an increase in calcium and magnesium in the middle part of the Hawkesbury Sandstone aquifer with slight increase in sulfate. The lower part of the strata is dominated by sulfate and calcium type water, characteristics of deeper aquifer with local increases in carbonate that could suggest some interactions with shallower groundwater (SLR, 2021a).

Water quality results for metals indicated that during the baseline period for LW W1 (prior to mining impact) the following bores have exceeded the ANZECC guidelines triggers for the following metals:

- Cu at P12A-C, P13A-B, P14B;
- Zn at P12A-C, P13A-C, P14A-D, P16A, P17; and
- Filtered Mn at P16A and Total Mn at P16A-B, P14D.

Private Bores

Private groundwater bores within the LW W3-W4 Study Area have not been continuously monitored for water quality, and therefore a detailed analysis of bore condition cannot be performed. However, a snapshot of current groundwater quality conditions is presented in the recent bore census (GeoTerra, 2021).

Groundwater from the private bores were tested for pH, EC, TDS, major ions (Na, Ca, K, Mg, Cl, F, SO4), Total phosphorus and total nitrogen, DOC, Total alkalinity as HCO3, and total and dissolved metals (As, Cd, Cu, Fe, Pb, Mn, Ni, Se, Zn, Al, Li, Ba, Sr). Results were compared to the National Health and Medical Research Council's (NHMRC) Australian Drinking Water Guidelines (NHMRC, 2011). The following exceedances of the NHMRC Criteria were noted (GeoTerra, 2021):

- GW72402 – pH, TDS, NA, Cl, Fe, Mn;
- GW105228 – pH, Cl, Fe, Mn;
- GW105467 – pH, Cl, Fe, Mn;
- GW105546 – pH, Fe, Mn; and
- GW115860 – pH, Fe, Mn.

It was noted in the baseline private bore assessment (GeoTerra, 2021) that many bores in the Study Area already have significant iron hydroxide levels. A summary of groundwater salinity data from the private bores indicates that water quality at bores within the Hawkesbury Sandstone is generally fresh and suitable for such purposes.

3.2.7 Groundwater Use

Groundwater Dependent Ecosystems

The Thirlmere Lakes are the closest 'High Priority' Groundwater Dependent Ecosystem (GDEs) within close proximity to the Tahmoor Mine. Lake Gandangarra is the closest lake to proposed LW W3-W4, however, this is approximately six (6) km from LW W3. Due to the distance between the area of proposed longwall extraction and the Thirlmere Lakes it is extremely unlikely that mining-related impacts due to the extraction of LW W3-W4 would have an impact on the groundwater system surrounding these Lakes (SLR, 2021a).

Springs

Literature indicates that is likely that the Hawkesbury Sandstone may contain springs that have developed in saturated and perched aquifers within the unit. No springs have been identified in the vicinity of this Study Area (SLR, 2021a).

Anthropogenic Use

Several privately-operated and licensed groundwater bores are present to the north and west of LW W3-W4, as identified in the most recent bore census for the Western Domain and surrounding area (GeoTerra, 2021) and illustrated in **Figure 3-5**. These bores include GW024750, GW035844, GW064469, GW072402, GW104090, GW105228, GW105467, GW105546, and GW115860.

The primary usage of these bores is for farming and irrigation, and the bores were constructed between 1968 to 2018. All water extracted at these bores is derived from the Hawkesbury Sandstone aquifer, with yields of up to 2.67 L/s (GeoTerra, 2021).

Further details of bore construction details is provided in the Baseline Private Bore Assessment (GeoTerra, 2021).

4 Predicted Subsidence Impacts and Environmental Consequences

4.1 Surface Water

The following subsections provide a summary of the predicted subsidence impacts and environmental consequences to water quantity, surface water related infrastructure, water quality and aquatic habitat. Further detail of subsidence impacts and environmental consequences to the above water resources is provided in the SWTR (HEC, 2021a), as well as a review of past subsidence impacts on surface water resources. Performance against LW W1-W2 Water Management Plan TARPs for LW W1-W2 are included in the relevant subsections.

4.1.1 Pool Water Level and Flow

Predicted Subsidence Impacts

The proposed extraction of LW W3-W4 is predicted to result in minor additional increases in subsidence, valley closure and upsidence along Matthews Creek and Cedar Creeks. 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 extracting). 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).

The predicted maximum additional movements associated with extraction of LW W3-W4 represent approximately 10 – 15% of the total maximum predicted movements associated with mining of LW W1-W4. The proposed extraction of LW W3–W4 is predicted to result in minor additional increases in the occurrence of subsidence, valley closure and upsidence along the reach of Stonequarry Creek within the Study Area. Despite the potential for low levels of vertical subsidence to occur in Stonequarry Creek, the creek is not expected to experience measurable conventional tilts, curvature or strains (MSEC, 2021).

Rockbar SR17 is located approximately 100 m from the commencing end of LW W3. Based on the observations during the mining of LW W1-W2 across Stonequarry Creek, it is expected that Rockbar SR17 will experience between 10 mm of opening and closure and is expected to experience very small conventional subsidence movements of approximately 20 mm due to the extraction of LW W3. Further details of observed and predicted subsidence movements across Stonequarry Creek including Rockbar SR17 are given in Section 5, Stonequarry Creek Rockbar Management Plan.

Whilst Stonequarry Creek is predicted to experience low levels of vertical subsidence, the creek is not expected to experience measurable conventional tilts, curvatures or strains. It is therefore expected that the pool extent and overall pool length will change only slightly due to the extraction of LW W3-W4. In addition, it is unlikely that the downstream section from Rockbar SR17 would experience adverse impacts due to increased levels of ponding, increased levels of scouring of the banks or changes in stream alignment (MSEC, 2021).

Minor tributaries are likely to only flow during periods of high or extended rainfall and, as such, potential impacts of mining are unlikely to have discernible impacts on these surface water resources and ecosystems. The majority of minor tributary gullies are predicted to experience negligible change in gradient and as such it is unlikely that there will be a change in ponding upstream of the gullies or increased potential for scour and erosion (MSEC, 2021).

Redbank Creek is located outside of the predicted 20 mm total subsidence contour and hence subsidence predictions are not presented for Redbank Creek itself although subsidence predictions are presented for Tributary 1 (main tributary) of Redbank Creek which runs adjacent to LW W4. This tributary is predicted to experience maximum total valley-related closure of 500 mm directly adjacent to LW W3 and LW W4. As the tributary is heavily modified by residential development, the potential impacts of mining on the tributary are unlikely to have discernible impact with respect to surface water resources and ecosystems. (MSEC, 2021).

Predicted Rockbar Impacts

The potential for 'Type 3' impacts along Matthews, Cedar and Stonequarry Creeks has been assessed using the rockbar impact model for the Southern Coalfield, which relates the likelihood of impact on rockbars with the predicted total valley closure along the stream based on previous longwall mining experience in the Southern Coalfield. A 'Type 3' impact is defined as fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow (MSEC, 2021).

The maximum predicted total closure for Matthews and Cedar Creeks due to the total extraction of the Longwalls W1-W4 is 200 mm. The predicted rate of impact for the pools along these creeks due to the extraction of the proposed longwalls, therefore, is less than 10 %. As advised in Report No. MSEC1019 as part of the Extraction Plan application for LW W1-W2, impacts are more likely to occur near the commencing ends of LW W1-W3, where Cedar Creek is located closest to these longwalls, and where Cedar and Matthews Creeks are located closest to the tailgate of LW W1. The impacts that have been observed in Cedar Creek during the mining of LW W2 are located where valley closure was predicted to be 200 mm, adjacent to the tailgate of LW W1. The impacts observed to date are, therefore, within expectations (MSEC, 2021).

The likelihoods of fracturing and surface flow diversions reduce with distance away from the proposed longwalls. It is possible, therefore, that mining-induced fractures could occur at Rockbar SR17 due to the extraction of LW W3. The rockbar is thinly bedded in places and natural fractures are already present at isolated locations. If mining-induced fractures occur, it is possible that fracturing could create surface flow diversions within the rockbar if they can connect hydraulically in order for surface water to divert underground and emerge further downstream of Rockbar SR17 (MSEC, 2021).

The commencing position of LW W3 was setback 50 metres further from Stonequarry Creek compared to LW W2 to reduce the potential for adverse impacts on Rockbar SR17. Based on the observations during the mining of LW W1-W2 across Stonequarry Creek, it is expected that Rockbar SR17 will experience between 10 mm of opening and closure. Further details of observed and predicted subsidence movements across Stonequarry Creek including Rockbar SR17 are given in Section 5, Stonequarry Creek Rockbar Management Plan.

Investigations and assessments have also been conducted by SCT (2021), who advise that valley closure movements are not expected to be large enough to cause significant impacts to the rockbar. Some opening of existing joints and the small fractures may form as minor readjustments occur in the ground around the rockbar in response to the proposed mining (MSEC, 2021).

In the event that impacts occur to Rockbar SR17 or any other rockbars, surface flow diversions can be remediated (MSEC, 2021). Rockbar remediation success at Myrtle Creek and Redbank Creek are discussed in **Section 6.2.2**, as well as potential stream remediation techniques that could be adopted.

Observed Impacts to Pool Water Level and Flow

During extraction of LW W1 (completed) and LW W2 (currently extracting), ground surveys have not measured valley closure across Cedar and Mathews Creeks to the western side of LW W1. Ground extension has been measured across the tops of the valleys by the GNSS units. Water levels measured in Pool CR14 in Cedar Creek were, however, measured to have reduced below previously lowest levels in December 2020 and January 2021 during periods of dry weather (MSEC, 2021).

SLR (2021) identified that a change in interaction between groundwater and surface water in Matthews Creek, Cedar Creek and Stonequarry Creek is inferred to have occurred over the period of mining LW W1 and W2. The potential change in groundwater contribution to these surface water systems (resulting in transitions from gaining to weakly losing or losing at some sites) was driven by the decline in groundwater levels associated with mining induced regional groundwater depressurisation. While the potential change in groundwater contribution did not result in a notable influence on water levels recorded at monitoring sites in Matthews Creek and Stonequarry Creek, notable influences were recorded at monitoring sites in Cedar Creek (SLR, 2021a).

Atypical surface water behaviour was recorded at monitoring site CB (pool CR14) from 8 October 2020 to late January 2021 and at monitoring site CA (pool CB10), located upstream of monitoring site CB (pool CR14) in Cedar Creek, from early December 2020 to late January 2021. A Level 4 TARP significance was triggered in relation to surface water level decline for the period 19 to 29 January 2021 at monitoring site CB (pool CR14) in Cedar Creek. Accordingly, a Subsidence Event Notification was submitted to DPIE, NRAR and Resources Regulator on 23 February 2021 in relation to surface water level decline at monitoring site CB (pool CR14) in Cedar Creek (HEC, 2021a).

Additional monitoring sites in Cedar Creek also recorded a water level decline below the pre-mining and or baseline minimum following commencement of mining LW W1 and W2, however did not result in a Level 4 TARP trigger as similar water level decline was observed in upstream pools situated beyond mining effects. These declines were as follows (HEC, 2021a):

- Monitoring site CC1A (pool CB3) declined below the pre-mining minimum water level in parts of December 2020 (moderate decline) and January 2021 (slight decline);
- Monitoring site CD (pool CR23) declined below the baseline minimum water level in October 2020, December 2020 and January 2021 (slight decline);
- Monitoring site CC (pool CB19) declined below the baseline minimum water level in December 2020 (moderate decline) and monitoring site CF (pool CR26) declined below the baseline minimum in January 2021 (moderate decline); and
- Monitoring site CE (pool CR25) declined to the baseline minimum water level in January 2021 and monitoring site CG (pool CR31) declined below the baseline minimum water level in January 2021 (slight decline).

A detailed investigation of the surface water level decline at these sites identified that (HEC, 2021a):

- There is evidence of a change in surface water characteristics in the reach of Cedar Creek within the Study Area;
- Monitoring site CC1A, CA and CB experienced a notable change in water level recessionary behaviour in December 2020 and in January 2021 at monitoring sites CA and CB;
- The pool water level decline is considered highly likely to be related to regional groundwater level decline associated with mining induced groundwater depressurisation, however further monitoring is required to confirm this; and
- Whilst not visible on the surface, it is likely that mining induced subsidence has mobilised existing fractures resulting in changes in water level recession rates in pools CB3 (monitoring site CC1A), CB10 (monitoring site CA) and CR14 (monitoring site CB). However, these effects only persisted at pool CB10 and pool CR14 and an additional period of monitoring data is required to confirm the longevity of these effects at these pools.

Visual inspections on 19 January 2021 found water levels were low in 7 pools from Pools CB10 to CB15 in Cedar Creek and Pools MR45 and M46 in Matthews Creek. Despite evidence of mining related effects on the water level characteristics of pools in Cedar Creek, there has been no visible evidence of cracking, splitting or spalling of the creek rock bar controls and levels of iron oxy-hydroxide precipitation have not exceeded levels observed during the baseline (pre-mining) period (SLR, 2021a).

In accordance with the LW W1 - W2 WMP, the Subsidence Performance Measure for Stonequarry Creek, Cedar Creek and Matthews Creek is considered to be exceeded if mining-induced fracturing in a rockbar or stream bed, or mining induced reduction in groundwater baseflow results in a reduction in pool water level below the historically recorded minimum level for:

- More than 10% of pools within the Study Area; and / or
- Pool SR17.

Less than 10% of the pools within the Study Area have been impacted. Only one pool has been confirmed to be impacted by mining (pool CR14), and 10% of pools in the Study Area was determined to be a total of 9 pools. In addition, no impacts to pool SR17 on Stonequarry Creek are evident. Consequently, there is negligible evidence to date of subsidence impacts with environmental consequences greater than minor associated with mining LW W1 and LW W2.

Minor valley closure movements (less than 25 mm) have been measured beyond the ends of LW W1-W2 near the confluence of Cedar and Stonequarry Creeks. No impacts have been observed to surface water at this stage. No measurable closure or impacts have been measured across Rockbar SR17 (MSEC, 2021).

4.1.2 Baseflow and Low Flow Regime

Observed Impacts to Baseflow

SLR (2021) describe baseflow reduction as '…the process of inducing leakage from a creek or river into the aquifer via a downward gradient or weakening an upward gradient from the aquifer into the watercourse and thereby reducing the rate at which baseflow occurs'.

Groundwater drawdown and depressurisation as a result of mining LW W1 has resulted in a reduction in baseflow and a change from gaining to losing conditions in some sections of the surface water systems within the Study Area. The reduction in baseflow contribution, potentially combined with subsurface fracturing, has led to pool water levels declining to below the baseline minimum or cease to flow level during periods of 2020 and early 2021 (SLR, 2021a).

Predicted Impacts to Baseflow

SLR (2021) note that, given the similarity in proximity of LW W1 to Matthews Creek and Cedar Creek and the proximity of LW W3 to Stonequarry Creek, empirically there is potential that groundwater level decline and associated baseflow reduction may influence pool water levels in Stonequarry Creek. Mining of LW W3 (and to a lesser degree LW W4) may result in groundwater depressurisation and enhanced losing conditions at surface water monitoring site SB and further downstream in Stonequarry Creek. This may potentially result in a disconnection between the surface water system and groundwater system, thereby increasing the frequency of creek / pool water level decline in the reach of Stonequarry Creek within the Study Area (SLR, 2021a).

SLR (2021) have made predictions of baseflow reductions for watercourses within the Study Area. The range of baseflow loss predictions were derived from groundwater modelling scenarios with varying degrees of fracturing and dilation simulated for the Hawkesbury Sandstone and low, medium and high hydraulic conductivities along the Nepean Fault system, which is in close proximity to LW W4 (SLR, 2021a).

Longitudinal and vertical connection between the goaf of LW W4 and Stonequarry Creek is considered the primary risk pathway in terms of impacts to the surface water system (SLR, 2021a). The permeability within the Nepean Fault zone in the vicinity of LW W4 would govern the longitudinal movement of groundwater along the fault zone, however, the permeability along the Nepean Fault zone is uncertain. As such, SLR (2021) conducted uncertainty and sensitivity scenarios in relation to the permeability of the Nepean Fault zone which is reflected in the minimum, mean, likely and maximum baseflow reduction predictions for the surface water systems within the Study Area presented in **Table 4-1.**

Table 4-1 Predicted Watercourse Baseflow Reduction

Watercourse	Baseflow Reduction Associated with LW W3-W4 (ML/year)			
	Minimum	Mean	Likely	Maximum
Cedar Creek to confluence with Stonequarry Creek	1	1	5	5
Matthews Creek to confluence with Cedar Creek	0	2	3	4
Stonequarry Creek at monitoring site SD	10	27	45	45
Main tributary of Redbank Creek	0	1	2	2
Redbank Creek to confluence with Stonequarry Creek	1	4	7	7

SLR (2021b) estimated a peak mean annual baseflow reduction associated with regional mining, including LW W3-W4, for the Stonequarry Creek Management Zone of approximately 50 ML/annum in 2023-2024 which is predicted to decline to approximately 25 ML/annum by approximately 2035. The mean annual flow volume recorded at Stonequarry Creek at Picton (GS 212053) is 5,627 ML. The peak predicted baseflow reduction of 50 ML/annum equates to 0.9% of the mean annual flow at Stonequarry Creek at Picton (GS 212053) which is a small and likely indiscernible reduction in flow at this location. (HEC, 2021a).

