Tahmoor Colliery
Longwalls 24 to 26

NATURAL FEATURES

SURFACE SAFETY AND SERVICEABILITY MANAGEMENT PLAN

REVISION H

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GENERAL

AUTHORISATION OF SURFACE SAFETY AND SERVICEABILITY MANAGEMENT PLAN

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Date:	4 August 2008

REVIEW

Date	**Rev**	**Comments**
10-Mar-06	A	Draft for SMP Application
15-Aug-06	B	Complete for Myrtle and Redbank Creeks Draft for Bargo River
18-May-07	C	Risk Assessment Meeting
25-Sep-07	D	Final for LW24A incorporating GHD Geotechnics AY158
05-Oct-07	E	Updated to include ground monitoring information
30-Oct-07	F	Updated to include further information on ground pegs as requested by DPI
16-Nov-07	G	Updated TARP for LW24A.
4-Aug-07	H	Updated for LW25
6-Apr-09	H	Updated for LW25 (amended by Geoterra)

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CHAPTER 1. INTRODUCTION

1.1. Background

Tahmoor Colliery is managed and operated by Tahmoor Coal Pty Limited, a fully owned subsidiary of Austral Coal Limited. Xstrata Coal has a controlling interest in Austral Coal and as such, management of Tahmoor Colliery. Tahmoor Coal holds coal leases CCL 716, ML 1539 and ML 1376.

1.2. Current and Proposed Operations

Tahmoor Colliery has begun extending its underground coal mining into an area designated "Tahmoor North", which is located in the Southern Coalfields of NSW.

From 2002, the equipment in use at the mine has been steadily updated, including a new underground longwall mining unit. This longwall has a production capacity of 3,500 tonnes per hour. New high capacity belt conveyors are transferring coal to the surface for treatment at the upgraded Coal Preparation Plant.

Roadway development is carried out using five continuous miner development units. With the introduction of this new equipment and upgraded facilities, the Colliery has increased its productive capacity from 2 million to 3.6 million tonnes per annum.

Longwalls 24 to 26 are a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall (LW) 22. LW24 was mined in two sections, LW24B and LW24A. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north. A portion of each longwall is located beneath the urban area of Tahmoor. It is also proposed that in a similar manner to LW24A & LW25, the south-eastern end of LW26 will be moved further away from the Bargo River Gorge from that outlined in the SMP application. While the location of LW25 has been confirmed the location of LW26 is still to be finalised.

A number of natural features have been identified in the vicinity of the longwalls. Assessment of the impact of subsidence as a result of that mining is the subject of this plan.

1.3. Predicted Subsidence Movements

Specific predictions of subsidence, tilt and strain are provided in the SMP Application (Report No. MSEC157). A summary of the predicted maximum incremental parameters over the whole subsided area, due to the extraction of each longwall, is shown in Table 1.1.

Table 1.1 Maximum Predicted Incremental Subsidence Parameters

Subsidence Parameter	LW 22	LW 23	LW 24	LW 25	LW 26
Vertical Subsidence (mm)	503	613	596	631	636
Transverse Tilt (mm/m)	3.5	4.9	4.7	5.0	5.1
Longitudinal Tilt (mm/m)	3.0	3.8	3.5	3.7	3.7
Transverse Tensile Strain (mm/m)	0.4	0.7	0.7	0.8	0.8
Longitudinal Tensile Strain (mm/m)	0.6	0.7	0.8	0.8	0.8
Transverse Compressive Strain (mm/m)	0.9	1.6	1.5	1.7	1.7
Longitudinal Compressive Strain (mm/m)	0.6	0.8	0.6	0.6	0.8
Transverse Hogging Curvature (km^{-1})	0.03	0.05	0.05	0.05	0.05
Longitudinal Hogging Curvature (km^{-1})	0.04	0.05	0.05	0.05	0.05
Transverse Sagging Curvature (km^{-1})	0.06	0.11	0.10	0.11	0.11
Longitudinal Sagging Curvature (km^{-1})	0.04	0.05	0.04	0.04	0.05

The maximum predicted cumulative subsidence parameters, after the extraction of each longwall, are shown in Table 1.2.

Please note that the locations at which maximum subsidence, tilt or strain is predicted to occur due to each longwall do not coincide with the locations at which subsidence, tilt or strain is predicted to occur at other longwalls. This explains why the maximum predicted cumulative subsidence parameters in Table 1.2 are not additions of maximum predicted incremental subsidence parameters in Table 1.1.

Table 1.2 Maximum Predicted Cumulative Subsidence Parameters

Subsidence Parameter	LW 22	LW 23	LW 24	LW 25	LW 26
Vertical Subsidence (mm)	503	756	850	892	934
Transverse Tilt (mm/m)	3.5	5.0	4.8	5.2	5.2
Longitudinal Tilt (mm/m)	3.0	4.4	4.9	5.1	5.2
Transverse Tensile Strain (mm/m)	0.4	0.7	0.7	1.0	1.3
Longitudinal Tensile Strain (mm/m)	0.6	0.7	0.8	0.9	0.9
Transverse Compressive Strain (mm/m)	0.9	1.6	1.7	1.7	1.8
Longitudinal Compressive Strain (mm/m)	0.6	0.8	0.8	0.8	0.8
Transverse Hogging Curvature (km^{-1})	0.03	0.05	0.05	0.07	0.09
Longitudinal Hogging Curvature (km^{-1})	0.04	0.05	0.05	0.06	0.06
Transverse Sagging Curvature (km^{-1})	0.06	0.11	0.11	0.11	0.12
Longitudinal Sagging Curvature (km^{-1})	0.04	0.05	0.05	0.05	0.05

It is important to note that the predictions presented above are upper-bound estimates of the expected subsidence effect. The method adopted for prediction of subsidence effects means that the subsidence estimates are unlikely to be exceeded, and the expectation is that lesser subsidence results will be observed. Further discussion is provided in Report No. MSEC157 (MSEC, 2006)

1.4. Limitations

This Surface Safety and Serviceability Management Plan (SSSMP) is based on the predictions of the effects of mining on the surface as provided in Report No. MSEC157 by Mine Subsidence Engineering Consultants. Predictions are based on the planned configuration of longwalls at Tahmoor Colliery (refer Fig. 1.1), along with available geological information and data from numerous subsidence studies for longwalls previously mined in the area.

The natural features considered in this SSSMP have been identified from aerial photographs, regional maps and from discussions between Tahmoor Coal representatives and various consulting firms with relevant expertise.

The impacts of mining on surface and sub-surface features have been assessed in detail. However, it is recognised that the prediction and assessment of subsidence can be relied upon only to a certain extent. The limitations of the prediction and assessment of mine subsidence are discussed in report MSEC157 by Mine Subsidence Engineering Consultants.

As discussed in that report, there is a low probability that ground movements and their impacts could exceed the predictions and assessments. However, the possibility of impacts caused by levels of movement beyond those predicted has also been considered in the assessment. This

SSSMP will not necessarily prevent impacts from longwall mining, but does identify appropriate procedures to manage the impacts within tolerable limits and identifies procedures that can be followed should evidence of increased impacts and unacceptable risk emerge.

1.5. Objectives

The objectives of this SSSMP are to establish procedures to measure, control, mitigate and repair potential impacts that might occur to natural features.

The objectives of the SSSMP are to:-

- Minimise or avoid impact on the natural environment
- Minimise the risk to public safety to within tolerable limits
- Minimise the level of public disruption and inconvenience

These objectives will be met by using the following methods:-

- Monitoring ground movements and the condition of natural features during mining
- Initiating action to mitigate or remedy potential significant impacts that are expected to occur on the surface
- Providing a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted
- Providing a forum to report, discuss and record impacts to the surface - this will involve Tahmoor Colliery, stakeholders, Department of Primary Industries, and consultants as required
- Establishing lines of communication and emergency contacts

Fig. 1.1 Aerial Photograph overlaid with Mine Plan

1.6. Scope

The SSSMP is to be used to protect and monitor the condition of natural features identified to be at risk due to mine subsidence. The major features at risk are:-

- The Bargo River
- Myrtle & Redbank Creeks
- Groundwater Resources
- Cliffs
- Steep Slopes
- Soils
- Flora & Fauna

This SSSMP covers natural features located within the general application area, which defines the extent of land that may be affected by mine subsidence as a result of mining Longwalls 24 to 26. The management plan does not include areas outside the extent of the general application area.

The SSSMP also applies to persons employed or engaged by Tahmoor Colliery requiring them to carry out activities described by this plan.

The Trigger Action Response Plan (TARP) (**Section 3.11)** has been developed to focus primarily upon appropriate trigger and response actions for mitigation of impact to Natural Features affected by the extraction of LW24A. These procedures will be updated accordingly in subsequent revisions of this SSSMP for LW25 onwards.

1.7. Proposed Mining Schedule

It is planned that each longwall will extract coal working northwest from the southeastern ends. This SSSMP covers longwall mining until completion of mining in Longwall 26 and for sufficient time thereafter to allow for completion of subsidence effects. It is proposed that the SSSMP will be in operation until the end of 2010, subject to ongoing monitoring needs.

The current schedule of mining is shown in Table 1.3.

Table 1.3 Schedule of Mining

Longwall	Start Date	Completion Date
Longwall 24B	October 2006	October 2007
Longwall 24A	November 2007	July 2008
Longwall 25	August 2008	September 2009
Longwall 26	October 2009	October 2010

1.8. Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 metres in front of the longwall face to an area 450 metres behind the longwall face.

This is termed the “active subsidence zone” for the purposes of this SSSMP, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 metres in front and 450 metres behind the active longwall face, as shown by Fig. 1.2.

