SIMEC

MEMBER OF GFG ALLIANCE

Tahmoor Coal Pty Ltd

WATER MANAGEMENT PLAN

Tahmoor North Western Domain
Longwalls West 1 and West 2

October 2020

simecgfg.com

This page has been left blank intentionally.

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 1 and West 2 – Water Management Plan
DOCUMENT NUMBER:	TAH-HSEC-224
PUBLICATION DATE:	October 2020
DOCUMENT STATUS:	Final (Version 4)
PREPARED BY:	April Hudson Approvals Specialist Tahmoor Coal– SIMEC Mining
APPROVED BY:	Zina Ainsworth Environment and Community Manager Tahmoor Coal– SIMEC Mining Signature: Zina Ainsworth Date: 6.10.2020
APPROVED BY:	Malcolm Waterfall Mining Engineering Manager Tahmoor Coal– SIMEC Mining Signature: Malcolm Waterfall Date: 07.10.2020
APPROVED BY:	Peter Vale General Manager Tahmoor Coal– SIMEC Mining Signature: Peter Vale Date: 7.10.20

simecgfg.com

This page has been left blank intentionally.

Table of Contents

List of Figures

List of Tables

This page has been left blank intentionally.

1 Introduction

1.1 Background

The 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 (**ROM**) 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.

The 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 subsidiary within the SIMEC Mining Division (**SIMEC**) of the GFG Alliance (**GFG**).

Tahmoor Coal has previously mined 32 longwalls to the north and west of the Tahmoor Mine's current pit top location.

Tahmoor Coal has extended underground coal mining to the north-west of the Main Southern Railway (referred to as the 'Western Domain') which will include Longwalls West 1 (**LW W1**) to West 4 (**LW W4**) at Picton and Thirlmere. The first two longwalls to be mined are LW W1 and Longwall West 2 (**LW W2**) (collectively referred to as **LW W1-W2**), which are the focus of this Water Management Plan. LW W1-W2 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the previously extracted Tahmoor North longwall series. The Western Domain is within Mining Lease (**ML**) 1376 and ML 1539, as illustrated in **Figure 1-2** of the Extraction Plan Main Document.

Tahmoor Coal received approval of the Extraction Plan for LW W1-W2 on 8 November 2019 and commenced extraction of LW W1 on 15 November, in accordance with Development Consents and Extraction Plan Approval.

1.2 Purpose

This Water Management Plan (**WMP**) has been prepared to support an Extraction Plan for the secondary extraction of coal from LW W1-W2. 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.

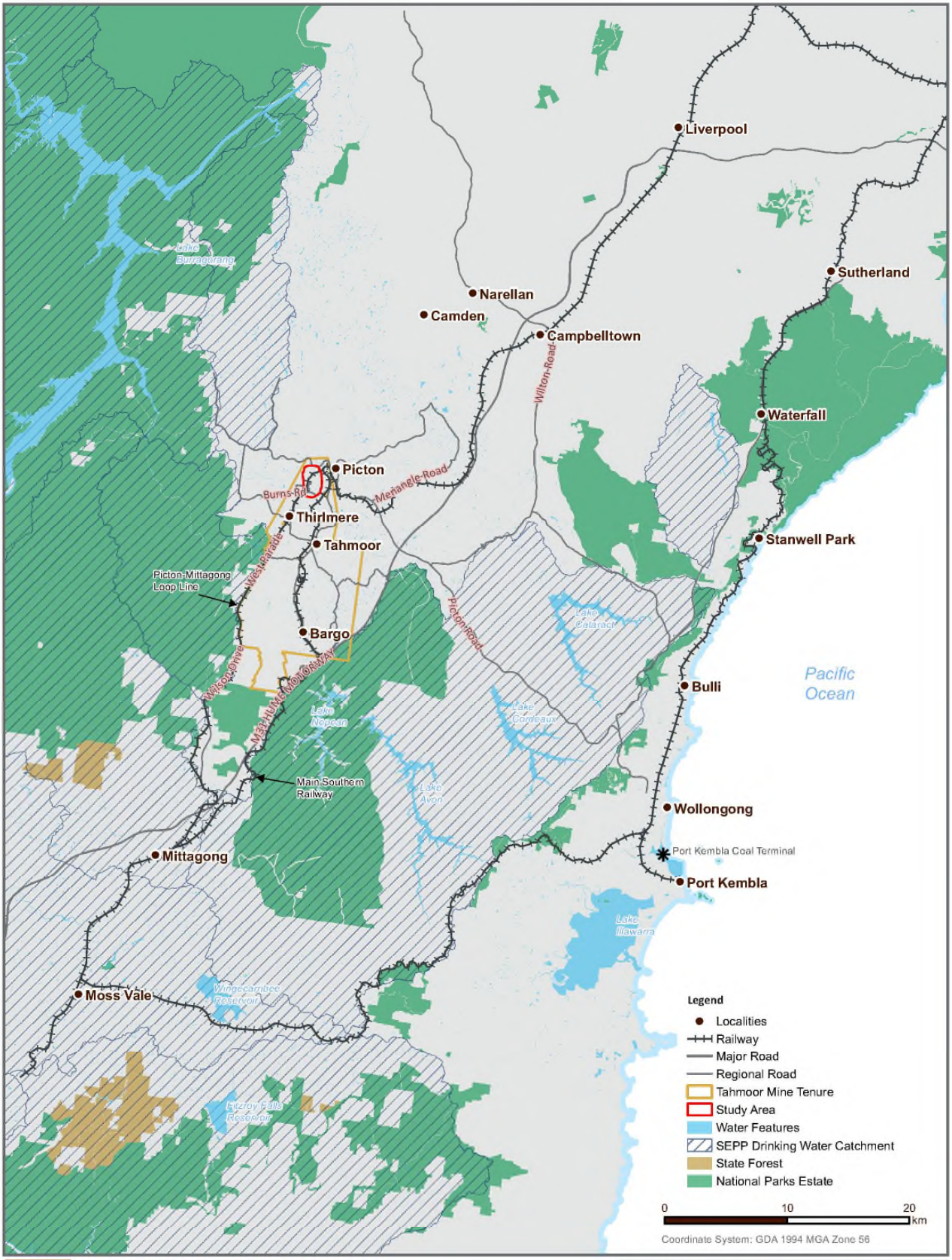
This WMP:

- Addresses specific requirements set by DA 67/98 Condition 13H(vii)(c) (refer to **Section 2.1**);
- Addresses related regulatory requirements (refer to **Section 2.1.3**);
- Addresses the monitoring and management of potential subsidence-related impacts to surface water and groundwater resources (refer to **Section 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 W1-W2 Extraction Plan approval granted by NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. In addition, this WMP has been updated to address the conditions of LW W1-W2 Adaptive Management Report approval granted by DPIE on 7 September 2020.

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

- Surface Water Technical Report (**SWTR**) (HEC, 2020) (**Appendix B**);
- Flood Impact Study (WRM, 2019) (**Appendix C)**;
- Groundwater Technical Report (**GTR**) (HydroSimulations, 2020) (**Appendix D**);
- Baseline Private Bore Assessment (GeoTerra, 2019) (**Appendix E**);
- Geotechnical Assessment (Douglas Partners, 2019) (**Volume 2**);
- Subsidence Geotechnical Report (SCT, 2019) (**Volume 1**); and
- Subsidence Predictions and Impact Assessments Report (MSEC, 2019) (**Volume 1**).



DOCUMENT FILE PATH

SIMEC MEMBER OF GFG ALLIANCE

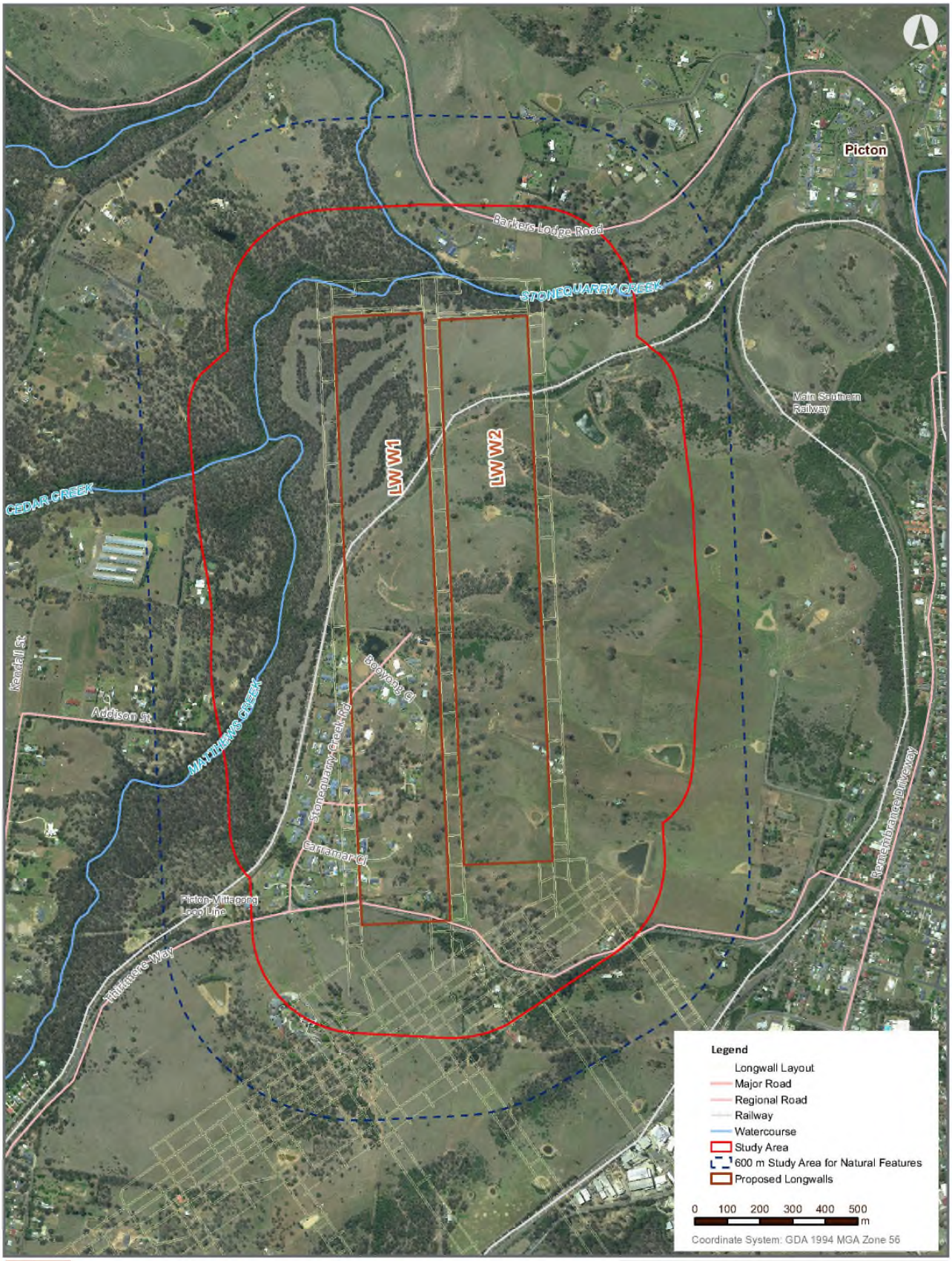
REGIONAL CONTEXT

Tahmoor North Western Domain Longwalls West 1 and West 2 Extraction Plan

FIGURE 1-1

Date: 27/05/2019

Data Sources:
© NSW DFSI (2019); © NSW Mining (2019); © SIMEC (2019)



DOCUMENT FILE PATH

SIMEC MEMBER OF GFG ALLIANCE

EXTRACTION PLAN STUDY AREA

Tahmoor North Western Domain Longwalls West 1 and West 2
Extraction Plan

FIGURE 1-2

Date: 4/07/2019

Data Sources:
© NSW DFSI (2019); © NSW Mining (2019); © SIMEC (2019)
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 W1-W2 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

Condition	Condition Requirement		Section(s) Addressed
Performance Measures – Built Features			
13E	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*.		Section 5, Section 6, Appendix A
Excerpt from Table 2	**Feature**	**Performance Measure**	
	Public Safety		
	Public Safety	• Public Safety	
Extraction Plan			
13H(vi)	Describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 1 and Table 2, and manage or remediate any impacts and/or environmental consequences;		Section 5.1, Section 5.2 and Section 6
13H(vii)(c)	Water Management Plan which has been prepared in consultation with EPA, DoI, 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:		This document, Section 2.3

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 6.2.3, 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:	Section 6.3, Section 6.5, Appendix A
	• appropriate triggers to warn of increased risk of exceedance of any performance measure; and	

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 *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 W1-W2 Extraction Plan on 8 November 2019, and conditions for the approval and where they are addressed in this document are outlined in **Table 2-3**.

Table 2-3 Conditions for LW W1-W2 Extraction Plan approval

<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.
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, Section 7.1</td></tr>
<tr><td>2</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>3</td><td>The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the Water Management Plan required under the Extraction Plan for Longwalls W1 and W2.</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>
</table>

Condition	Condition Requirement	Section(s) Addressed
Water Management Plan		
5	Within 10 weeks of this Extraction Plan approval, the Water Management Plan for the Longwalls W1 and W2 Extraction Plan must be updated to the satisfaction of the Secretary. This plan must be developed in consultation with Council and BCD and:	Noted Section 2.3.2
5(a)	include performance indicators capable of managing and monitoring compliance with the performance measures in condition 1 of this Extraction Plan approval;	Section 5.1, Section 7.1
5(b)	include suitable revisions to the Trigger Action Response Plan to include: - Level 1, 2 and 3, and exceeding prediction triggers to enable trends in data to be identified, actioned and reported as potential impacts escalate; - separation of actions and responses; - methodology and relevant monitoring stations; - higher frequency monitoring of pool water levels; - justification of the proposed flow triggers; and - specific figures relevant to the baseline data;	Appendix A Note that site SB was upgraded from manual monthly pool water level to automated pool water level, and an automated pool water level site has been included in the mid-section of pool SR17 (monitoring site SC2).
5(c)	include a detailed adaptive management strategy that sets quantifiable assessment criteria and provides parameters for when additional setbacks from relevant watercourses should be implemented; and	Section 6.5.1
5(d)	address the comments from the Department's Water Group dated 30 September 2019. (Comments from Water Group replicated below)	See below
	Groundwater quality and level monitoring programme be continued as outlined in the extraction plan.	Noted
	Make good provisions for users impacted by mining activities to be included in the trigger action plan.	Section 6.2.4
	Adopt adaptive management strategies for water resources management, including but not limited to: - provision for additional relevant monitoring bores being installed and included in the monitoring network, based on impacts to local water resources	Section 6.5.2
	Update the Water Management Plans to reference the correct water sharing plan, groundwater source and management zone.	Section 2.2
Adaptive Management		
6	At least 2 months prior to extraction of Longwall W2, the Applicant must submit an Adaptive Management report for approval to the Secretary. The report must include a summary of the: a) Applicant's performance under the Extraction Plan and this Extraction Plan approval; b) implementation of the revised Water Management Plan Trigger Action Response Plan; and c) outcomes of the adaptive management strategy, including any additional setbacks proposed to be implemented for Longwall W2. If no additional setbacks are proposed, detailed justification must be provided with reference to observed and predicted impacts.	Section 6.5.1, Section 7.1

Condition	Condition Requirement	Section(s) Addressed
7	The Applicant may not undertake any secondary extraction in Longwall W2 until the Secretary is satisfied that the Adaptive Management report includes appropriate adaptive management outcomes and selected setback distances from creek lines would achieve the requirements of condition 1.	Noted

2.1.4 Adaptive Management Report Conditions of Consent

Tahmoor Coal completed a review of observations of subsidence impacts and environmental consequences as a result of mining the first 1,000 m of LW W1 to determine whether additional setback for the commencing end of LW W2 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 W2 was not proposed.

DPIE confirmed on 7 September 2020 that, based on the Adaptive Management Report, there was no reason to impose a further setback distance of LW W2 from nearby creek lines. However, to provide additional safeguards, DPIE requested the following amendments to monitoring frequencies during the extraction of LW W2:

- Pool MR45 – increased frequency of data download of automated pool water level and visual inspection of natural drainage behaviour from monthly to fortnightly, during active subsidence period;
- P12 – increased frequency of download from monthly to fortnightly, during mining; and
- TNC036 – increased frequency of data download from monthly to fortnightly, during mining.

These additional requests have been incorporated into the Subsidence Monitoring Program for LW W1-W2, as demonstrated in **Table 5-3.**

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 sub-sections below.

2.2.1 Water Management Act 2000

The NSW Department of Industry – Water (**DoI-Water**) implements water regulation according to the *Water Management Act 2000*. A primary objective is the sustainable management and use of water resources, balancing environmental, social and economic considerations. DoI-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 (WRM, 2019).

The surface water and groundwater in the area surrounding the Study Area are regulated by individual WSPs. Surface water use is managed under the Greater Metropolitan River Unregulated River Water Sources (NOW, 2011c). Under this WSP the Tahmoor Mine footprint falls within the Stonequarry Creek Management Zone and the Maldon Weir Management Zone of the Upper Nepean River Water Source. The area occupied by LW W1-W2 however is managed only under the Stonequarry Creek Management Zone.

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 and annualised limit on entitlement of 99,568 megalitres (NOW, 2011a), while current entitlement is 25,658 megalitres (based on the WaterNSW Water Register 2018-2019 water year)[1].