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). A peak mean annual baseflow reduction of 50 ML equates to 7.3% of the total issued share component of the Stonequarry Creek Management Zone for unregulated river access respectively. The predicted baseflow reduction 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 (HEC, 2021a).

The predicted baseflow reduction 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 (SLR, 2021a). A review of the WAL licencing requirements has been completed following the completion of investigations and characterisation of the Nepean Fault zone in proximity to LW W4 to confirm the likely baseflow reductions as a result of LW W3-W4 mining. Tahmoor Coal are progressing the purchase of Water Access Licences.

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 deep groundwater and surface water systems is not predicted to occur (SLR, 2021a). It is more likely that diverted flow will re-emerge further downstream of monitoring site SD on Stonequarry Creek. As such, the estimated baseflow reduction for Stonequarry Creek associated with mining LW W1–W4 is highly conservative as a portion of the diverted flow is likely to re-emerge further downstream (SLR, 2021a).

4.1.3 Flood Regime – Matthews, Cedar and Stonequarry Creeks

A flood study has been undertaken to assess the impacts to flooding due to predicted subsidence within the Study Area (WRM, 2020). Hydrologic and hydraulic modelling was undertaken to assess the cumulative impacts of longwall panels LW W1 and LW W4 on peak flood levels in the three creeks for the 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events. The modelling assessment and predictions are detailed in WRM (2020), which is included as **Appendix C**.

The flood study found that the 1% AEP flood extent will be contained within the main creek channels providing Barkers Lodge Road with a 1% AEP flood immunity. The peak flood level is predicted to decrease by up to 0.11 m in localised areas within creek channels, although may increase by up to 0.05 m at other localised areas within creek channels (WRM, 2020).

The peak flood velocity change is predicted to increase by up to 0.15 m/s in localised areas, although the predicted velocity increases in most areas are expected to be generally less than 0.05 m/s. The modelling predictions indicate a very similar flood extent in the existing and post-subsidence conditions. As such, the impacts due to the proposed subsidence associated with the Western Domain on the three creeks in 1% AEP flood conditions are predicted to be negligible (WRM, 2020).

The flood study also found that the PMF flood extent will also be contained within the main channels of Matthews and Cedar Creeks, however flood break out would occur from portions of Stonequarry Creek, resulting in flooding of Barkers Lodge Road under existing and post-subsidence conditions by up to 1.5 m. The peak flood level is predicted to decrease by 0.11 m and increase by up to 0.1 m in localised areas. The flood velocity is predicted to increase by up to 0.2 m/s in localised areas, although the predicted velocity is expected to increase by less than 0.1 m/s generally. The modelling predictions indicate a similar flood extent in the existing and post-subsidence conditions. As such, the impacts due to the proposed subsidence associated with the

Western Domain on the three creeks in PMF conditions are predicted to be negligible (WRM, 2020).

4.1.4 Flood Regime – Local Tributary Gullies

Several tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek overlie the proposed LW W3-W4. A hydraulic (surface flow) model was developed for each tributary and associated culverts to assess the change in flood level for the 50% AEP (representative of frequently occurring flows) and 1% AEP (representing rare events) peak flow rates based on the subsidence predictions for the Study Area. **Figure 4-1** illustrates the tributaries within the Study Area that were included in the hydraulic model.

Changes to average water depth and/or velocity in the tributaries of the creeks are likely to occur, as described below:

- Localised areas of Stonequarry Creek tributaries (SC Trib 1, SC Trib 2 and Rail 1) are likely to be associated with minor increases in depth and velocity, however, these increases are predicted to occur in low risk areas (undeveloped areas with limited infrastructure);
- At the Matthews Creek tributary MC Trib 2, the water depth is predicted to increase by a maximum of 0.074 m for a 1% AEP event post-mining LW W3-W4. The depth increase is not predicted to result in the 1% AEP event flood extent reaching the residential buildings in this area;
- At the inlet of the Stonequarry Creek Road culverts on Matthews Creek (SC-C2 and SC-C3), slight increases in depth (up to 0.05 m) are predicted to occur for both the 50% AEP and 1% AEP events (refer Figure E10 and Figure E12, Appendix E). The slight increase in depth may result in water ponding at the inlet of the culverts for a short duration of time, however, will not result in a notable increase in flow depth over Stonequarry Creek Road;
- Upstream of railway culvert 89.216 km, the depth is predicted to increase by 0.032 m for a 1% AEP event and decrease by 0.07 m for a 50% AEP event due to changes in the flood characteristics of the upstream tributaries of Redbank Creek. The slight depth increase predicted for a 1% AEP event may result in water ponding against the railway embankment for a short duration of time, however, will not exceed the height of the railway embankment;
- Increases in velocity are predicted to occur at the outlet of farm dams which are located along Redbank Creek tributaries RC Trib 1, RC Trib 2 and RC Trib 3. The predicted increase in velocity may result in some increased scouring at the outlet of the dam during flood events. These dams will be visually inspected following flood events as detailed in Douglas Partners (2021); and
- Three residential buildings, downstream of CR-C1, on lots 1, 2 and 3 of plan DP1057554 are predicted to be within the existing inundation extent of the 1% AEP event associated with Redbank Creek tributary RC Trib 3. The maximum depth increases for flood water abutting these buildings during a 1% AEP event is predicted at 0.038 m, 0.039 m and 0.037 m for lots 1, 2 and 3 respectively. This represents an increase in depth of 3%, 5% and 3% respectively in comparison with the predicted pre-mining 1% AEP depth. The maximum velocity increase for flood water abutting these buildings during a 1% AEP event is predicted at 0.027 m/s, 0.031 m/s and 0.039 m/s for lots 1, 2 and 3 respectively. This represents an increase in velocity of 1%, 10% and 12% respectively in comparison with the predicted pre-mining 1% AEP velocity.

All other changes are likely to be negligible to low with no perceived impacts likely to result to railway infrastructure, dams, roads, culverts or buildings.

Details of the hydraulic model outcomes are provided in **Appendix B** (HEC, 2021a).

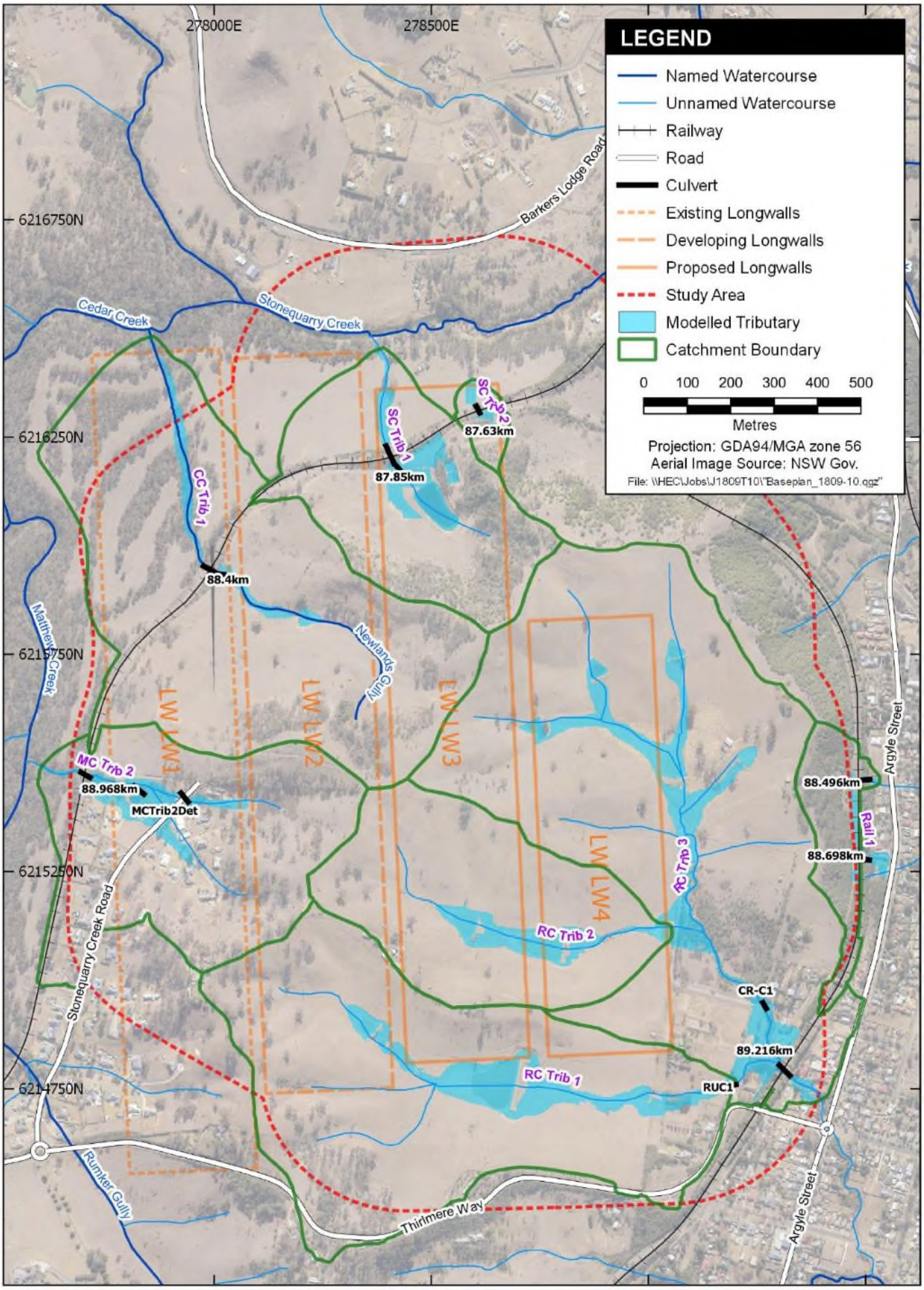

Figure 4-1 Flood Assessment Tributary Locations, Catchment and Culvert Alignments (HEC, 2021a)

4.1.5 Overland Flow

The maximum predicted incremental tilt is 4.5 mm/m due to mining of LW W3 and LW W4 (MSEC, 2021). The minimum natural gradient overlying LW W3 is approximately 37 mm/m while the minimum natural gradient overlying LW W4 is approximately 47 mm/m. As the maximum predicted tilt is insignificant in comparison with the natural gradient, there are no locations in which the natural gradient will flatten or change direction. As such, while there may be some minor changes to the drainage pathways, remnant ponding in the landscape (excluding the watercourses) is unlikely to occur as a result of mining of LW W3 and W4 (HEC, 2021a).

4.1.6 Farm Dams

Potential Impact to Farm Dams

Several farm dams are present within the Study Area which may potentially be impacted by subsidence associated with mining in the Western Domain (HEC, 2021a).

Potential hazards from the impact of mine subsidence on farm dams can include:

- Vertical subsidence can cause change in drainage paths or dam catchment;
- Tensile strain has the potential to result in cracking in the dam wall or liner, particularly where the dam is not lined or is located in rocky areas; and
- Tilt can cause change overflow point level and reduction in dam capacity.

A review of subsidence impacts to dams overlying previously mined LW 22 to LW 30 was completed by HEC (2021). This review noted that the majority of dams overlying these longwalls have not been observed, or reported by landowners, to have been affected by subsidence, except for three dams overlying LW 26 which reported a loss of water holding capacity (GeoTerra, 2014). The maximum observed subsidence following mining of LW 26 was 1,382 mm with the three impacted dams overlying the longwall ribline zones.

The greatest subsidence at existing dams is predicted to occur at FD-4 and FD-6. The maximum total subsidence predicted for FD-4, which overlies LW W3, and FD-6, which overlies LW W2, is 975 mm following mining of LW W4. As the maximum predicted total subsidence is significantly less than that experienced following mining of LW 26, it is anticipated that impacts to these dams will be reduced (HEC, 2021a).

The maximum predicted tilt for the farm dams within the Study Area is 5.0 mm/m. Mining-induced tilts can affect the water level around the perimeters of farm dams, with the freeboard increasing on one side and decreasing on the other. Tilt can also potentially reduce the storage capacity of farm dams, by causing them to overflow, or affect the stability of dam walls (MSEC, 2021).

The predicted changes in freeboard for the farm dams within the Study Area are small, varying from less than 20 mm to 150 mm. It is unlikely that the dams would experience adverse impacts on the storage capacities due to these small changes in freeboard (MSEC, 2021).

There are eight farm dams located directly above LW W3-W4 which could experience cracking in their bases of walls due to mining. However, extensive experience of mining directly beneath farm dams in the Southern Coalfield indicates that the incidence of impacts is very low. Farm dams are commonly constructed with cohesive materials in the bases and walls which can absorb the conventional subsidence movements typically experienced in the Southern Coalfields without the development of substantial cracking. Non-conventional cracking movements can result in localised cracking and deformations at the surface and, where coincident with farm dams, could result in adverse impacts (MSEC, 2021).

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 (Douglas Partners, 2021).

A high-level dam break analysis to determine the consequence of farm dam failure to property or human lives was completed for dams within the Study Area (Douglas Partners, 2021). This analysis found that the consequence of dam break is 'Significant' and 'High C' for farm dams in excess of 5 ML in stored volume located in the tributaries of Redbank Creek if they failed in series, one after the other. The remaining farm dams located in the western and northern parts of the Study Area were assessed to be in the very low to low ranges (Douglas Partners, 2021).

A detailed assessment is currently being carried out for farm dams located in the tributaries of Redbank Creek to assess the quality of construction of the larger farm dams and to complete a dam break analysis to assess the extent of the flooding impact downstream.

A monitoring plan is detailed in **Section 5.2** to monitor embankment integrity and water level of dams prior to, during operations and post mining of LW W3-W4. Should impacts be reported, a rehabilitation program will be implemented.

Observed Impact to Farm Dams

Geotechnical inspection of farm dams within the active subsidence zone was undertaken monthly by Douglas Partners during the period of mining LW W1 and W2. Douglas Partners advise that mining of LW W1 and W2 (to date) has not resulted in a measurable impact on farm dams and that there were no exceedances of the Level 1 TARP significance (normal conditions) for farm dams (Douglas Partners, 2021).

4.1.7 Water Quality

Predicted Impact to Water Quality

Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur in Stonequarry Creek, Matthews Creek and Cedar Creek due to subsidence induced changes in surface water runoff, throughflow and baseflow discharging to these surface water systems. Localised and periodic increases in electrical conductivity and concentrations of dissolved iron, manganese, zinc, sulphate and nickel were recorded at monitoring sites in Redbank Creek overlying and downstream of LW24B to LW32 during and shortly following mining (HEC, 2021a).

While there were some periodic increases in constituents recorded at locations downstream of mining impacts, potentially due to re-emergence of upstream diverted flow, the increases were found to be temporary and decreased to baseline levels with time. However, because Stonequarry Creek, Matthews Creek and Cedar Creek will not be directly mined beneath, the subsidence related impacts to water quality are likely to be less than that recorded previously in Redbank Creek following mining of LW25 to LW32 (HEC, 2021a).

Groundwater seepage has been observed at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (GeoTerra, 2014). As such, subsidence related impacts to water quality may be more pronounced at this location. Ferruginous deposition is prevalent in Cedar Creek and may be exacerbated by subsidence induced emergence of ferruginous springs (HEC, 2021a).

Observed Impact to Water Quality

To date there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Matthews Creek, Cedar Creek or Stonequarry Creek. A water quality TARP significance above Level 2 has not been reported for any sites in Matthews Creek, Cedar Creek or Stonequarry Creek since commencement of mining LW W1 and W2 (HEC, 2021a).

4.1.8 Aquatic Habitat

Predicted Impacts to Aquatic Habitat

MSEC (2021) has predicted that less than 10% of pools along Stonequarry Creek, Matthews Creek and Cedar Creek are likely to experience fracturing and associated reduction in standing water level based on the predicted total valley closure. As such, there is likely to be less than 10% reduction in overall pool aquatic habitat in Stonequarry Creek, Matthews Creek and Cedar Creek (Niche, 2021). In the event of cracking, potential localised reduction in available habitat and macroinvertebrate biomass may occur as a result of reduced water levels. Additionally, temporal reduction in fish passage during low flow periods may occur (Niche, 2021).