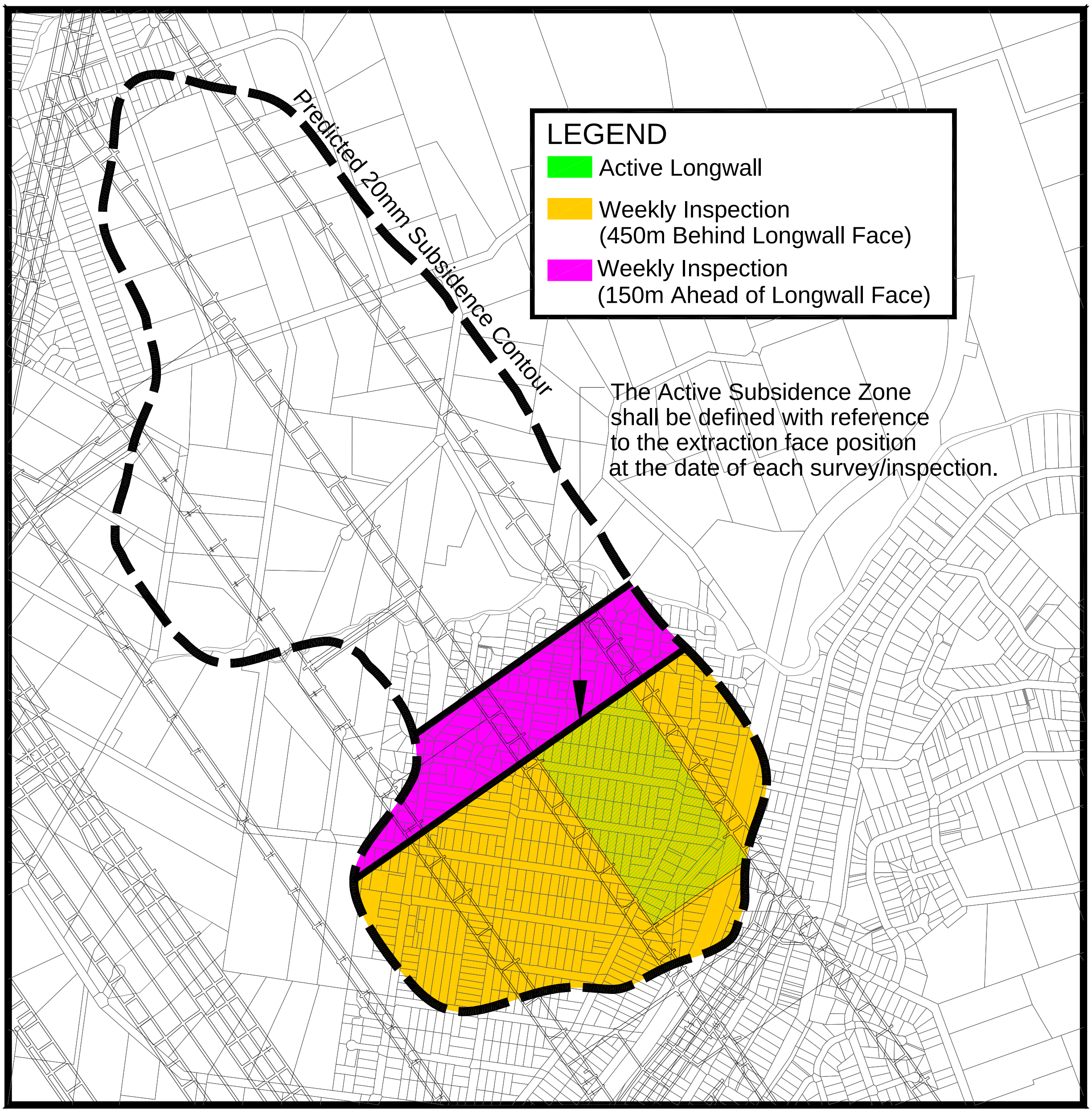


Fig. 1.2 Diagrammatic Representation of Active Subsidence Zone

CHAPTER 2. RISK MANAGEMENT METHOD

2.1. General

The risk matrix used for this assessment was initially developed by the Landslide Risk Management sub-committee of the Australian Geomechanics Society and reported/published in AGS (2000). It has subsequently been reviewed in the light of 7 years of use, and recently published (Australian Geomechanics Society 2007) within the "Practice Note Guidelines for Landslide Risk Management 2007".

This paper was developed by the AGS Landslide Taskforce, Landslide Practice Note Working Group, with funding assistance from the National Disaster Mitigation Program (NDMP). It has been peer reviewed nation-wide. This risk matrix was specifically developed for landslide issues, which include rockfalls, and the risk assessment group agreed that it was particularly relevant to the majority of issues surrounding natural features in the subsidence area.

The risk matrix complies with the requirements of both AS/NZ 4360:1995 and 2004. The Australian/New Zealand standard for Risk Management defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of risk. The general terms in AS4360 as adopted for landslide risk management (and presented in AGS 2007) are discussed below:-

2.1.1. *Likelihood*

Used as a qualitative description of probability or frequency. The likelihood can range from barely credible to almost certain.

Table 2.1 Qualitative Measures of Likelihood

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}		10 years		The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-2}	100 years	20 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-3}	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-4}	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-5}	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	5×10^{-6}	1,000,000 years	200.000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

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

2.1.2. ***Consequence***

The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event. The consequences of a hazard are rated from insignificant to catastrophic.

Table 2.2 Qualitative Measures of Consequence to Property

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

Notes:

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

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

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

2.1.3. ***Hazard***

This is a source of potential harm or a situation with a potential to cause loss.

2.1.4. ***Risk***

The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood. The risk combines the likelihood of an impact occurring with the consequence of the impact occurring. The risk is rated from very low to very high. In this study, the likelihood and consequence are combined via the qualitative risk analysis matrix shown in Table 2.3, to determine an estimated level of risk for particular events or situations.

The Risk Analysis Matrix is similar to the example provided in AS/NZS 4360:1995, Appendix D, p.25.

Table 2.3 Qualitative Risk Analysis Matrix – Level of Risk to Property

LIKELIHOOD		CONSEQUENCES (With indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	Catastrophic 200%	Major 60%	Medium 20%	Minor 5%	Insignificant 0.5%
A - Almost Certain	10^{-1}	VH	VH	VH	H	M or L (5)
B - Likely	10^{-2}	VH	VH	H	M	L
C - Possible	10^{-3}	VH	H	M	M	VL
D - Unlikely	10^{-4}	H	M	L	L	VL
E - Rare	10^{-5}	M	L	L	VL	VL
F – Barely Credible	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk

(6) When considering a risk assessment it must be clearly stated whether it is for existing condition or with risk control measures which may not be implemented at the current time.

2.1.5. *Risk Level Implications*

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

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

This SSSMP adopts a common system of nomenclature to summarise each risk analysis, which is **"LIKELIHOOD / CONSEQUENCE → LEVEL OF RISK".**

For example, if the likelihood of a risk is assessed as "**UNLIKELY**", and the consequence of a risk is assessed as "**MAJOR**", the risk analysis would be summarised as **"UNLIKELY / MAJOR → MODERATE"**.

CHAPTER 3. RISKS TO NATURAL FEATURES

3.1. Bargo River

3.1.1. *Introduction*

The Bargo River crosses the south-eastern part of the SMP Area. Longwalls 24 to 26 do not mine directly beneath the river.

With respect to Longwall 25, the closest distance to the centreline of the Bargo River is approximately 509 metres, which is beyond a 35 degree angle of draw by approximately 200 metres. The closest cliffs along the Bargo River are at a distance of approximately 433 metres from Longwall 25.

Further assessments are currently being undertaken and the position of the end of Longwall 26 is yet to be finalised.

The section of river within the SMP Area consists of a deeply incised gorge in Hawkesbury Sandstone. The depth of the river valley within the SMP Area varies between 40 metres and 104 metres. The base of the river is Hawkesbury Sandstone.

The section of river within the SMP Area is part of a longer section of the Bargo River that is listed as an Indicative Place on the Register of the National Estate. The area has a very high aesthetic significance with diverse flora and fauna, and significant cliffs, cascades and pools, and also has significance to the local indigenous community. Detailed site investigations have been undertaken by Tahmoor Colliery as part of its baseline study, which are provided in Report No. MSEC157. A "virtual tour" of the Bargo River gorge area (baseline photographic record) has also been prepared.

The water flows in the Bargo River within the SMP Area are derived from two main sources: flows sourced from the catchment areas; and flows sourced from Licensed Discharges from Tahmoor Colliery. The river is also fed by groundwater seepage and intermittently by a number of small ephemeral tributaries during rain events.

Water flows vary greatly in the Bargo River. The licensed discharges from Tahmoor Colliery are the main source of flow for the section of river within the SMP Area. The median flows along the river are approximately 5 ML/day, although some of these flows are naturally diverted below the river bed. There are also some sections of river where there is no surface flow during times of low flow.

The quality of the water is predominantly dependent on the quality of licensed discharge, particularly during times of dry weather. The water quality changes significantly in the river downcreek of the discharge point, becoming more alkaline and saline, with higher nitrate, copper, zinc and nickel (Geoterra, 2006). However, during times of wet weather, the proportion of flows sourced from the catchment area increases.

A summary of the predicted upsidence and closure along the river is provided below. The upper bound predictions are based on the revised start position of Longwall 25.

Table 3.1 Predicted Maximum Upsidence and Closure along the Bargo Riverdue to Longwall 25 (MSEC 2008)

Stage of Mining	Maximum Incremental Upsidence (mm)	Maximum Incremental Closure (mm)
After Longwall 24A	40	80

The following sections of 3.1 assess the risks to natural features as a result of the mining of longwalls 24- 26 at Tahmoor Colliery. The assessment has been conducted on the original layout shown in the SMP application. As outlined in Section 1.2 it is proposed that the south-eastern end positions of longwalls 24A, 25 and 26 will be further away from the Bargo River

Gorge than that depicted in the SMP Application. It is therefore reasonable to conclude that the relevant risks outlined below are on the higher end of those that might now be anticipated from the proposed revised locations.

3.1.2. ***<u>Potential for Change of Grade Affecting Pool Levels Leading to Terrestrial Habitat Damage</u>***

The potential for ponding and flooding is discussed in Report No. MSEC157. Due to the mine layout geometry, no subsidence has been predicted for the river. A small amount of valley bulge or "upsidence" has however been predicted as a far-field effect. The expression of the upsidence will be variable along the river bed. Average flow in the river currently varies from 3-7ML/day due to mine discharge and rainfall events. The current average gradient of the river bed is 35mm/m which is considered very steep and makes the Bargo River one of the steepest rivers in the Southern Coalfields. It is noted that the gradient will vary over small distances but the average change of grade due to mining is expected to be around 1mm/m (which is less than 3% of the current average natural grade). Possible effects of gradient change include impacts on terrestrial habitats and the possibility of lifting or lowering control points which may affect monitoring results. During average flow it is considered unlikely that these small changes in grade will have a perceivable effect to observers visiting the river bed.