A review of the NSW Water Register[2] identified six properties within or near the Study Area with a Water Supply Works and Water Use Approval. The approvals pertain to diversion works from an adjacent surface water system (pumping) and/or through collection in a farm dam for irrigation purposes.

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.

2.2.2 NSW Aquifer Interference Policy

Underground mining generally requires the dewatering of the geological strata. In accordance with the NSW Aquifer Interference Policy 2012 (**AI Policy**), such activity is classified as an 'Aquifer Interference'. In order to meet the requirements of the 'minimal impact considerations', outlined within the AI Policy, a groundwater assessment is conducted (HydroSimulations, 2020).

The AI Policy 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" for any mining activity not subject to the Gateway process, 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" (HydroSimulations, 2020).

The AI Policy 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 AI Policy 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 (HydroSimulations, 2020).

The AI Policy categorises groundwater source productivity (highly productive or less productive) based on characteristics of salinity and aquifer yield. The 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 (HydroSimulations, 2018; HydroSimulations, 2020).

[1] See: https://waterregister.waternsw.com.au/water-register-frame

[2] https://waterregister.waternsw.com.au

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 (HydroSimulations, 2020).

2.2.3 Water Licensing

A Water Access Licence (**WAL**) has been awarded to Tahmoor Coal under the authority of the *Water Management Act 2000*. **Table 2-3** outlines the details of this licence.

Table 2-4 Water Access Licence Details

Works Approval	WAL Title	Issued	Purpose	Share
10WAl18745	WAL36442	Dec 2013	Mining dewatering (groundwater)	1642 units

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, 2020).

2.2.4 Protection of the Environment Operations Act 1997

EPL 1389 includes licensed discharge points for surface water. The conditions of EPL 1389 would not be affected by on-going mining and coal processing operations related to LW W1 and subsequent longwalls in the Western Domain.

2.3 Consultation

2.3.1 Consultation during Extraction Plan Preparation

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

- NSW Department of Planning and Environment – Resources Regulator (now NSW Department of Planning, Industry and Environment (DPIE) – Resources Regulator);
- DoI-Water;
- NSW Industry – Natural Resources Access Regulator (**NRAR**);
- NSW Environment Protection Authority;
- NSW Office of Environment and Heritage;
- 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.

2.3.2 Consultation during WMP Update

As required by Condition 5 of LW W1-W2 Extraction Plan approval conditions, Tahmoor Coal consulted with Wollondilly Shire Council and DPIE Biodiversity Conservation Division (BCD) during the development of the updated WMP. A summary of the consultation to date is provided in the sections below.

DPIE Biodiversity Conservation Division

A meeting with DPIE Biodiversity Conservation Division (BCD) was held on 10 January 2020 at the DPIE Illawarra Office at 84 Crown Street, Wollongong. Representatives from Tahmoor Coal and HEC met with Martin Krogh and Meagan Hinds, and representatives from DPIE also dialled in via teleconference. Table 2-5 outlines the discussion with BCD and how the comments have been addressed in this Water Management Plan.

Table 2-5 Discussion with DPIE Biodiversity Conservation Division, 10 January 2020

Discussion and comments	Section(s) Addressed / Response
Tahmoor Coal provided a review of the current mining to date and issues. No impacts yet observed from mining. BCD stated that they wouldn't have expected to see any impacts to date as we are surrounded by solid coal.	Noted.
Tahmoor Coal provided a review of the consultation. BCD stated the document was sent through at 10pm the night prior. Tahmoor Coal acknowledged this, and assured BCD this was the start of consultation and further consultation to occur. DPIE stated that further consultation would occur with BCD once draft submitted if required.	Noted.
Review of Performance Measures. BCD stated 10% of pools as a performance measure doesn't consider the size of the pools, and their importance. Tahmoor Coal stated this had been considered and the pool with SB logger was considered the most important and is treated as such in the Adaptive Management Plan. Tahmoor Coal noted that SB would be considered in the performance indicators in the WMP.	Section 5.1 Section 5.2 – additional automatic logging station will be placed in proximity to SC2 in pool SR17. Appendix A
Review of TARP and requirement to 'increase frequency of monitoring'. BCD noted this was referring to the opinion that monthly flow monitoring was not enough and that additional divers should be implemented at all manual monitoring pool locations. Tahmoor Coal noted that additional divers will be installed.	Section 5.2 – additional automatic logging station will be placed in proximity to SC2 in pool SR17, at SB and CC1A Appendix A
BCD commented that there was not adequate monitoring of the large pool (SB) at Stonequarry Creek. Tahmoor Coal stated that SB would be made into an automatic logging station. BCD suggested one also at SC2. Tahmoor Coal will install an automatic logging station at this location.	Section 5.2 – additional automatic logging station will be placed in proximity to SC2 in pool SR17, at SB and CC1A Appendix A
BCD noted difference between automatic and manual levels at a few pools and requested an explanation. Tahmoor Coal to investigate.	Noted. Tahmoor Coal has investigated differences and corrected data is presented in Appendix B.
BCD stated the intent behind the first TARP (surface water flow) was unclear, and noted it was more appropriate to focus on upstream and downstream flows and the difference rather than catchment wide. HEC stated that all the TARPs are complementary and all need to be considered, for example the next TARP is about the pool levels. HEC stated the TARP could be tested by running simulations with existing data.	Noted. Simulations to test TARP will be completed.
New performance measures for surface to seam connectivity. DPIE stated they were a requirement for this in the Extraction Plan Approval conditions. BCD suggested tritium monitoring or extensometers. HEC suggested measuring water-take underground, however BCD didn't think this would be enough. The performance measure will be detailed in the WMP.	Section 5.1

Discussion and comments	Section(s) Addressed / Response
BCD noted that there was no mention of Creek Remediation should impacts occur. Tahmoor Coal said this was a requirement of the current WMP and is outlined in the TARP, and pools will be remediated.	Appendix A
BCD made comment that they believed MSEC had not included the pools on Eastern Tributary (Metrop) and an Appin area in their calculations. Tahmoor Coal to follow up, however believes this addressed previously.	Noted. MSEC followed up and confirmed the appropriate pools had been included in their calculations.
BCD noted in the data there was evidence of pumping from some pools by landowners. HEC noted this also. Follow up to occur on any pumping noted on the relevant creeks, subject to data being available.	Noted. Tahmoor Coal to follow up on this investigation.
BCD wanted to see evidence of the BACI method used (before-after-control-impact). What is the reference site? BCD noted that a reference site was not necessarily articulated to date in the Extraction Plan documents.	Appendix A
BCD suggested to simulate a loss in model to test water flow TARP, and other TARPs to determine if delivering according to impact.	Noted. Simulations to test TARP will be completed.
BCD not satisfied with the use of percentiles as a flow metric (flow TARP). HEC stated it is from the ANZECC Guidelines and is the accepted methodology from Water NSW for another coal mine in the area.	Noted.
BCD confirmed that two weeks would be sufficient to respond with comments on the updated Water Management Plan.	Noted.

Wollondilly Shire Council

A meeting with Wollondilly Shire Council (WSC) was held on 13 January 2020 at the WSC Offices in Picton. Representatives from Tahmoor Coal met with Alex Stengl and David Henry from WSC. Table 2-6 outlines the discuss with WSC with regards to the update of the Water Management Plan and how the comments have been addressed in this Water Management Plan.

Table 2-6 Discussion with WSC, 13 January 2020

Discussion and comments	Section(s) Addressed / Response
Tahmoor Coal provided a timeframe for WMP update and purpose of this meeting. Draft WMP to be submitted to DoP by 17 Jan 2020, copy to be provided to WSC for comments. WSC confirmed that two weeks to provide comments on the updated draft WMP would be sufficient.	Noted.
Tahmoor Coal provided an overview of updates to WMP relating to performance measure condition.	Section 5.1
WSC asked if Ian Bertham (rom WSC has been consulted yet with regards to flooding in the catchment. Tahmoor Coal noted that a Flood Impact Assessment was completed and indicated that changes to the flood regime in the study area was likely to be negligible and wasn't seen as necessary.	Noted.
WSC noted that it is good to see a prescriptive subsidence performance indicator (i.e. 9 of 88 pools impacted) against the new performance measure for creeks which is also quantitative. This was useful to enable councillors to respond to community concerns.	Section 5.1
Tahmoor Coal provided an overview of updates to WMP Trigger Action Response Plan (TARP) and focus on monitoring of pool SR17 (the key pool along Stonequarry	Appendix A

Discussion and comments	Section(s) Addressed / Response
Creek). Also highlighted that site specific triggers have been added at the back of the TARP.	
WSC noted creeks would be fairly dry at the moment due to weather. Tahmoor Coal outlined the results from the recent creek survey which showed that climate has impacted flow and the water volume in the creeks.	Noted.
Tahmoor Coal provided an example of 'traffic light' figure for current monitoring and correlation to TARP for natural drainage behaviour.	Noted.
Tahmoor Coal provided an overview of update to the Adaptive Management Strategy to consider likely impacts to both 10% of pools and pool SR17.	Section 6.5.1
WSC asked if comments from EES (Department of Environment, Energy and Science; or DPIE BCD) have been considered. Tahmoor Coal noted that additional flow monitoring locations are in the process of being incorporated into the monitoring program, as well as updates to the WMP to consider the importance of pool SR17.	Section 5.2 – additional automatic logging station will be placed in proximity to SC2 in pool SR17, at SB and CC1A Appendix A
WSC noted that they were pleased with the information that was presented and the changes that have been incorporated into the WMP. In particular, the focus on Stonequarry Creek would assist in reducing any community concern with the project.	Noted.

3 Existing Environment

3.1 Surface Water

3.1.1 Natural Waterways in the Study Area

The Study Area is located in the Stonequarry Creek Catchment with the natural waterway features comprising Matthews Creek, Cedar Creek, and Stonequarry Creek (refer to **Figure 1-2**). The south-west portion of the Study Area discharges to Matthews Creek while the north-northwest portion of the area discharges to Cedar Creek and Stonequarry Creek (HEC, 2020).

Matthews Creek and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 200 m west of LW W1. Stonequarry Creek also rises to the west and flows to the east along the northern boundary of the Study Area, joining Cedar Creek approximately 130 m north of LW W2, before flowing east and south through the town of Picton (refer to **Figure 1-2**) (HEC, 2020).

The proposed LW W1-W2 Study Area includes several minor tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek. The eastern tributaries of Matthews Creek within the Study Area are ephemeral and are predominately first and second order streams, excepting a portion of Rumker Gully which is a third order stream from the Picton Mittagong Loop Line Railway to the confluence with Matthews Creek. The first and second order tributaries flow beneath Stonequarry Creek Road and a residential area along this road known as “Stonequarry Estate” located to the east of the Picton Mittagong Loop Line. Surface water runoff from these tributaries has been partially diverted by urban drainage associated with “Stonequarry Estate” and flows through stormwater detention basins/dams and culverts under the rail line, with runoff from the tributaries flowing into Matthews Creek during periods of extended or significant rainfall (HEC, 2020).

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 Nepean River near and downstream of the Study Area are not part of a WaterNSW Drinking Water Catchment Area (HEC, 2020).

Further detail of the waterways in the Study Area and surrounding regions is provided in the SWTR (HEC, 2020).

3.1.2 Baseline Data for Pool Water Levels and Surface Water Flow Rate

Continuous (automated) pool and surface water level data has been collected by Tahmoor Coal at three locations on Matthews Creek, six locations on Cedar Creek and two locations on Stonequarry Creek (refer to **Figure 3-1**). The pool and surface water level data have been recorded hourly using a water level sensor. Flow rating relationships are in the process of being developed which will allow estimation of flow rate from recorded depth in the future. The cease to flow (**CTF**) level for each site has also been recorded (HEC, 2020).

Detailed information on pool water levels and surface water flow rates is provided in the SWTR (HEC, 2020). The recorded water levels and estimated flow rates for Matthews Creek, Cedar Creek and Stonequarry Creek is discussed further below.

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 two sites on Stonequarry Creek. Water levels are measured on a monthly basis at these sites. Continuous water level sensors will installed at Site SB and another in proximity to SC2 on Stonequarry Creek in early 2020. An additional continuous water level sensor has been installed at CC1A.

Matthews Creek

Continuous (automated) water level data is available for three sites (MB, ME, and MG) on Matthews Creek for the period November 2018 to November 2019.

Water level records for ME and MG were predominantly below the CTF levels during the monitoring period except for short periods during and shortly following rainfall events, while in contrast the water level record at MB (the most upstream site) was more subdued, remaining near the CTF level for most of the period, with the notable exception of the period from the end of July 2019 until late September 2019 and mid-October onwards. The above data indicates that pools on Matthews Creek within the Study Area experience natural periods of no flow (HEC, 2020).

Visual inspections prior to the commencement of LW W1 and in December 2019 found that there was no connective overland water flows in Matthews Creek due to the prolonged drought. Most pools were dry with a few pools holding water at low to medium levels.

Cedar Creek

Continuous water level data is available for six sites (CCR, CA, CB, CD, CE and CG) on Cedar Creek for the period November 2018 to November 2019 and at CC1A for the period May 2019 to November 2019.

Water level records for CA, CB and CD monitoring sites were fairly consistent during the monitoring period with subdued small peaks in water level recorded during rainfall periods. The water level at CA remained above the CTF level for the majority of the monitoring period, while the water level at CB and CD remained above the cease to flow level for the entire monitoring period. Sharp increases in water level were recorded at CCR (the most upstream site) and CC1A following rainfall events followed by steep recessions, however, the water level at CCR was below the CTF level for the majority of the monitoring period prior to rising above the cease to flow level following rainfall in late January 2019 and again in March (HEC, 2020). The water level at CE and CG remained above the CTF level for the duration of the monitoring period with small peaks in water level recorded during rainfall periods. A small gradual rise in recorded water level was observed in late autumn 2019 at CE and in winter 2019 at CG in the absence of rainfall.

The water level records indicate increased flow persistence with distance downstream along Cedar Creek (HEC, 2020).

At the commencement of extraction of LW W1, a trickle flow was observed to flow in Cedar Creek at the confluence with Stonequarry Creek. In December 2019, prior to the development of mine subsidence movements, no connective overland water flows were observed in Cedar Creek upstream of the confluence with Matthews Creek due to the prolonged drought. Most pools were dry with a few pools holding water at low to medium levels. Downstream of Matthews Creek, pools in Cedar Creek were full with a trickle flow observed out of the majority of the pools. The sand substrate at the lower reaches of Cedar Creek near the confluence with Stonequarry Creek had no observable flow, though the stream would have been flowing into Stonequarry Creek through the sand. Pools in this section were either dry or at low levels.

Stonequarry Creek

Continuous water level data is available for two sites (SA and SD) on Stonequarry Creek for the period November 2018 to November 2019.

Water level at SA remained above the CTF level for the majority of the monitoring period, declining below the CTF level for the duration of July, for a short period in September and from the beginning of October 2019 to the end of the monitoring period.The water level at SD (located further downstream) more regularly fell below the CTF level, exhibiting rapid responses to rainfall events followed by steeper recessions (HEC, 2020).

Visual inspections have observed a trickle flow continuing over Rockbar SR17, which retains water levels in the long pool SC2 in November and December 2019.

In addition to the monitoring within the Study Area undertaken by Tahmoor Coal, recorded streamflow data is available from a WaterNSW station located on Stonequarry Creek at Picton (GS212053), approximately 5 km downstream of the confluence with Cedar Creek (refer to **Figure 3-1**). The catchment area to the streamflow gauging station is 83 square kilometres. Streamflow has been recorded at the gauging station from November 1990 to December 2019 (i.e. more than 28 years), and indicates that Stonequarry Creek at Picton is near perennial with a non-zero streamflow rate recorded 98.4% of the time, while the flow rate exceeds 0.03 mm/d (2.2 ML/d) approximately 50% of the time (HEC, 2020).