For invertebrates, while total biomass will likely be reduced, it is unlikely that a sub-catchment to catchment scale change in overall assemblage and family richness will be measurable. The majority of the stream biota observed in the Study Area are able to adapt to drying conditions and have the potential to recruit back to pools once the water holding capacity is re-established. For pools which experience long-term reduction in water holding capacity, this could lead to permanent changes to stream biota within the affected pools and restrict the recovery of biota that require stream connectivity e.g. fish (Niche, 2021).

The liberation of contaminants from subsidence induced fracturing in watercourses, with resulting localised and transient water quality impacts, has the potential to impact aquatic biota. This is particularly the case where increased iron precipitation occurs. Streams that are acidic and have low alkalinity are more likely to be impacted as these surface water systems have less buffering capacity against changes to pH (Niche, 2021).

Where localised and transient pulses in metals are observed, the impacts to stream fauna are similarly expected to be localised, with fauna likely to recover from transient spikes in concentrations. Localised long-term changes to fauna may occur if metal concentrations are elevated for prolonged periods of time (Niche, 2021).

Observed Impacts to Aquatic Habitat

Three aquatic ecology monitoring programs have been conducted by Niche since commencement of mining LW W1 and LW W2 – Autumn 2020, Spring 2020 and Autumn 2021 (preliminary). During the Autumn 2020 monitoring program, which occurred following a period of considerably higher rainfall than the previous years, it was observed that all sites had similar riparian and channel condition to baseline conditions, however, there was more aquatic habitat available and less iron flocculation observed in Cedar Creek (Niche, 2021).

AUSRIVAS scores with either comparable to previous results or higher than any scores observed during the baseline period and the number of taxa were above or within the range of pre-mining results. Macroinvertebrate assemblages indicated spatial and temporal variability with evidence that differences observed between the Spring 2019 and Autumn 2020 surveys were driven by a reduction in common macroinvertebrate families. However, this was observed at both control sites and potential impact sites and therefore is unlikely to be a result of subsidence related influences (Niche, 2021).

During the Spring 2020 monitoring, no change in stream morphology or condition was observed, the water quality was comparable with control sites, AUSRIVAS scores were either comparable to or higher than scores observed pre-mining and number of taxa were above or within the range of pre-mining results (Niche, 2021).

Niche (2021) concluded that, based on the Spring and Autumn 2020 aquatic monitoring programs, the creeks within the Study Area were at Level 1 TARP significance (normal conditions) and that mining of LW W1 had not resulted in a measurable impact on aquatic ecology in Autumn and Spring 2020.

The preliminary AUSRIVAS results from the Autumn 2021 monitoring program identified that AUSRIVAS scores were within the range of, or above, pre-mining AURIVAS scores and natural variability. No water quality or stream morphological changes were observed that could be related to potential subsidence impacts from LW W1 and LW W2. The preliminary Autumn 2021 monitoring results confirmed that all sites were considered to be 'normal' according to the TARPs for aquatic ecology (macroinvertebrate indicators and aquatic habitat) and that no TARP triggers had been exceeded (Niche, 2021).

Observed Impacts to Riparian Vegetation

Small although reasonably persistent gas bubbles were observed in pool MR45 in Matthews Creek during the creek visual inspections conducted in February to June, October, November and December 2020. This equated to a Level 3 TARP significance during these periods in accordance with the LW W1–W2 WMP (HEC, 2021a).

Samples from pool MR45 were collected and analysed through gas chromatography. The results of the analysis indicated that the gas emissions were likely to be from the shallow Hawkesbury Sandstone and / or shallow anoxic, muddy alluvium and were not indicative of water discharged from the deep Hawkesbury Sandstone or deeper strata aquifers. The results of the gas chromatography analysis were insufficient to provide a direct linkage between mining related influences and the observed gas emissions, although a connection was considered probable (GeoTerra, 2020a).

Methane is naturally present in many natural shallow surface water and groundwater systems as a result of organic decomposition and redox-methanogenesis reactions (DoP, 2008). When sediments are disturbed by mining related subsidence effects, methane derived naturally may be released more rapidly in surface water systems (DoP, 2008). The generative fluxes and concentrations are generally low and inconsequential (DoP, 2008).

In areas where gas releases occur into the water column, there is insufficient time for substantial amounts of gas to dissolve into the water column (MSEC, 2021). Rare and isolated dieback of riparian vegetation has been reported in the Southern Coalfield due to release of gas emissions to the atmosphere (DoP, 2008). However, Niche (2021) have not reported evidence of vegetation dieback due to observed gas emissions in pool MR45 in Matthews Creek.

4.2 Groundwater

The potential impacts to groundwater can be divided into two principal types:

- Impacts to groundwater level, i.e. drawdown and depressurisation, and associated changes in groundwater quantity due to groundwater discharge into the mine workings and changes to strata permeability and porosity; and
- Impacts to water quality characteristics due to enhanced aquifer connectivity/mixing.

Potential impacts have been assessed by SLR (2021) utilising a numerical groundwater model that has simulated the progressive extraction of LW W3-W4. Further information about the Tahmoor Mine Groundwater Model and recent model updates are provided in the GTR (**Appendix D**).

4.2.1 Groundwater Inflows (Groundwater Make)

From the simulated groundwater inflows to LW W3-W4, inflow to the Western Domain is expected to lie in the range of 3-4 ML/d during 2021-2022, with the potential to peak slightly higher for short period. The extraction of LW W3-W4 would increase the duration of inflow to Tahmoor North, with a total of approximately 4-5 ML/d of inflow during late 2021-2022 (SLR, 2021a).

4.2.2 Groundwater Levels – Groundwater Table

Groundwater drawdown refers the lowering of the groundwater table in a given aquifer. This mechanism is a typical response to aquifers that are associated with mining, as the groundwater within workings is removed to aid extraction. Following the cessation of mining recovery of groundwater levels can occur (SLR, 2021a).

Predicted Impacts to the Groundwater Table

An assessment of the extent of groundwater drawdown was conducted for this groundwater technical report to understand the extent of incremental lowering of the regional groundwater table that will occur due to the extraction of LW W3-W4. This information will assist in the prediction of potential impacts to 'water supply works', as required by the AIP, as well as providing a basis to develop groundwater triggers (SLR, 2021a).

The model showed that the extraction of LW W3-W4 has little to no effect on the regional pressure head, especially in comparison to the depressurisation simulated to have occurred at the Appin Mine to the east of LW W3-W4. Incremental water table drawdown of 2 m is expected to be contained to the area within and adjacent (maximum distance of 600 m from edge of panel) to LW W3-W4 with a greater spread of drawdown in the range of 0.2-1 m (SLR, 2021a).

The model results indicate that the areas in immediate vicinity of LW W3-W4 will experience the greatest impacts from the extraction of LW W3-W4 (SLR, 2021a).

Further information regarding specific groundwater drawdown is provided in **Appendix D**.

Observed Impacts to Monitoring Bores

During the mining of LW W1-W2, the following impacts to monitoring bore water levels have been observed based on the trigger exceedances assessment (SLR, 2021a):

- Ongoing drawdown due to mining along the western side of LW W1 was identified in the mid Hawkesbury Sandstone aquifer at the open standpipes P12C, P13C, P16B and P16C, and at TNC036 in the three upper instruments HBSS-65m, HBSS-97m and BGSS-169m. Within the lower Hawkesbury Sandstone, this depressurisation is likely related to strata dilation (leading to an increase in porosity and hence storage) in the above and adjacent to LW W1. As of December 2020, groundwater trends at P12C, P13C, P16B and P16C, and at TNC036 (intakes HBSS-65m, HBSS-97m and BGSS-169m) triggered the Level 4 TARP criteria;
- The shallower open standpipes at the Western Domain do not show signs of depressurisation due to mining (less than 1 m) and meet the Level 1 TARP level criteria; and

- Deeper strata at TNC036 (BGSS-214m; BGSS-412.5m) have undergone a clear depressurisation. The observed drawdown at these two intakes exceeds the modelled drawdown from August 2020, however as the levels remain within the 30 m predicted drawdown, a Level 2 TARP Level criteria applies.

Due to the two Level 4 TARP triggers for groundwater level in accordance with the LW W1-W2 Water Management Plan, a subsidence event notification for groundwater level reduction that triggered the Level 4 TARP triggers was provided to DPIE, Resources Regulator and NRAR on 30 December 2020. An investigation into groundwater depressurisation has been completed, and a Surface Water and Groundwater Investigation Report was submitted to DPIE, Resources Regulator and NRAR on 9 April 2021.

The key findings from the investigations regarding groundwater depressurisation were:

- The decline in groundwater level recorded at groundwater monitoring sites within the Investigative Area is likely attributed to mining induced regional depressurisation of deeper aquifers;
- The groundwater model predictions underestimated the groundwater level decline recorded at deeper groundwater monitoring bores (piezometers P12C, P13C, P16B and P16C);
- The rate of groundwater level decline has reduced and levels have been relatively stable since late 2020 (as indicated by groundwater levels); and
- Groundwater levels at P12 appear to have stabilised since mid-February 2021, however, may be subject to further groundwater depressurisation as LW W2 progresses due to the proximity of P12 to LW W2.

4.2.3 Groundwater Levels - Private Bores

Predicted Impacts to the Private Bores

An assessment of maximum predicted drawdown was completed in the GTR (SLR, 2021a) to predicted the potential impacts to the relevant private bores. Maximum and cumulative drawdown were predicted for the private bores. It is noted that the AIP (NSW Government, 2012) established a 2 m threshold as the maximum allowable drawdown for 'water supply works' in order to satisfy the considerations for 'minimal harm'.

Maximum incremental (due to the extraction LW W3-W4) drawdown in excess of 2 m is predicted to occur at all bores except for GW035844, GW064469 and GW115860. The maximum incremental drawdown is estimated to be 56.1 m at GW104090, however this result is expected as this bore lies directly over LW W2 and is adjacent to LW W3 (SLR, 2021a).

The cumulative impacts of LW W3-W4 and current and historic mining, at Tahmoor Mine are predicted to cause drawdown in excess of 2 m at eight of the nine private bores. The greatest predicted drawdown is expected to occur at GW104090, GW105546 and GW105546, with estimates of 8. 114.5 m, 36.7 m and 17.5 m respectively. The drawdown experienced at GW024750 will be inconsequential because the borehole has collapsed. The five remaining bores with drawdown in excess of 2 m are predicted to experience drawdown in the range of approximately 3.3 to 10.5 m (SLR, 2021a).

The extent of predicted drawdown at these bores is consistent with the drawdown due to previous mining activity at Tahmoor Mine at other shallow bores (e.g. P1-P5 bores), with drawdown being the greatest at bores directly overlying mine workings, and typically about 1 m at shallow bores located away from the longwall footprint (SLR, 2021a).

Due to the high density of watercourses in this region it is possible that the simulation of watercourses and the applied river stage may affect predicted drawdown in areas near to watercourses. As such, actual drawdown, particularly in during drier climatic periods, may be greater than the predictions presented here. For this reason, on-going monitoring of shallow groundwater levels is critical, which is detailed in the proposed LW W3-W4 water monitoring program (refer to **Section 5.2**).

Observed Impacts to the Private Bores

From available information collected during the extraction of LW W1-W2, there is no depressurisation identified at GW072402 and no groundwater level exceedances are recorded at this location. The drawdown at the remaining private bores locations was noted to result in exceedances potentially breaching the TARP Level 2 at GW105467 and GW105546 for various aquifer intakes. These exceedances must be managed with caution as calculations rely on observed groundwater level conditions at nearby monitoring bores and an assumed linear relationship between drawdown and distance to LW W1, and does not take in account local in-situ ground conditions (hydraulic conductivity, transmissivity) at the private/monitoring bores, whose water levels may respond differently to mining (SLR, 2021a).

No significant loss of yield that could impede groundwater use was recorded at the private bores following the extraction of LW W1. There are no recent claims of reduced bore yield or effects on water quality by neighbouring bore owners.

4.2.4 Groundwater Quality

Observed Impacts to Groundwater Quality

During the mining of LW W1-W2, the following impacts to water quality from monitoring bores have been observed based on the trigger exceedances assessment (SLR, 2021a):

- The decline in groundwater levels at the deeper of the open standpipes is accompanied with short-term reduction in pH at P12C, P16B and P16C and short-term increases (less than 3 months) in metal concentrations, returning to non-exceedance levels as of March 2021, for Cu (P12C), Mn (P12C) and Zn (P16A). Metal concentration exceedances (TARP Level 2) remain active as of January/February 2021 for Li (P13A,B,C), Al (P17) and for several metals (Fe, Mn, Cu, Pb, Zn, Al, Ba) at P16B. Suitability to assess groundwater quality at 16B will be evaluated in the next monitoring period due to the addition of oxalic acid in January 2021 during groundwater sampling;
- Short-term fluctuation (less than 3 months) in Pb and Cu (P12A, P12B) and in pH (P16A, P13A) returning to non-exceedance levels as of March 2021. To note, the recent increase observed in pH at P13A that may be related to weather conditions and anthropogenic activities conducted on the surface; and
- Single exceedances in metal concentrations have been recorded in all private bores after extraction of LW W1, which have triggered TARP level 2. The recent rise in Zn could be linked to mining operations. On-going and future groundwater quality monitoring at the private bores will allow to confidently assess the trend in metal concentration, if correlated to mining or to natural effects.

Based on visual observations, there are no significant changes in iron-staining at the private bores between the pre and mining periods at the Western Domain. GW072402 presents strong iron-staining from March 2019 (pre-LW W1) to October 2020. GW105467 and GW105546 have a moderate to low degree of iron staining since monitoring started in March 2019, prior to LW W1 (SLR, 2021a).

4.2.5 Nepean Fault

Predicted Impacts relating to the Nepean Fault Complex

During the mining of LW W1, observed subsidence has been substantially less than predicted, and LW W2 observed subsidence is also likely to be less than predicted. It is possible that increased subsidence could develop above LW W3 and LW W4 as these longwalls are closer to the Nepean Fault. However, while the possibility for significant differential movement across the Nepean Fault complex to the side of proposed LW W3-W4 cannot be ruled out, the likelihood is considered to be very low based on the experiences observed to date (MSEC, 2021).

This is supported by the assessment provided by SCT (2021; **Appendix F** of the Extraction Plan Main Document). This report found that the presence of the Nepean Fault Complex could cause an increase in subsidence above longwalls W3 and W4, especially so for W4 given its proximity. SCT also concluded that "in the unlikely event that greater than predicted subsidence occurs over Longwalls W3 and W4, there is no expectation of significantly greater than predicted subsidence outside the panel footprint" and that mobilisation of fault structures due to longwall subsidence is not likely.

5 Subsidence Monitoring Program

5.1 Performance Measures and Indicators

Performance measures referring directly to the management of surface water and groundwater 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 flooding and is listed in **Table 5-1**.

A performance measure for Stonequarry Creek, Cedar Creek and Matthews Creek was provided as part of the conditions for LW W3-W4 Extraction Plan approval, as listed in **Table 5-1.**

Table 5-1 Subsidence Performance Measures and Performance Indicators for Surface Water and Groundwater Resources

Feature	**Subsidence Performance Measures**	**Subsidence Performance Indicators**
DA 67/98 Conditions of Consent – Condition 13E **Table 2: Subsidence impact performance measures – built features**		
Public safety	Negligible additional risk	This performance indicator will be considered to be exceeded if subsidence results in the post-mining 1% AEP flood level being above the floor level of one or more dwelling.
LW W1-W2 Extraction Plan Approval Conditions of Consent – Condition 7(1) **Table 1: Subsidence impact performance measures – natural features**		
Stonequarry Creek, Cedar Creek and Matthews Creek	No subsidence impact or environmental consequence greater than minor*	This performance indicator will be considered to be exceeded if mining-induced fracturing in a rockbar or stream bed, or mining induced reduction in groundwater baseflow results in a reduction in pool water level below historically recorded water levels, taking into account rainfall and observations during the baseline monitoring period, for: • More than 10% of pools located within the 600 m Study Area for Natural Features; and/or • Pool SR17.
	No connective cracking between the surface, or the base of the alluvium, and the underground workings	This performance indicator will be considered to be exceeded if analysis of inflow data suggests high correlation to rainfall events and significant departure from recent groundwater model predictions. This would be supported by analysis of pre- and post-mining goaf centreline bore data.

*Minor is defined as *not very large, important or serious.*

With regards to the subsidence performance measure for public safety, '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.

With regards to the subsidence performance measure for the creeks, the conditions of LW W3-W4 Extraction Plan Approval have been defined minor as 'not very large, important or serious'. The performance indicator in **Table 5-1** is consistent with the impact assessment that was provided in the Extraction Plan.

The 600 m Study Area for Natural Features (refer to **Figure 1-2**) was defined in the Extraction Plan for LW W3-W4 and is consistent with the recommendation in the independent inquiry report titled "Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield – Strategic Review" (NSW Department of Planning (DoP), 2008). In addition, predicted valley closure is typically 20 mm or greater for pools within the 600 m Study Area for Natural Features.