In summary, very slight movements are predicted to occur as a result of mining. The likelihood of some level of ponding and flooding is therefore assessed as **ALMOST CERTAIN**.

The average tilt along the river is an order of magnitude steeper (ie 10 times steeper) than the maximum predicted mining-induced opposing tilt. The consequence of ponding and flooding is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **ALMOST CERTAIN / INSIGNIFICANT → LOW**.

3.1.3. ***<u>Potential for Change of Grade Affecting Pool Levels Leading to Aquatic Habitat Damage</u>***

The potential for ponding and flooding is discussed in Report No. MSEC157. Due to the mine layout geometry, no subsidence has been predicted for the river. A small amount of valley bulge or "upsidence" has however been predicted as a far-field effect. The expression of the upsidence will be variable along the river bed. Average flow in the river currently varies from 3-7ML/day due to mine discharge and rainfall events. The current average gradient of the river bed is 35mm/m which is considered very steep and makes the Bargo River one of the steepest rivers in the Southern Coalfields. It is noted that the gradient will vary over small distances but the average change of grade due to mining is expected to be around 1mm/m (<3% of average natural grade). Possible effects of gradient change include impacts on aquatic habitats and the possibility of lifting or lowering control points which may affect monitoring results. During average flow it is considered unlikely that these small changes in grade will have a perceivable effect.

In summary, very slight movements are predicted to occur as a result of mining. The likelihood of some level of ponding and flooding is therefore assessed as **ALMOST CERTAIN**.

The average tilt along the river is an order of magnitude steeper than the maximum predicted mining-induced opposing tilt. The consequence of ponding and flooding is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **ALMOST CERTAIN / INSIGNIFICANT → LOW**

3.1.4. ***<u>Potential for Flooding as a Result of Gradient Change</u>***

The potential for flooding is discussed in Report No. MSEC157. As previously discussed for impacts on pool levels, the predicted gradient change is insignificant from a flooding perspective.

In summary, very slight mining-induced movements are predicted to occur. The likelihood of flooding is assessed as **BARELY CREDIBLE**.

The average tilt along the river is an order of magnitude steeper than the maximum predicted mining-induced opposing tilt. The consequence of ponding and flooding is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **BARELY CREDIBLE / INSIGNIFICANT→ VERY LOW.**

3.1.5. *Potential for River Bed Scouring as a Result of Gradient Change*

The potential for scouring is discussed in Report No. MSEC157. The bed of the Bargo River in this section is Hawkesbury Sandstone with large boulders, exposed sandstone and colluvium covering large sections.

Given that the bed of the river is Hawkesbury Sandstone, the risk of scouring is assessed as **BARELY CREDIBLE / MINOR → VERY LOW.**

3.1.6. *Potential for Scouring of the River Bank as a Result of Gradient Change*

The potential for scouring is discussed in Report No. MSEC157. The bed of the Bargo River in this section is Hawkesbury Sandstone with large boulders, exposed sandstone and colluvium covering large sections. It would take a major change of gradient to cause flow to commence in existing pools and increase the likelihood of scouring.

Given that the bed of the river is Hawkesbury Sandstone, the risk of scouring is assessed as **RARE / INSIGNIFICANT → VERY LOW.**

3.1.7. *Potential for Changes to Creek Alignment as a Result of Gradient Change*

The potential for scouring is discussed in Report No. MSEC157. The banks and bed consist of exposed Hawkesbury Sandstone as well as large boulder fields. This will effectively resist creek alignment change.

Predicted changes in transverse gradients are very small and are likely to be an order of magnitude less than the existing gradients, the risk of changes to creek alignment is assessed as **BARELY CREDIBLE / INSIGNIFICANT → VERY LOW.**

3.1.8. *Potential for Fracturing in the River Bed and Rock Bars that Causes Water Loss*

The potential for fracturing in the river bed and rock bars is discussed in Report No. MSEC157. The upper bound upsidence prediction is 140mm at bed of creek (cumulative movement from Longwalls 24A to 26). In the Southern Coalfields, fracturing of rock bars has been observed up to 400m distant from a longwall goaf area.

The natural processes involved in the development of the river mean that natural fracturing of the rockmass has occurred due to valley bulging and will continue to occur regardless of mining. Bedding planes, shelving areas of rock bars, dykes, fractures and jointing all present planes of weakness that may be prone to activation in response to elevated horizontal stress at the river bed – whether due to natural processes or accelerated through mining influences. It is likely in certain areas of the river bed that additional stresses due to mining may cause displacement on these surfaces or the creation of additional near-surface fractures. The specific fracturing hazards will vary with the stratigraphy and lithology (ie massive and cross-bedded sandstone, interbeds of siltstone, the presence of bedding partings and natural fractures) at each particular location in the gorge.

The four major elements at risk with regard to fracturing are pond depth, river flow, water quality and aesthetics.

Only two fractures have been observed from previous experiences within the Southern Coalfield at similar distances as is proposed for Longwalls 24 to 26. The observed fractures at these distances from a goaf edge have not led to flow-reduction impacts. An important element of the assessment is that river bed damage that has been observed in the Southern Coalfield has occurred when mining has extended beneath the footprint of the river in question – this is not the case for the proposed Longwalls 24 to 26 which are no closer than 290 metres to the river.

Nevertheless, it is recognised that additional valley bulge may be promoted in the river bed and rock bars as a result of mining Longwalls 24 to 26, leading to some minor fracturing. The likelihood of fracturing is therefore assessed as **LIKELY**.

Any fracturing that does occur however, is likely to be minor, localised in nature, and close to the surface. Due to the high level of base flow as a result of the colliery discharge, it is unlikely that any water loss due to fracturing would be readily perceived. It is also considered unlikely that remediation would be required following mining. The consequence of fracturing is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **LIKELY / INSIGNIFICANT → LOW**.

3.1.9. *Potential for Fracturing in the River Bed and Rock Bars that Causes Plate Buckling*

The potential for fracturing in the river bed and rock bars is discussed in Report No. MSEC157. Plate buckling requires very specific geographic, geological and stratigraphic conditions to occur. Plate buckling has not been observed in the Southern Coalfield as a result of mining longwalls offset this far from a river. The mechanism is similar to the natural river forming processes associated with floor heave in the base of the river through concentration of lateral stress (through a "notch" effect).

The stratigraphic conditions in this section of the Bargo River and relative positioning of the longwalls are unlikely to promote plate buckling. In the areas where the river bed might otherwise be susceptible to plate buckling, the rock appears massive rather than thinly bedded. Elsewhere, the mechanism is not viable as, existing natural planes of movement are clearly present (which act to relieve stress). It is recognized that it remains still possible that some buckling may occur in the river bed and rock bars as a result of mining Longwalls 24 to 26 but the likelihood of this is considered **RARE**.

Plate buckling that might occur is, as a result of the geomechanics involved, likely to be minor and localised. As the process utilises the free face provided by the surface, confinement at depth provides a control on vertical propagation of any new fracturing created. It is unlikely that any remediation would be required following mining. Although the minor, localised and shallow character of plate buckling points to an insignificant consequence ecologically, the aesthetic/trip hazard consequence is also considered. Although this is potentially higher, the extent still being localised rather than wide-spread leads to an overall consequence assessed as **MINOR**.

The risk is therefore assessed as **RARE / MINOR → VERY LOW**.

3.1.10. *Potential for Fracturing in the River Bed and Rock Bars that Causes Reductions in Pond Depths Beyond that Caused by Known Existing Subsurface Diversions*

The potential for fracturing in the river bed and rock bars is discussed in Report No. MSEC157. The main risk of increased surface water flow diversion is that it may result in complete diversion of water from the surface. If the rate of flow in the river is greater than the rate of surface water diversion, some water will still flow on the surface but if the rate of flow in the river is lower than the rate of surface water diversion, there may be no water flowing on the surface. This has been observed to naturally occur in two sections within the SMP Area even at the relatively high levels of flow maintained by the colliery discharge.

Most existing subsurface diversion in the Bargo River appears to move through eroded bedding planes. If bedding planes are further activated by mining then the changes in the volume of flow through them will not be significant when compared to the current flow regime of the river. Changes due to existing vertical cracking are inherently difficult to assess. The depth of any new sub-vertical cracks formed in response to mining is controlled by the thickness of the near-surface horizons. Thick horizons tend to prevent the formation of sub-vertical cracks through their inherent ability to accept strong lateral compressive loads. Larger fractures, if they occur, will utilise the free face at the surface and would typically be expressed as sub-horizontal shear failure. Changes to the length of subsurface diversions due to delamination of existing strata can be influenced by creek bed gradient - the steeper the gradient, the shorter the diversion.

With respect to perceptible impact, the most important factor to be considered is background water flow. Water flow makes a critical difference to the significance of any subsurface diversion as a result of natural or mining-induced fracturing. Natural catchment and groundwater-fed background flow in the Bargo River is between 0.5 to 1ML/day. Under normal conditions, between rainfall events and without the addition of mine water, the Bargo River would present as a series of isolated ponds. Natural lowering of existing pond depth has been observed during periods of very low flow (Hydrometric Consulting Services 2006). This effect is masked by the mine discharge flows.

Due to the low natural background flow and the large number of approved water extraction licences upcreek of the SMP area, the actual flow volume in the river is largely dependent on the rate of licensed discharge from Tahmoor Colliery, which generally releases approximately 3-5 ML/day. Elsewhere at this rate of flow, surface water was observed to flow along all rivers that have been previously mined beneath, such as the Cataract, Bargo and Georges Rivers. In the case of rivers that have experienced mining-induced subsidence movements, but have not been directly mined beneath, surface water was observed to flow along rivers if the flow was greater than 2 ML/day. Flow monitoring in the Bargo River indicates that levels lower than this occur only very rarely.

In summary, the lithological and stratigraphic conditions in this section of the Bargo River, in conjunction with the artificially maintained flow levels, are controls against potential reductions in pond depth due to mining. However, it is still possible that some fracturing may occur in the vicinity of pools that causes reductions in pond depths as a result of mining Longwalls 24 to 26. The likelihood is therefore assessed as **RARE**.

The elements considered at risk are habitat, cultural heritage values and aesthetic values. The consequence of a reduction in pond depth is assessed as **MEDIUM**.

The risk is therefore assessed as **RARE / MEDIUM → LOW**.