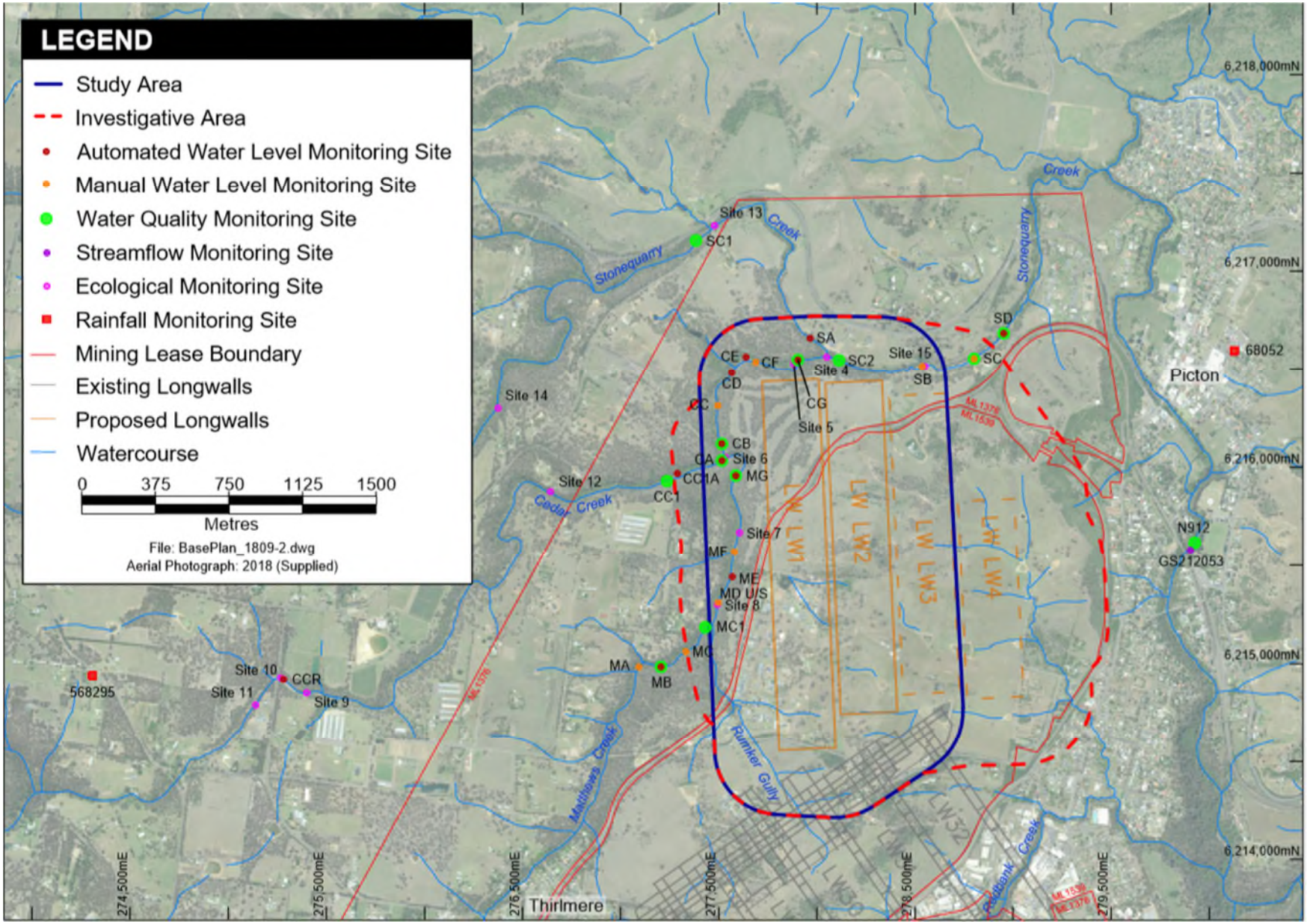


Figure 3-1 Rainfall, Surface Water and Ecological Baseline Monitoring Locations (HEC, 2020)

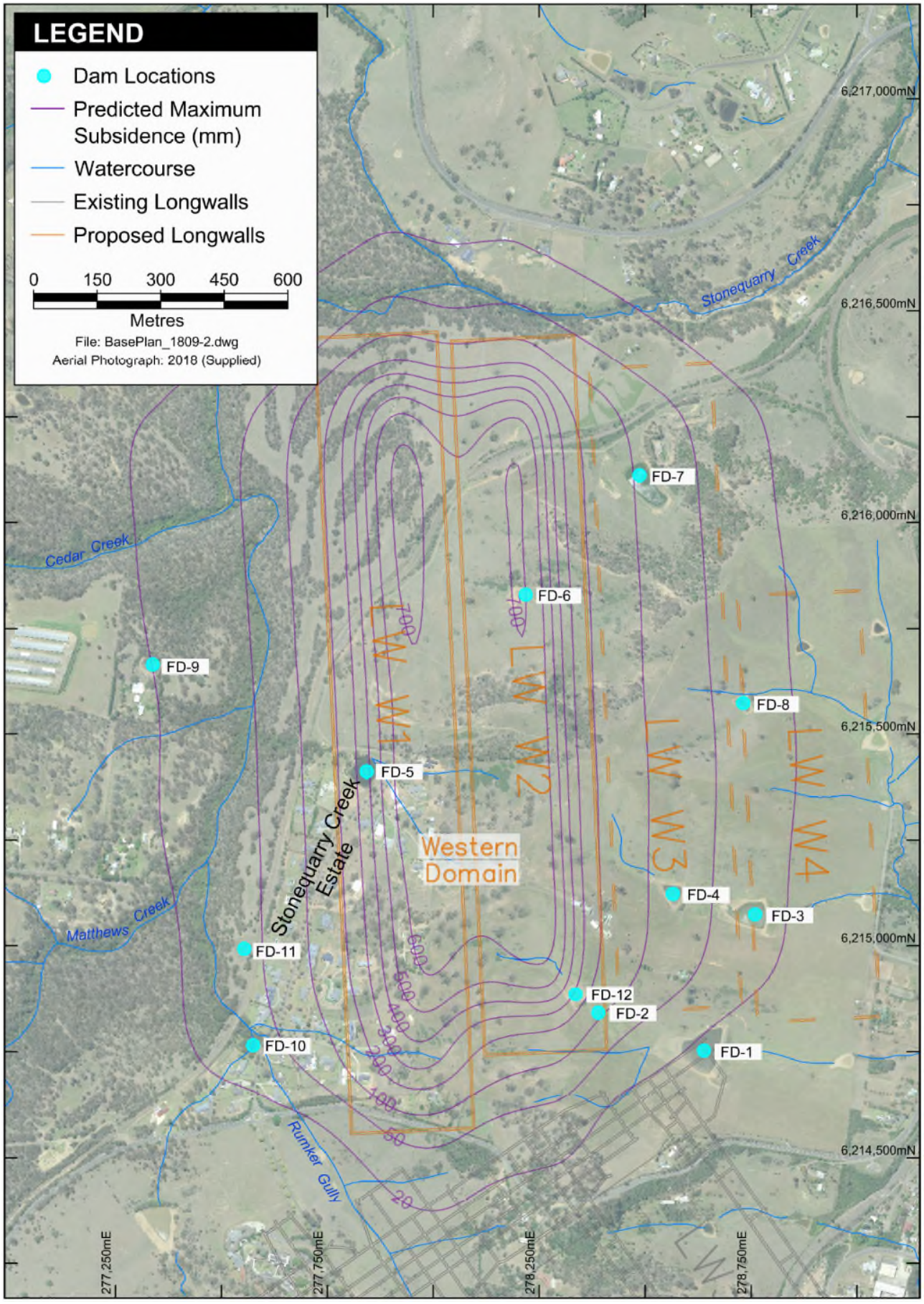


Figure 3-2 Locations of Farm Dams and Predicted Maximum Subsidence (HEC, 2020)

3.1.3 Baseline Data for Surface Water Quality

Baseline 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 and May 2018 (Niche, 2014; and Niche, 2019). A programme of water quality monitoring was commenced by Tahmoor Coal since January 2019 and is planned to continue through and beyond the period of mining of the Western Domain. The location of the monitoring sites is shown in **Figure 3-1**.

The baseline water quality data has been assessed against Australian and New Zealand Guidelines for Fresh and Marine Water Quality (**ANZECC Guidelines**) (ANZECC, 2000) default guideline trigger levels for the protection of Aquatic Ecosystems and Recreational Uses in accordance with the perceived principal beneficial uses of the surface water resources in the area. In NSW, the level of protection applied to most waterways is that for 'slightly to moderately disturbed' ecosystems, for which the ANZECC Guidelines recommend adoption of the 95% protection level trigger values for aquatic ecosystems. The ANZECC Guidelines apply to all parameters excepting nutrients and chlorophyll-a. For nutrients and chlorophyll-a, the Healthy Rivers Commission (HRC, 1998) water quality triggers apply, as specified by the NSW Government in a Statement of Joint Intent (2001) (HEC, 2020).

Detailed information on water quality is provided in the SWTR (HEC, 2020). Below is a summary of water quality trends as observed from the available data for Matthews Creek, Cedar Creek and Stonequarry Creek.

Matthews Creek

Water quality data from Matthews Creek was available from Site 7 and Site 8 (October 2014, November 2017 and April 2018), MC1 (November 2014, and January to November 2019), and MB and MG (January to November 2019) (HEC, 2020).

From this available data, the following water quality trends were observed (HEC, 2020):

- pH – generally within the default guideline trigger range at all sites, although minimum values were slightly below the lower bound default guideline trigger value at each site;
- Electrical Conductivity (**EC**) – the maximum value of EC recorded at MG slightly exceeded the default guideline trigger value, while the median and maximum values of EC at MB and MC1 exceeded the ANZECC default guideline trigger value;
- Dissolved Oxygen (**DO**) – generally below the default guideline trigger range at all sites;
- Total Nitrogen and Total Phosphorus – generally exceeded the default guideline trigger values at MC1, MB and MG for total nitrogen and the maximum concentration of total phosphorus exceeded the default guideline trigger value at all sites;
- Heavy metals – exceedances of the default guideline trigger value for:
  - Total iron at all sites for all samples;
  - Total aluminium for median and maximum concentrations at MC1 and maximum concentrations at MB and MG;
  - Slightly elevated maximum concentrations of total copper at all sites; and
  - Total zinc for most samples at MB and MG and the maximum concentration at MC1.

Cedar Creek

Water quality data from Cedar Creek was available from sampling locations Site 5 and Site 6 (October 2014, November 2017 and April 2018), Site 9 (November 2017 and April 2018), Site 10 (November 2017), Site 11 (November 2017), Site 12 (April 2018), CB and CC1 (November 2014, and January to November 2019), CG (January to November 2019), and CA (April to November 2019) (HEC, 2020).

From this available data, the following water quality trends were observed (HEC, 2020):

- pH – acidic (below the default guideline trigger range) to near neutral (within the guideline trigger range) at all sites;
- EC – generally above the default guideline trigger value at all sites;
- DO – generally below the default guideline trigger range at all sites;
- Total Nitrogen – maximum values exceeded the default guideline trigger concentration at CA, CB and CC1;
- Total Phosphorus – maximum concentration exceeded the default guideline trigger value at CA and CC1;
- Heavy metals – exceedances of the default guideline trigger value for:
  - Median and maximum concentrations of total manganese at all sites;
  - Maximum concentrations of total copper at CB, CC1 and CC1;
  - Total iron at all sites and all samples;
  - Total zinc at CA, CB and CC1 (for all samples and CG (maximum and median concentrations);
  - Total aluminium at CC1 (all samples), CB and CG (maximum concentrations) and CA (median and maximum concentrations); and
  - Total nickel at CB and CC1 (median and maximum concentrations) and CA (maximum concentrations).

Stonequarry Creek

Water quality data from Stonequarry Creek was available from sampling locations SC1, SC2 and SC (November 2014) and Site 4 (October 2014, November 2017 and April 2018), Site 4, Site 14 and Site 15 (November 2017 and April 2018), Site 13 (November 2017), SC1 (January to November 2019), SC2 (January to December 2019) and SC and SD (January to November 2019) (HEC, 2020).

From this available data, the following water quality trends were observed (HEC, 2020):

- pH – slightly acidic (below the default guideline trigger range) at SC1 and near neutral to slightly alkaline at all other sites;
- EC – above the default guideline trigger value at all sites;
- DO – generally below the default guideline trigger range at all sites;
- Total Nitrogen – maximum concentrations exceeded the default guideline trigger value at SC1, SC2 and SD;
- Total Phosphorus – median and maximum concentrations exceeded the default guideline trigger value at SC1, while the maximum concentration exceeded the default guideline trigger value at SC2 and SD;
- Heavy metals – exceedances of the default guideline trigger value for:
  - Total iron at SC2 and SD (median and maximum concentrations), SC (maximum concentration) and SC1 (both samples taken in February and April 2019);

- Total aluminium at SC, SC2 and SD (maximum concentrations) and SC1 (all samples);
- Total zinc at SD and SC2 (median and maximum concentration) and SC1 (all three samples taken in January to April 2019); and
- Total copper at SC2, SC and SD (maximum concentrations) and SC1 (all three samples taken in January to April 2019).

Water quality data monitored by WaterNSW was provided for Stonequarry Creek at Picton (location N912 in **Figure 3-1**) for the period from 2014 to 2019. Water quality data from Stonequarry Creek at Picton was near neutral during the period of data with pH values within the default guideline trigger value range. The median and maximum EC values were greater than the ANZECC default guideline trigger value (350 µS/cm), consistent with EC values recorded at other monitoring sites upstream on Stonequarry Creek. The total nitrogen and total phosphorus concentration exceeded the HRC guideline trigger values in 22% and 16% of the samples respectively. The default guideline trigger value for zinc was exceeded in 5% of samples, total aluminium in 67% of samples, total copper in 19% of samples and total iron in 95% of samples (HEC, 2020).

3.1.4 Surface Water Related Infrastructure

A number of small farm dams and stormwater culverts overlie the predicted subsidence impact area (refer to **Figure 3-2**). This includes twelve farm dams and detention basins within the Study Area. FD-5 and FD-10 appear to be detention basins within the Stonequarry Creek Estate. Of these water features, one detention basin located directly above LW W1 (FD-5) and three dams located directly above LW W2 (FD-2, FD-6 and FD-12).

3.1.5 Aquatic Habitat and Stream Health

The aquatic habitat in creeks within the Study Area consists primarily of pools with moderate riparian and channel health (Niche, 2019). The streams are 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 (HEC, 2020).

The 2014 aquatic habitat survey (Niche, 2014) and 2017-2019 aquatic habitat survey (Niche, 2019) found that the riparian and channel condition of Cedar Creek, Matthews Creek and Stonequarry Creek were in moderate to good condition with the highest rated habitat found in gorges along Matthews and Cedar Creeks. 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 having highly sensitive and moderately sensitive aquatic habitat in 2014 (Niche, 2014). Few fish were caught as part of the fish surveys in 2017 to 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.

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 (HydroSimulations, 2020).

The key hydrogeological units relevant to the Study Area is summarised below (HydroSimulations, 2020):

- 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 and recharged is expected be predominantly from rainfall and peak streamflow events. Alluvial units occur to the east of LW W1-W2 along the lower reaches of Stonequarry Creek and do not intersect the LW W1-W2 mine footprint;
- Wianamatta Formation – composed of shales with poor permeability and water quality, and limited potential as aquifers. This formation is present over the surface of the area occupied by the LW W1-W2 mine footprint;
- 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 over the 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. Hawkesbury Sandstone exhibits a range of salinities (fresh to saline) with a median value of approximately 500 milligrams per litre (**mg/L**) (GeoTerra, 2013); and
- Illawarra Coal Measures – 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 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.

Pre-mining packer test (**Kh**) and core testing (**Kv**) data has been provided in the GTR (HydroSimulations, 2020), and a summary of key points is provided below (HydroSimulations, 2020):

- Variation between measured horizontal core permeabilities compared to the values derived from packer tests. This is not uncommon and is expected because packer tests measure the (local scale) joint and fracture permeability whilst the core data typically measure the host rock mass permeability (i.e. conductivity of the intergranular pore spaces);
- The packer test dataset from Tahmoor Coal suggests a decreasing permeability with depth of the rock mass as a whole; however, the trend seems to be in two parts:
  - Decreasing from the Hawkesbury Sandstone down to the Wombarra Claystone, an apparent step up between Wombarra Claystone and the Bulli Coal seam;

- A further decreasing trend in the units older than the Bulli Coal Seam. There is a weak trend of decreasing matrix permeability with depth observed in the core data;

- The difference in the strength of the trend in the packer and core data is unsurprising, as depth of cover is unrelated to matrix lithology, although this can cause some reduction of intergranular pore space. Depth of cover has more influence on the presence or absence, and the magnitude of open joints and fractures, with more open joints expected at shallower depths;
- The core data set provides a useful lower bound on hydraulic conductivity, however packer tests do not necessarily provide the upper bound, due to the scale at which testing is effective. Pumping tests may, or may not, be able to stress connected joint and fracture networks, leading to higher measured permeabilities; and
- Alluvial hydraulic conductivity has not been measured at or near the site.

3.2.3 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 W1-W2, however, this is approximately five km from LW W1. Due to the distance between the area of proposed longwall extraction and the Thirlmere Lakes it is unlikely that mining-related impacts due to the extraction of LW W1-W2 would have an impact on the groundwater system surrounding these Lakes (HydroSimulations, 2020).

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 (GeoTerra, 2013).

Anthropogenic Use

Several privately-operated and licensed groundwater bores are present to the north and west of LW W1-W2, as identified in the most recent bore census for the Western Domain and surrounding area (GeoTerra, 2019) and illustrated in **Figure 3-3**. These bores include GW024750, GW035844, GW064469, GW072402, GW104090, GW105228, GW105467 and GW105546. The primary usage of these bores is for farming and irrigation, and the bores were constructed between 1968 to 2004. All water extracted at these bores is derived from the Hawkesbury Sandstone aquifer, with yields of up to 2.67 L/s (GeoTerra, 2019). Further details of bore construction details is provided in the Baseline Private Bore Assessment (GeoTerra, 2019).