The total number of pools within the 600 m Study Area for Natural Features is 88, and consists the following:

- Matthews Creek – 42 pools including MR5 to MR46;
- Cedar Creek – 32 pools including CR1 to CR32; and
- Stonequarry Creek – 14 pools including SR5 to SR18.

Accordingly, the subsidence performance indicator is considered to have been exceeded if more than 9 pools experience impacts as defined in

Table 5-1.

It is acknowledged that pools within the 600 m Study Area for Natural Features have different level of significance. Pool SR17 is noted to be a significant rockbar-constrained pool along the Stonequarry Creek, extending for approximately 676 m from the downstream rockbar (labelled SR17) to the upstream rockbars CR32 and SR16 (and includes monitoring point SC2) (refer **Figure 5-1**). A specific performance measure for this pool has been included in **Table 5-1**.

The performance measure for connective cracking is proposed to be measured considering the following:

- Comparison of inflow data to rainfall events and groundwater model predictions; and
- Analysis of pre- and post- mining goaf centreline bore data, including defect count, permeability and groundwater level response. Tahmoor Coal is currently proposing to install a borehole to determine height of groundwater depressurisation in proximity to the centreline of LW W2 (to be installed following LW W3-W4 impacts).

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 surface water and groundwater resources has been compiled in **Table 5-3**, and the locations of surface water monitoring sites are illustrated in **Figure 5-1** and **Figure 5-2**. A summary of monitoring actions along each stream is shown in Appendix F.

It is noted that monitoring and management of features such as springs and GDEs is not considered necessary due to the absence of these features in the LW W3-W4 Study Area.

A Before-After-Control-Impact (BACI) framework has been implemented, where feasible, for surface water and groundwater monitoring and has been incorporated in the design of the TARP triggers. The monitoring program aims to develop a baseline (before) dataset for a range of surface water and groundwater features and to assess operational and post-mining (after) impacts through the monitoring of reference (control) and performance measure (impact) sites. The TARP triggers have been designed to enable identification of potential impacts based on the before and after monitoring at reference and performance measure sites.

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 monitoring period. Extraction in the Western Domain commenced on 15 November 2019 (LW W1 extraction. Baseline monitoring leading up to 15 November 2019 found that surface flow and pool water levels were continuing to fall below their lowest previously recorded levels due to the prolonged drought conditions. The length of LW W1 extraction at the end of December 2019 was 122 metres. Subsidence monitoring found that the ground has subsided only negligible amounts at this period of time. It is therefore planned to adopt readings up to 31 December 2019 as the baseline monitoring period, noting that pool water levels may continue to fall further below their lowest previously recorded level due to the ongoing drought;
- During Mining – monitoring of the condition of the site during active subsidence within the active subsidence zone to establish whether there has been any change to the site or if changes have occurred from the effects of subsidence. This monitoring is also referred to as active subsidence monitoring. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 m in front of and 450 m behind the active longwall face. Monitoring during the period of active subsidence will continue after the longwall face has moved away from a site by more than 450 m if ongoing adverse changes are observed; 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 ground surface conditions have stabilised. This monitoring is also referred to as the post mining monitoring. Tahmoor Coal will continue monitoring for 12 months after LW W2 extraction has finished. The Environmental Response Group (ERG) will then determine whether to extend the post-mining monitoring period based on the following considerations:
  - Observed rates of change in subsidence movements;
  - Observed rates of change in mining-induced impacts and environmental consequences on surface water and groundwater and aquatic ecology;
  - The ERG is satisfied that the change will not adversely impact the ERG's ability to assess the nature and extent of mining-induced impacts on surface water and groundwater due to the extraction of LW W3-W4; and
  - The ERG is satisfied that the change will not adversely impact the ERG's ability to assess the effectiveness of remediation measures, where they have been completed.

  Tahmoor Coal will inform DPIE, EES and Wollondilly Shire Council of any extension of monitoring via the Six Month Subsidence Impact Reporting.

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 triggered response strategies.

Details of planned monitoring works and investigations that are in addition to the proposed monitoring program are provided in the following subsections.

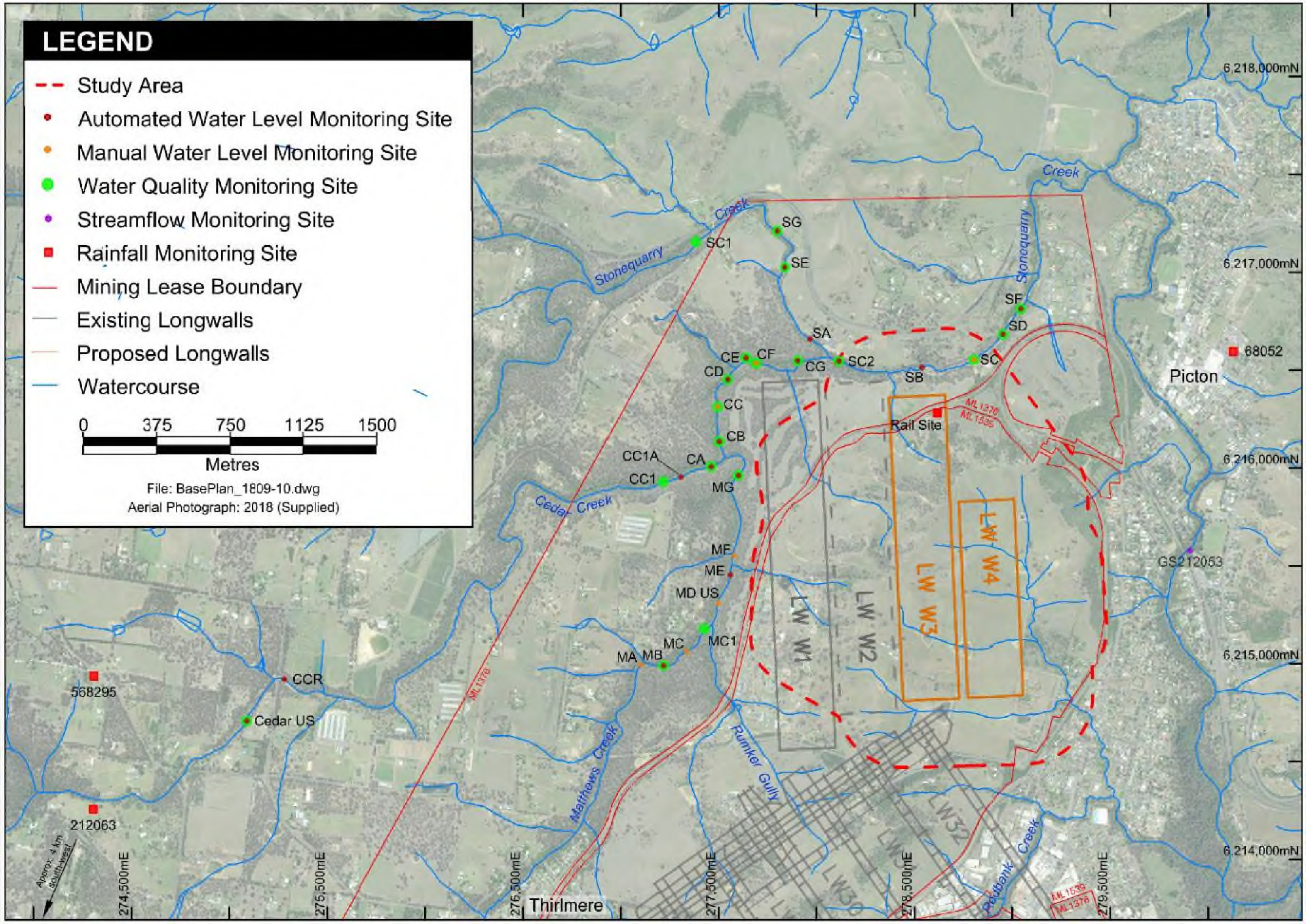

Figure 5-1 Surface Water Monitoring Plan (provided by HEC, 2021a)

5.2.1 Water Quality Parameters

Table 5-2 outlines the water quality parameters as required for surface water and groundwater quality monitoring.

Table 5-2 Water Quality Parameters for Monitoring

Monitoring Program	Field Analysis Parameters	Laboratory Analysis Parameters (analysis at a NATA accredited laboratory)
Surface Water Quality	• pH • EC • DO • Temperature • ORP	• Physical parameters: pH, EC, TDS; • Alkalinity; • Major ions: Na, Ca, K, Mg, Cl, F, SO4; • Nutrients: nitrate+nitrite, kjeldahl nitrogen, phosphorus; • Dissolved metals: Al, As, Ba, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe; and • Total metals: Mn, Zn, Fe.
Groundwater Quality	• pH • EC	• Physical parameters: pH, EC, TDS; • Major ions: Na, Ca, K, Mg, Cl, F, SO4; • Total phosphorus and total nitrogen; • Total alkalinity as HCO3; • Total and dissolved metals: As, Cu, Fe, Pb, Mn, Ni, Se, Zn, Al; and • Total metals: Fe, Mn.

5.2.2 Investigations and the Installation of Additional Water Monitoring Devices

Temporary Creek Flow Monitoring Devices

Tahmoor Coal investigated the feasibility of further developing the streamflow monitoring network in the Study Area to focus on measuring low flows accurately at pool MR5 (monitoring site MB), upstream Matthews Creek; pool CB2, upstream Cedar Creek; pool CR31 (monitoring site CG) or pool CR32, downstream Cedar Creek; and pool SR5 or monitoring site SF, downstream Stonequarry Creek.

The Tahmoor Mine Western Domain Streamflow Monitoring Feasibility Report (HEC, 2021b) for the investigation of the potential for streamflow monitoring in Matthews Creek, Cedar Creek and Stonequarry Creek has been completed. As discussed in this report, the potential benefits that may be gained through accurate streamflow monitoring are not justifiable due to the following factors:

- Lack of highly suitable sites in upstream Cedar Creek or downstream Stonequarry Creek; and
- Only a limited period of data would be able to be acquired due to timing restrictions of approvals and the anticipated start of LW W3 mining.

Therefore, Tahmoor Coal would not be progressing with any streamflow works in the Western Domain.

Continuous Water Level Unit at MR45

Tahmoor Coal investigated the potential for installation of continuous water level monitoring equipment at MR45. A comparison of five manual water level measurements from pools MR45 and MR46 with manual water level measurements from pool MR42 (monitoring site MG) was completed as part of ongoing monthly surface water monitoring, and concluded that there was no notable variability in water level behaviour between the manual water level measurements recorded to date at the sites. Therefore, the installation of the continuous water level monitoring device at MR45 is not considered to be required at this stage.

Groundwater Monitoring Bore P15

The risks associated with groundwater drawdown and associated with potential basal shears should decline with distance between panels and features. Of the two panels proposed, LW W3 is closest to watercourses (specifically Stonequarry Creek). The current setback is similar in distance to the distance between LW W1 and Matthews Creek (where observed effects on pools have been minimal), but less than the distance between LW W1 and some affected pools (e.g. at monitoring site CB) along Cedar Creek.

Installation of four shallow piezometers (P15) between LW W3 and Stonequarry Creek has been completed.

Groundwater Monitoring Bore P40

Installation of a piezometer at a location (P40) adjacent to Cedar Creek monitoring site CB has been completed. This site was installed to monitor the Hawkesbury Sandstone at or just below creek level to inform post-mining groundwater levels and the relationship with surface water levels at monitoring site CB. The piezometer was installed on the plateau to the immediate east of the monitoring site.

Groundwater Monitoring Bore near Monitoring Site CD

The need for an additional piezometer immediately to the east of monitoring site CD was reviewed by Tahmoor Coal and was not deemed necessary based on recent monitoring data.

Groundwater Monitoring Bore P41

Tahmoor Coal is in the process of installing a monitoring bore (P41) location within the Nepean Fault Complex mapped by SCT (2021).

Height of Fracturing Boreholes

Tahmoor Coal has committed to the installation of two boreholes (pre-mining and post-mining) close to the centreline of LW W2 to determine height of groundwater depressurisation as a result of mining in the Western Domain. These boreholes will provide pre-mining and post-mining goaf centreline bore data, including defect count, permeability and groundwater level response. Geophysical investigations, packer testing and the installation of multi-string Vibrating Wire Piezometers (VMPs) will be completed in both boreholes. It is anticipated that a VMP will be installed in the Bulgo Sandstone, Hawkesbury Sandstone, and the Bald Hill Claystone subject to conditions encountered during construction.

The pre-mining borehole (WD01) is located above a chain pillar between the Western Domain LW W1-W2, 570 m from the closest Tahmoor North goaf and was completed while LW W1 was 400 m away. WD01 was installed with eight WVPs, and the hole was packer tested.

The post-mining borehole (WD02) is yet to be installed and will be located above the centre-line of LW W2, 780 m from the closest Tahmoor North goaf. The centre line of LW W2 is representative of the height of depressurisation for the panel, and will provide estimates for depressurisation, fracturing and hydraulic conductivity properties (SCT, 2020). The measured groundwater depressurisation in the subsurface will be assessed and verified in future model predictions. The installation of WD02 will be completed post extraction of LW W4.

Nepean Fault Investigations

SCT (2021) discusses the risk of ground movement within the Nepean Fault Complex, noting that the fault splays (based on surface mapping) are less than 50 m from the north-eastern corner of the proposed footprint of LW W4. Further investigation and characterisation of the fault zone in this area has been completed through drilling from surface and in-seam drilling from existing roadways in the underground mine. This drilling investigated the displacement of any fault trace in the vicinity of the north-eastern corner of proposed LW W4, noting its proximity to the surface trace.

Characterisation of the inferred nearby fault splay with the drilling of an angled borehole has been completed, and logging results assessed.