3.1.11. *Potential for Fracturing in the River Bed and Rock bars that Causes Deterioration of Water Quality Beyond Existing Background Levels*

The potential for fracturing in the river bed and rock bars is discussed in Report No. MSEC157. The quality of the water is highly variable and predominantly dependent on the quality of licensed discharge, particularly during times of dry weather. The water quality in the River often exceeds the ANZECC 2000 (95% protection of aquatic species) trigger levels for pH, salinity, Ni, Zn, Se, Al and P/N nutrients due to the very large variability of runoff in the catchment and the wide range of urban, agricultural and industrial pollutant sources discharging into the river (Geoterra, 2006). Despite this, a recent aquatic ecology study found that the Bargo River was in good ecological health in the SMP area (Biosis 2007).

The types of pollution events historically related to fracturing in the Southern Coalfields have been considered as part of this assessment. Pollution events only occur in the discrete location of the fracture. These events have been observed to cause a maximum input of pollutant (sulphuric acid) of 100 moles/day. This must be balanced by the dilutional contribution of the existing water flow in the river which currently varies between 4 to 7 ML/day, the majority of which is mine water. As mentioned previously, the natural catchment and groundwater fed background flow is between 0.5 to 1ML/day. Also, mine water possesses a natural alkalinity and has the capacity to neutralise a significant amount of any pollution resulting from a major fracture. In the Bargo River below Tea Tree Gully, the alkalinity of the water varies between 220 and 240 mg/L (Biosis 2007). The addition of pollutants to the river system from fractures only persists for a maximum of 3 months in the Southern Coalfields due to the natural self-armouring of fractures. Based on the current water chemistry and flow regime of the Bargo

River, it is expected that any addition of pollutant material from a fresh fracture will be undetectable.

In summary, the geochemical and stratigraphic conditions in this section of the Bargo River as well as the water characteristics and flow volumes, are unlikely to lead to fracture related pollution incidents. The likelihood of fracturing causing water quality deterioration is therefore assessed as **BARELY CREDIBLE**.

Any fracturing leading to water quality deterioration that does occur is likely to be minor and localised in nature. Another consideration with respect to deterioration of water quality is the existence of natural examples of iron hydroxide precipitation on existing fractures. It is unlikely that any remediation would be required following mining. The consequence is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **BARELY CREDIBLE / INSIGNIFICANT → VERY LOW**.

3.1.12. ***Potential for Visible Fracturing in the Riparian Zone***

The potential for fracturing in the river bed and rock bars is discussed in Report No. MSEC157. This assessment is concerned purely with aesthetic impacts of the river banks and not fracture events resulting in flow diversion, water quality deterioration or other issues previously covered. Neither is the assessment considering impacts to cliffs which will be dealt with separately. Based on geological and ecological investigations it can be observed that two thirds of the valley is alluvium/colluvium and one third is exposed sandstone. While fracturing of soil surfaces can occur, these types of issues have not been observed at distances greater than 200m from a longwall in the Southern Coalfields. From an ecological and safety perspective the fracturing of non-hydraulic sections of the Bargo River are unlikely to have any effect.

In summary, the distance from the longwalls, the geological and stratigraphic conditions in this section of the Bargo River as well as the nature of the riparian soil profile and habitat are unlikely to produce fractures in the riparian zone. Although natural and induced ground stresses are higher at the base of the valley profile, it is still possible that some fracturing may occur in the riparian zone as a result of mining Longwalls 24 to 26. The likelihood is therefore assessed as **POSSIBLE.**

The elements considered to be at risk included aesthetic values, ground stability and habitat. Any fracturing that does occur is likely to be minor and localised in nature. The consequence is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **POSSIBLE / INSIGNIFICANT → VERY LOW**.

3.1.13. ***Potential for Gas Emissions***

The potential for gas emissions is discussed in Report No. MSEC157. There have been no previously reported surface gas emissions at Tahmoor and despite regular inspections by various consultants over recent years, gas emissions have not been observed in the Bargo River area. Experience in other areas of Southern Coalfields indicates that Hawkesbury Sandstone contains methane near the surface and this can be released when cracking occurs. Any cracking or fracturing that occurs is usually due to mobilisation of existing joints or bedding planes. The presence of existing natural fractures, but the apparent absence of gas emissions, may point to a low propensity for gas emissions in the subject area.

Naturally formed methane emissions can also occur as a result of the anaerobic decomposition of vegetation. This appears unlikely as the Bargo is a rough river from a hydraulic perspective which keeps sediment deposition low. This is evidenced in the section of river affected by mining as there is very little sediment present. Vegetation die-off as a result of methane emissions is also unlikely for most of the length of the river but possible at the upcreek end of subsidence zone where there are some vegetated sand banks located near the exposed dykes.

In summary, given the distance from the longwalls, it is still possible that some fracturing as a result of mining Longwalls 24 to 26 may lead to gas emissions so the likelihood is assessed as **POSSIBLE.**

The element considered at risk is terrestrial habitat change, particularly in areas with sediment deposits. There is a low level of sediment in the river and the areas that may be affected are located at the extreme end of the SMP area. Any fracturing that does occur is likely to be minor and localised in nature. Within the specific ecological setting the exposure to potential ecological harm through vegetation die-off is very limited. The consequence of a gas emission is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **POSSIBLE / INSIGNIFICANT → VERY LOW**.

3.2. Myrtle and Redbank Creeks

Myrtle and Redbank Creeks will be directly mined beneath by the proposed longwalls. A summary of the predicted subsidence movements are provided in the table below.

Table 3.2 Predicted Maximum Subsidence, Upsidence, Closure and Compressive Strain due to Closure along the Creeks

Watercourse	Maximum Predicted Subsidence (mm)	Equivalent Valley Depth (m)	Maximum Cumulative Upsidence (mm)	Maximum Cumulative Closure (mm)	Maximum Compressive Strain due to Closure (mm/m)
Myrtle Creek	925	3 to 33	155	100	7.8
Redbank Creek	615	2 to 35	100	75	6.5

3.2.1. *Potential for Change of Grade Affecting Pool Levels*

The potential for grade changes affecting pool levels is discussed in Report No. MSEC157. The expression of the subsidence, upsidence and valley closure will be variable along the creek bed. The current average gradient of both creeks is between 22 to 27mm/m. Possible effects of any upsidence include impacts on terrestrial or aquatic habitats. Both creeks are ephemeral with very few standing pools and serve primarily as stormwater conduits for the urban and rural areas of Tahmoor/Thirlmere. As a result of this level of flow it is assessed that the small changes in grade will have an insignificant effect on flow rates or habitat.

In summary, very slight changes to grade are predicted to occur as a result of mining. The likelihood of some level of localised ponding and flooding is assessed as **ALMOST CERTAIN**.

The average tilt along the creeks is an order of magnitude steeper than the maximum predicted opposing mining-induced tilt. The consequence of ponding and flooding is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **ALMOST CERTAIN / INSIGNIFICANT → LOW**.

3.2.2. *Potential for Raising Flood Levels Above Habitable Floor Levels as a Result of Gradient Change*

The potential for flooding is discussed in Report No. MSEC157. A Flood Study commissioned as part of the SMP application identifies a decrease in RL's of habitable floor levels resulting in slight raising of flood levels in 1:100 events. There are no residential premises already situated below, or set to be below, the 1:100 event level as a result of subsidence.

Due to the gradient of the creeks and the nature of urban stormwater drainage these flood events, when they occur, are extremely short lived. The highly disturbed nature of the local vegetation, the mobility of the fauna and the very short term nature of flood events in urban creeks are factors to be considered when assessing potential impacts on habitat. As previously discussed for impacts on pool levels, the predicted gradient change is insignificant from a flooding perspective.

In summary, very slight mining-induced grade changes are predicted to occur as a result of mining. The likelihood of increased flood levels above habitable floor levels is assessed as **RARE.**

The consequence of increased flood levels above habitable floor levels would involve moderate disturbance to structure and is therefore assessed as **MEDIUM**.

The risk is therefore assessed as **RARE / MEDIUM→** LOW.

3.2.3. *Potential for Fracturing in the Creek Beds*

The potential for fracturing in the creek beds and rock bars is discussed in Report No. MSEC157. Fracturing of creek beds in Myrtle Ck has occurred on two occasions in areas where the creek bed is accessible. The reports of these events have come from colliery consultants carrying out inspections, not from the community. While the cracks can be of significant size they have occurred in sediment and have not resulted in water diversions.

In summary, it is therefore possible that some fracturing may occur in the creek bed as a result of mining Longwalls 24 to 26. The likelihood of fracturing in creek beds is therefore assessed as **LIKELY**.

Any fracturing that does occur is likely to be localised in nature. Some fractures may not be visible due to a thick covering of sediment and vegetation. The sediment in the creeks could also fill any mining-induced fractures that may occur and reduce the rate of any surface flow diversion. The consequence of fracturing is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **LIKELY / INSIGNIFICANT →** LOW.

3.2.4. *Potential for Surface Water Flow Diversion Beyond Natural Levels*

The potential for surface water flow diversion is discussed in Report No. MSEC157. Both Myrtle and Redbank Creeks are catchment and groundwater dependent ephemeral creeks. As a result, most of the time there is little water flow in these creeks and very few standing pools. When the creeks do flow it is usually a high flow event meaning that if there was some subsurface diversion this would be difficult to perceive.

The cracks that have been observed in Myrtle Creek have only been found in deep sediment and this sediment has been observed to effectively close subsurface paths otherwise available for diversion of flow. Due to the background sediment load in these creeks, any cracks that do form are expected be filled rapidly.

In times of low run-off coinciding with low groundwater levels, however, some of the water could be diverted for limited distances along the creek. The impact of this is assessed as primarily aesthetic (for those with access to see), rather than ecological. Pre-mining field investigations along Redbank Creek indicate that water quality is relatively poor in some sections during times of low flow. Terrestrial flora and fauna investigations indicate that the vegetation and fauna habitats in Myrtle and Redbank Creeks are generally degraded as a result of urban development (Biosis Research, 2006).

In summary, it is possible that fracturing of creek beds could potentially lead to the temporary loss of water from the creek into the dilated strata beneath. It is unlikely however, that there would be any net loss of water from the catchment since any diverted flow would be expected to emerge a short distance downcreek.

As a surface diversion requires flow and an absence of the sealing effect of natural sediment load, the likelihood of surface diversion is considered **UNLIKELY**. The consequence, if diversion were to occur, is assessed as essentially aesthetic but short-term (and limited to those with access to see) and is therefore considered **MEDIUM**.