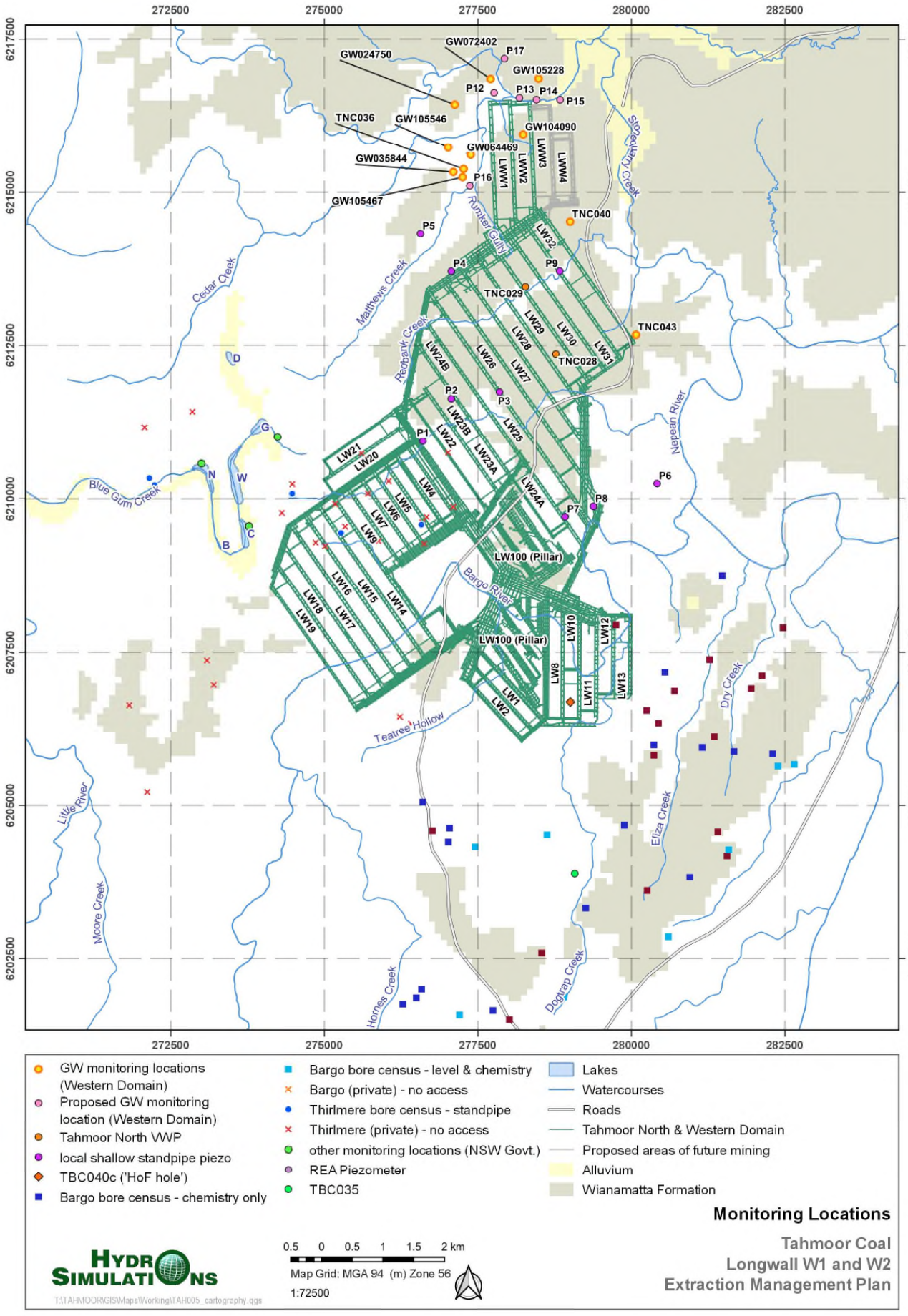


Figure 3-3 Groundwater Monitoring Locations (HydroSimulations, 2020)

3.2.4 Groundwater Levels – Baseline Data

For the purpose of monitoring the subsidence related impacts that may result following the extraction of LW W1-W2 a monitoring network consisting of ten bores has been established as per **Figure 3-3** (HydroSimulations, 2020). These monitoring bores include:

- TNC36 – Multi-level Vibrating Wire Piezometer (**VWP**) located west of LW W1 and Matthews Creek. This piezometer has seven data sensors placed in the Hawkesbury and Bulgo Sandstones at various depths, as well as one in the Bulli Coal Seam;
- TNC40 – Multi-level VMP located south-east of LW W1-W2 and adjacent to LW32. This piezometer originally had eight data sensors positioned within various geology, however a partial failure in February 2019 resulted in the lower four VMP sensors no longer being active (GES, 2019);
- TNC43 – Multi-level VMP located south-east of LW W1-W2 on the eastern side of LW32. This piezometer originally had seven data sensors, however only two sensors are active due to sensor failure in 2018 due to subsidence of LW32;
- P9 – Cluster of shallow open standpipe bores that screen the Hawkesbury Sandstone at three depths. This cluster of bores is located on the northern bank of Redbank Creek. Only the shallower bore is operational;
- P12, P13, P15, P16 - Clusters of open standpipe bores, each cluster screening three depths. These bores are located in the LW W1-W2 Study Area and have all been installed with the exception of P15 due to land access issues;
- P14 – Cluster of open standpipe bores screening four depths. This bore is located in the LW W1-W2 Study Area; and
- One open standpipe bore (P17) with one depth in the LW W1-W2 Study Area, which has been installed.

Further information for each bore is provided in the GTR (HydroSimulations, 2020).

Data from TNC36 has been collected since 2010, however consistent data that appears representative of local groundwater conditions has been collected at the VWP from 2016. Depressurisation is apparent in the Bulli Coal Seam and the lower Bulgo Sandstone (BGSS 412.5) for the period from February 2016 to February 2019. Such declines are not observed in water levels at shallower monitoring locations. The decline in water levels in the lower Bulgo Sandstone and Bulli Coal Seam is likely related to regional drawdown of deeper aquifers due to the cumulative impact of mining at Tahmoor Mine (HydroSimulations, 2020).

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. The greatest declines are observed in the Bulli Coal Seam, with water levels falling by approximately 110 m from May 2016 until February 2019. More than half of this decline (approximately 60 m) occurred from June 2018, in response to recent mine workings, until the bore ceased operating in September 2018. The three uppermost sensors (WNFM 27, HBSS 65 and HBSS 111) do not appear to show influence from mining. Instead these loggers, particularly WNFM 27, show good correlation with the rainfall trend (HydroSimulations, 2020).

A vertical profile of potentiometric head for bore TNC040 showed that the head profiles for this period of 2010 to 2013 in the shallow Wianamatta Shale were the highest before dropping in the Hawkesbury Sandstone and then rising again in deeper strata. Potentiometric heads for the deeper strata in the more recent profiles (2017 to 2019) do not show the same behaviour as the earlier data these loggers reflecting the regional depressurisation of the water table due to mining in other areas of the Tahmoor Mine (HydroSimulations, 2020).

Data from TNC043 has been collected since July 2010. Water levels at HBSS 65 and 111.5 present similar trends to one another, responding well to rainfall. Since the beginning of 2019, water levels at these sensors have dropped sharply, by about 5 m. This decline may be 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 (HydroSimulations, 2020).

The lower stratigraphies at this monitoring location (all BGSS sensors and the Bulli Coal Seam sensor), show higher groundwater heads than those in the Hawkesbury Sandstone, suggesting higher pressures that may result from aquifer confinement. 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 from Tahmoor Mine and possibly due to the Bulli Seam Operations (**BSO**) Mine in Appin (HydroSimulations, 2020).

Data from P9 has been recorded since October 2017, however data collection from the two shallowest monitoring locations (V1 and V2) commenced in May 2018. 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 indicates the water drains from shallowest horizons and recharges a slightly deeper horizon, which correlates with the data from P6.

3.2.5 Historic Groundwater Inflows to Tahmoor North

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 for the period May 2018 to May 2019 is 3.7 ML/d. Average inflows for the previous year were slightly higher at 3.9 ML/d.

3.2.6 Groundwater Quality – Baseline Data

A summary of groundwater salinity data from the private bores discussed in **Section 3.2.3** indicates that water quality at bores within the Hawkesbury Sandstone is generally fresh and suitable for such purposes (HydroSimulations, 2020).

There has been no continuous collection and monitoring of water level or quality data at these bores throughout the history of their use, and therefore a detailed analysis of bore condition cannot be performed. However, a snapshot of current groundwater quality conditions was presented in the recent bore census for four private groundwater bores (GeoTerra, 2019).

Groundwater from the private bores were tested for:

- Physical parameters: pH, EC and TDS;
- Major ions: Na, Ca, K, Mg, Cl, F, SO_4;
- Total phosphorus and total nitrogen;
- Dissolved Organic Carbon (**DOC**);
- Total alkalinity as $CaCO_3$, HCO_3, CO_3; and

- Total and dissolved metals: (As, Cd, Cu, Fe, Pb, Mn, Ni, Se, Zn, Al).

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, 2019):

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

It was noted in the baseline private bore assessment (GeoTerra, 2019) that many bores in the Study Area already have significant iron hydroxide levels.

4 Predicted Subsidence Impacts and Environmental Consequences

4.1 Surface Water

The following sections 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, 2020), as well as a review of past subsidence impacts on surface water resources.

4.1.1 Water Quantity

Potential Impact to Low Flow Regime

MSEC (2019) has assessed 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 mining-induced changes in grade along these creeks are predicted to be negligible, it is unlikely that increased levels of ponding or scouring will be observed. Monitoring of these creeks to assess impacts is proposed (refer to **Section 5.2**) and TARPs have been developed to manage impacts should they occur (refer to **Section 6.3**) (HEC, 2020).

The third order section of Rumker Gully is predicted to experience vertical subsidence of less than 20 mm and as such is not expected to experience measurable conventional tilts, curvatures or strains (MSEC, 2019). Due to the maximum predicted total compressive strain, the third order section of Rumker Gully may experience fracturing and associated reduction in standing water level. However, the maximum predicted total closure is 80 mm in this reach and as such less than 10% of pools are likely to experience impacts (MSEC, 2019).

A maximum total closure of 200 mm is predicted for the first and second order reaches of Rumker Gully. This is expected to occur following mining of LW 32 and minimal additional closure is predicted following mining of LW W1 and LW W2. In the first and second order sections of Rumker Gully, the tributary is ephemeral and has been heavily modified by the development of the Stonequarry Creek Estate. These sections of Rumker Gully do not contain any significant surface water features (i.e. rock bars, pools and aquatic habitat). As such, potential impacts of mining on Rumker Gully are unlikely to have discernible impact with respect to surface water resources and ecosystems as the gully is ephemeral and only flows for short periods of time after significant rainfall.

Minor tributaries located directly above LW W1-W2 may experience the full range of predicted subsidence movements (MSEC, 2019). Mining-induced compression due to valley closure effects may result in dilation and the development of bed separation in the upper strata underlying the tributaries (MSEC, 2019). These 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 minimal change in gradient and as such it is unlikely that there will be increased ponding upstream of the gullies or increased potential for scour and erosion (MSEC, 2019).

The hydrogeological assessment predicts that the height of connected fracturing due to mining of LW W1 and W2 will not extend to the surface (HydroSimulations, 2020). As such, although there may be some temporary loss of flow (diversion) from the surface water systems in the event of cracking, connectivity between the groundwater and surface water systems is not predicted (HydroSimulations, 2020).

Flow diversion occurred in Redbank Creek following mining of Tahmoor North LW 25 to 32, however, the diverted flow was observed to re-emerge downstream of each longwall and no overall loss of streamflow was reported (Tahmoor Coal, 2018). As Stonequarry Creek, Matthews Creek and Cedar Creek will not be directly mined beneath, the subsidence related impacts to streamflow are likely to be less than that observed previously in Redbank Creek as LW 25 to LW 32 directly mined beneath the creek. Nevertheless, monitoring of pool water level and catchment streamflow is proposed (refer to **Section 5.2**) and TARPs have been developed to manage impacts should they occur (refer to **Section 6.3**) (HEC, 2020).

Predicted Impact to 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, 2019). Hydrologic and hydraulic modelling was undertaken to assess the impacts of longwall panels LW W1 and LW W2 on peak flood levels in the three creeks for the 1% Annual Exceedance Probability (**AEP**) and Probable Maximum Flood (**PMF**) events.

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 0.01 m to 0.07 m based on subsidence predictions for the Western Domain. There are no locations where the 1% AEP flood level is predicted to increase following mining. The flood velocity change is predicted to range between an increase of up to 0.02 m/s and a decrease of up to 0.03 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 (HEC, 2020).

The flood study also found that the PMF 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 by up to 1.4 m during the PMF event under existing and post-subsidence conditions. The peak flood level is predicted to decrease by 0.02 to 0.06 m based on subsidence predictions for the Western Domain. There are no locations where the PMF event flood level is predicted to increase following mining. The flood velocity change is predicted to range between an increase of up to 0.02 m/s and a decrease of up to 0.03 m/s. 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 (HEC, 2020).

Predicted Impact to Flood Regime – Local Tributary Gullies

Several tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek overlie the Study Area. A flood study has been undertaken to assess the impacts to flood flows in these tributary gullies due to subsidence within the Study Area (HEC, 2020). Structural and Geotechnical Assessments undertaken for the Tahmoor Mine Extraction Plan LW W1–W2 have identified that the most cost-effective subsidence mitigation measure for sandstone railway culverts in the Study Area is to “sleeve” the masonry structures with concrete pipes – this includes four railway culverts. Installation of these “sleeves” has been included in the assessment.

Table 4-1 presents the estimated 50% AEP and 1% AEP peak flow rates at the downstream end of each tributary catchment. The change in longitudinal gradient for each tributary is also given, with a positive change indicating an increase in gradient based on subsidence predictions and a negative change indicating a decrease in gradient.

Table 4-1 Predicted Tributary Flow Rate and Change in Gradient (HEC, 2020)

Catchment	Tributary	Peak flow rate (m^3/s)		Maximum Predicted Reduction in Ground Level (mm)	Average Change in Tributary Gradient (%)
		50% AEP	1% AEP		
Matthews Creek	Rumker Gully	1.7	19.3	27	-0.01
	Tributary 2 (MC Trib 2)	0.6	7.4	405	-0.10
	Tributary 2a (MC Trib 2a)	0.2	2.4	920	-0.16
Cedar Creek	Tributary 1 (CC Trib 1)	0.8	9.1	940	-0.06
Stonequarry Creek	Tributary 1 (SC Trib 1)	0.5	5.7	500	-0.02
	Tributary 2 (SC Trib 2)	0.04	0.5	190	+0.04

In summary, modelling of 50% AEP and 1% AEP peak flow rates in the minor tributaries likely to be affected by subsidence associated with the Western Domain indicates that peak flood levels should be lower, peak flood depths will increase by a maximum of 0.23 m for the 50% AEP and 0.26 m for the 1% AEP peak flow at MC Trib 2a, while peak flow velocities will increase by a maximum of 0.1 m/s for the 50% AEP and 0.4 m/s for the 1% AEP at MC Trib 2a (HEC, 2020).

The concrete sleeve culverts are predicted to result in a maximum increase in the 1% AEP flood level upstream of the railway of 0.7 m at Rumker Gully, 0.3 m at MC Trib 2, 0.5 m at CC Trib 1 and 1.6 m at SC Trib 1 immediately upstream of the railway culvert. Predicted increased water levels are all well below the top of the railway embankment.

Based on the predicted subsidence associated with the Western Domain and with the concrete pipe sleeves in place, the 50% AEP and 1% AEP peak flood levels for each tributary are predicted to be lower, peak flood depths are predicted to increase by a maximum of 0.35 m for the 50% AEP and 1.6 m for the 1% AEP peak flow immediately upstream of the railway culvert at CC Trib 1. Predicted increased water levels are all well below the top of the railway embankment. Peak flow velocities are predicted to increase by a maximum of 0.5 m/s for the 50% AEP and 1.8 m/s for the 1% AEP immediately downstream of the railway culvert at SC Trib 1.

Potential Impact to Overland Flow

The maximum predicted incremental tilt is 3 mm/m due to mining of LW W1 and 5 mm/m due to mining of LW W2 (MSEC, 2019). The minimum natural gradient overlying LW W1 is 19 mm/m while the minimum natural gradient overlying LW W2 is approximately 29 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 (HEC, 2020).

Potential Impact to Water Supply

As discussed in **Section 2.2**, there are six properties within the Study Area with a Water Supply Works and Water Use Approval. For the surface water systems in which pumping would occur, MSEC (2019) has predicted that less than 10% of pools are likely to experience fracturing and associated reduction in standing water level. As such, while minor impacts to water supply may occur, the potential impacts to water supply should be manageable through implementation of monitoring, mitigation and management measures and through contingency planning.

4.1.2 Surface Water Related Infrastructure

Several stormwater culverts, stormwater detention basins and farm dams are present within the Study Area which may potentially be impacted by subsidence associated with mining in the Western Domain (HEC, 2020).

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 28 was completed by HEC (2019). 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-5 and FD-6 (refer to Figure 3- 2). The maximum total subsidence predicted following the extraction of LW W2 for FD-5 (overlies LW W1) is 625 mm, and for FD-6 (overlies LW W2) is 750 mm. 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, 2020).

The predicted tilt for the farm dams is 5.0 mm/m causing changes in freeboard by a maximum of 140 mm. This small change in freeboard is unlikely to have adverse impacts on the storage capacity of the farm dams (MSEC, 2019).

There are four farm dams located directly above LW W1-W2 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 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, 2019). Based on the low levels of tensile strain, it is unlikely that farm dams will be exposed to significant cracking based on previous mining experience.

The potential impacts on the structural integrity of the dam embankments is addressed further in the Geotechnical Assessment (Douglas Partners, 2019). As the farm dams are located in valleys, the likelihood of development of a flood wave due to topographical features is negligible. Cracking of the top surface may cause breaching of the dam embankment, however, it is unlikely that flooding of adjacent buildings will occur due to the higher elevation of the buildings relative to the dams (Douglas Partners, 2019).

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 W1-W2. Should impacts be reported, a rehabilitation program will be implemented.