Table 5-3 Monitoring Program for Surface Water and Groundwater Resources

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Daily rainfall	• WaterNSW stations 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes)[1] • Automatic rainfall stations at the Rail Site and Whiteys Site (refer **Figure 5-1**).	Data recorded daily and downloaded monthly.	Data recorded daily and downloaded monthly.	Data recorded daily and downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Automated pool water level	Tahmoor Coal automated pool level sites (refer to **Figure 5-1**): Baseline / Impact sites: • Cedar Creek (CA, CB, CD, CE, CG) • Matthews Creek (ME, MG) • Stonequarry Creek (SA, SB, SC2, SD, SF) Reference / Control sites: • Cedar Creek (Cedar US, CCR, CC1A) • Matthews Creek (MB) • Stonequarry Creek (SE, SG)	Continuous record. Data downloaded at start of mining. Baseline data recorded since October 2018 at majority of sites.	Continuous record. Data downloaded monthly.	Continuous record. Data downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Manual pool water level	Tahmoor Coal manual pool water level sites (refer to **Figure 5-1**): Baseline / Impact sites: • Cedar Creek (CC, CF) • Matthews Creek (MC, MD U/S (upstream), MF, pool MR45, pool MR46) • Stonequarry Creek (SC)	Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 at majority of sites.	Monthly manual level reading at all sites. Visual inspection of natural drainage behaviour using photo points.	Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
	Reference / Control sites: • Cedar Creek (Cedar US, CCR, CC1A) • Matthews Creek (MA, MB) • Stonequarry Creek (SE, SG)			
Stream water quality	Tahmoor Coal water quality sites (refer to **Figure 5-1**): Baseline / Impact sites: • Cedar Creek (CA, CB, CC, CD, CE, CF, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD, SF) Reference / Control sites: • Cedar Creek (Cedar US, CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE, SG)	Monthly sampling and analysis for 12 months prior to secondary extraction (refer to **Section 5.2.1** for parameters). Baseline data recorded since January 2019 at majority of sites.	Monthly sampling and analysis (refer to **Section 5.2.1** for parameters).	Monthly sampling and analysis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details, and **Section 5.2.1** for parameters).
Stream and riparian vegetation	• As per Biodiversity Management Plan.	Completed as part of baseline monitoring for LW W1-W2.	Bi-annually (Spring and Autumn).	Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group.
Private dams	Impact sites: • FD1-8 and FD12-20 as shown in **Figure 3-3.**	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 by Tahmoor Coal and monthly by a Geotechnical Engineer during active subsidence period using fixed location photo points.	Dam embankment integrity and water level observation using fixed location photo points on a 3-monthly basis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Physical features and natural behaviour of pools	Baseline / Impact sites: • Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area as illustrated in **Figure 3-2**. Reference / Control sites: • Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area as illustrated in **Figure 3-2**.	Observations prior to mining using fixed location photo points. Baseline data first recorded in 2014, and in November 2019 prior to mining LW W1.	Observations every month during the active subsidence period (after 200 m of secondary extraction of LW W1-W4), for sites within and adjacent to the active subsidence zone[3], by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1,000 m of extraction of LW W3-W4 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed.	Observations using fixed location photo points on a 3-monthly basis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Flood levels[2]	• All dwelling within the 1% AEP flood extent.	Pre-mine modelling (using surveyed pre-mine topography) to establish 1% AEP flood levels and extents in areas potentially impacted by subsidence (complete). Pre-mining modelling was completed in May 2019 and January 2020 (WRM, 2019; WRM, 2020).	None. (Subsidence surveys to be conducted along local roads and railway as defined in the Subsidence Monitoring Program.)	Post-mine modelling (using surveyed post-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence.
First and second order tributaries	• Subsidence survey marks as defined in the Subsidence Monitoring Program.	Prior to mining of each longwall as defined in the Subsidence Monitoring Program.	As defined in the Subsidence Monitoring Program.	As defined in the Subsidence Monitoring Program.
Groundwater quality at monitoring bores and private groundwater bores	Groundwater bores (refer to **Figure 3-5**). Impact sites: • P12, P13, P14, P15, P16, and any additional bore(s) (to be drilled).	Field water quality and laboratory analysis monthly (refer to **Section 5.2.1** for parameters). Baseline data available since May 2019.	Field water quality and laboratory analysis monthly (refer to **Section 5.2.1** for parameters).	Field water quality and laboratory analysis on a monthly basis (refer to **Section 5.2.1** for parameters) for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
	Control sites: • P17			Response Group (refer to **Section 5.2** for further details).
	Groundwater bores (refer to **Figure 3-5**). Control sites: • Private groundwater bores GW72402, GW105228, GW105467, GW115860 and GW105546 and any other private bores where access is negotiated with landholder.	Field water quality (EC, pH, temperature) and iron staining. Pre-mining testing completed during bore census (GeoTerra, 2019; GeoTerra, 2021). Baseline data was first collected in 2014, and further data was collected in March and April 2019, and November 2020.	Field water quality and laboratory analysis on a 3-monthly basis (refer to **Section 5.2.1** for parameters).	Field water quality and laboratory analysis on a 3-monthly basis (refer to **Section 5.2.1** for parameters) for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Groundwater level at monitoring bores and private groundwater bores	Groundwater bores (refer to **Figure 3-5**). Impact sites: • P12, P13, P14, P15, P16, and any additional bore(s) (to be drilled) Control sites: • P17, and possibly P11	Minimum continuous 24-hourly readings with monthly logger download and dip meter. Baseline data available since May 2019.	Minimum continuous 24-hourly readings with logger download and dip meter completed monthly. Fortnightly logger download for P14 and P15 from the start of LW W3 to 400 m of extraction.	Minimum continuous 24-hourly readings with monthly logger download and dip meter for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
	Groundwater bores (refer to **Figure 3-5**). Control sites: • Private groundwater bores GW72402, GW105228, GW105467, GW115860 and GW105546 and any other private bores where access is negotiated with landholder.	Standing Water Level (where available) and yield data. Pre-mining testing completed in bore census (GeoTerra, 2019; GeoTerra, 2021). Baseline data was first collected in 2014, and further data was collected in March and April 2019, and November 2020.	Manual monitoring (flow rate and, where available, standing water level) on a 3-monthly basis.	Manual monitoring (flow rate and, where available, standing water level) on a 3-monthly basis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Shallow groundwater pressures at VWPs TNC036, TNC040, WD01 and WD02 (once installed)	Groundwater bores/VWPs (refer to **Figure 3-5**). Impact sites: • TNC36, WD01 and WD02 (once installed). Control sites: • Groundwater bores/VWPs TNC40.	Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since 2010.	Minimum continuous 24-hourly readings with monthly logger download.	Minimum continuous 24-hourly readings with monthly logger download for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Deep Groundwater Pressures at VWPs TNC036	Groundwater bores/VWPs (refer to **Figure 3-5**). Impact sites: • TNC36. Control sites: • Groundwater bores/VWPs TNC40.	Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since 2010.	Minimum continuous 24-hourly readings with monthly logger download.	Minimum continuous 24-hourly readings with monthly logger download for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).

NOTES:

[1] Refer https://realtimedata.waternsw.com.au/

[2] Potential impact to flood levels assessed based on monitored subsidence and/or revised subsidence predictions.

[3] Survey area to include upstream pools (beyond mining effects) where a potential Level 4 TARP trigger has occurred at an impact site(s).

5.3 Baseline Monitoring to Support Future Extraction Plans

5.3.1 Surface Water Baseline Monitoring

To assist in the preparation of future Extraction Plans, surface water monitoring as outlined in **Table 5-3** would provide sufficient baseline data to assist. Monitoring data collected during the mining of LW W3-W4 would be used in the review of observed subsidence impacts to inform future Extraction Plans for the Tahmoor South mining domain.

5.3.2 Groundwater Baseline Monitoring

A period of post-mining monitoring is to occur for all monitoring bores of interest. This is to ensure that any changes to conditions at these bores are continually monitored while also providing baseline data to support future groundwater extraction plans, both in terms of the conceptual understanding of the effects of longwall mining (e.g. height of fracturing and depressurisation) and improving confidence in the ability to simulate these in numerical models.

The post-mining borehole (WD02) will be located above the centre-line of LW W2, 780 m from the closest Tahmoor North goaf and will be installed post extraction of LW W4. The centre line of LW W2 is representative of the height of depressurisation for the panel, and will provide estimates for depressurisation, fracturing and hydraulic conductivity properties (SCT, 2020). The measured groundwater depressurisation in the subsurface will be assessed and verified in future model predictions.

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**).

An adaptive Management Strategy has been developed and its relevant to mine design is detailed in **Section 6.5**.

6.2 Management Protocol and Remediation Measures

6.2.1 Flood Management Protocol

The flood assessment (WRM, 2020; **Appendix C**) predicted that the peak 1% AEP flood extent will be contained within Matthews, Cedar and Stonequarry Creeks meaning that Barkers Lodge Road has at least a 1% AEP flood immunity.

The modelling indicates that the peak flood level for a 1% AEP flood event is predicted to decrease by up to 0.11 m in localised areas within creek channels, although may increase by up to 0.05 m at other localised areas within creek channels. Negligible changes in depth and velocity across Stonequarry Creek Road, Star Street, Rumker Gully and Connellan Crescent are predicted to occur for either the 50% or 1% AEP events. As such, it is not anticipated that access to Stonequarry Creek Road, Star Street, Rumker Gully or Connellan Crescent will be measurably impacted as a result of mining LW W3-W4.

As outlined in the Monitoring Program (**Table 5-3**) and the TARP (**Appendix A**), should subsidence predictions be updated, or observed subsidence be in excess of that predicted, flood modelling will be revised. The post-mining flood assessment will be conducted following completion of mining in the Western Domain. Updated information (including subsidence and flooding predictions) will be provided to the State Emergency Service and Wollondilly Shire Council regarding privately-owned residences that could be adversely affected by lack of access during 1% AEP flood events. If required, Tahmoor Coal will then work with landowners, State Emergency Service and WSC to develop evacuation plans to ensure landowners are informed as to the appropriate course of action in the event of emergency as a result of a 1% AEP flood event, if required.

6.2.2 Stream Remediation Measures

In the event of a TARP Level 4 Trigger, further investigations are undertaken and stream remediation measures may be required. These measures would be detailed in a Corrective Action Management Plan (CAMP) to reduce and address subsidence impacts to streams associated with longwall mining.

Various stream remediation techniques that have been previously adopted with success in the Southern Coalfields are summarised below in **Table 6-1**.

Table 6-1 Available Stream Remediation Techniques

Restoration Techniques	Description	Applications and Limitations
Hand grouting	Sealing of cracks exposed on the surface using hand applicators. A variety of sealants can be used including sealants that can be applied under water.	• Limited to surface cracks which can be accessed using hand held application equipment.
Shallow pattern grouting	Drilling shallow holes using small hand held drilling equipment and low pressure injection of a grout using a portable pump. Use of expanding Polyurethane (PUR) grouts to seal fracture networks. Alternative grouting materials can also be used.	• Used to seal shallow fractures in rock bars and pools. • Applicable to sensitive areas where access for larger equipment is problematic. • More effective results can be obtained if the target fractures are dewatered.
Deep pattern or curtain grouting	Drilling deeper holes using traditional air and or reverse circulation drilling rigs. Use of expanding PUR grouts to seal fracture networks. Alternative grouting materials can also be used.	• Used to seal fracture networks at greater depths. • Can seal larger and deeper fractures. • Larger equipment may necessitate constructing access tracks. • Less suitable for remote or difficult access sites.
Deep angle hole cement grouting	Remote directional drilling techniques can be used to access otherwise inaccessible sites. The same grouting methods as deep pattern/curtain grouting outlined above can be used.	• Specialised technique which can be used in situations where drill access is available close to target site.
Polyurethane (PUR) grouting	Use of expanding Poly Urethane Resin (PUR) grouts to seal fracture networks. PUR, which is a rapid setting grout that sets under water, is pumped into closely spaced drill holes (pattern drilling) and fractures filled systematically from the "bottom up".	• Technique used successfully in Myrtle Creek by Tahmoor Coal and Waratah Rivulet by Helensburgh Coal Pty Ltd. • Can be used under water and under low flow conditions. • PUR is non-toxic to the environment • Can be used to fill large aperture fractures in stages.

The full range of available techniques would be considered by Tahmoor Coal in the design of any future stream restoration programs should these be required.

Prior to the implementation of remediation, the following preparatory work would be undertaken:

- Obtain required regulatory approvals;
- Plan and secure land access agreements;

- Prepare relevant management plans and protocols;
- Prepare high resolution detailed pool and rock bar mapping; and
- Drill investigation bores to characterise sub-surface conditions.

Following remediation using one or more of the techniques listed in **Table 6-1**, ongoing monitoring in accordance with the monitoring program (**Table 5-3**) will also be required to evaluate the success of the stream remediation measure(s).

The details of stream remediation, if required, will be defined in a CAMP, which will be prepared in consultation and approval by the Resources Regulator.

Current Rockbar Remediation Success and Future Application

Tahmoor Coal has commenced remediation of pools in Myrtle Creek and Redbank Creek with successful results, in consultation with the Tahmoor community, neighbouring landowners, Wollondilly Shire Council, NSW DPIE, including NSW Resources Regulator, and NSW Department of Primary Industries – Fisheries.

A series of trials in 2019 and 2020 were conducted, building on the results of successful stream remediation projects at other longwall mining sites in the local area.

The remediation trial at Pool 23 rockbar on Myrtle Creek comprised injection of polyurethane into the fracture network in order to restore the pool holding capacity. Aesthetic values have improved following remediation and the water level has remained elevated for a period for over a year. Further details of remediation progress at Myrtle Creek is documented by SCT in the Myrtle Creek Rehabilitation Report (SCT, 2021; **Appendix F** of the Extraction Plan Main Document).

Similar trials are currently being undertaken for pools in Redbank Creek with remediation progress continuously assessed.

In the case of Rockbar SR17, it is noted that no further mining will be conducted near the rockbar after the extraction of LW W3. LW W4 is set back substantially from Stonequarry Creek to reduce the potential for impacts on the Picton Railway Tunnel. In the unlikely event of impacts, remediation could commence based on observations soon after the influence of LW W3. Rockbar SR17 can also be accessed by vehicle (MSEC, 2021).

6.2.3 Farm Dam remediation

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.*

6.2.4 Groundwater Bore remediation

Should private groundwater users be impacted by mining activity the appropriate make good provisions will be enacted. These are currently defined in **Section 7.1** and **Section 7.2** of the Tahmoor Coal Groundwater Management Plan (Tahmoor Coal, 2015), and this document should be referred to for a full definition of the make good provisions that apply to subsidence related impacts to private bore groundwater yield and quality. A summary of these provisions is included below.

Should there be a reduction in the available yield at a private bore due to subsidence related impacts Tahmoor Coal is required to provide an alternative water supply until the bore recovers. If the bore does not recover, remediation measures including but not limited to the establishment of a new bore, will be carried out. If drawdown in the bore exceeds 10 m over a period of 2 months as a result of subsidence it is outlined that negotiations will be undertaken between the mine, landowner and SA NSW to identify one or more appropriate actions outlined in the Groundwater Management Plan for the remediation of the bore.

Should the private bore experience an adverse change in water quality (particularly salinity or iron) that is assessed to be a result of mining-related subsidence the mine will enter into negotiations with the landowner in order to formulate a remediation agreement. This remediation may consider one or all of the three measures outlined in the Groundwater Management Plan which involve remediation of the bore, providing an alternate water source or compensation.

6.2.5 Verification of Groundwater Model Predictions

Groundwater monitoring results will be compared to groundwater model predictions to compare actual and predicted groundwater levels and/or drawdowns and groundwater inflows to the mine. This process will occur every month during the monthly review of data, as well as part of the Six Monthly Subsidence Impact Report review.

Groundwater model predictions will also be reviewed and revised (if required) as part of any detailed review of groundwater monitoring results and following any revisions to the Tahmoor Mine Groundwater Model. Following the approval of the Tahmoor South Project on 23 April 2021, the Tahmoor Mine Groundwater Model will be revised within two years of the approval date. The Groundwater Model will also be revised to include the following features or aspects:

- Analysis and incorporation of post-mining permeability data from bore WD02 above LW W2;
- Incorporation of relevant findings from the Thirlmere Lakes Research Program; and
- Any further refinements to the conceptual model regarding height of connected fracturing, surface cracking and similar subsidence effects relevant to groundwater and surface water.

6.3 Trigger Action Response Plan

A TARP has been developed using the performance indicators for management of surface water and groundwater resources 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.

For further details on the analysis method for surface water monitoring data to determine the level of impact to surface water, refer to the SWTR (HEC, 2021a; **Appendix B**). The sections below provides a summary of the impact assessment trigger criteria for groundwater level and quality, which are used in the groundwater TARPs to determine the TARP trigger level that has occurred. Further details of the methodology used to derives these criteria is provided in the GTR (**Appendix D**).

6.3.1 Impact Assessment Trigger Criteria for Groundwater Level

Trigger levels for 'P' bores (i.e. P12-P14 and P16-P17) and VWPs (TNC036, TNC040, TNC043) were developed using the predicted (modelled) groundwater level drawdown for higher trigger levels. The TARP Significance Levels (2, 3 and 4) were assigned a trigger corresponding to a calculated groundwater elevation for each groundwater monitoring bores (refer **Table 6-2**).

The groundwater trigger level for the TARP Level 2 is based on the approved groundwater TARP using a 2 m drawdown for P bores and 5 m drawdown for shallow VWPs, based on climate variability. The trigger level for TARP Level 2 for shallow open standpipes or shallow VWPs was calculated by subtracting the 2 m drawdown and 5 m drawdown respectively, to the maximum observed groundwater level at each bore or piezometer prior to extraction of LW W1. Variation to this methodology was adopted at locations P12A, P13A, P17 and TNC036 (HBSS-65m), which is described in more detail in the GTR (**Appendix D**).

The groundwater trigger level for TARP Level 4 at each groundwater site was calculated based on the maximum modelled drawdown due to a single deterministic scenario (base case model) between the start of LW W1 and the end of the prediction period (year 2500). The maximum modelled drawdown was then subtracted to the maximum observed groundwater level prior mining at LW W1.

The groundwater trigger level for TARP Level 3 at each groundwater site was calculated based on the average between trigger level for TARP Level 2 and Level 4.

Table 6-2 Proposed Trigger Levels for Groundwater Level TARPs

Bore	Groundwater Trigger Level (mAHD)		
	TARP Level 2	TARP Level 3	TARP Level 4
Shallow Open Stand Pipe			
P12A	168.6	See table 6.11 of the GTR	See table 6.11 of the GTR
P12B	169.1	See table 6.11 of the GTR	See table 6.11 of the GTR
P12C	179.5	175.0	170.4
P13A	165.7	163.7	161.6
P13B	165.0	163.0	161.1
P13C	168.5	163.1	157.7
P14A	167.2	165.0	162.9
P14B	165.2	159.8	154.3
P14C	165.2	159.9	154.6
P14D	163.6	158.3	152.9
P15A	163.4	156.4	149.4
P15B	163.9	156.9	149.9
P15C	163.3	156.3	149.4
P16A	209.9	209.3	208.8
P16B	205.9	202.3	198.7
P16C	200.6	193.9	187.2
P17	169.7	170.6	171.6
Shallow VWPs (<200m)			
TNC036 – HBSS-65	204.5*	See table 6.12* of the GTR	See table 6.12* of the GTR

Bore	Groundwater Trigger Level (mAHD)		
	TARP Level 2	TARP Level 3	TARP Level 4
TNC036 – HBSS-97	191.3*	185.7*	180*
TNC036 – BGSS-169	192.5*	135.7*	79*
TNC040 – WNFM-27	203.3	198.2	193.1
TNC040 – HBSS-65	182.1	175.8	169.5
TNC040 – HBSS-111	#	#	#
TNC043 – HBSS-65	153.7	152.5	151.3
TNC043 – HBSS-111.5	150.6	148.5	146.5
WD01 – HBSS – 70	206.2	202.4	198.6
WD01 – HBSS – 90	191.4	186.7	182.0
WD01 – HBSS – 190	F	F	F
Deep VWPs (>200m)			
TNC036 – BGSS-214	See table 6.13 of the GTR	See table 6.13 of the GTR	See table 6.13 of the GTR
TNC036 – BGSS-298.5	*	*	*
TNC036 – BGSS-412.5	See table 6.13 of the GTR	See table 6.13 of the GTR	See table 6.13 of the GTR
TNC036 – BUSM-463.5	*	*	*
TNC040 – HBSS-225	#	#	#
TNC040 – BHCS-252	#	#	#
TNC040 – BGSS-352	#	#	#
TNC040 – SCSS-482	#	#	#
TNC040 – BUCO-501.9	#	#	#
TNC043 – HBSS-213	#	#	#
TNC043 – BGSS-240	#	#	#
TNC043 – BGSS-332.6	#	#	#
TNC043 – BGSS-405.2	#	#	#
TNC043 – BUCO-476.3	#	#	#

Notes: "#" no data after LW W1

"*" groundwater data not reliable, but will still be reported on.