The risk is therefore assessed as **UNLIKELY / MEDIUM →** LOW.

3.2.5. *Potential for Creek Bed and Bank Erosion and Bed Load Movement*

Cracking of creek beds and banks can create new surface water conduits thus subsidence may induce minor bed or bank erosion (Geoterra, 2006). As the creeks are well vegetated, no significant change is anticipated (Geoterra, 2006).

In summary, the likelihood of creek bed and bank erosion is therefore considered to be **UNLIKELY**.

If erosion occurs in the creek, it may cause a minor increase in potential bed load movement (Geoterra, 2006). If erosion and bed load movement occurs, remediation will be required. This consequence is considered to be **MINOR**.

The risk is therefore assessed as **UNLIKELY / MINOR → LOW**.

3.2.6. *Potential for Impacts on Water Quality*

Cracking of sewer mains has the potential to contribute to existing sewage contamination from both septic leakage and livestock faecal contamination in both Myrtle and Redbank Creeks. This specific issue is addressed in Sydney Water - Sewer SSSMP. See also the assessment of Potential for Creek Bed and Bank Erosion and Bed Load Movement and Potential for Upland Spring Induction. No adverse impacts on water quality are expected as there are no groundwater seeps discharging into the plateau creeks (Geoterra, 2006).

In summary, the likelihood of impacts on water quality is assessed as **UNLIKELY**.

The water quality in the creeks is highly variable and dependent on the amount of flow. The consequence of impacts on water quality is assessed as **MINOR**.

The risk is therefore assessed as **UNLIKELY / MINOR → LOW**.

3.3. Groundwater Resources

Investigations by Geoterra and drilling data from the Department of Natural Resources indicate that Hawkesbury Sandstone has generally low permeability and no continuous permeable zones have been inferred above the longwalls. The quality of the groundwater is generally fresh to brackish salinity (Geoterra, 2006). There are no registered bores in use within the SMP area.

3.3.1. *Potential for Impacts on Groundwater Levels and Bore Yields > 20m Below Ground Level*

From past experience, groundwater levels may initially reduce as mining commences and stay at that reduced level until maximum subsidence develops. However, it is anticipated that groundwater levels will recover over a few months as the secondary void space is recharged by rainfall infiltration. It is therefore expected that there will be no permanent reduction in groundwater levels (Geoterra, 2006).

There is only one registered bore in the SMP area and six in the overall monitoring area. The bore in the SMP area is not in use at this time. Groundwater levels in bores in the area ranges from 94 metres to 14 metres with variation in discrete bore water levels of up to 9 metres. Monitoring results show that water levels tend to drop as a longwall passes and then recharge and fill fracture void spaces over the medium term. Eventually the yield increases due to the greater void spaces but another effect is that bores also recharge and discharge more quickly.

In summary, the likelihood of temporary changes to groundwater levels is therefore assessed as **ALMOST CERTAIN**.

Given that the groundwater levels are expected to return after a few months, and there are no registered bores in use within the SMP area, the consequence of the temporary change in groundwater levels is assessed as **INSIGNIFICANT.** In the event that a bore is installed in the future, water can be temporarily supplied to the landowner.

The risk is therefore assessed as **ALMOST CERTAIN / INSIGNIFICANT → LOW**.

3.3.2. *Potential for Impacts on Groundwater Quality*

Previous observations across the Southern Coalfield indicate that water quality of subsided bores has not generally been affected. However, there may be increased iron hydroxide precipitation and lowering of pH if the groundwater is exposed to "fresh" surfaces in the strata with dissolution of unweathered iron sulphide (marcasite) (Geoterra, 2006).

While this precipitation does not pose a health hazard, it can cause clogging of pumping equipment and piping in extreme cases. It is also noted that many bores in the Southern Coalfield already have significant iron hydroxide levels (Geoterra, 2006).

In summary, the likelihood of a reduction in groundwater quality is therefore assessed as **LIKELY**. The consequence of this risk is considered **INSIGNIFICANT**, given that there are no registered bores in use within the SMP area.

The risk is therefore assessed as **LIKELY / INSIGNIFICANT → LOW**.

3.3.3. *Potential for Upland Spring Induction Affecting Dam or Groundwater Quality*

Subsidence in upland areas can cause increased separation between Wianamatta and Hawkesbury geologies. This can increase subsoil storage of groundwater which in turn can reduce drainage from creeks that previously depended on groundwater recharge. As a result, outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. This can cause interference with dam recharge rates (up or down) if dams are present in affected areas. Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. Adding nutrients to these systems from pollution sources, such as infiltration from sewage leaks, enhances bacterial action and thus increases the concentration of iron/manganese in waters.

Previous observations across the Southern Coalfield indicate that water quality and water levels in subsided bores has not generally been affected by the process. There are a large number of dams that are groundwater dependent to varying degrees and therefore may be exposed to spring induction impacts.

In summary, the likelihood of a reduction in groundwater quality is assessed as **RARE**.

The consequence of this risk is considered **INSIGNIFICANT**, given that there are no registered bores and only one off-line dam in use within the potentially affected area.

The risk is therefore assessed as **RARE/ INSIGNIFICANT → VERY LOW**.

3.3.4. *Potential for Upland Spring Induction Affecting Habitat in the Immediate Vicinity of the Spring During Low Water Flow (<3ML/day)*

Upland subsidence can cause increased separation between Wianamatta and Hawkesbury geologies. This can increase subsoil storage of groundwater which in turn can reduce drainage from creeks that previously depended on groundwater recharge. As a result, outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. Adding nutrients to these systems from pollution sources, such as infiltration from sewage leaks, enhances bacterial action and thus enhances the concentration of iron/manganese in waters.

Previous observations across the Southern Coalfield indicate that the potential for damage to habitat in close proximity to the spring under low flow conditions may be reasonably large. However, the impacts are limited to the immediate spring area and don't procede downcreek to any great distance. The existing goaf areas adjacent to the SMP area have not indicated a propensity for ferruginous spring induction.

In summary, the likelihood of an induced spring impacting habitat is assessed as **RARE**.

The consequence of this risk is considered **MAJOR**, due to the potential for ecotoxicity effects under low flow conditions in a limited area.

The risk is therefore assessed as **RARE/MAJOR → LOW**.

3.3.5. ***Potential for Upland Spring Induction Affecting Habitat Downcreek of the Spring During High Water Flow (>3ML/day)***

Upland subsidence can cause increased separation between Wianamatta and Hawkesbury geologies. This can increase subsoil storage of groundwater which in turn can reduce drainage from creeks that previously depended on groundwater recharge. As a result, outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. Adding nutrients to these systems from pollution sources, such as infiltration from sewage leaks, enhances bacterial action and thus enhances the concentration of iron/manganese in waters.

Previous observations across the Southern Coalfield indicate that even under low flow regimes the potential for damage to habitat downcreek of the spring entry point is low. The existing buffering effect of the mine water flow in the Bargo River as well as the relatively high flow rates (3 to 7ML/day) will ensure that acidity, water deoxygenation and hydrous iron oxide blanketing don't procede downcreek to any great distance.

The existing goaf areas adjacent to the SMP area have not indicated a propensity for ferruginous spring induction.

In summary, the likelihood of impacts on habitat downcreek of the spring is therefore assessed as **RARE**.

The consequence of this risk is considered **INSIGNIFICANT**, given the volume and buffering effects of flows in the Bargo River.

The risk is therefore assessed as **RARE/INSIGNIFICANT → VERY LOW**.

3.4. Cliffs

In addition to visual impact, cliff collapse places people at risk. In this situation, it is recognised that an assessment of risk to life is required. This has been conducted in a qualitative manner to permit a comparison to tolerable risk levels to be undertaken (AGS 2007). The results of the qualitative risk to life assessment outcomes have been converted to the risk assessment terminology used in the rest of this document for ease of comparison.

By way of background, the information provided in Report No. MSEC157 follows:

> A number of cliffs have been identified within the SMP Area. For the purposes of this report, a cliff has been defined as a continuous rock face with a minimum height of ten (10) metres and a slope steeper than 0.5 to 1 (H:V), i.e. having a minimum angle to the horizontal greater than about 65°.
>
> The cliffs were identified using a combination of site inspections, aerial photographs and a 2 metre surface contour drawing provided by the Department of Lands. The cliffs are typically located along the Bargo River and lie outside the predicted limit of subsidence.
>
> A detailed assessment of potential impacts is provided in Report No. MSEC157. In summary, it is assessed that the likelihood of cliff instabilities is very low. This assessment has been made for the following reasons:

- The predicted movement at the cliffs is very small.
- No major cliff instability has been observed beyond the goaf in the Southern Coalfield. However, four relatively minor rockfalls have been observed beyond the

goaf of Appin Longwall 301 in the Cataract River Gorge. All other cliff instability that has occurred has been located directly above extracted longwalls.

- The proposed longwalls are located well over 100 metres from the nearest cliff - the nearest cliff along the Bargo River is approximately 220 metres from the proposed longwalls.

The land to the north of the Bargo River within the SMP Area is privately owned and there is no public access to the top of the gorge. There are, however, public tracks on the southern side of the river which allow access into the base of the Bargo River. It is noted that public access to the river requires a full day to reach and return.

The potential rockmass failure mechanisms relevant to the clifflines above the Bargo River off the ends of Longwalls 24 to 26 are:

- Block size failure of discrete joint controlled sandstone bedrock. Blocks from relatively small size up to 6m x 6m x 3m (ie 100m^3 volume or 250 tonnes mass) have been observed on the river bed. These blocks of sandstone have become detached from the steeply faced Hawkesbury Sandstone cliffines either side of the Bargo River. It is likely that these blocks have travelled only a short distance downstream from their point of trajectory.
- Collapse of overhangs within the cliff face. The overhangs are produced through erosion and block failure beneath the overhang to produce projecting un-jointed sandstone bedrock. Within the SMP area, overhangs of up to 6m depth and tens of metres long have been observed. The loss of integrity of such overhangs relies upon either a reduction of the shear strength of the body of the overhang, or exposure of a through-going joint in the overhang as a result of weathering of the rock-face.
- Large scale, structure-controlled, rock-face collapse. For this mechanism to eventuate, through-going (perhaps sub-vertical) natural fractures must exist which promote the potential for large defect-controlled masses of rock to become detached from the cliff-face. The through-going natural fractures provide rockmasses that can either topple (through outward rotation) or collapse (through the presence of basal failure or wedge failure through a basal release plane). The inter-bedded nature of the sandstone rockmass limits the likelihood of through-going geological structures (such as persistent sub-vertical joints). This larger scale failure mechanism is therefore intuitively less frequent that individual block failure, though the mass involved usually makes the event potentially more hazardous. Frequently, entry of water into the rockmass is a trigger, though temperature effects and toe erosion can provide triggers for this larger scale event.