4.1.3 Water Quality

Isolated, episodic pulses of reduced pH and increased 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 (EC) and concentrations of dissolved iron, manganese, zinc, sulphate and nickel were observed at monitoring sites in Redbank Creek overlying and downstream of LW 25 to 32 during and shortly following mining. While there were some periodic increases in constituents observed 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 (HEC, 2020). As 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 as LW 25 to LW 32 directly mined beneath the creek (HEC, 2020).

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 along with reduced pH is prevalent in Cedar Creek and may be exacerbated by subsidence induced emergence of ferruginous springs (HEC, 2020).

Water quality monitoring upstream and downstream of mine areas are detailed in **Section 5.2** and TARPs have been developed to assess the need for remediation. Stream remediation measures (refer to **Section 6.2.2**) would be conducted on stream reaches of second order and above where subsidence results in the draining of pools in stream sections between controlling rock bars, where the remediation measures are considered technically feasible.

4.1.4 Aquatic Habitat

MSEC (2019) 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, 2019). 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, 2019).

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, 2014).

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, 2014).

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, 2014).

If gas releases occur into the water column, there is insufficient time for substantial amounts of gas to dissolve into the water column (MSEC, 2014). Rare and isolated dieback of riparian vegetation has been reported in the Southern Coalfields due to release of gas emissions to the atmosphere (DoP, 2008). However, gas emissions have not been observed in streams or pools above mining at Tahmoor Colliery (Tahmoor Colliery, 2013) and are not expected to be observed following mining of LW W1-W2 (HEC, 2020).

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 HydroSimulations (2020) utilising a numerical groundwater model that has simulated the progressive extraction of LW W1-W2. Two scenarios of the numerical groundwater models were run to assess the influence the extraction of LW W1-W2 will have on the regional groundwater system. Model scenario A predicted groundwater response to the proposed extraction of LW W1-W2, while scenario B presents the results for groundwater behaviour without the extraction of LW W1-W2 but including the remainder of the historical and approved Tahmoor Mine. A comparative assessment of the results from each of these model runs isolates the impact of LW W1-W2 on the groundwater system in this region (HydroSimulations, 2020).

A summary of the model design is included in the GTR (HydroSimulations, 2020), and full details are provided in the HydroSimulations (2018) report.

The following sections provide a summary of the potential groundwater impacts based on the outcomes of the model. Detailed descriptions of potential groundwater impacts are provided in the GTR (HydroSimulations, 2020).

4.2.1 Groundwater Take (Direct)

From the simulated groundwater inflows to LW W1-W2, inflow to LW W1-W2 is expected to lie in the range of 0.1 ML/d to 2.2 ML/d, with the greatest inflow predicted during the extraction of LW W1. This generates on average an additional 0.7 ML/d of inflow to the rates predicted for the mine in the scenario without the extraction of LW W1-W2 being simulated (HydroSimulations, 2020).

4.2.2 Loss of Flow in Streams

'Baseflow capture' is 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 (HydroSimulations, 2020).

Incremental effects from the extraction of LW W1-W2 are predicted to cause baseflow loss from Redbank Creek and Stonequarry Creek. As reported in the table below, this loss is predicted to be 0.0015 ML/d and 0.004 ML/d respectively. The predicted loss from Stonequarry Creek represents cumulative baseflow depletion as it receives water from upstream tributaries. The cumulative losses for all watercourses as a result of approved Tahmoor North extraction along with the proposed extraction at LW W1-W2 are also included in Table 4-2. The incremental losses due to LW W1-W2 for Redbank Creek and Stonequarry Creek represent 3.1% and 1.7% accordingly of the maximum estimated cumulative baseflow loss from these watercourses.

Table 4-2 Flow depletion at nearby watercourses

Watercourse	LW W1-W2 incremental effect		Tahmoor Coal Mine Cumulative Impacts	
	Best estimate Max. (ML/d)	Best estimate Max. (ML/yr)	Best estimate Max. (ML/d)	Best estimate Max. (ML/yr)
Matthews Creek	-	-	0.033	12
Cedar Creek	-	-	0.017	6
Redbank Creek	0.0015	0.5	0.049	18
Stonequarry Creek	-	-	0.042	15
Stonequarry Creek accumulated total	0.004	1.4	0.230	52

The groundwater model prepared for the GTR has since been revised in order to satisfy conditions for the Tahmoor South Amended Project Report (submitted 13 January 2020). As a result of this revision new estimates have become available for the predicted maximum loss from streams. The results have been reported in a letter report prepared by SLR (SLR, 2019). These revised baseflow loss estimates have been reported according to the relevant management zones as per the surface water WSP. Both Stonequarry Creek and Cedar Creek fall within the Stonequarry Creek Management Zone. From this the maximum take from the Stonequarry Creek Management Zone is estimated to be 0.035 ML/d, with the maximum loss occurring over the period 2051-2060. This estimate considers cumulative impacts from approved and proposed mining at Tahmoor North and the Western Domain (including LW W3-W4). The revised modelling provides lower estimates of baseflow loss than what was provided by the modelling performed for the groundwater technical report (HydroSimulations, 2020; and Table 4-2 above).

4.2.3 Groundwater Drawdown

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 (HydroSimulations, 2020).

Groundwater Table

An assessment of the extent of groundwater drawdown was conducted in the GTR in order to understand the extent of incremental lowering of the regional groundwater table that will occur as a result of the extraction of LW W1-W2. This information will assist in the prediction of potential impacts to 'water supply works', as required by the AI Policy, as well as providing a basis to develop groundwater triggers (HydroSimulations, 2020).

The model showed that the extraction of LW W1-W2 has little to no effect on the regional pressure head, especially in comparison to the depressurisation simulated to have occurred at the BSO Mine to the east of LW W1-W2. The incremental water table drawdown is expected to be contained to the area within and adjacent (maximum distance of 180 m from edge of panel) to LW W1-W2 and is within the range of 2 to 10 m. Drawdown within the Bulli Coal Seam is predicted to occur radially around LW W1-W2. Maximum drawdown of 400-500 m is predicted to occur within the longwall footprint. The 2 m drawdown contour extends approximately 1 km beyond the edge of LW W1-W2 (HydroSimulations, 2020).

Drawdown was calculated for each model layer as predicted for the centre of LW W2. Marginal drawdown (<1 m) is predicted for the lower Hawkesbury Sandstone (model layer 3) compared to the ~5 m predicted to occur in the upper Hawkesbury (model layer 1). This difference is likely to be a result of the changes in hydraulic parameters simulated to occur as a result of surface cracking in the upper layer (HydroSimulations, 2020).

Additional drawdown for the Bulgo Sandstone and Bulli Coal Seam in areas to the south-east of the longwalls adjacent to longwalls recently extracted by Tahmoor Coal is estimated to be approximately 18 and 35 m respectively. Simulated water levels in both model scenarios for the Hawkesbury Sandstone are predicted to the almost the same (HydroSimulations, 2020).

In the area north of LW W1-W2, the extraction of LW W1-W2 is expected to have an additional ~20 m of drawdown in the Bulgo Sandstone, and a further ~100 m in the Bulli Coal Seam. This area currently experiences regional drawdown as a result of mining in other areas of Tahmoor Mine (HydroSimulations, 2020).

The results indicate that the areas in immediate vicinity of LW W1-W2 will experience the greatest impacts from the extraction of LW W1-W2 (HydroSimulations, 2020).

Private bores

An assessment of maximum predicted drawdown was completed in the GTR (HydroSimulations, 2020) to predicted the potential impacts to the relevant private bores (**Figure 3-3**). Maximum and cumulative drawdown were predicted for the private bores.

It is noted that the AI Policy (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 W1-W2) drawdown in excess of 2 m is only predicted to occur at GW104090, with a maximum incremental drawdown of 2.9 m. This is expected as this bore directly overlies LW W2. The remaining bores are all predicted to experience a maximum drawdown within the range of 1.0 to 1.8 m. (HydroSimulations, 2020).

The cumulative impacts of LW W1-W2, along with current and historic mining, at the Tahmoor Mine are predicted to cause drawdown in excess of 2 m at six of the eight private bores. The greatest predicted drawdown is expected to occur at GW024750 and GW104090, with estimates of 8.4 and 7.6 m respectively. However, drawdown experienced at GW024750 will be inconsequential because the borehole has collapsed. The four remaining bores with drawdown in excess of 2 m are predicted to experience drawdown in the range of approximately 3.5 to 5 m (HydroSimulations, 2020).

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 (HydroSimulations, 2020).

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 (HydroSimulations, 2020).

Tahmoor Coal has committed to ‘make good’ provisions for any groundwater users shown to be adversely affected by mine operations and associated impacts (HydroSimulations, 2020).

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 W1-W2 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 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 W1-W2 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 and consistent with DPIE's view, as expressed in Section 3 of the Extraction Plan Approval (second last bullet point under the sub-heading titled "High-order streams".

The 600 m Study Area for Natural Features (refer to **Figure 1-2**) was defined in the Extraction Plan for LW W1-W2 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.

It is anticipated that the above performance measures will be achieved during and after mining of LW W1-W2.

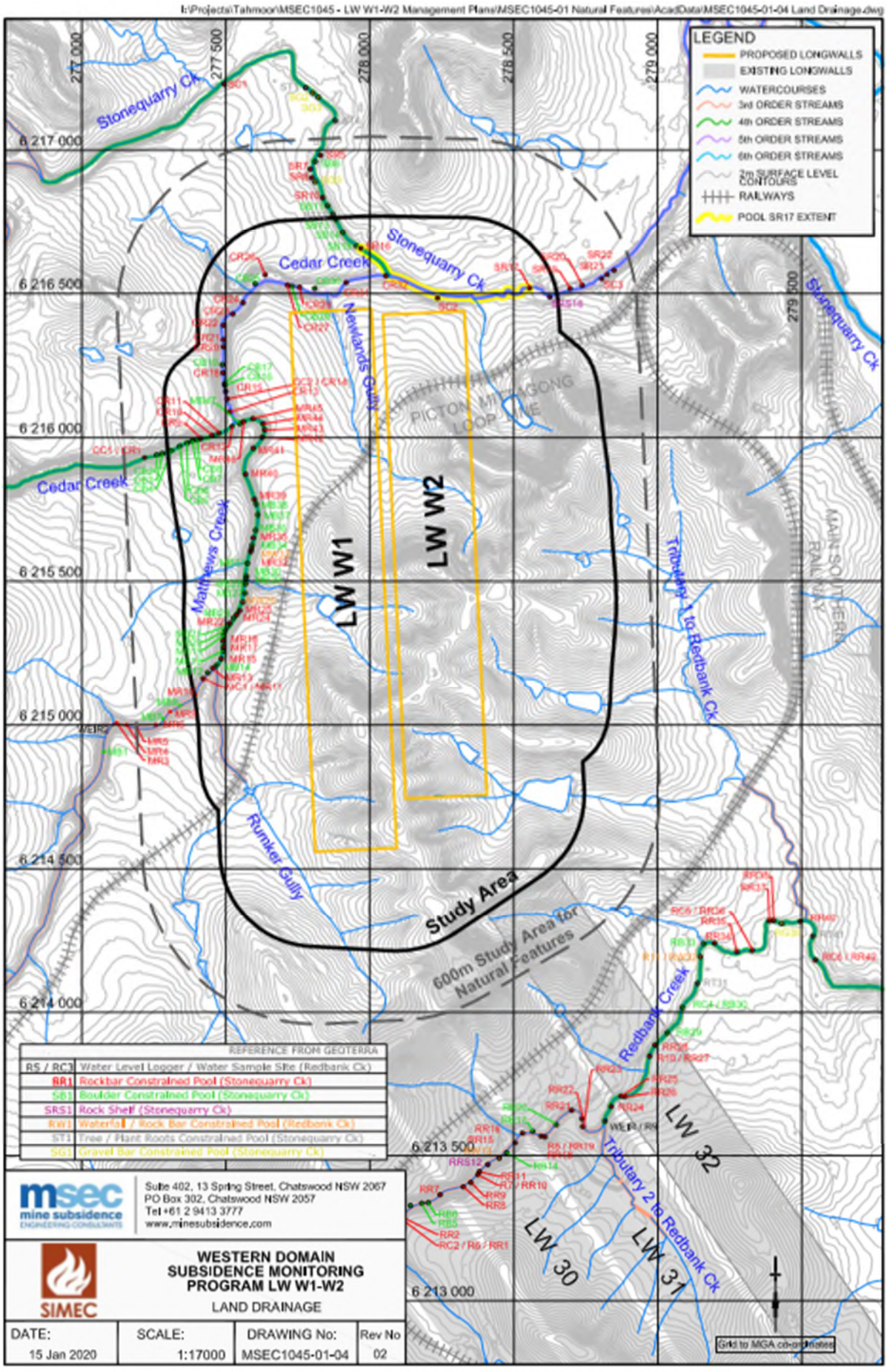


Figure 5-1 600 m Study Area for Natural Features and pools of interest (provided by MSEC)

5.2 Monitoring Program

A monitoring program for surface water and groundwater resources has been compiled in **Table 5-3**, and the locations of monitoring sites are illustrated in **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 W1-W2 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. LW W1 commenced extraction on 15 November 2019. As described in Section 3.1.2, 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 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 millimetres (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 W1-W2; 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-monthly 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.

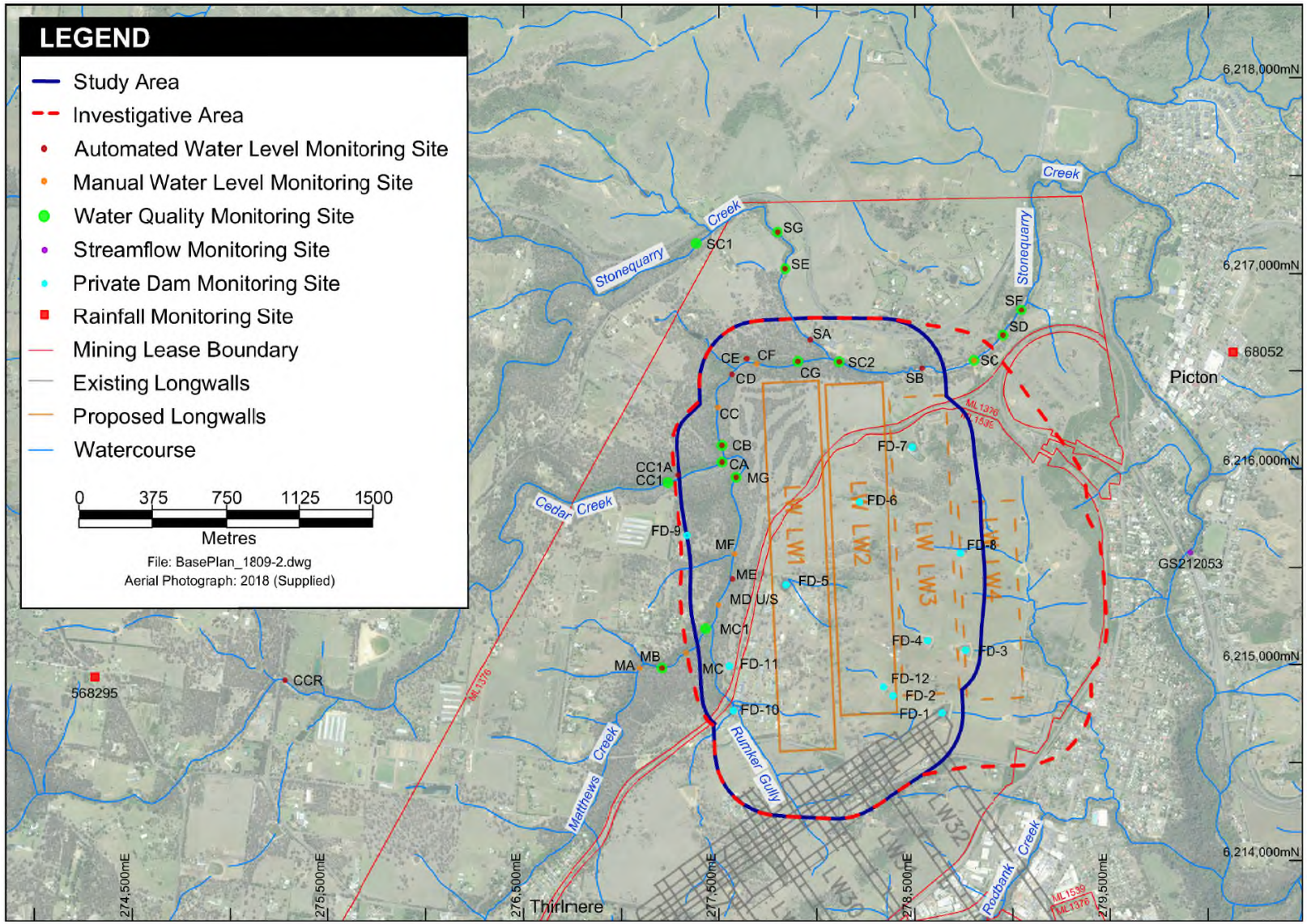


Figure 5-2 Surface Water Monitoring Plan (provided by HEC)