"F" Sensors failed during mining of LW W1 and LW W2.

6.3.2 Impact Assessment Trigger Criteria for Groundwater Quality

Trigger values have been established for pH, EC and metals at each groundwater monitoring bore a private bore in the Western Domain. **Figure 6-1** provides a summary of the proposed trigger levels for groundwater quality TARPs, as derived from the GTR (**Table 6-2** of the SLR, 2021a; **Appendix D**). Further detail on the methodology used to derive the groundwater quality TARP triggers is provided in the GTR (**Appendix D**).

Table 6-2 Summary of Proposed Trigger Levels for Groundwater Quality TARPs

Bore	Trigger Level			Trigger Level Concentrations (mg/L) for metals											
	EC (µS/cm)	pH lower	pH upper	Fe	Mn	Cu	Pb	Zn	Ni	Al	As	Li	Ba	Sr	Se
P12A	942	5.4	8.1	26.4	1.7	0.0110	0.0044	75.90	0.011	0.06	0.011	0.06	0.3	0.1	0.011
P12B	729	5.0	8.2	15.2	1.3	0.0044	0.0076	50.6	0.011	0.04	0.011	0.04	0.4	0.2	0.011
P12C	528	5.9	9.2	23.1	0.8	0.0034	0.0011	0.90	0.011	0.04	0.011	0.1	0.2	0.1	0.011
P13A	1232	5.2	9.4	69.3	1.5	0.0036	0.0014	0.91	0.011	0.04	0.011	0.03	0.4	0.3	0.011
P13B	1269	5.4	9.6	16.6	1.2	0.0020	0.0011	0.22	0.011	0.06	0.011	0.04	0.2	0.3	0.011
P13C	376	6.3	10.2	46.2	1.4	0.0011	0.0011	0.1	0.011	0.1	0.011	0.02	0.1	0.3	0.011
P14A	396	4.1	9.1	15.4	2.0	0.0022	0.0011	0.21	0.011	0.05	0.011	0.01	0.1	0.1	0.011
P14B	915	4.6	8.8	46.2	0.9	0.0022	0.0011	0.22	0.011	0.04	0.011	0.07	0.1	0.2	0.011
P14C	1881	5.3	9.4	19.8	1.5	0.0011	0.0011	0.04	0.011	0.1	0.011	0.11	0.2	0.4	0.011
P14D	1198	5.5	9.6	11.0	1.9	0.0011	0.0011	0.04	0.011	0.04	0.011	0.35	0.1	0.2	0.011
P16A	1539	4.9	7.8	116.0	3.9	0.0011	0.0011	0.1	0.011	0.04	0.011	0.06	0.3	0.5	0.011
P16B	1180	5.9	9.6	41.8	1.8	0.0011	0.0011	0.03	0.011	0.05	0.011	0.04	0.2	0.1	0.011
P16C	1212	6.2	9.5	46.6	1.6	0.0011	0.0011	0.02	0.011	0.05	0.011	0.1	0.1	0.1	0.011
P17	2019	4.8	8.3	10.6	0.6	0.0011	0.0011	0.2	0.011	0.04	0.011	0.11	0.2	0.7	0.011
GW105546	448	3.5	7.2	37.4	1.6	0.0011	0.0011	0.1	0.011	0.03	0.011	0.011	0.05	0.04	0.011
GW105467	1041	3.7	6.8	77.0	3.9	0.094	0.0019	0.2	0.039	0.04	0.011	0.072	0.1	0.04	0.011
GW105228	1793	4.6	7.1	31.4	2.7	0.0011	0.0011	0.2	0.0181	0.04	0.011	0.026	0.23	0.15	0.011
GW072402	8151	4.7	7.5	63.8	0.9	0.0019	0.0011	0.2	0.011	0.03	0.011	0.157	0.3	0.5	0.011
GW115860	948.2	4.9	7.25	14.85	0.85	0.001	0.001	0.02	0.01	0.02	0.01	0.03	0.3	0.18	0.01

Figure 6-1 Summary of Proposed Trigger Levels for Groundwater Quality TARPs (SLR, 2021a)

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 a CAMP 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 CAMP, the Annual Review and Six Monthly Subsidence Impact Reports (refer to **Section 6.1** of the Extraction Plan Main Document).

6.5 Adaptive Management Strategies

6.5.1 Review of LW W3 Start Position

Overview

An Adaptive Management Strategy is proposed to review mining-induced ground movements, subsidence impacts and environmental consequences to streams during the extraction of LW W2.

As described in the Water Management Plan, Tahmoor Coal implemented a detailed monitoring program to measure and record mining induced ground movements and impacts on Matthews, Cedar and Stonequarry Creeks during the mining of LW W1-W2. A review of relevant observations was undertaken after the LW W2 face had mined a sufficient distance such that the majority of mining-induced movements had occurred at the commencing end of LW W2 (after approximately 1,000 m of extraction).

According to the Adaptive Management Strategy, if impacts to streams were greater than anticipated, Tahmoor Coal would review (based on more detailed investigation as described in the sections below) amending the commencing position of LW W3 to further reduce the potential for impacts on streams within the 600 m Study Area for Natural Features, in particular pool SR17 on Stonequarry Creek.

Adaptive Management Process

The adaptive management strategy sets quantifiable assessment criteria and provides parameters for when additional setbacks from relevant watercourses should be implemented.

The following sections detail the process for assessing and determining if additional setback is required from Stonequarry Creek, which is also illustrated in **Figure 6-2.**

Review and assess results of monitoring during LW W2

A review of monitoring results during the extraction of LW W2 was undertaken as part of the Adaptive Management Strategy. The review was incremental, in the sense that new information was collected and reviewed on a regular basis (e.g. monthly) as mining occurred.

Once the length of extraction of LW W2 exceeded approximately 1,000 m, it was expected that vertical subsidence would have approached maximum levels above LW W2 and rates of change in ground movements in the valleys located around the commencing end of LW W2 would have reduced to low levels. Whilst mine subsidence movements would continue to develop as mining progressed, it was expected that sufficient information would be available to conduct a review as part of the Adaptive Management Strategy.

Given the complex nature of the monitoring data, no single monitoring parameter was used to definitively guide the outcome of the Adaptive Management Strategy. However, key considerations as a minimum reviewed included:

- Valley and rockbar closure – among the many mine subsidence parameters that are measured and calculated during mining, valley and rockbar closure is a key indicator that is used to assess impacts on streams. The following quantifiable assessments were conducted in relation to valley closure:
  - Comparison of predicted and observed closure (valley and/or rockbar closure, depending on availability of information), taking into account the effects of survey tolerance;
  - Distribution of valley and/or rockbar closure relative to LW W2, with particular focus to the section of Stonequarry Creek between the confluence with Cedar Creek and Rockbar SR17; and
  - Relationship between observed valley and/or rockbar closure and observed impacts.
- Water level – a comparison of baseline and during mining water levels in relevant pools was completed. This comparison considered recorded pre-mining (LW W1) recession rates and visual observations of pool cracking; and
- Cracking or any other subsidence impact or movement – observations of any of these subsidence impacts observed at pool SR17 and the associated rockbar.

The relevant results were assessed and a determination made regarding whether the current start position of LW W3 was likely to result in an exceedance of subsidence impact performance measures for streams within the 600 m Study Area for Natural Features and/or pool SR17.

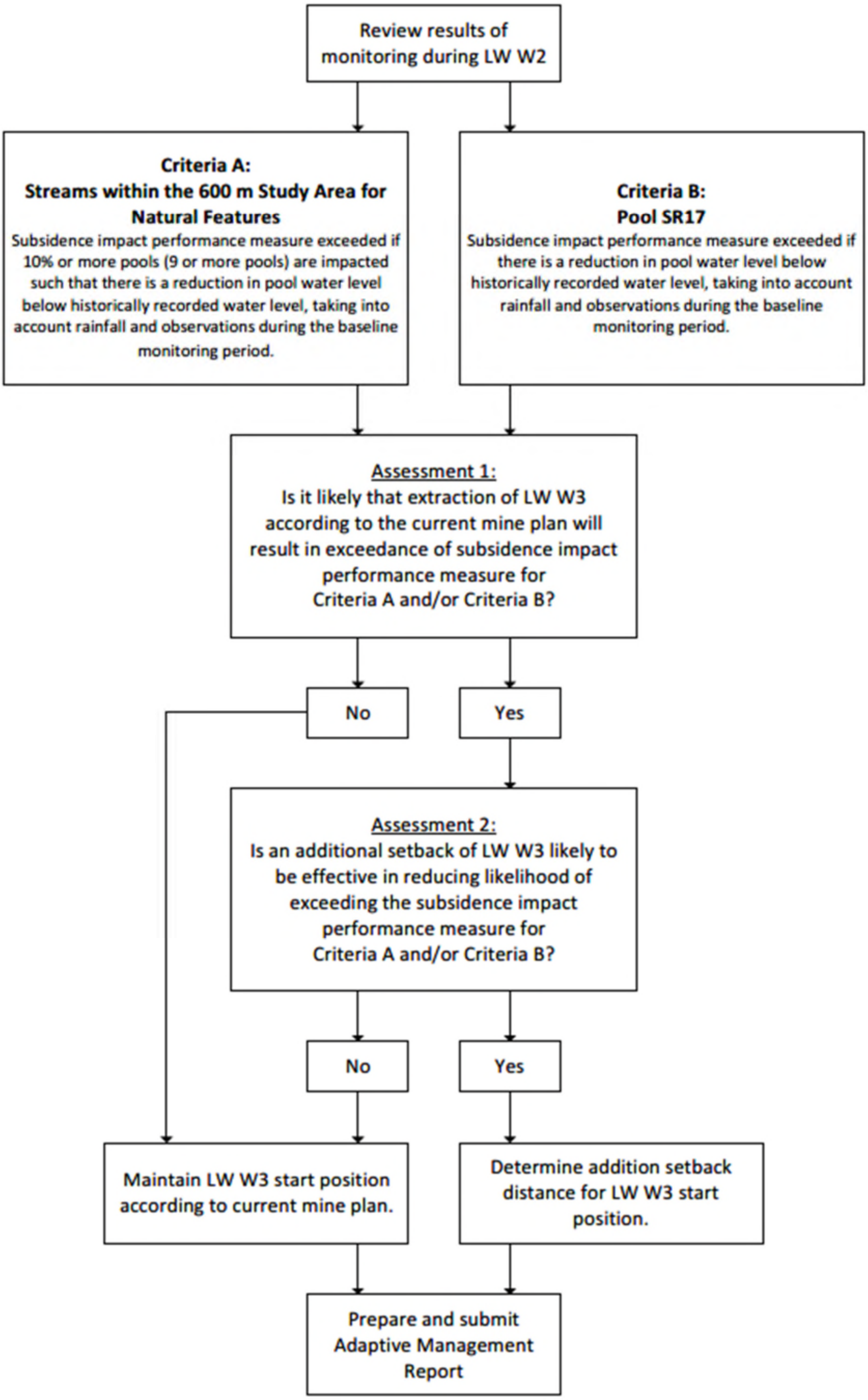

Figure 6-2 Adaptive Management Strategy decision flowchart

Determination of setback (if required)

If it was determined that the current position of LW W3 was likely to result in an exceedance of the subsidence impact performance measure for stream and/or pool SR17, detailed analysis would be undertaken to determine if setback of LW W3 is likely to result in an exceedance of the subsidence performance measures. If a setback is likely to reduce the likelihood of an exceedance occurring, an appropriate set back distance would be determined. This process would be completed by re-generating the subsidence model for LW W3 to include observed LW W2 subsidence measurements, and generating potential subsidence predictions for defined incremental setbacks from the streams and pool SR17.

LW W2 Adaptive Management Report Outcomes

Tahmoor Coal completed a review of observations of subsidence impacts and environmental consequences following the mining of the first 1,000 m of LW W2 in June 2021. This review was to determine whether additional setback for the commencing end of LW W3 was likely to further reduce the potential for subsidence impacts on Stonequarry Creek. The review found that there had been no exceedances of the subsidence impact performance measures, and a modification of the starting position of LW W3 was not proposed.

6.5.2 Adaptive Management Strategies for Groundwater

In order to support the adaptive management strategy outlined above for the mitigation and monitoring of subsidence related impacts to the streams, an adaptive management strategy has been developed for the groundwater monitoring network.

The current groundwater monitoring network includes several recently drilled open-standpipe bores that are positioned within the shallow aquifer adjacent to Stonequarry Creek, specifically bores P12, P13, P14 and P17. These bores are positioned progressively along Stonequarry Creek so as to collect data that would determine the downstream distance any potential subsidence related impacts in the watercourse. However, as part of the adaptive management strategy for groundwater it is necessary to have provisions that allow for additional groundwater monitoring bores be drilled should any of the existing bores cease to function, or it is determined that the data being collected is insufficient or not representative of the local conditions.

Identifying potential subsidence related impacts to local water resources and network sufficiency should be made by a suitably qualified person following the assessment of groundwater level data collected at as a result of mining of LW W1-W3. An assessment of pre- and post-mining permeability data collected from LW W2 will also be used in assessing whether the existing monitoring network is sufficient.

Should additional monitoring bores be required it would be necessary to convene with the Environmental Response Group and suitably qualified professionals as to the best location to install these bores in consultation with the relevant landowners.

7 Review and Improvement

This section of the WMP describes the key elements of implementation relevant to the management of surface water and groundwater resources. 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 additional reporting requirements specific to the management of surface water and groundwater 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 additional review or auditing requirements specific to the management of surface water and groundwater 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. The roles specified in the Extraction Plan main Document are appropriate for the implementation of surface water and groundwater resource 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

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8.2 Glossary of Terms

The Extraction Plan Main Document provides a compiled 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
AEP	Annual Exceedance Probability
AIP	NSW Aquifer Interference Policy
ANZECC Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
BACI	Before-After-Control-Impact framework
CAMP	Corrective Action Management Plan
DO	Dissolved Oxygen
DOC	Dissolved organic carbon
DPIE Water	NSW Department of Planning, Industry and Environment – Water
DoP	NSW Department of Planning (former)
DPE	NSW Department of Planning and Environment (former) Now known as NSW Department of Planning, Industry and Environment (DPIE)
DPIE	NSW Department of Planning, Industry and Environment

Abbreviation	Definition
EC	Electrical conductivity
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
EES	NSW Department of Planning, Industry and Environment – Environment, Energy and Science Group
ERG	Tahmoor Coal Environmental Response Group
GDE	groundwater dependant ecosystems
GTR	Groundwater Technical Report
Kh or Kx	hydraulic conductivity – horizontal
Km	Kilometre/s
Kv or Kz	hydraulic conductivity – vertical
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
M	Metre/s
mm	Millimetre/s
mg/L	milligrams per litre (measure of salinity)
ML/d	megalitres per day (megalitre(s) = 1,000,000 litres)
ML	mining lease
NHMRC	National Health and Medical Research Council's Australian Drinking Water Guidelines
NOW	NSW Office of Water
NRAR	NSW Natural Resources Access Regulator
NSW	New South Wales
OEH	NSW Office of Environment and Heritage Now known as DPIE – Environment, Energy and Science (EES) Group
PMF	Probable Maximum Flood
PUR	Polyurethane
SMP Application	Subsidence Management Plan Application
SWTR	Surface Water Technical Report
Tahmoor Coal	Tahmoor Coal Pty Ltd
Tahmoor Mine	Tahmoor Coal Mine
TARP	Trigger Action Response Plan
TDS	total dissolved solids
VWP	Vibrating Wire Piezometers
WAL	Water Access Licence
WMP	Water Management Plan

Abbreviation	Definition
WSP	Water Sharing Plan

8.4 Change Information

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

Table 8-2 Document History

Version	Date Reviewed	Reviewed By	Change Summary
1.0	May 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	New document
2.0	September 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	Updated Subsidence Performance Measure for Stonequarry Creek; Update to TARP
3.0	September 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	Updated document in light of LW W3-W4 Extraction Plan Condition Approval and relevant requirements.
4.0	September 2021	Zina Ainsworth, David Talbert, Malcolm Waterfall	Updated TARP as a result of discussions with DPIE regarding inclusion of revision of streamflow data, as well as inclusion of Shallow Groundwater Level Decline TARP.