Cliffs by nature are marginally stable at any time, particularly if they contain large overhangs. Evidence of previous rockfalls can be found within the SMP Area in the form of boulder beds and fresh rock faces in the cliff lines. Should rockfalls occur during mining, it would be difficult to determine, whether they were due to natural or mining-related causes, despite mining related movements being very small.

It is also noted that the section of the Bargo River within the SMP is off the end of Longwalls 24 to 26, rather than to the side of the longwalls (or undermined by the longwalls). In terms of performance in the Southern Coalfield, it has been recognised by MSEC that rockfalls are less frequent in this position relative to the longwall goaf.

As mentioned at the start of this section, the following assessments of risk are based on a conversion of the findings presented in the document AY158 by GHD Geotechnics to the risk terminology used in this document. The report has found that longwall mining in the area is unlikely to elevate the risk above that exists naturally.

3.4.1. ***Potential for Rockfall in Gorge (<=100m^3)***

Natural gorge forming processes have resulted in many rockfalls along this stretch of river and they will continue into the future since the gorge is a dynamic geomechanical environment. Sandstone blocks of 6m x 6m x 3m in dimension appear to represent the largest block-style failure (ie that is controlled at this scale by jointing and bedding in the gorge cliffline). This block size, whilst part of a wide range of debris size, is likely to be the “design” size for analysis. It is approximately 100m^3 and thereby is the upper limit of block size within this category.

Timing is the key element in considering the risk of rockfalls. As was recently demonstrated in the Mt Keira rockfall, intense rainfall often coincides with rockfalls. It is not only the timing of such rainfall events, and the opportunity for water to enter the rockmass, but also the timing of persons-at-risk to be in the path of the rockfall. There are a number of partial probabilities involved in such an assessment.

Ground movement as a result of subsidence may shear existing joints and bedding planes and in the Southern Coalfields most subsidence related rockfalls appear to occur either coincident with or within a period of a few months of under-mining.

The likelihood of a rockfall occurring is considered **LIKELY TO UNLIKELY**. The likelihood of a rockfall coinciding with a person or persons is considered **RARE**. Clearly the consequence of this risk is considered **CATASTROPHIC**.

The existing risk is therefore assessed as **RARE / CATASTROPHIC → MODERATE**. This is not anticipated to change as a result of mining.

3.4.2. ***Potential for Cliff Collapse in Gorge (>100m^3)***

The likelihood of a large cliff collapse of rock sections >100m^3 is perhaps one or two orders of magnitude less likely than for rock sections of <100m^3 (GHD Geotechnics 2007)

Natural gorge forming processes have resulted in many rockfalls along this stretch of river and they will continue into the future because the gorge is a dynamic geomechanical environment.

Ground movement as a result of subsidence may loosen existing joints and bedding planes. The principal mechanism associated with large rockfalls requires very close proximity of full extraction mining to the footprint of the rockface.

Examples of this include: Dombarton (near Wollongong); Angus Place (Lithgow); Nattai North (Burragorang Valley); Hassans Walls (Lithgow); oil shale mining at Newnes and at Dog face Rock, Katoomba; and Huntley (Avon Reservoir). The mechanism is not toppling but comprises failure through basal shear and crushing of large slabs of sandstone which become separated from the cliffline as a result of mining subsidence. Importantly, undermining of the clifflines of the Bargo River is not proposed for Longwalls 24 to 26, nor thereafter, and so this mechanism for large scale cliff-face failure is not viable.

Potential large scale rockfalls from the face of the clifflines of the Bargo River with a natural origin however cannot be discounted. The nexus of mining activity with naturally triggered rockfalls - as a result of persistent natural fractures (principally persistent sub-vertical joints) and rainfall or high flood levels within the river – remains a possibility.

In the Southern Coalfield, most rockfalls appear to occur within a period of a few months of subsidence occurring. Based on observations and measurements from the large rockfall in the Burragorang Valley at Nattai North Colliery, a period of 2-5 years is considered a reasonable upper-bound period for rockfall activity post-subsidence.

The likelihood of a cliff collapse of this magnitude occurring is considered **RARE**. The likelihood of a cliff collapse coinciding with a person or persons is considered **BARELY CREDIBLE**. Clearly the consequence of this risk is considered **CATASTROPHIC**.

The risk is therefore assessed as **BARELY CREDIBLE / CATASTROPHIC →** LOW. This is not anticipated to change as a result of mining.

3.5. Steep Slopes

A detailed assessment of steep slopes and potential impacts on structures is provided in section 3.7 of Report MSEC157 and accompanying reports on Houses on Steep Slopes prepared by GHD Geotechnics.

In summary, it is possible that impacts to steep slopes could result from the slippage of soils down the slopes, causing tension cracks to appear at the tops of the slopes and compression ridges at the bottoms of the slopes. The likelihood of soil slippage is considered to be low as the slopes are founded in Hawkesbury Sandstone and the depth of cover is greater than 400 metres.

It is unlikely that mine subsidence will cause any large-scale slope failures as such failures have not been reported due to mining in the Southern Coalfields, where the depth of cover exceeds 400 metres.

3.5.1. *Potential for Slope Instability Resulting in Landslip*

The likelihood of landslip is considered **UNLIKELY**.

If landslip occurs and the area is not immediately remediated then the possibility of further movement or soil erosion is likely. There may also be possible impacts on fauna habitat, native vegetation and aesthetics. The consequence is therefore assessed as **MEDIUM**

The risk is therefore assessed as **UNLIKELY / MEDIUM →** LOW

3.5.2. *Potential for Slope Instability Resulting in Debris Scour*

The likelihood of soil or slope movement resulting in debris scour is considered **BARELY CREDIBLE**.

There are few slopes that contain loose materials that could be prone to causing a debris scour and virtually none outside of river or creek valleys. If however a debris scour did occur and was left untreated it is possible that further soil erosion could occur. The consequence is therefore assessed as **MINOR**

The risk is therefore assessed as **BARELEY CREDIBLE / MINOR →** VERY LOW

3.5.3. *Potential for Slope Instability Resulting in Soil Erosion*

The likelihood of tension cracking appearing at the tops of the slopes is considered **POSSIBLE**.

If tension cracks were left untreated soil erosion could occur. The consequence is therefore assessed as **INSIGNIFICANT**

The risk is therefore assessed as **POSSIBLE / INSIGNIFICANT →** VERY LOW

3.6. Other Impacts to Flora & Fauna

This assessment covers all terrestrial areas (i.e. not creeks or rivers). Natural springs are covered in Section 3.3.

3.6.1. *Potential for Soil Disturbance and Surface Cracking*

The majority of the land in the SMP area has been previously disturbed and now hosts residential, commercial or rural activities. There has been some minor surface cracking observed over Longwall 23B. This cracking did not pose a risk to any structure, person, livestock or habitat.

In summary the likelihood of surface cracks appearing is considered **ALMOST CERTAIN**.

If left unmanaged it is possible that there may be some impact on safety, habitat or water quality. The majority of the terrestrial area in the SMP is already heavily disturbed and under current active disturbance. The consequence is therefore assessed as **INSIGNIFICANT**.

The risk is therefore assessed as **ALMOST CERTAIN / INSIGNIFICANT→VERY LOW**

3.7. Land Prone to Flooding or Inundation

Please refer to Section 3.1 & 3.2.

3.8. Water-Related Ecosystems

The risk assessment for water-related ecosystems is discussed in Sections 3.1 and 3.2.

3.9. Summary of Risk Assessments for Natural Features

A summary of the levels of risk for natural features is provided in Table 3.3. The levels of risk have been determined using upper bound subsidence predictions. The risk assessment was based on the SMP mine plan. The start position of LWs 24A and 25 have since been relocated further from the Bargo River.