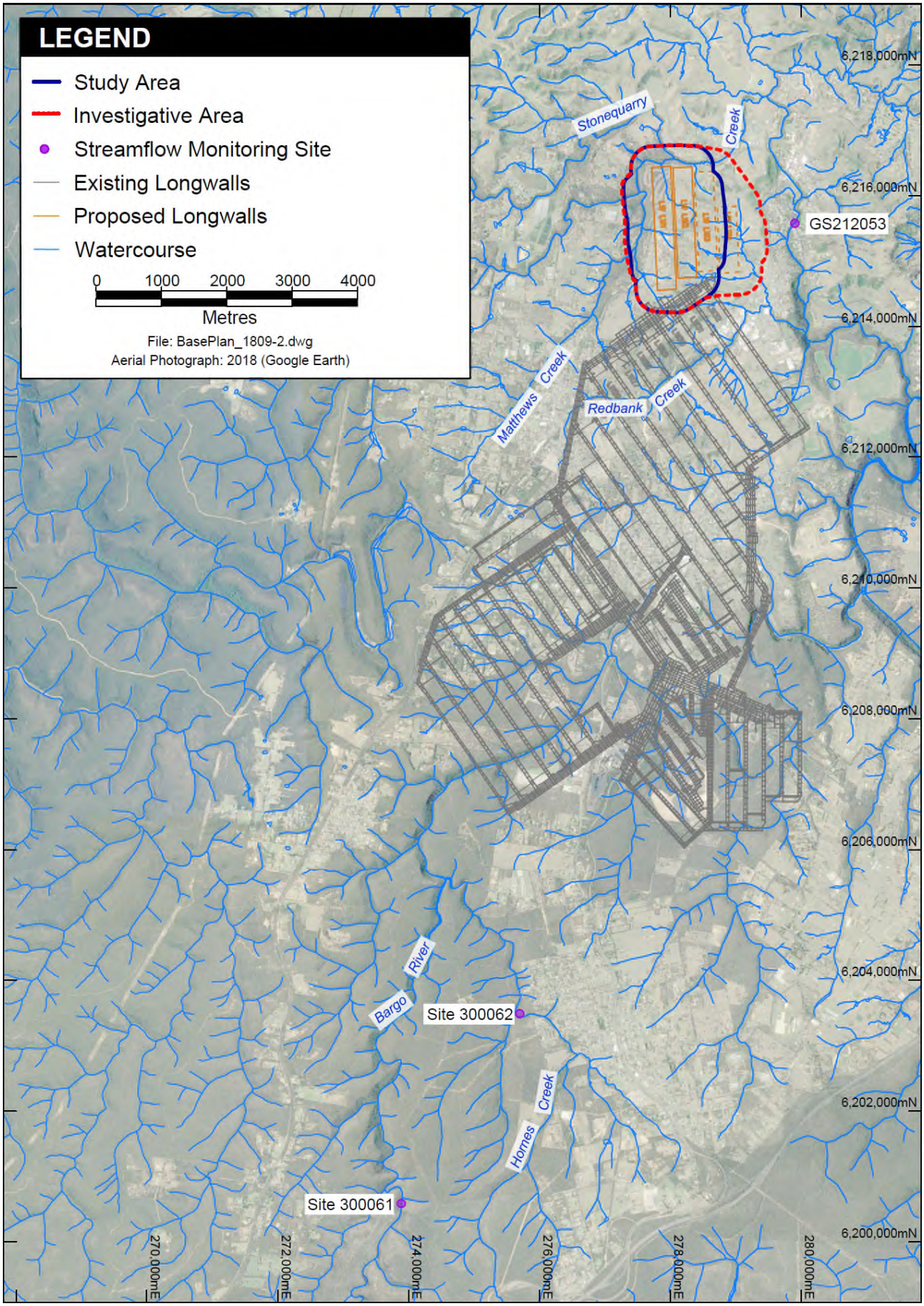


Figure 5-3 Regional Flow Monitoring Plan (provided by HEC)

5.2.1 Water Quality Parameters

Table 5-2 outlines the water quality parameters as required for surface water and groundwater quality monitoring outlined in **Table 5-3**.

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; and • Total and dissolved metals: Al, As, Ba, Cu, Pb, Li, Mn, Ni, Se, Sr, 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; • Dissolved Organic Carbon (DOC); • Total alkalinity as CaCO3, HCO3, CO3; and • Total and dissolved metals: (As, Cd, Cu, Fe, Pb, Mn, Ni, Se, Zn, Al).

5.2.2 Additional Monitoring for Groundwater

In addition to the monitoring measures in **Table 5-3**, the following groundwater monitoring has been recommended by HydroSimulations (2020):

1. Hydraulic conductivity or permeability testing via packer and core testing is conducted at many of the bores drilled at Tahmoor Mine. This practice should continue, and results recorded in a database. This should include a record of whether testing occurs in a 'pre-mining' or 'post-mining' environment, to assist in the understanding of how longwall subsidence affects strata permeability. In order to gain data on the pre-mining conditions in the strata surrounding LW W1-W2, three bores, with up to ten VWPs in each, should be installed within the centre of panel and in the chain pillar between the longwalls. These holes should be packer tested prior to mining. These bores should be installed by the end of 2019, however, this will be subject to obtaining Land Access Agreements. Following mining it is proposed that additional holes should be drilled and packer tested to assess permeability; and
2. Height of groundwater depressurisation should be completed through the drilling of one additional bore (two in total) within the longwall footprint of both LW W1 and LW W2. These bores should have piezometers installed under both pre- and post-mining conditions to monitor groundwater depressurisation in the subsurface and should be used to assess or verify predictions. This is consistent with guidance by IEPMC (2018). Additionally, a bore should be drilled above the chain pillar to monitor depressurisation between the panels.

With regards to recommendation 1, Tahmoor Coal has been prevented from completing the recommended bores due to land access.

With regards to recommendation 2, Tahmoor Coal is currently proposing to install a borehole close to the centreline of LW W2 to determine height of groundwater depressurisation as a result of LW W1-W2 extraction. This borehole (drilled both pre-mining and post-mining) will provide pre-mining and post-mining goaf centreline bore data, including defect count, permeability and groundwater level response.

The pre-mining borehole at this location has been installed, and the post-mining borehole will be constructed after the majority of subsidence has finished. Geophysical investigations, packer testing and the installation of multi-string Vibrating Wire Piezometers (VMPs) have / 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.

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	• Bureau of Meteorology (**BoM**) Station 68052 (Picton Council Depot)[1] • WaterNSW stations 568295 (Lakesland Road), 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes)[2] • Additional automatic rainfall stations to be installed (including Stonequarry Creek catchment, Picton to Mittagong rail corridor and additional locations depending on land owner access agreements)	Data recorded daily and downloaded monthly (other than Stonequarry Creek catchment station).	Data recorded daily and downloaded monthly.	Data recorded daily and downloaded monthly 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).
Streamflow	Impact Assessment Site: • WaterNSW gauging station GS212053 (Stonequarry Creek at Picton)2 – streamflow only (refer to Figure 5-2) Control Sites: • Bargo River upstream (300061)[3] • Hornes Creek (300062)[3]	Continuous record. Data downloaded at start of mining.	Continuous record. Data downloaded monthly.	Continuous record, data downloaded monthly 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).
Automated Pool Water Level	Tahmoor Coal automated pool level sites (refer to **Figure 5-2**) Impact sites: • Cedar Creek (CA, CB, CD, CE and CG) • Matthews Creek (ME, MG) • Stonequarry Creek (SA, SB, SC2) Control sites: • Cedar Creek (CCR, CC1A)	Continuous record. Data downloaded at start of mining. Baseline data recorded since October 2018 in the Western Domain (excluding SC2 and SB).	Continuous record. Data downloaded fortnightly at site MG (during LW W2 extraction) and monthly for all other monitoring locations.	Continuous record. Data downloaded monthly 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).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
	• Matthews Creek (MB) • Stonequarry Creek (SD, SE, SF and SG)			
Manual Pool Water Level	Tahmoor Coal manual pool water level sites (refer to **Figure 5-2**): Impact sites: • Cedar Creek (CC, CF) • Matthews Creek (MC, MD U/S (upstream), MF) Control sites: • Matthews Creek (MA) • Stonequarry Creek (SC)	Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 in the Western Domain.	Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points.	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).
Stream Water Quality	Tahmoor Coal sites (refer to Figure 5-2): Impact sites: • Cedar Creek (CA, CB, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD and SF) Control sites: • Cedar Creek (CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE and SG)	Monthly sampling and analysis for 12 months prior to secondary extraction (refer to **Section 5.2.1** for parameters) [4]. Baseline data was recorded at some site during 2014 and all sites since January 2019.	Monthly sampling and analysis (refer to **Section 5.2.1** for parameters).	Monthly sampling and analysis 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, and **Section 5.2.1** for parameters).
Stream and Riparian Vegetation	As per Biodiversity Management Plan.	As per baseline monitoring.	Bi-annually (first occurring in Spring 2019).	Bi-annually (Spring and Autumn for 3-5 years).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
Private Dams	Impact sites: • FD-1 to FD-12 as shown in **Figure 5-2**[5]	Dam embankment integrity and water level observation every month for at least two months immediately prior to undermining using fixed location photo points. Pre-mining inspections commenced in November 2019.	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 W2. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Impacts to natural drainage behaviour (channel and bank stability)	Impact sites: • Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area as illustrated in **Figure 5-1**. Control sites: • Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area as illustrated in **Figure 5-1**.	Observations prior to mining using fixed location photo points. Baseline data first recorded in 2014, and in November 2019 prior to mining.	Observations every fortnight for Pool MR45 and every month for all other pools during active subsidence period (after 200 m of secondary extraction of LW W1-W2) by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1000 m of extraction of LW W1-W2 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 W2. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Flood levels[6]	• 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.	None, though subsidence surveys will 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.

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
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	Groundwater bores (refer to **Figure 3-3**) Impact sites: • P9, P12, P13, P14, P16 Control sites: • P17	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 W2. 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 3-3**) Control sites: • Private groundwater bores GW72402, GW105228, GW105467, 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). Baseline data was first collected in 2014, and further data was collected in March and April 2019.	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 W2. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Groundwater Level	Groundwater bores (refer to **Figure 3-3**) Impact sites: • P9, P12, P13, P14, P16 Control sites: • P17	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 fortnightly for P12 and monthly for all other bores.	Minimum continuous 24-hourly readings with monthly logger download and dip meter 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).

Feature	Monitoring Component / Location	Monitoring		
		Prior to Mining	During Mining	Post Mining
	Groundwater bores (refer to **Figure 3-3**) Control sites: • Private groundwater bores GW72402, GW105228, GW105467, 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). Baseline data was first collected in 2014, and further data was collected in March and April 2019.	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 W2. This period may be extended as per the decision by the Environmental Response Group (refer to **Section 5.2** for further details).
Groundwater Pressure	Groundwater bores/VWPs (refer to **Figure 3-3**). Impact sites: • TNC36 and proposed bore to be drilled (refer to Section 5.2.2). Control sites: • Groundwater bores/VWPs TNC40 and TNC43 (refer to Figure 3-3).	Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since 2010.	Minimum continuous 24-hourly readings with logger download completed fortnightly for TNC36 and monthly for all other bores.	Minimum continuous 24-hourly readings with monthly logger download 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).

NOTES:

[1] Refer http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=68052

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

[3] Site 300061 is located on the Bargo River and Site 300062 is located on Hornes Creek (refer **Figure 5-3**).

[4] Only field analysis undertaken for SF and SG.

[5] Pending negotiation of access with landholder.

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

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 the preparation of the Extraction Plan for LW W3-W4. Monitoring data collected during the mining of LW W1-W2 would be used in the review of observed subsidence impacts for future Extraction Plans.

The waterways that will be affected by LW W3-W4 will primarily be Stonequarry Creek and tributaries of Redbank Creek.

A brief review of the adequacy of established water quality and pool water level monitoring sites to support the LW W3-W4 Extraction Plan was completed. With regards to Stonequarry Creek, it was identified that there are sufficient monitoring sites located upstream of potential impacts (e.g. SC1, SE, CC1, MB), within the impact zone (e.g. SC2, SC), and downstream of potential impacts (e.g. SD, GS212053, N912) along Stonequarry Creek and the connecting creeks of Cedar Creek and Matthews Creek to provide an understanding of impacts to Stonewater Creek quality and pool water levels as a result of mining.

The proposed location of LW W3-W4 will be upstream of Redbank Creek. Monitoring for surface water quality and pool water levels is ongoing along Redbank Creek at a number of sites as part of mining and post-mining monitoring for Longwalls 32 and previous longwalls. This includes site RC6 (coordinates 279542mE, 6214187mN in GDA94 Zone 56) which is located downstream of the confluence of an unnamed tributary (3rd order tributary flowing south from the Western Domain) and Redbank Creek. Site RC6 will provide a monitoring location downstream of LW W3-W4. However this is not an ideal downstream monitoring site as the site will be impacted by urban development and has been impacted by previous longwall extraction.

The establishment of monitoring locations along tributaries upstream of Redbank Creek in the Western Domain will be problematic due to their intermittent flow nature and poor watercourse definition. A monitoring location (coordinates 279420mE, 6214737mN in GDA94 Zone 56) downstream of the confluence of two tributaries and upstream of the majority of Picton urban development will be investigated for water level and water quality monitoring. However, it is noted that this site may not be suitable as a monitoring site due to the poor watercourse definition of the tributaries.

5.3.2 Groundwater Baseline Monitoring

As indicated in **Table 5-3,** 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.

6 Subsidence Management Strategies

6.1 Mine Design Considerations

Tahmoor Coal submitted a Subsidence Management Plan Application (**SMP Application**) for Longwalls 31 to 37 (LW31-37) in the Bulli Coal Seam in December 2014, which included longwalls in the Western Domain. The current mine plan is a revision of this SMP Application mine plan, which was reviewed based on many factors including feedback received from the community following submission of the SMP Application in 2014 and additional information gathered from underground conditions, which influenced the orientation of the proposed longwalls (MSEC, 2019). The current mine design has been designed specifically in response to the sensitive surface features of the environment in order to avoid significant impact. 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 through the extraction of LW W1-W2 in the Western Domain, north of the previously extracted longwall series. The proposed LW W1-W2 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the currently active 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, 2019) 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 predictions indicate a virtually unchanged flood extent in the existing and post-subsidence conditions with no predicted increase in flood level. A maximum increase in flow depth over Stonequarry Creek Road of 0.04 m is predicted to occur for the 1% AEP flood event based on predicted post-subsidence conditions. The predicted increase is within the bounds of model accuracy and is considered to be negligible. As such, it is not anticipated that access to Stonequarry Creek Road will be measurably impacted during a 1% AEP flood event and access routes during a 1% AEP flood event are expected to be retained for pre and post-mine conditions.

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 Council 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, stream remediation measure may be required. These measures would be detailed in a Corrective Management Action Plan 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 Proposed 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.

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 Corrective Management Action Plan (CMAP), which will be prepared in consultation with the NSW DPIE Resources Regulator.

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 Sections 7.1 and 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, negotiations will be undertaken between the mine, landowner and Subsidence Advisory 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 determined 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 on an annual basis to compare actual and predicted groundwater levels and/or drawdowns and groundwater inflows to the mine.

This process will also serve to validate predictions from the numerical groundwater model against contemporary monitoring data in order to assess the performance and on-going reliability of model predictions.

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 W1-W2 mining (refer to **Appendix A**). Where performance indicators indicate that a level of risk has been triggered greater than a normal level (Levels 2, 3 and 4 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 **Table 24** of the SWTR (HEC, 2020).

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 Corrective Management Action Plan is required in accordance with the TARP, this plan will be prepared in accordance with **Section 3.6.3** of the Extraction Plan Main Document. The success of remediation measures that has been implemented for any TARP exceedance would be reviewed as part of any Corrective Action Management Plan, the Annual Review (refer to **Section 6.1.5** of the Extraction Plan Main Document), and the End of Panel Report for each longwall.

6.5 Adaptive Management Strategies

6.5.1 LW W2 Setback from Stonequarry Creek

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 W1.

As described in this Water Management Plan, Tahmoor Coal has 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. A review of relevant observations will be undertaken after the LW W1 face has mined a sufficient distance such that the majority of mining-induced movements have occurred at the commencing end of LW W1 (after approximately 1,000 m of extraction).

If impacts to streams are greater than anticipated, Tahmoor Coal will consider amending the commencing position of LW W2 to further reduce the potential for impacts on streams within the 600 m Study Area for Natural Features, in particular pool SR17.

A similar review will be undertaken during the extraction of LW W2 prior to confirming the commencing position of future longwalls, which will be detailed in the next Extraction Plan.