Appendix A – Trigger Action Response Plans

Trigger Action Response Plan - Water Management Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impact to pool water level	AUTOMATED POOL WATER LEVEL **Locations** (refer to Figure 5-2) Impact sites: • Cedar Creek (CA, CB, CD, CE and CG) • Matthews Creek (ME, MG) • Stonequarry Creek (SA, SD, SF) • SR17 (SB, SC2) Control sites: • Cedar Creek (Cedar US, CCR, CC1A) • Matthews Creek (MB) • Stonequarry Creek (SE, SG) **Frequency** Pre-mining – Continuous record, data downloaded monthly. Baseline data recorded since October 2018 in the Western Domain at the majority of Western Domain sites. During mining - Continuous record, data downloaded monthly. Post mining - Continuous record, data downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details). MANUAL POOL WATER LEVEL **Locations** Impact sites: • Cedar Creek (CC, CF) • Matthews Creek (MC, MD U/S (upstream), MF) Control sites: • Matthews Creek (MA) • Stonequarry Creek (SC) **Frequency** Pre-mining - Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 in the Western Domain. During mining - Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Post mining - Monthly manual level reading and visual inspection of natural drainage behaviour using photo points for 12 months following the completion of LW W2. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• The recorded water level has not declined below the recorded baseline minimum level (in one 24 hour period for automated pool water level). OR • The recorded water level has declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level) but the decline is due to a monitoring or sensor error or the magnitude of the decline (below the recorded baseline minimum level) is within the range of sensor accuracy.	• Continue monitoring as per monitoring program. • Continue monthly review of data.	• No response required.
		Level 2		
		• The recorded water level has declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level). AND • The above has occurred at one of the upstream pools (beyond mining effects).	• Continue monitoring as per monitoring program. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• The recorded water level has declined, although not atypically^, below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level). AND • The above has not occurred at one of the upstream pools (beyond mining effects).	• Continue monitoring as per monitoring program. • Continue monthly review of data. • Review relevant surface water level, groundwater level and streamflow data to assess comparative trends. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing download and review of data frequency to fortnightly for sites where Level 3 has been reached. • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline.
		Level 4		
		• The recorded water level has declined atypically^ below the previously recorded minimum level (for more than one 24 hour period for automated pool water level). AND • Similar behaviour has not occurred at one of the upstream pools (beyond mining effects).	• Increase download and review of data frequency to fortnightly for sites where Level 4 has been reached. • Continue monthly download and review of data for all other sites. • Review relevant surface water level, groundwater level and streamflow data to assess comparative trends. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • Conduct detailed investigation of surface water level decline including review and assessment of streamflow records for downstream monitoring sites in comparison with suitable reference sites. • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline. • If it is concluded that there has been a mining-related impact then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator (refer to Section 6.2.2 of the WMP).

Footnotes:

^ 'Atypical' surface water characteristics relate to a notable and / or rapid water level decline or change in the slope of the falling limb of the hydrograph or the water level recessionary behaviour below the CTF level which is inconsistent with baseline conditions and cannot be attributed to climatic conditions.

Feature	Methodology and relevant monitoring	Management – Trigger	Management – Action	Management – Response
Impact to physical features and natural behaviour of pools	VISUAL INSPECTIONS **Locations** Baseline / Impact sites - Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek including SR17 within the Study Area (refer to Figure 5-1 in the Water Management Plan). Reference / Control sites - Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area (refer to Figure 5-1 in the Water Management Plan). **Frequency** Pre-mining- Observations prior to mining using fixed location photo points. Baseline data first recorded in 2014, and in November 2019 prior to mining. During mining – Observations every month during the active subsidence period excluding SR17** (after 200 m of secondary extraction of LW W1-W4), for sites within and adjacent to active subsidence zone*, by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1,000 m of extraction of LW W3-W4 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed. Post mining - Observations using fixed location photo points on a 3-monthly basis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details). **Note: Refer to Stonequarry Creek Rockbar Management Plan for visual inspections of pools at SR17	Level 1		
		• No observed impacts to pool level, drainage or overland connected flow.	• Continue monthly monitoring. • Continue monthly review of data.	• No response required.
		Level 2		
		• Visually observed reduction in pool level, drainage or overland connected flow. AND • The above has occurred at one of the upstream pools (beyond mining effects). OR • Visual monitoring of pools has not noted any mining related impacts¥.	• Continue monitoring as per monitoring program. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• Rock bar and/or stream base cracking, gas release, or iron precipitation noted during visual inspection (in excess of baseline conditions). AND • No reduction in pool water level, drainage or overland connected flow, taking into account climatic conditions and observations during baseline monitoring period.	• Continue monitoring as per monitoring program. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate.	• As defined by Environmental Response Group. • Consider increasing inspection and review of data frequency to fortnightly for sites where Level 3 has been reached.
		Level 4		
		• Visually observed reduction in pool water level, drainage or overland connected flow, taking into account climatic conditions and observations during baseline monitoring period. AND • The above change has not occurred at one of the upstream pools (beyond mining effects).	• Increase inspection and review of data frequency to fortnightly for sites where Level 4 has been reached. • Continue monthly download and review of data for all other sites. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate. • Conduct visual inspection of downstream reaches beyond mining effects to identify if flow re-emergence is occurring. • If flow re-emergence sites are located, implement water quality monitoring at these location(s).	• Report to DPIE and relevant agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • Conduct detailed investigation of surface water level decline including review and assessment of streamflow records for downstream monitoring sites in comparison with suitable reference sites. • If it is concluded that there has been a mining-related impact then implement a corrective action management plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator (refer to Section 6.2.2 of the WMP).

Footnotes:

* Survey area to include upstream pools (beyond mining effects) where a potential Level 4 TARP trigger has occurred at an impact site(s)

¥ Rockbar and/or stream base cracking, gas release, or iron precipitation in excess of baseline conditions

<table>
<tr><th rowspan="2">Feature</th><th rowspan="2">Methodology and relevant monitoring</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="4">Impact to flood levels</td><td rowspan="4">FLOOD LEVELS
Locations
All dwellings within the 1% AEP flood extent
Frequency
<u>Pre-mining</u> – Pre-mine modelling (using surveyed pre-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence. Pre-mining modelling was completed in May 2019.
<u>Post mining and subsidence</u> - Post-mine modelling (using surveyed post-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence.</td><td colspan="3">Level 1</td></tr>
<tr><td>• No dwellings that were outside the pre-mine 1% AEP flood extent are within the post-mine 1% AEP flood extent.</td><td>• No action required.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 4</td></tr>
<tr><td>• Subsidence results in the post-mining 1% AEP flood level being above the floor level of one or more dwellings.</td><td>• Provide up-to-date predicted flood information (including actual subsidence and flooding predictions) to the State Emergency Service, Wollondilly Shire Council and landowners.</td><td>• Negotiate remediation or compensation with landowners.</td></tr>
</table>

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impacts to dams	PRIVATE DAMS **Locations** Identified farm dams within the Study Area **Frequency** Pre-mining - 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. During mining - Dam embankment integrity and water level observation every week during active subsidence period using fixed location photo points by Tahmoor Coal; and every month during the active subsidence period using fixed photo points by a geotechnical consultant. Post mining - Dam embankment integrity and water level observation using fixed location photo points on a 3-monthly basis for 12 months following the completion of LW W2. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• No cracks develop within dam wall (i.e. other than natural desiccation cracking).	• Continue monitoring in accordance with the monitoring program. • Continue monthly review of data.	• No response required.
		Level 2		
		• Development of isolated cracks (<10 mm wide) within dam wall (i.e. 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 (i.e. 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 of geotechnical consultant to weekly during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		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 of geotechnical consultant to weekly during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs where necessary. • Reduce dam water level as recommended by Geotechnical Consultant. • 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.

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Stream water quality impact	STREAM WATER QUALITY **Locations** (refer to Figure 5-2) Impact sites: • Cedar Creek (CA, CB, CC, CD, CE, CF, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD SF) Control sites: • Cedar Creek (Cedar US, CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE, SG) **Frequency** Pre-mining- Monthly sampling for 12 months prior to secondary extraction. Baseline data was recorded at some site during 2014 and all sites since January 2019. During mining - Monthly sampling and analysis. Post mining - Monthly sampling and analysis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• The triggers for pH, EC and dissolved metals defined below do not occur, and there is no visual evidence of an increase in iron precipitation that was not observed in the baseline period.	• Continue monitoring as per monitoring program. • Continue monthly review of data.	• No response required.
		Level 2		
		• The trigger for pH, EC or dissolved metals defined below occurs in one month, and there is no visual evidence of an increase in iron precipitation that was not observed in the baseline period.	• Continue monitoring as per monitoring program. • Continue monthly review of data including analysis of water quality trend along creek (upstream to downstream) to identify spatial changes. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• The trigger for pH, EC or dissolved metals defined below occurs in one month, and there is visual evidence of an increase in iron precipitation that was not observed in the baseline period.	• Continue monitoring as per monitoring program. • Continue monthly review of data to assess if the trigger was exceeded during the baseline period prior to commencement of mining and undertake analysis of water quality trend along creek (upstream to downstream) to identify spatial changes. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing monitoring and review of data frequency to fortnightly at sites where Level 3 has been reached.
		Level 4		
		Any of the following: • pH: the value* falls below a corresponding control (upstream) site(s) mean minus two standard deviations or the site-specific baseline mean minus two standard deviations (i.e. the sample becomes more acidic) for more than two consecutive months OR the value rises above the corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations (i.e. the sample becomes more alkaline) for more than two consecutive months. • EC: the value* rises above corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations for more than two consecutive months. • Dissolved metals: a specific metal or metals laboratory value/s rises above corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations for more than two consecutive months.	• Increase monitoring and review of data frequency to fortnightly for sites where Level 4 has been reached. • Continue monthly monitoring and review of data for all other sites. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate. • Immediately undertake additional water quality sampling and analysis of the site where the trigger has occurred and relevant control sites to confirm results and that the trigger exceedance is continuing. • Undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects (e.g. whether there has been subsidence induced cracking upstream), other catchment changes, unrelated pollution or the prevailing climate.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • Conduct detailed investigation of water quality changes. • If it is concluded that there has been a mining-related impact then implement a corrective action management plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator (refer to Section 6.2.2 of the WMP).

Footnote:
* Field and laboratory records of pH and EC are collected for quality assurance purposes. The field values will be used in the TARP assessment unless erroneous values are identified in which the laboratory values will be adopted in the assessment.

‡ Log transformations (i.e. base 10 logs of the water quality concentrations) will be used to calculate the arithmetic means and standard deviations. Log transformations are commonly applied to concentrations as part of statistical analyses in water resources studies as is evidenced by the following statement from a US Geological Survey publication regarding such analyses: "In order to make an asymmetric distribution become more symmetric, the data can be transformed or re-expressed into new units. These new units alter the distances between observations on a line plot. The effect is to either expand or contract the distances to extreme observations on one side of the median, making it look more like the other side. The most commonly-used transformation in water resources is the logarithm. Logs of water discharge, hydraulic conductivity, or concentration are often taken before statistical analyses are performed." (Helsel and Hirsch, 2002).

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Groundwater Quality at monitoring bores and private groundwater bores.	GROUNDWATER QUALITY – Monitoring bores **Locations** (refer to Figure 3-5) <u>Impact sites</u> – P12, P13, P14, P15, P16, and any additional bore(s) (to be drilled) <u>Control sites</u> – P17 **Frequency** <u>Pre-mining</u> - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters). <u>During mining</u> - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters). <u>Post mining</u> - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters) for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details). GROUNDWATER QUALITY – Private groundwater bores **Locations** (refer to Figure 3-5) <u>Control sites</u> - GW72402, GW105228, GW105467, GW115860 and GW105546 and any other private bores where access is negotiated with landholder. **Frequency** <u>Pre-mining</u> - Field water quality (EC, pH) and iron staining. Pre-mining testing completed during bore census (GeoTerra, 2019). <u>During mining</u> - Field water quality and laboratory analysis on a 3-monthly basis (refer to Section 5.2.1 for parameters). <u>Post mining</u> - Field water quality and laboratory analysis on a 3-monthly basis (refer to Section 5.2.1 for parameters) for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• No observable change in salinity, pH or metals outside of the baseline variability.	• Continue monitoring program. • Ongoing review of water quality data.	• No response required.
		Level 2		
		• Short term increase (< 3 months) in salinity and/or metals, or change in pH outside of baseline variability*. The effect does not persist after a significant rainfall recharge event. AND/OR • A similar trend or response has been noted at other monitored bores or private groundwater bores.	• Continue monitoring program. • Ongoing review of water quality data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 3		
		• Short term increase (< 3 months) in salinity and/or metals or change in pH outside of baseline variability*. The effect persists after a significant rainfall recharge event. AND/OR • The change in water quality is determined not to be controlled by climatic or anthropogenic factors.	• Continue monitoring program. • Ongoing review of water quality data and consideration of mining and external stresses (in groundwater monthly report). • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 4		
		• Medium to long term increase in salinity and / or metals or a change in pH outside of baseline variability* with the effect persisting for greater than 3 months or after a significant rainfall recharge event. AND • The reduction in water quality is determined not to be controlled by climatic or anthropogenic factors.	• Continue monitoring and review as per monitoring program. • Continue review of water quality data and consideration of mining and external stresses (in groundwater monthly report). • Convene Tahmoor Coal Environmental Response Group to review response.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • For monitoring bores: If it is concluded that there has been a mining-related impact, then implement an investigation report. • For private groundwater bores: If it is concluded that there has been a mining-related impact, then implement actions in accordance with the make good provisions (Section 6.2.4 of the Water Management Plan) in consultation with the affected landholder.

Footnote:
* The baseline variability was estimated using available data and refers to the proposed trigger levels (refer to Section 6.2.2 and Table 6.2 of the Groundwater Technical Report.

<table>
<tr><th rowspan="2">Feature</th><th rowspan="2">Methodology and relevant monitoring</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8">Groundwater Levels at monitoring bores and private groundwater bores.</td><td rowspan="8">GROUNDWATER LEVEL – Monitoring bores
Locations (refer to Figure 3-5)
<u>Impact sites</u> – P12, P13, P14, P15, P16, and any additional bore(s) (to be drilled)
<u>Control sites</u> – P17, and possibly P11
Frequency
<u>Pre-mining</u> - Minimum continuous 24-hourly readings with monthly logger download and dip meter. Baseline data available since May 2019.
<u>During mining</u> - Minimum continuous 24-hourly readings with monthly logger download and dip meter.
<u>Post mining</u> - Minimum continuous 24-hourly readings with monthly logger download and dip meter for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).