Table 3.3 Summary of Risk Assessments for Natural Features

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
Bargo River							
1	Potential for change of grade affecting pool levels leading to terrestrial habitat change.	• No subsidence predicted. • Variable upsidence along river bed. 1mm/m variation expected. • Ave grade is 35mm/m at moment. One of the steepest rivers in southern coalfields. Average change of grade 3% of existing. • May lift or lower control points which may effect monitoring. Flow already varies from 3-5ML due to mine discharge and rainfall. • Future water treatment and reuse of mine discharge may reduce flows before mining is completed near river.	• Variable mine discharge. • Offset of longwalls. • Not undermining river bed. • Off end of LW not beside it. • Existing average steep hydraulic gradient of river bed.	• Terrestrial habitat change	ALMOST CERTAIN	INSIGNIFICANT	**LOW**
2	Potential for change of grade affecting pool levels leading to aquatic habitat change.	• As for Item 1. • Experience suggests that the effects will be minimal.	• Variable mine discharge. • Offset of longwalls. • Not undermining river bed. • Off end of LW not beside it.	• Aquatic habitat change	ALMOST CERTAIN	INSIGNIFICANT	**LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
			• Existing average steep hydraulic gradient of river bed.				
3	Potential for flooding as a result of gradient change	• Gradient change is insignificant from a flooding perspective.	• As Item 2	• Habitat change • Bushwalker fatality	BARELY CREDIBLE	INSIGNIFICANT	**VERY LOW**
4	Potential for river bed scouring as a result of gradient change	• As for Item 1 & 2	• Hawkesbury Sandstone • Boulders in creek bed • Lack of sediment	• Terrestrial & aquatic ecology	BARELY CREDIBLE	MINOR	**VERY LOW**
5	Potential for river bank scouring as a result of gradient change	• As for item 1 & 2. • No scouring in pools will occur unless there is a MAJOR change in gradient in pool which causes water to flow.	• Hawkesbury Sandstone	• Terrestrial & aquatic ecology	RARE	INSIGNIFICANT	**VERY LOW**
6	Potential for changes to creek alignment as a result of gradient change	• As for Item 5			BARELY CREDIBLE	INSIGNIFICANT	**VERY LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
7	Potential for fracturing in the river bed and rock bars that causes water loss	• Observed fracturing of rock bars up to 400m distant from side, end or corner of LW in the Southern Coalfields. • Current bedding shows signs of movement in response to existing stresses. • Bedding seams, dykes, jointing & shelving present planes of weakness that may be prone to activation as a result of LW goafing. • Natural fracturing will occur • Compressional environment driving rock load • Compound upper bound cumulative upsidence prediction is 140mm at bed of creek. • It is likely in certain areas of river bed that additional stresses may cause shifting between bedding planes. • Hazards will vary with the style of rock present at a particular location in the gorge.	• Distance of LW from river • Panels end on • Natural processes • Confinement at depth limits vertical propagation	• Rock bars • Bed rock • Water quality • Pool levels • Surface flow • Habitat	LIKELY	INSIGNIFICANT	**LOW**
8	Potential for fracturing in the river bed and rock bars that causes plate buckling	• Has not been observed at these offset distances. • Larger rock bars by their nature are massive, resistant horizons. • Character and interrelated nature of the different local horizons in the bed of river means that the occurrence of the right conditions for this to occur is less than likely. • Requires specific geographic and stratigraphic conditions to occur.	• Requires near surface thin bedding which is not present • No longwalling beneath river bed • Thickness of underlying bed rock	• Aesthetics • Safety risk for walkers	RARE	MINOR	**VERY LOW**
9	Potential for fracturing in the river bed and rock bars that causes	• Most subsurface diversion appears to move through eroded bedding planes. If bedding planes are further activated by subsidence then the changes will not be significant. • Changes due to vertical cracking not	• Thickness of rock bars • Characteristics of pool constrained by	• Aesthetics • Habitat • Cultural heritage value	RARE	MEDIUM	**LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
	reductions in pond depths beyond that caused by known existing subsurface diversions	previously occurrences can't be calculated as they depend on knowing the fracture zone volume. • Length of subsurface diversion changes due to delamination of existing strata can be influenced by creek bed gradient. • Water flow volumes make a huge difference to the significance of any subsurface diversion as a result of fracturing. • Current flow volume is artificial. Natural background flow is between 0.5 to 1ML/day. Without mine water (5ML/day) the Bargo would be a series of isolated ponds.	the rockbar. • Volume of water flow • Existing natural subsurface flow diversions				
10	Potential for fracturing in the river bed and rock bars causing deterioration of water quality beyond existing background levels	• Need to understand that we are referring to any single location of cracking. At worst this has been observed to cause a maximum input of pollutant (sulphuric acid) of 100 moles/day. • This must be balanced by the dilutional contribution of the existing water flow in the river. • Mine water possesses a natural alkalinity and has a neutralising capacity to any major fracture related pollution addition. • Pollution from fractures only persists for 3 months maximum in Southern Coalfields due to self armouring of fractures. • Expected to be undetectable based on the maintenance of current mine water flow.	• Mine water masking (chemical and dilutional) • Rainfall contribution	• Habitat • Aesthetics	BARELY CREDIBLE	INSIGNIFICANT	**VERY LOW**
11	Potential for visible fracturing in the riparian zone	• Not resulting in other issues previously covered in this RA. • Within the gorge area but not including cliffs. • 2/3 of the valley is alluvium/colluvium and 1/3 is exposed sandstone.	• Longwalls not beneath river valley • Masking by colluvium/ alluvium	• Aesthetics • Stability • Habitat • Safety	POSSIBLE	INSIGNIFICANT	**VERY LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
		• Not seen more than 200m from a longwall	• Offset distance from LW > 200m				
12	Potential for gas emissions	• No reported gas emissions at Tahmoor. Gas never observed by consultants involved in regular inspections. • Very low amounts of sediment in affected area of gorge and therefore anaerobic generation of methane unlikely. • Vegetation die-off is also unlikely for most of the river but possible at upcreek end of subsidence zone where there is sand banks (near the dyke zone). • Rough river from an hydraulic perspective which keeps sediment levels low. • Experience in other areas of Southern Coalfields indicates that Hawkesbury Sandstone contains methane near the surface which is released when cracking occurs. This is usually due to mobilisation of an existing joint or new cracking.	• Low sediment levels in river • Areas that may be affected at extreme end of SMP area.	• Terrestrial habitat change	POSSIBLE	INSIGNIFICANT	**VERY LOW**
Myrtle and Redbank Creeks							
13	Potential for change of grade affecting pool levels.	• As for Items 1 & 2 for the Bargo River • Creeks are basically sewage polluted stormwater channels or degraded urban creeks. • Ave gradient 22-27mm/m for both creeks	• Poor quality habitat • Ephemeral creeks • Few pools	• Ecology	ALMOST CERTAIN	INSIGNIFICANT	**LOW**
14	Potential for raising flood levels above habitable floor levels as a result of gradient change	• Flood study identifies a decrease in RL's resulting in slight raising of flood levels in 1:100 events.	• Structures above 1:100 event level • Flood study	• Structures • Safety	RARE	MEDIUM	**LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
15	Potential for fracturing in the creek beds	• Cracking in Myrtle Ck has occurred in accessible areas. • No reports from the community have been received. • Cracks can be of significant size.	• Can't access most of the creek • Ephemeral creek • Few pools • Alluvial beds	• Minor ecology issues • Bank & bed destabilisation and erosion • Aesthetic	LIKELY	INSIGNIFICANT	**LOW**
16	Potential for surface water flow diversion beyond natural levels	• Most of the time there is little water flow in these creeks and very few standing pools. • When the creeks do flow it is usually a high flow event and surface cracks there are no subsurface paths for the water to follow. • Will be filled rapidly by sediment. • May be significant to residents backing onto sections with standing ponds.	• Ephemeral creek • Few pools • Alluvial beds	• Aesthetic • Ecology	UNLIKELY	MEDIUM	**LOW**
17	Potential for creek bed and bank erosion and bed load movement	• Cracks can create new surface water conduit and thus cause erosion. • The amount of cracking currently observed is very minor	• Vegetation • Ephemeral creek • Existing high bedload movement	• Water quality • Aesthetic • Habitat • Bank stability	UNLIKELY	MINOR	**LOW**
18	Potential for impact on water quality	• Cracking of sewer mains may contribute to pollution. This is already addressed in Sydney Water Sewer SSSMP. See also Upland Spring Induction, Item 21 and Item 19.	• Existing poor water quality • Septic tank seepage	• Water Quality • Ecology	UNLIKELY	MINOR	**LOW**
Groundwater Resources							
19	Potential for impacts on groundwater levels and bore yields > 20m	• There is 1 registered bore in the SMP area and 6 in the monitoring area. • Groundwater levels in bores ranges from 94m to 14m with variation in discrete bore water levels of up to 9m.	• No bores in use	• Water levels	ALMOST CERTAIN	INSIGNIFICANT (based on current known usage)	**LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
	below ground level	• Water levels tend to drop as longwall passes and generally tend to recharge and fill fracture void spaces over the medium term. • Eventually the yield increases due to the greater void spaces but recharges and discharges faster.					
20	Potential for impact on groundwater quality	• Temporary reduction in water quality	• Local groundwater is very high in iron • Local groundwater is fresh to brackish	• Bore yields	LIKELY	INSIGNIFICANT	**LOW**
21	Potential for upland spring induction.	• Bore usage in the SMP area is zero. • There are a large number of dams that are groundwater catchments to a degree. • Existing goaf areas adjacent to and relevant to study area have not indicated a propensity. • Soil cracking occurs between longwalls and in natural drainage lines. • Upland subsidence causes increased separation between Wianamatta and Hawkesbury. This increases subsoil storage of groundwater which reduces creek drainage as it naturally occurred prior to subsidence. As a result outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. This can cause interference with dam recharge in areas that this occurs either by increasing or decreasing recharge rates. • Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. • Nutrients to these systems enhance bacterial	• High alkalinity of mine waters • No previous spring induction in the area	• Dam water quality • Groundwater quality. • Groundwater availability for use	RARE	INSIGNIFICANT	**VERY LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
		action and thus enhance the concentration of iron/manganese in waters.					
22	Potential for upland spring induction.	• Bore usage in the SMP area is zero. • There are a large number of dams that are groundwater catchments to a degree. • Existing goaf areas adjacent to and relevant to study area have not indicated a propensity. • Soil cracking occurs between longwalls and in natural drainage lines. • Upland subsidence causes increased separation between Wianamatta and Hawkesbury. This increases subsoil storage of groundwater which reduces creek drainage as it naturally occurred prior to subsidence. As a result outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. This can cause interference with dam recharge in areas that this occurs either by increasing or decreasing recharge rates. • Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. • Nutrients to these systems enhance bacterial action and thus enhance the concentration of iron/manganese in waters.	• High alkalinity of mine waters • No previous spring induction in the area	• Habitat in the immediate vicinity of the spring during low water flow *(<=3ML/day)*	RARE	MAJOR	**LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
23	Potential for upland spring induction.	• There are a large number of dams that are groundwater catchments to a degree. • Existing goaf areas adjacent to and relevant to study area have not indicated a propensity. • Soil cracking occurs between longwalls and in natural drainage lines. • Upland subsidence causes increased separation between Wianamatta and Hawkesbury. This increases subsoil storage of groundwater which reduces creek drainage as it naturally occurred prior to subsidence. As a result outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. This can cause interference with dam recharge in areas that this occurs either by increasing or decreasing recharge rates. • Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. • Nutrients to these systems enhance bacterial action and thus enhance the concentration of iron/manganese in waters.	• High alkalinity of mine waters • No previous spring induction in the area	• Habitat in the immediate vicinity of the spring during high water flow *(>3ML/day)*	RARE	INSIGNIFICANT	**VERY LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
24	Potential for upland spring induction.	• Existing goaf areas adjacent to and relevant to study area have not indicated a propensity. • Soil cracking occurs between longwalls and in natural drainage lines. • Upland subsidence causes increased separation between Wianamatta and Hawkesbury. This increases subsoil storage of groundwater which reduces creek drainage as it naturally occurred prior to subsidence. As a result outflow from these storage areas can be diverted and appear as a ferruginous spring at another location. This can cause interference with dam recharge in areas that this occurs either by increasing or decreasing recharge rates. • Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs. • Nutrients to these systems enhance bacterial action and thus enhance the concentration of iron/manganese in waters.	• High alkalinity of mine waters • No previous spring induction in the area	• Aesthetics	RARE	MAJOR	**LOW**
Cliffs							
25	Potential for rockfall in gorge (<=100m^3)	• Natural gorge forming processes have resulted in many rockfalls and will continue into the future. • It is a dynamic geomechanical environment. • Timing is the key element in considering the risk of this element. Movement may loosen joints etc however most rockfalls appear to occur during the period of a few months after subsidence. 10 years is a good time period to use based on Burragorang Valley movements. • Risk needs to be assessed quantitatively. 6m x6m x3m dimensions appear to	• Naturally occurring process which will not vary due to mining • Longwall not mining under the river or cliffs • Low numbers of people entering the gorge area	• Aesthetics • Safety • Habitat • Cultural heritage	RARE	CATASTROPHIC	**MODERATE**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
		represent the main model failure due to jointing in the gorge cliffline. Mining is unlikely to significantly increase the likelihood of modal failure. • Pells Sullivan Maynick has been engaged to review the risks associated with the end positions of longwalls 25 and 26.					
26	Potential for cliff collapse in gorge (>100m^3)	• As for Item 25 • Need info on number of walkers/visitors to gorge including mine staff and contractors as well. • Need more data on rockfalls etc related to mining in southern coalfields.	• Naturally occurring process • Longwall not mining under the river or cliffs • Low numbers of people entering the gorge area	• Aesthetics • Safety • Habitat • Water Flow • Water quality	BARELY CREDIBLE	CATASTROPHIC	**LOW**
Steep Slopes							
27	Potential for slope instability resulting in a landslip	• Assessed as unlikely based on soil type and underlying geology. • Steep slopes reports have identified general low likelihood of landslip in the SMP Application Area	• Local geology and soils resist landslip • Low rainfall and good drainage of soils reduced hydraulic loading	• Aesthetics • Habitat • Water Flow • Water quality	UNLIKELY	MEDIUM	**LOW**
28	Potential for slope instability resulting in a debris scour	• As 27 • Loose soil and rock sections that may be prone to scour rare and generally confined to river or creek valleys	• As for 27	• Aesthetics • Habitat • Water Flow • Water quality	BARELY CREDIBLE	MINOR	**VERY LOW**
29	Potential for slope instability resulting in soil erosion	• As 27 • Tension cracking at top of slope is possible allowing soil erosion if left untreated.	• As for 27	• Aesthetics • Habitat • Water Flow	POSSIBLE	INSIGNIFICANT	**VERY LOW**