Adaptive Management Process

As required by Condition 5(c) of the LW W1-W2 Extraction Plan approval conditions, 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. This process is also illustrated in **Figure 6-1.**

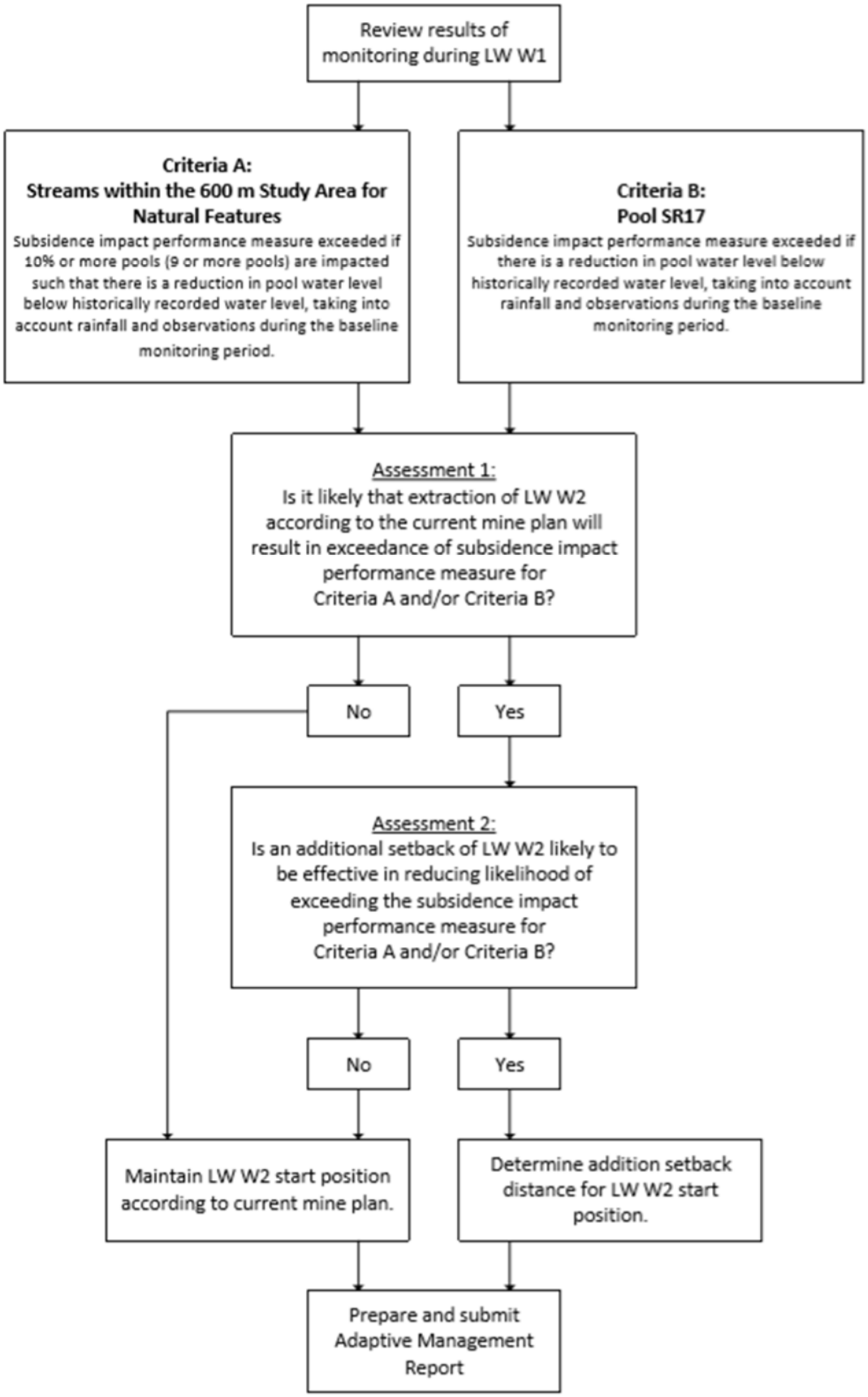


Figure 6-1 Adaptive Management Strategy decision flowchart

Review and assess results of monitoring during LW W1

A review of monitoring results during the extraction of LW W1 will be undertaken as part of the Adaptive Management Strategy. The review will be incremental, in the sense that new information will be collected and reviewed on a regular basis (e.g. monthly) as mining occurs. Additional investigations and other actions may be considered and implemented based on the findings of the ongoing reviews.

Once the length of extraction of LW W1 exceeds than approximately 1,000 m, it is expected that vertical subsidence will have approached maximum levels above LW W1 and rates of change in ground movements in the valleys located around the commencing end of LW W1 will have reduced to low levels. Whilst mine subsidence movements will continue to develop as mining progresses, it is expected that sufficient information will 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 can be used to definitively guide the outcome of the Adaptive Management Strategy. However, key considerations as a minimum to be reviewed include:

- 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 will be 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 W1, 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 will be completed. This comparison will also consider recorded pre-mine (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 associated rockbar.

The relevant results will be assessed, and a determination made regarding whether the current start position of LW W2 is 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.

Determination of setback (if required)

If it is determined that the current position of LW W2 is likely to result in an exceedance of the subsidence impact performance measure for stream and/or pool SR17, detailed analysis will be undertaken to determine if setback of LW W2 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 will be determined. This process would be completed by re-generating the subsidence model for LW W2 to include observed LW W1 subsidence measurements, and generating potential subsidence predictions for defined incremental setbacks from the streams and pool SR17.

As required by Condition 6 of the LW W1-W2 Extraction Plan approval conditions, Tahmoor Coal will then submit an Adaptive Management Report for approval to the Secretary of DPIE at least 2 months prior to the commencement of extraction of Longwall W2. The details of this reporting are discussed further in **Section 7.1**.

Adaptive Management Report Outcomes

Tahmoor Coal completed a review of observations of subsidence impacts and environmental consequences as a result of mining the first 1,000 m of LW W1 in July 2020. This review was to determine whether additional setback for the commencing end of LW W2 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 W2 was not proposed.

DPIE confirmed on 7 September 2020 that, based on the Adaptive Management Report, there was no reason to impose a further setback distance of LW W2 from nearby creek lines. However, to provide additional safeguards, DPIE requested amendments to monitoring frequencies during the extraction of LW W2. These requests are addressed in Table 5-3 of this document.

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. An assessment of pre- and post-mining permeability data collected from LW W1 as outlined in Section 5.2.2 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 ERG 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 W1-W2 are discussed in the Extraction Plan Main Document.

7.1 Reporting Requirements

Generic reporting requirements for the LW W1-W2 Extraction Plan are discussed in Section 6.1 of the Extraction Plan Main Document.

As required by Condition 6 of the LW W1-W2 Extraction Plan approval conditions, Tahmoor Coal will submit an Adaptive Management Report for approval to the Secretary of DPIE at least 2 months prior to the commencement of extraction of Longwall W2. Extraction of LW W2 will not commence until Secretary's approval has been granted, in accordance with Condition 7 of the LW W1-W2 Extraction Plan approval conditions.

The Adaptive Management Report will include a summary of the following information:

- Tahmoor Coal's performance under the LW W1-W2 Extraction Plan and approval;
- Implementation of the revised Water Management Plan TARP; and
- Outcomes of the adaptive management strategy discussed in **Section 6.5**. If additional setback is proposed for the commencing position of LW W2, the report will include details of this setback. If no additional setback is proposed for the commencing position of LW W2, the report will include detailed justification with reference to observed and predicted impacts.

As required by Condition 5(a) of the LW W1-W2 Extraction Plan approval conditions, Tahmoor Coal will include a review of the performance measures detailed in Table 5-1 in the Annual Report following the completion of each longwall. This review will enable Tahmoor Coal to monitor compliance with the performance measures for Stonequarry Creek, Cedar Creek and Matthews Creek as set out in Condition 1 of the LW W1-W2 Extraction Plan approval conditions.

7.2 Review and Auditing

Generic review and auditing requirements for the LW W1-W2 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 W1-W2.

7.3 Roles and Responsibilities

Generic roles and responsibilities applicable for the implementation of the LW W1-W2 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 W1-W2.

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

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy, Paper No. 4. Volume 1. The Guidelines, Chapter 1-7.

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

Department of Planning (DoP) (2008), Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield: Strategic Review, State of New South Wales through the NSW Department of Planning.

Douglas Partners (2019), Report on Geotechnical Assessment, Extraction Plan Longwall West 1 and West 2, prepared for Tahmoor Coal.

GeoTerra (2013), Tahmoor South – Shallow groundwater baseline monitoring. Report for Tahmoor Coal, document BAR3 – R1A.

GeoTerra (2014), Longwall Panels 31 to 37 Streams, Dams and Groundwater Assessment. Prepared for Tahmoor Colliery, document TA25-R1A.

GeoTerra (2019), Longwall West 1 and West 2 Baseline Private Bore Assessment, prepared for Tahmoor Coal, document TA36-R1A.

Groundwater Exploration Services [GES] (2019), TNC40 – Vibrating Wire Piezometer Partial Failure, 6th February 2019.

Healthy Rivers Commission (HRC) (1998), Independent inquiry into the Hawkesbury Nepean River system: final report August 1998 / Healthy Rivers Commission of New South Wales, Sydney, Healthy Rivers Commission of New South Wales.

Hydro Engineering & Consulting (2018), Tahmoor South Project Surface Water Baseline Study. Report prepared for Tahmoor Coal Pty Ltd, November.

Hydro Engineering & Consulting (2020), Tahmoor Mine Extraction Plan LW W1-W2 – Amended Surface Water Technical Report, prepared for Tahmoor Coal, document J1809-2_R1f v5.

HydroSimulations (2018), Tahmoor South Project EIS: Groundwater Assessment. Report HS2018/52 for Tahmoor Coal Pty. Ltd., December 2018.

HydroSimulations (2020), Tahmoor Mine LW W1-W2 Extraction Plan: Groundwater Technical Report, prepared for Tahmoor Coal, document HS2019/14.

IEPMC (2018), Initial report on specific mining activities at the Metropolitan and Dendrobium coal mines. 12 November 2018. Available via http://www.chiefscientist.nsw.gov.au/reports/independent-expert-panel-for-mining-in-the-catchment.

Mine Subsidence Engineering Consultants (2014), Tahmoor Colliery, Longwalls 31 to 37, Subsidence Predictions and Impact Assessments for Natural and Built Features in Support of the SMP Application, Report No. MSEC647, Revision A, December 2014.

Mine Subsidence Engineering Consultants (2019), Tahmoor Coking Coal Operations – Longwalls W1 and W2, Subsidence Predictions and Impact Assessments for Natural and Built Features due to the Extraction of the Proposed Longwalls W1 and W2 in Support of the Extraction Plan Application. Prepared for Tahmoor Coal, May 2019, document MSEC1019.

NHMRC (2011), Australian Drinking Water Guidelines, published by National Health and Medical Research Council, latest publication May 2019.

Niche (2014), Tahmoor North Longwalls 31 to 37 Aquatic Ecology Assessment. Prepared for Tahmoor Colliery, December.

Niche (2019), Aquatic Ecology Baseline Monitoring Report – Tahmoor North Western Domain (2017-2019). Prepared for Tahmoor Coal.

NSW Government (2001), Statement of Joint Intent for the Hawkesbury-Nepean River System.

NSW Government (2012), Aquifer Interference Policy. September 2012.

NSW Office of Water (NOW) (2011a), Report Card for the Nepean Sandstone Groundwater Source.

NSW Office of Water (NOW) (2011b), Water Sharing Plan – Greater Metropolitan Regional Groundwater Sources: Background Document. http://www.water.nsw.gov.au/__data/assets/pdf_file/0005/548105/wsp_metro_groundwater_background.pdf

NSW Office of Water (NOW) (2011c), Water Sharing Plan – Greater Metropolitan Regional Unregulated River Water Sources: Background Document. http://www.water.nsw.gov.au/__data/assets/pdf_file/0003/548058/wsp_metro_surface_water_background.pdf

SCT (2018), Redbank Creek Shallow Groundwater Investigation, Report for SIMEC Mining, doc TAH4909, December 2018.

SLR (2019), Tahmoor Coal Mine Surface Water Licencing Advice, Prepared for SIMEC Mining (Internal Use), November 2019.

Tahmoor Colliery (2013), Environmental Management Plan- Longwalls 27 to 30, Revision D, Tahmoor Coal Pty Ltd.

Tahmoor Coal (2015), Tahmoor Underground Plan for Groundwater Management Plan. Prepared for Tahmoor Coal, December 2015.

Tahmoor Coal (2018). Redbank Creek Corrective Management Action Plan, December.

WRM (2019), Matthew Creek Flood Impact Study for LW W1-W2, Prepared for Tahmoor Coking Coal Operations, May 2019, document 1072-05-B1.

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
AI Policy	NSW Aquifer Interference Policy
ANZECC Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
BoM	Bureau of Meteorology
BSO	Bulli Seam Operations mine (Appin)
CTF	Cease to flow
CMAP	Corrective Management Action Plan
DO	Dissolved Oxygen
DOC	Dissolved organic carbon
DoI-Water	NSW Department of Industry Water (formerly Office of Water, DPI Water, CL&W)
DoP	NSW Department of Planning (former)
DPE	NSW Department of Planning and Environment
EC	electrical conductivity
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
GES	Groundwater Exploration Services
GDE	groundwater dependant ecosystems
GFG	GFG Alliance
GTR	Groundwater Technical Report
HRC	Healthy Rivers Commission
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

Abbreviation	Definition
NOW	NSW Office of Water
NRAR	NSW Natural Resources Access Regulator
NSW	New South Wales
OEH	NSW Office of Environment & Heritage
PMF	Probable Maximum Flood
PUR	Polyurethane
ROM	run of mine
SIMEC	SIMEC Mining Division
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 (for underground coal mines)
TDS	total dissolved solids
TCCO	Tahmoor Coking Coal Operations
VWP	Vibrating Wire Piezometers
WAL	Water Access Licence
WMP	Water Management Plan
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	July 2019	Ron Bush	New document.
2.0	January 2020	Zina Ainsworth	Update as required by LW W1-W2 Extraction Plan approval conditions.
3.0	March 2020	Zina Ainsworth	Update with feedback from government agencies.
4.0	October 2020	Zina Ainsworth	Updates to include additional monitoring requirements for LW W2 as required by Adaptive Management Plan approval conditions.

Appendix A – Trigger Action Response Plan

Trigger Action Response Plan - Water Management Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Downstream reduction in catchment flow rate in Stonequarry Creek at Picton Gauging Station (GS212053)	RAINFALL **Locations** • Bureau of Meteorology (BoM) Station 68052 (Picton Council Depot) • WaterNSW stations 568295 (Lakesland Road), 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes) • Additional automatic rainfall stations to be installed (including Stonequarry Creek catchment, Picton to Mittagong rail corridor and additional locations depending on land owner access agreements) **Frequency** Pre-mining – Data recorded daily and downloaded monthly (other than Stonequarry Creek catchment station). During mining - Data recorded daily and downloaded monthly and used in analysis as outlined in the methodology for streamflow below. Post mining - Data recorded daily and downloaded monthly 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). STREAMFLOW **Locations** Impact Assessment site – WaterNSW gauging station GS212053 (Stonequarry Creek at Picton) Control sites - Bargo River (Site 300061) and Hornes Creek (Site 300062)†. Locations illustrated in Figure 5-3 of the Water Management Plan. **Frequency** Pre-mining – Continuous record, data downloaded at start of mining; data from the end of mining of LW25 (21/2/2011) has been used to calibrate a pre-mining streamflow model. The period from 21/2/2011 to the commencement of secondary extraction from LW W1 is the baseline data period. During mining - Continuous record, data downloaded monthly and analysed six monthly to compare monitored to model predicted flows as follows: 1. Monitored flows will be filtered in order to assess only low flows (flows > 0.24 ML/d [mean flow] will be set to modelled flows); 2. Filtered monitored flows will be summed to give 14 day totals for comparison with corresponding 14 day totals of predicted flow from the catchment model. The ratio of filtered, monitored flows divided by the modelled flows will be calculated at 14 day intervals commencing at the beginning of the baseline data period and advancing to the end of the assessment period. The median of the ratios will be analysed over a sliding window of 1 year. Post mining - Continuous record, data downloaded monthly 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 median of the ratios **does not fall below** the 40th percentile* of the baseline data at GS212053 (refer to Table 1 for baseline ratios).	• Continue monitoring as per monitoring program. • Six monthly review and assessment of data.	• No response required.
		Level 2		
		• The median of the ratios falls below the 40th percentile but **does not fall below** the 20th percentile* of the baseline data at GS212053 (refer to Table 1 for baseline ratios).	• Continue monitoring as per monitoring program. • Six monthly review and assessment of data. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response.	• As defined by Environmental Response Group.
		Level 3		
		• The median of the ratios **falls below** the 20th percentile* of the baseline data at GS212053 (refer to Table 1 for baseline ratios). AND • A similar trend **has occurred** at the control sites†.	• Continue monitoring as per monitoring program. • Six monthly review and assessment of data. • Convene Tahmoor Coal Environmental Response Group to review possible cause and response.	• As defined by Environmental Response Group. • Consider increasing review of data to monthly. • Undertake the analysis of monitored flow rate versus modelled flow in control catchments†. Filtered monitored flows at the control sites will be summed to give 14 day totals for comparison with corresponding 14 day totals of predicted flow from catchment models for these sites (calibrated for the baseline data period).
		Level 4		
		• The median of the ratios **falls below** the 20th percentile* of the baseline data at GS212053 (refer to Table 1 for baseline ratios). AND • A similar trend **has not occurred** at the control sites†.	• Continue monitoring as per monitoring program. • Increase review and assessment of data to monthly. • 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.	• Continue monitoring and monthly assessment (until assessment indicates that the trigger is no longer occurring or it can be established whether the effect is mining related). • Report to DPIE 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 then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Footnotes:

* The 40th and 20th percentiles of the baseline data have been adopted for each trigger level. The 20th percentile is an accepted metric of a significant variation from 'normal' conditions while the 40th percentile represents a slight deviation from the median or 'normal' conditions. As such, the range between the 40th percentile and the 20th percentile represents a slight deviation from 'normal' conditions to a significant variation from 'normal' conditions. Refer to Table 1 for baseline ratios.

† The control sites will include as a minimum the Bargo River (Site 300061) and may include other sites upstream of the impacts of longwall mining.