GROUNDWATER LEVEL – Private groundwater bores
Locations (refer to Figure 3-5)
<u>Control sites</u> - GW72402, GW105228, GW105467, GW115860 and GW105546 and any other private bores where access is negotiated with landholder.
Frequency
<u>Pre-mining</u> - Standing Water Level (where available) and yield data. Pre-mining testing completed in bore census (GeoTerra, 2019).
<u>During mining</u> - Manual monitoring (flow rate and, where available, standing water level) on a 3-monthly basis.
<u>Post mining</u> - Manual monitoring (flow rate and, where available, standing water level) on a 3-monthly basis for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).</td><td colspan="3">Level 1</td></tr>
<tr><td>• Groundwater level remains consistent within baseline variability and/or pre-mining trends, with reductions in groundwater level less than two metres and does not trigger Level 2 to Level 4 Significance Levels (refer to Table 6-2).</td><td>• Continue monitoring program.
• Ongoing review of water level data.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Greater than 2 m water level reduction following the commencement of extraction at LW W1 (and LW W2, W3, W4) (refer to Table 6-2 for TARP Significance Level 2).
AND
• The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.</td><td>• Continue monitoring program.
• Ongoing review of water level data.
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Convene Tahmoor Coal Environmental Response Group to review response.</td><td>• As defined by the Environmental Response Group.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• Water level declines below the water level of TARP Significance Level 3 (refer Table 6-2, calculated as the average of TARP Significance Level 2 and Level 4) following the commencement of extraction at LW W1 (and LW W2, W3 and W4).
AND
• The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.</td><td>• Continue monitoring program.
• Ongoing review of water level data and consideration of mining and external stresses (in groundwater monthly report).
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Compare against base case and deterministic model scenarios.
• Convene Tahmoor Coal Environmental Response Group to review response.</td><td>• As defined by the Environmental Response Group.</td></tr>
<tr><td colspan="3">Level 4</td></tr>
<tr><td>• Water level reduction greater than the maximum modelled drawdown (refer to Table 6-1 for TARP Significance Level 4) following the commencement of extraction at LW W1 (and LW W2, W3 and W4).
AND
• The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.</td><td>• Continue monitoring and review as per monitoring program.
• Ongoing review of water level data and consideration of mining and external stresses (in groundwater monthly report).
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Convene Tahmoor Coal Environmental Response Group to review response.
• Compare against base case and deterministic model scenarios.</td><td>• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document).
• For monitoring bores: If it is concluded that there has been a mining-related impact, then implement an investigation including review and assessment of streamflow records for downstream monitoring sites in comparison with suitable reference sites.
• For private groundwater bores: If it is concluded that there has been a mining-related impact, then implement actions in accordance with the make good provisions (Section 6.2.4 of the Water Management Plan) in consultation with DPIE and the affected landholder.</td></tr>
</table>

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Shallow Groundwater Pressures at VWPs TNC036, TNC040, WD01 and WD02 (once installed).	GROUNDWATER PRESSURE **Locations** Impact sites – TNC36, WD01 and WD02 (once installed) (refer to Section 5.2.2). Control sites - Groundwater bores/VWPs TNC40 (refer to Figure 3-5). **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download. During mining - Minimum continuous 24-hourly readings with monthly logger download. Post mining - Minimum continuous 24-hourly readings with monthly logger download for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• No observable mining induced change at VWP intakes located at or above (i.e. shallower than) 200 m depth.	• Continue monitoring program. • Ongoing review of water level data.	• No response required.
		Level 2		
		• Greater than 5 m water level reduction in VWP intakes located at or above (i.e. shallower than) 200 m depth following the commencement of extraction at LW W1 (and LW W2, W3 and W4) (refer to Table 6-2 for TARP Significance Level 2). AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• Continue monitoring program. • Ongoing review of water level data. • Convene with Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 3		
		• Water level declines below the water level of TARP Significance Level 3 (refer Table 6-2, calculated as the average of TARP Significance Level 2 and Level 4) following the commencement of extraction at LW W1 (and LW W2, W3 and W4). AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• Continue monitoring program • Ongoing review of water level data and consideration of mining and external stresses (in groundwater monthly report). • Compare against base case and deterministic model scenarios. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 4		
		• Water level reduction greater than the maximum modelled drawdown (refer to Table 6-2 for TARP Significance Level 4) following the commencement of extraction at LW W1 (and LW W2, W3 and W4). AND • The reduction in water level is determined not to be controlled by climatic or anthropogenic factors.	• Continue monitoring and review as per monitoring program. • Ongoing review of water level data and consideration of mining and external stresses (in groundwater monthly report). • Convene Tahmoor Coal Environmental Response Group to review response. • Compare against base case and deterministic model scenarios.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • If it is concluded that there has been a mining-related impact, implement an investigation report.

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Deep Groundwater Pressures at VWPs TNC036.	GROUNDWATER PRESSURE **Locations** Impact site – TNC36 (refer to Figure 3-5). Control site - Groundwater bores/VWPs TNC40 (refer to Figure 3-5). **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download. During mining - Minimum continuous 24-hourly readings with monthly logger download. Post mining - Minimum continuous 24-hourly readings for 12 months after LW W4 completed. Monthly logger downloaded for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).	Level 1		
		• Observed data does not exceed predicted (modelled) impacts at VWP intakes located below (i.e. deeper than) 200 m depth (excluding those monitoring the Bulli Coal Seam).	• Continue monitoring program. • Ongoing review of water level data.	• No response required.
		Level 2		
		• Calculated or observed drawdown (based on 2009-2015 baseline data) for VWP intakes below 200 m depth (excluding those within the Bulli Coal Seam) is within 30 m of predicted (modelled) drawdown.	• Continue monitoring program. • Ongoing review of water level data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 3		
		• Calculated or observed drawdown (based on 2009-2015 baseline data) for VWP intakes below 200 m depth (excluding those within the Bulli Coal Seam) exceeds predicted (modelled) drawdown by 30 m for a period of 6 months or more.	• Continue monitoring program. • Ongoing review of water level data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group. • Consider increasing download frequency at groundwater bores where Level 3 has been reached to a fortnightly basis. Consider increasing review frequency to fortnightly.
		Level 4		
		• Calculated or observed drawdown (based on 2009-2015 baseline data) for VWP intakes below 200 m depth (excluding those within the Bulli Coal Seam) exceeds predicted (modelled) drawdown by 30 m for a period of 12 months or more.	• Continue monitoring and review as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess whether change in behaviour is related to LW W1-W2 mining effects.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • If it is concluded that there has been a mining-related impact, implement an investigation report.

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Groundwater – Surface Water Interaction (Stonequarry Creek)	The aim of this TARP is to provide a leading indicator for potential changes to hydrology in Stonequarry Creek near LW W3, and is considered complementary to other TARPS. The Performance Indicator of flow over the rockbar at SR17 is more directly assessed via other TARPs described above: • Impact to pool water level; and • Impact to physical features & natural behaviour of pools. SURFACE WATER **Location**: Impact site – Monitoring Site SB (Pool SR17) **Frequency** Pre-mining – Continuous record, data downloaded monthly. Baseline data recorded since October 2018 in the Western Domain at the majority of Western Domain sites. During mining to 400 m (LW W3) – Continuous record, data downloaded monthly. Post mining – Continuous record, data downloaded monthly for 12 months after LW W4 completed. Monthly logger downloaded for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details). GROUNDWATER **Location**: Impact site – P14, P15 **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since May 2019 (P14) and since March 2021 (P15). During mining to 400 m (LW W3) - Minimum continuous 24-hourly readings with fortnightly logger download and dip meter. Post mining - Minimum continuous 24-hourly readings with monthly logger download and dip meter for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details). **TARP Trigger Levels:** TARP Level 2 = base of the pool [mAHD] +1.1m = 165.0 mAHD TARP Level 3 = base of the pool [mAHD] +0.6 m = 164.5 mAHD TARP Level 4 = base of the pool [mAHD] +0.1 m = 164.0mAHD	Level 1		
		• Inferred groundwater and surface water interaction remains consistent with baseline variability and pre-mining trends with weakening of gaining or strengthening of losing condition not persisting after significant rainfall recharge event.	• Continue monitoring program. • Ongoing review of water level data.	• No response required.
		Level 2		
		• Inferred groundwater levels at surface water monitoring site decline below the TARP Level 2 following the commencement of extraction at LW W1 (and LW W2, W3 and W4). AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• Continue monitoring program. • Ongoing review of water level data. • Review relevant surface water level, groundwater level and streamflow data to assess comparative trends. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group.
		Level 3		
		• Inferred groundwater levels at surface water monitoring site decline below the TARP Level 3 following the commencement of extraction at LW W1 (and LW W2, W3 and W4). AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• Continue monitoring program. • Ongoing review of water level data and consideration of mining and external stresses (in impact report) • Review relevant surface water level, groundwater level and streamflow data to assess comparative trends. • Compare against base case and deterministic model scenarios. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group. • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline. • Report to DPIE.
		Level 4		
		• Inferred groundwater levels at surface water monitoring site decline below the TARP Level 4 following the commencement of extraction at LW W1 (and LW W2, W3 and W4). AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• Continue monitoring and review as per monitoring program. • Ongoing review of water level data and consideration of mining and external stresses (in impact report) • Review relevant surface water level, groundwater level and streamflow data to assess comparative trends. • Compare against base case and deterministic model scenarios. • Convene Tahmoor Coal Environmental Response Group to review response.	• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • Review surface water data to assess for surface water level decline at SB (SR17). • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline. • If it is concluded that there has been a mining-related impact, then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator (refer to Section 6.2.2 of the WMP).

<table>
<tr><th rowspan="2">Feature</th><th rowspan="2">Methodology and relevant monitoring</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8">Shallow Groundwater Level Decline
(Stonequarry Creek)</td><td rowspan="8">The aim of this TARP is to provide a leading indicator for potential changes to hydrology in Stonequarry Creek near LW W3, and is considered complementary to other TARPS. The Performance Indicator of flow over the rockbar at SR17 is more directly assessed via other TARPs described above:
• Impact to pool water level; and
• Impact to physical features & natural behaviour of pools.

GROUNDWATER
<u>Location</u>: <u>Impact site </u>– P14B, P15A (spatial average)
Groundwater level change (m/d) is calculated as a rolling fortnightly average (to filter out short-term fluctuations) of the shallowest HBSS piezometer at each site, and compare this to historically observed rates of decline (m/d).

<u>Frequency</u>:
<u>Pre-mining</u> - Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since May 2019 (P14) and since March 2021 (P15).
<u>During mining</u> to 400 m (LW W3) - Minimum continuous 24-hourly readings with fortnightly logger download and dip meter.
<u>Post mining</u> - Minimum continuous 24-hourly readings with monthly logger download and dip meter for 12 months following the completion of LW W4. This period may be extended as per the decision by the Environmental Response Group (refer to Section 5.2 for further details).

TARP Trigger Levels (rate of GWL decline):
TARP Level 2 >= similar to Sept/Oct-2020 = 0.012 m/d
TARP Level 3 >= historical max (early Jan-2021) = 0.030 m/d.
TARP Level 4 >= historical max +50% = 0.045 m/d</td><td colspan="3">Level 1</td></tr>
<tr><td>• Inferred groundwater levels decline by less than Level 2 rate following commencement of LW W3.</td><td>• Continue monitoring program.
• Ongoing review of water level data.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Inferred groundwater levels decline by more (faster than) than Level 2 rate following start of LW W3.</td><td>• Continue monitoring program.
• Ongoing review of water level data.
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Convene Tahmoor Coal Environmental Response Group to review response.</td><td>• As defined by the Environmental Response Group.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• Inferred groundwater levels decline by more (faster than) than Level 3 rate following start of LW W3.</td><td>• Continue monitoring program.
• Ongoing review of water level data and consideration of mining and external stresses (in impact report)
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Compare against base case and deterministic model scenarios.
• Convene Tahmoor Coal Environmental Response Group to review response.</td><td>• As defined by the Environmental Response Group.
• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline.
• Report to DPIE.</td></tr>
<tr><td colspan="3">Level 4</td></tr>
<tr><td>• Inferred groundwater levels decline by more (faster than) than Level 4 rate following start of LW W3.</td><td>• Continue monitoring and review as per monitoring program.
• Ongoing review of water level data and consideration of mining and external stresses (in impact report)
• Review relevant surface water level, groundwater level and streamflow data to assess comparative trends.
• Compare against base case and deterministic model scenarios.
• Convene Tahmoor Coal Environmental Response Group to review response.</td><td>• Report to DPIE and relevant government agencies within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document).
• Review surface water data to assess for surface water level decline at SB (SR17).
• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline.
• If it is concluded that there has been a mining-related impact, then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator (refer to Section 6.2.2 of the WMP).</td></tr>
</table>

Appendix B – Surface Water Technical Report

Appendix C – Flood Impact Study

Appendix D – Groundwater Technical Report

Appendix E – Baseline Private Bore Assessment

Appendix F – Summary of Surface Water Monitoring

Summary of surface water monitoring during the extraction of LW W3-W4

Pool ID	Pool within 600m Study Area	Ground survey ID	Visual monitoring during active subsidence	Continuous water level monitoring ID	Manual water level monitoring ID	Water quality sampling ID
MB1	-	-	-	-	-	-
Weir 2	-	-	-	-	MA	-
MR3	-	-	-	-	-	-
MR4	-	-	-	-	-	-
MR5	✓	-	✓	MB	-	MB
MR6	✓	-	✓	-	-	-
MB7	✓	-	✓	-	MC	-
MR8	✓	-	✓	-	-	-
MB9	✓	-	✓	-	-	-
MR10	✓	-	✓	-	-	-
MR11	✓	MR11	✓	-	-	-
MB12	✓	-	✓	-	-	MC1
MR13	✓	MR13	✓	-	-	-
MB14	✓	-	✓	-	-	-
MR15	✓	-	✓	-	-	-
MB16	✓	MR16	✓	-	-	-
MR17	✓	-	✓	-	-	-
MR18	✓	-	✓	-	-	-
MB19	✓	-	✓	-	MD U/S	-
MB20	✓	MB20	✓	-	-	-
MB21	✓	-	✓	-	-	-
MR22	✓	MR22	✓	-	-	-
MB23	✓	-	✓	-	-	-
MR24	✓	-	✓	-	-	-
MR25	✓	MR25	✓	-	-	-
MW26	✓	-	✓	ME	-	-
MB27	✓	-	✓	-	-	-
MB28	✓	-	✓	-	-	-
MB29	✓	-	✓	-	-	-
MB30	✓	MB30	✓	-	MF	-
MB31	✓	-	✓	-	-	-
MR32	✓	MR32	✓	-	-	-
MW33	✓	-	✓	-	-	-
MB34	✓	-	✓	-	-	-
MR35	✓	-	✓	-	-	-
MB36	✓	-	✓	-	-	-

Pool ID	Pool within 600m Study Area	Ground survey ID	Visual monitoring during active subsidence	Continuous water level monitoring ID	Manual water level monitoring ID	Water quality sampling ID
MB37	✓	-	✓	-	-	-
MB38	✓	-	✓	-	-	-
MR39	✓	MR39	✓	-	-	-
MR40	✓	-	✓	-	-	-
MR41	✓	MR41	✓	-	-	-
MR42	✓	MR42	✓	MG	-	MG
MR43	✓	MR43	✓	-	-	-
MR44	✓	MR44	✓	-	-	-
MR45	✓	-	✓	-	MR45	-
MR46	✓	-	✓	-	MR46	-
Cedar Creek Road	-	CCR	-	CCR	-	-
CR1	✓	-	✓	-	-	-
CB2	✓	CB2	✓	-	-	CC1
CB3	✓	-	✓	CC1A	-	-
CB4	✓	-	✓	-	-	-
CB5	✓	CB5	✓	-	-	-
CB6	✓	-	✓	-	-	-
CB7	✓	-	✓	-	-	-
CB8	✓	-	✓	-	-	-
CR9	✓	-	✓	-	-	-
CR10	✓	-	✓	CA	-	CA
CR11	✓	CB11	✓	-	-	-
CR12	✓	-	✓	-	-	-
CR13	✓	CR13	✓	-	-	-
CR14	✓	-	✓	CB	-	CB
CR15	✓	-	✓	-	-	-
CB16	✓	-	✓	-	-	-
CB17	✓	-	✓	-	-	-
CR18	✓	-	✓	-	-	-
CB19	✓	CB19	✓	-	CC	CC
CR20	✓	CR20	✓	-	-	-
CR21	✓	-	✓	-	-	-
CR22	✓	-	✓	-	-	-
CR23	✓	CR23	✓	CD	-	CD
CR24	✓	-	✓	-	-	-
CB25	✓	-	✓	CE	-	CE

Pool ID	Pool within 600m Study Area	Ground survey ID	Visual monitoring during active subsidence	Continuous water level monitoring ID	Manual water level monitoring ID	Water quality sampling ID
CR26	✓	CR26	✓	-	CF	CF
CR27	✓	CR27	✓	-	-	-
CB28	✓	-	✓	-	-	-
CR29	✓	-	✓	-	-	-
CB30	✓	CC01	✓	-	-	-
CR31	✓	CC02 CC03 CC04	✓	CG	-	CG
CR32	✓	-	✓	-	-	-
SC1	-	-	-	-	-	SC1
ST1	-	-	-	-	-	-
SG2	-	-	✓	SG	-	SG
SG3	-	-	-	-	-	-
ST4	-	-	✓	-	-	-
SR5	✓	-	✓	SE	-	SE
SB6	✓	-	-	-	-	-
SR7	✓	-	-	-	-	-
SR8	✓	SQ01	-	-	-	-
SG9	✓	-	-	-	-	-
SR10	✓	-	-	-	-	-
SB11	✓	-	-	-	-	-
ST12	✓	SQ02	-	-	-	-
SB13	✓	-	✓	-	-	-
SB14	✓	-	✓	-	-	-
SB15	✓	-	✓	-	-	-
SR16	✓	-	✓	SA	-	-
SR17	✓	SQ03 to SQ13 lines Rockbar SR17 3D GNSS Sites 12 to 13	✓	SB and SC2	-	SC2
SRS18	✓	-	✓	-	-	-
SR19	-	-	✓	-	-	-
SR20	-	-	✓	-	-	-
SR21	-	-	✓	-	SC	SC
SR22	-	-	✓	-	-	-
SD Pool	-	-	✓	SD	-	SD
SF Pool	-	-	✓	SF	-	SF

Appendix G – Memorandum in response to IAPUM Advice