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, SB, SC2) Control sites: • Cedar Creek (CCR, CC1A) • Matthews Creek (MB) • Stonequarry Creek (SD, SE, SF and SG) **Frequency** Pre-mining – Continuous record, data downloaded monthly. Baseline data recorded since October 2018 in the Western Domain (excluding SC2 and SB). During mining - Continuous record, data downloaded fortnightly at site MG (during LW W2 extraction) and monthly for all other monitoring locations.. Post mining - Continuous record, data downloaded monthly 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). 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 dropped below** the previously recorded minimum level (in one 24 hour period for automated pool water level) (refer to Table 2 for baseline minimum recorded water level).	• Continue monitoring as per monitoring program. • Six monthly review of data.	• No response required.
		Level 2		
		• The recorded water level **has dropped below** the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 2 for baseline minimum recorded water level). AND • The above **has occurred** at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools **has not noted** any mining related impacts.	• Continue monitoring as per monitoring program. • Six 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 dropped below** the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 2 for baseline minimum recorded water level). AND • The above **has occurred** at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools **has noted** mining related impacts.	• Continue monitoring as per monitoring program. • Six monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing review of data to monthly.
		Level 4		
		• The recorded water level **has dropped below** the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 2 for baseline minimum recorded water level). AND • Similar behaviour **has not occurred** at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools **has noted** mining related impacts.	• Continue monitoring as per monitoring program. • Increase review of data to monthly. • 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.	• Report to DPIE 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 then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impact to pool level, natural drainage behaviour or overland connected flow	VISUAL INSPECTIONS **Locations** Impact sites - Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area as illustrated in Figure 5-1 of the Water Management Plan. Control sites - Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area as illustrated in Figure 5-1 of 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 fortnight for Pool MR45 and every month for all other pools during active subsidence period (after 200 m of secondary extraction of LW W1-W2) by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed (refer to triggers in Level 4). Post mining - Observations 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 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). AND • Visual monitoring of pools **has not noted** any mining related impacts.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• Rock bar and/or stream base cracking, or gas release, or increased iron precipitation **noted** during visual inspection. 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. • 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.	• As defined by Environmental Response Group. • Consider increasing inspection and reporting frequency to fortnightly for sites where Level 3 has been reached.
		Level 4		
		There appear to be impacts to natural drainage behaviour such that: • **Visually observed** reduction in pool water level, drainage or overland connected flow. AND • The above change **has not occurred** at one of the upstream pools (beyond mining effects).	• Continue monitoring as per monitoring program. • 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 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 then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

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

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impacts to dams	PRIVATE DAMS **Locations** Impact sites - FD-1 to FD-12 as shown in Figure 5-2 **Frequency** Pre-mining - Dam embankment integrity and water level observation every month for at least two months immediately prior to undermining using fixed location photo points. Pre-mining inspections commenced in November 2019. During mining - 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. 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 (other than natural desiccation cracking).	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data.	• No response required.
		Level 2		
		• **Development** of small isolated cracks developed within dam wall <5 cm (other than natural desiccation cracking).	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• **Development** of cracking within dam wall > 5 cm (other than natural desiccation cracking) and isolated in nature.	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing to weekly monitoring by geotechnical engineer during active subsidence period.
		Level 4		
		• **Development** of cracking within dam wall > 5 cm (other than natural desiccation cracking) and non-isolated in nature. • **Reduction** in water holding capacity compared to baseline, taking into account climatic conditions; or cracking causing embankment instability.	• Weekly monitoring by geotechnical engineer during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs where necessary. • Reduce dam water level by at least half dam volume, pending land access and land owner consent.	• 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, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD and SF) Control sites: • Cedar Creek (CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE and 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. Analysis is to comprise comparison of pH, EC and specific dissolved metals: manganese, nickel, zinc and iron recorded at sites within mining effects and at control (upstream) sites. The value at a given site (within mining effects) is to be compared with the corresponding control (upstream) site(s), and at the site itself, mean plus two standard deviations‡ using the full period of data for the control (upstream) sites. For each surface water system: • Matthews Creek MC1 and MG results are to be compared with results from MB; • Cedar Creek CB and CG results are to be compared with combined results from MB and CC1; • Stonequarry Creek SC2, SC and SD are to be compared with combined results from MB, CC1, SC1 and SE. Post mining - Monthly sampling and analysis 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 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 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), or at the site itself, mean minus two standard deviations (i.e. the sample becomes more acidic) for more than two consecutive months OR the value rises above corresponding control (upstream) site(s), or at the site itself, 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), or at the site itself, 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), or at the site itself, mean plus two standard deviations for more than two consecutive months.	• Continue monitoring as per monitoring program. • 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. • 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 W1-W2 mining effects (e.g. whether there has been subsidence induced cracking upstream), other catchment changes, unrelated pollution or the prevailing climate.	• Report to DPIE 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 then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE 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 3-3) Impact sites – P9, P12, P13, P14, P16 Control sites - P17 **Frequency** Pre-mining - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters). Baseline data available since May 2019. During mining - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters). Post mining - Field water quality and laboratory analysis monthly (refer to Section 5.2.1 for parameters) 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). GROUNDWATER QUALITY – Private groundwater bores **Locations** (refer to Figure 3-3) Control sites - GW72402, GW105228, GW105467, and GW105546 and any other private bores where access is negotiated with landholder. **Frequency** Pre-mining - Field water quality (EC, pH) and iron staining. Pre-mining testing completed during bore census (GeoTerra, 2019). Baseline data was first collected in 2014, and further data was collected in March and April 2019. During mining - Field water quality and laboratory analysis on a 3-monthly basis (refer to Section 5.2.1 for parameters). Post mining - 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 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 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. • Conduct review of data to confirm whether water level reduction is not caused by climatic or anthropogenic impacts. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group. • Consider increasing monitoring frequency at monitoring bores where Level 3 has been reached to fortnightly, and private groundwater bores where Level 3 has been reached to a more regular timeframe than ordinarily monitored as per negotiations with the landholder. Consider increasing review of data to fortnightly.
		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 level is determined **not to be controlled** by climatic or anthropogenic factors.	• Continue monitoring and review as per monitoring program or at revised frequency decided under Level 3 TARP response. • 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 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 a corrective management action plan for the site in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP). • For private groundwater bores: If it is concluded that there has been a mining-related impact, then implement a corrective management action plan for the bore in accordance with the make good provisions (Section 6.2.4 of the Water Management Plan) in consultation with the affected landholder.

Footnote:

* Baseline variability is to be defined as soon as practicable after the commencement of extraction in the Western Domain using representative pre-mining data collected at each bore.

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Groundwater Levels at monitoring bores and private groundwater bores.	GROUNDWATER LEVEL – Monitoring bores **Locations** (refer to Figure 3-3) Impact sites – P9, P12, P13, P14, P16 Control sites - P17 **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download and dip meter. Baseline data available since May 2019. During mining - Minimum continuous 24-hourly readings with logger download and dip meter completed fortnightly for P12 and monthly for all other bores. Post mining - Minimum continuous 24-hourly readings with monthly logger download and dip meter 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). GROUNDWATER LEVEL – Private groundwater bores **Locations** (refer to Figure 3-3) Control sites - GW72402, GW105228, GW105467, and GW105546 and any other private bores where access is negotiated with landholder. **Frequency** Pre-mining - Standing Water Level (where available) and yield data. Pre-mining testing completed in bore census (GeoTerra, 2019). Baseline data was first collected in 2014, and further data was collected in March and April 2019. During mining - Manual monitoring (flow rate and, where available, standing water level) on a 3-monthly basis. Post mining - Manual monitoring (flow rate and, where available, standing water level) 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**		
		• Groundwater level **remains consistent** within baseline variability and/or pre-mining trends, with reductions in groundwater level not persisting after significant rainfall recharge events.	• Continue monitoring program. • Ongoing review of water level data.	• No response required.
		Level 2		
		• Up to 2 m water level **reduction** over a period of up to 3 months following the commencement of extraction at LW W1. Groundwater level rise in response to significant rainfall recharge event is observed. AND/OR • The reduction in water level is determined **to be controlled** by climatic factors or local bore usage for private water supply bores.	• 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		
		• Up to 2 m water level **reduction** over a period of up to 3 months following the commencement of extraction at LW W1. Negligible water level rise in response to a significant rainfall recharge event. AND/OR • 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. • Conduct review of data to confirm whether water level reduction is not caused by climatic or anthropogenic impacts. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by the Environmental Response Group. • Consider increasing monitoring frequency at monitoring bores where Level 3 has been reached to fortnightly, and private groundwater bores where Level 3 has been reached to a more regular timeframe than ordinarily monitored as per negotiations with the landholder. Consider increasing review frequency to fortnightly.
		Level 4		
		• Greater than 2 m water level **reduction** for a period greater than 3 months. AND • Water level (for a specific depressurisation event) **does not return** to within 1 m of the pre 'event' level (or trend occurring prior to the 'event') after 6 months of the 'event'. 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 or at revised frequency decided under Level 3 TARP response. • 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 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 a corrective management action plan for the site in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP). • For private groundwater bores: If it is concluded that there has been a mining-related impact, then implement a corrective management action plan for the bore in accordance with the make good provisions (Section 6.2.4 of the Water Management Plan) in consultation with the affected landholder.

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Shallow Groundwater Pressures at VWPs TNC036, TNC040, and TNC043.	GROUNDWATER PRESSURE **Locations** Impact sites – TNC36 and proposed bore to be drilled (refer to Section 5.2.2). Control sites - Groundwater bores/VWPs TNC40 and TNC43 (refer to Figure 3-3). **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since 2010. During mining - Minimum continuous 24-hourly readings with logger download completed fortnightly for TNC36 and monthly for all other bores. Post mining - Minimum continuous 24-hourly readings with monthly logger download 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 observable** mining induced change at VWP intakes located at or above 200 m depth.	• Continue monitoring program. • Ongoing review of water level data.	• No response required.
		Level 2		
		• Up to 5 m water level **reduction** in VWP intakes located at or above (i.e. shallower than) 200 m depth over a period of up to 3 months following the commencement of extraction at LW W1. Groundwater level rise in response to significant rainfall recharge event is observed. AND/OR • The reduction in water level is determined **to be controlled** by climatic factors.	• 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		
		• Up to 5 m water level **reduction** in VWP intakes located at or above (i.e. shallower than) 200 m depth over a period of up to 3 months following the commencement of extraction at LW W1. Negligible response following a significant rainfall recharge event. AND/OR • The reduction in water level is determined **not to be controlled** by climatic or anthropogenic factors.	• Continue monitoring program • Ongoing review of water level data. • Conduct review of data to confirm whether water level reduction is not caused by climatic or anthropogenic impacts. • 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		
		• Greater than 5 m water level **reduction** in VWP intakes located at or above (i.e. shallower than) 200 m depth for a period greater than 3 months. AND • Water level (for a specific depressurisation event) **does not return** to within 5m of the pre 'event' level (or trend occurring prior to the 'event') after 6 months of the 'event' in VWP intakes located at or above 200 m depth. 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 or at revised frequency decided under Level 3 TARP response. • 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 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, then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Deep Groundwater Pressures at VWPs TNC036, TNC040, and TNC043.	GROUNDWATER PRESSURE **Locations** Impact sites – TNC36 and proposed bore to be drilled (refer to Section 5.2.2). Control sites - Groundwater bores/VWPs TNC40 and TNC43 (refer to Figure 3-3). **Frequency** Pre-mining - Minimum continuous 24-hourly readings with monthly logger download. Baseline data available since 2010. - Minimum continuous 24-hourly readings with monthly logger download. During mining - Minimum continuous 24-hourly readings with logger download completed fortnightly for TNC36 and monthly for all other bores.. Post mining - Minimum continuous 24-hourly readings for 12 months after LW W2 completed. Monthly logger downloaded 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		
		• 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 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, then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

The baseline ratio of monitored to modelled flows for each trigger level proposed to assess the downstream reduction in catchment flow rate in Stonequarry Creek at Picton Gauging Station (GS212053) are presented Table 1. As specified in Table 1, the 40th and 20th percentiles of the baseline data have been adopted for each trigger level. The 20th percentile is an accepted metric of a significant variation from 'normal' conditions while the 40th percentile represents a slight deviation from the median or 'normal' conditions. As such, the range between the 40th percentile and the 20th percentile represents a slight deviation from 'normal' conditions to a significant variation from 'normal' conditions.

Table 1 Baseline Ratio of Monitored to Modelled Flow

Surface Water System	Adjusted Baseline Ratio of Monitored to Modelled Flow	
Stonequarry Creek at Picton (GS212053)	20th Percentile	0.52
	40th Percentile	0.79

Table 2 Baseline Minimum Recorded Water Level

Surface Water System	Monitoring Site	Minimum Recorded Water Level (m AHD)*
Matthews Creek	MB	219.048
	ME	201.313
	MG	189.057
Cedar Creek	CC1A	0.668 (m)
	CA	180.448
	CB	178.872
	CD	172.822
	CE	171.709
	CG	170.345
Stonequarry Creek	SA	167.799
	SD	160.285

Footnote:
* Subject to additional baseline data acquisition for the period prior to non-negligible subsidence from LW W1.

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 W1-W2

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	✓	-	✓	-	-	-
MR8	✓	-	✓	-	MC	-
MB9	✓	-	✓	-	-	-
MR10	✓	-	✓	-	-	-
MR11	✓	MR11	✓	-	-	MC1
MB12	✓	-	✓	-	-	-
MR13	✓	MR13	✓	-	-	-
MB14	✓	-	✓	-	-	-
MR15	✓	-	✓	-	-	-
MB16	✓	MR16	✓	-	-	-
MR17	✓	-	✓	-	-	-
MR18	✓	-	✓	-	-	-
MB19	✓	-	✓	-	-	-
MB20	✓	MB20	✓	-	-	-
MB21	✓	-	✓	-	MD U/S	-
MR22	✓	MR22	✓	-	-	-
MB23	✓	-	✓	-	-	-
MR24	✓	-	✓	-	-	-
MR25	✓	MR25	✓	-	-	-
MW26	✓	-	✓	-	-	-
MB27	✓	-	✓	ME	-	-
MB28	✓	-	✓	-	-	-
MB29	✓	-	✓	-	-	-
MB30	✓	MB30	✓	-	-	-
MB31	✓	-	✓	-	MF	-
MR32	✓	MR32	✓	-	-	-
MW33	✓	-	✓	-	-	-
MB34	✓	-	✓	-	-	-
MR35	✓	-	✓	-	-	-
MB36	✓	-	✓	-	-	-
MB37	✓	-	✓	-	-	-

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
MB38	✓	-	✓	-	-	-
MR39	✓	MR39	✓	-	-	-
MR40	✓	-	✓	-	-	-
MR41	✓	MR41	✓	MG	-	MG
MR42	✓	MR42	✓	-	-	-
MR43	✓	MR43	✓	-	-	-
MR44	✓	MR44	✓	-	-	-
MR45	✓	-	✓	-	-	-
MR46	✓	-	✓	-	-	-
Cedar Creek Road	-	CCR	-	CCR	-	-
CR1	✓	-	✓	-	-	CC1
CB2	✓	CB2	✓	-	-	-
CB3	✓	-	✓	CC1A	-	-
CB4	✓	-	✓	-	-	-
CB5	✓	CB5	✓	-	-	-
CB6	✓	-	✓	-	-	-
CB7	✓	-	✓	-	-	-
CB8	✓	-	✓	-	-	-
CR9	✓	-	✓	-	-	-
CR10	✓	-	✓	-	-	-
CR11	✓	CB11	✓	CA	-	CA (TBA)
CR12	✓	-	✓	-	-	-
CR13	✓	CR13	✓	-	-	-
CR14	✓	-	✓	CB	-	CB
CR15	✓	-	✓	-	-	-
CB16	✓	-	✓	-	-	-
CB17	✓	-	✓	-	-	-
CR18	✓	-	✓	-	-	-
CB19	✓	CB19	✓	-	-	-
CR20	✓	CR20	✓	-	CC	-
CR21	✓	-	✓	-	-	-
CR22	✓	-	✓	-	-	-
CR23	✓	CR23	✓	-	-	-
CR24	✓	-	✓	CD	-	-
CB25	✓	-	✓	CE	-	-
CR26	✓	CR26	✓	-	CF	CF
CR27	✓	CR27	✓	-	-	-

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
CB28	✓	-	✓	-	-	-
CR29	✓	-	✓	-	-	-
CB30	✓	CC01	✓	-	-	-
CR31	✓	CC02 CC03 CC04	✓	CG	-	CG
CR32	✓	-	✓	-	-	-
SC1	-	-	-	-	-	SC1
ST1	-	-	✓			
SG2	-	-	✓			
SG3	-	-	✓	SG	-	SG
ST4	-	-	✓			
SR5	✓	-	✓	SE	-	SE
SB6	✓	-	✓			
SR7	✓	-	✓			
SR8	✓	SQ01	✓			
SG9	✓	-	✓			
SR10	✓	-	✓			
SB11	✓	-	✓			
ST12	✓	SQ02	✓			
SB13	✓	-	✓			
SB14	✓	-	✓			
SB15	✓	-	✓	SA	-	-
SR16	✓	-	✓			
SR17	✓	SQ03 to SQ13 lines Rockbar SR17 3D GNSS Sites 12 to 13	✓	SB and SC2	SB	SC2
SRS18	✓	-	✓			
SR19	-	-	✓			
SR20	-	-	✓			
SR21	-	-	✓	-	-	SC
SR22	-	-	✓			
SD Pool	-	-	✓	SD	-	SD
SF Pool	-	-	✓	SF	-	SF