Item	Hazard	Review Comments	Existing Controls	Element at risk	Likelihood	Consequence	Level of Risk
				• Water quality			
Other Impacts to Flora and Fauna							
30	Potential for soil disturbance and surface cracking	• All terrestrial areas (i.e. not creeks or rivers). • We have some natural springs in the area that have a small probability of disturbance.	• Most land has been disturbed previously. Dominated by commercial, urban & agricultural land	• Habitat • Water quality • Safety	ALMOST CERTAIN	INSIGNIFICANT	**VERY LOW**

3.10. Monitoring Plan

3.10.1. *Ground Monitoring – Bargo River*

Angle of Draw Monitoring Lines

Monitoring lines are located beyond the ends of Longwalls 24A, 25 and 26 and are shown in Fig. 3.2. The purpose of the monitoring lines is to establish the extent of vertical subsidence beyond the edge of the longwalls towards the Bargo River. The monitoring lines are located within private property.

The monitoring lines will be surveyed using conventional 2D survey techniques (levels in AHD and strain distances) as per the Tahmoor Colliery Specification for Monitoring Lines, which is attached in Appendix B.

All of the angle of draw monitoring lines have been installed and initially surveyed.

The angle of draw will also be estimated by observations from monitoring lines that have been installed to connect valley closure monitoring points X3L, X3aL, X4L, X4aL and X5L to the overall survey grid from Progress Street. These monitoring lines will measure levels in AHD only. The survey results will be be compared against the trigger levels described in **Section 3.11**

Valley Closure Monitoring Points

Survey marks have been installed at the tops of the cliffs on either side of the Bargo River at 9 locations and are shown in Fig. 3.2. A conventional survey mark has been installed on the “L” side of the river and a permanent reflector has been installed on the “R” side of the river.

Where possible, the valley closure monitoring points are aligned with the rockbar monitoring lines. It is not possible to gain a line of sight directly across the top of the valley sides at Mermaid Pool due to the relatively gently sloping sides and thick vegetation and valley closure points have not been installed at this location.

The surveys will measure relative vertical and horizontal movements between each pair of points. Survey marks X3L, X3aL, X4L, X4aL and X5L have also been surveyed to AHD.

The accuracy of the surveys is limited by instrument height and visibility of the target. The horizontal distance between the monitoring points will be surveyed to an accuracy of ± 3 mm. The relative vertical height between the points will be surveyed to an accuracy of ± 5 mm.

All monitoring points have been installed and surveyed prior to the commencement of Longwall 24A. Survey results will be compared against the trigger levels described in **Section 3.11**.

Rockbar Monitoring Lines

Survey marks have been installed along identified rockbars within the Bargo Gorge at 9 locations. One monitoring line has been installed across bedrock (X4 Line), making a total of 10 monitoring lines. The monitoring lines are shown in Fig. 3.2.

The monitoring lines are located in the base of the Bargo River and extend as far as possible across the valley base. The extents of the monitoring lines are mainly limited by cliffs and thick vegetation. Most of the monitoring lines have been located near the apex of the bend in the river closest to the longwalls.

Photographs of approximate locations of the monitoring lines are shown in accompanying figures below. The survey marks consist of nails driven into the bedrock and are spaced approximately 5 metres apart on average. In the case of the X3 Line, it is not possible to establish a monitoring line due to access and vegetation restrictions. Three marks have been placed in this location, which are located 20 to 30 metres apart.

The surveys will measure relative vertical and horizontal movements along the monitoring line. A theodolite will be placed at one point in the line. Measurements will be taken to a hand held reflector at all other points, recording horizontal distance (± 3 mm) and height difference (± 3 mm). The relative accuracy between individual marks may be better than this as errors in instrument set up and instrument height will be constant for all measurements. However, the accuracy is not expected to achieve better than ± 2 mm.

Where reasonably possible, the monitoring lines will be connected to corresponding valley closure points to provide a full cross-sectional survey. This will be done by surveying into the gorge from some valley closure points to a reflector mounted on a tripod. The X1 Line will be surveyed independently from the corresponding valley closure points X1L and X2L. The X3 Line will be connected to the X3a valley closure points. The accuracy of the survey is limited by instrument height and heighting on very steep lines. The horizontal distance between the monitoring points will be surveyed to an accuracy of ± 5 mm. The relative vertical height between the points will be surveyed to an accuracy of ± 10 mm.

All monitoring points have been installed and surveyed prior to the commencement of Longwall 25. Survey results will be compared against the trigger levels described in **Section 3.11**.

3.10.2. ***Water Level Monitoring – Bargo River***

Five (5) automated pressure transducer loggers (Fig. 3.1) record water levels on a daily basis and are downloaded monthly by Hydrometric Consulting Services (HCS). Bolts have been placed in other pools and the vertical distance between the bolt and the water level is measured by HCS on a monthly basis. The locations of all loggers and bolts are shown in Fig. 3.2. Results will be compared against trigger levels described in **Section 3.11**.

Fig. 3.1 Automated Water Level Logger at Pool H

3.10.3. ***Water Flow Monitoring – Bargo River***

Water flow monitoring is undertaken at eight locations along the Bargo River by HCS on monthly intervals, three of which are well upstream of the SMP Area. Five locations are within or near the SMP Area and these are shown in Fig. 3.2. Flows are measured in the same pools but downstream of the automated water level loggers, with the exception of Pool H as the water naturally drains from this pool beneath the downstream rockbars. Flow rating curves have been developed so that daily water flows can be calculated from the measured daily water levels. Licensed discharge is also recorded by Tahmoor Colliery every day. Results will be compared against trigger levels describe in **Section 3.11**.

3.10.4. *Water Quality Monitoring – Bargo River*

Water quality monitoring is undertaken by Geoterra as per the recommendations in its report (Geoterra, 2006) and outlined in Section 3.11. The locations of the monitoring stations are shown in Fig. 3.2. Triggers and responses for monitored changes in water quality are detailed in **Section 3.11**.

3.10.5. *Visual Inspections – Bargo River Gorge*

Visual inspections will be undertaken by Tahmoor Colliery staff, HCS and Geoterra at frequencies stated in the Risk Control Procedures. Any identified potential impacts to the river bed, cliff lines, steep slope areas and evidence of strata gas escape will be compared against recorded pre-mining baseline conditions and trigger levels described in **Section 3.11**.

3.10.6. *Monitoring Plan for Groundwater Interactions*

Currently, the opportunity to monitor groundwater interactions with mining is limited for LW25, with only 1 private and 1 colliery installation in the immediate vicinity of LW25, however there are some regional installations (see **Figure 3.3)**. Monitoring groundwater interaction for LW25 will largely be dependant on monitoring for evidence of significant surface to mine connectivity as detailed in **Section 3.11**. Tahmoor Colliery has installed two piezometers between the ends of LW's 25 & 26 and the Bargo Gorge to detect any localised impacts on groundwater levels. The Colliery will be developing a regional groundwater program in consultation with Department of Water and Energy (DWE) as mining progresses. It is envisaged that this regional groundwater monitoring program will include a network of piezometers and extensometers to assist with increasing the knowledge of the groundwater regime in the area. These will be utilised to assess the impacts of mining on groundwater.

3.10.7. *Monitoring Plan for Upland Streams*

Monitoring of upland creeks is undertaken by Geoterra as per its recommendation as part of the original SMP application (Geoterra, 2006). Monitoring in these affected areas includes baseline observations, water flow, field chemical paramters, surface flow diversion, areas of increased flooding, including associated erosion and scouring impacts Monitoring locations are shown in **Figure 3.3**. Results will be compared against trigger levels describe in **Section 3.11**.

3.10.8. *Triggers and Response*

Monitoring serves to advise subsidence impacts are occurring as predicted or alternatively alert stakeholders that an abnormal condition relating to subsidence has developed. Each program has established triggers used to indicate levels of subsidence impact and an appropriate response. The fundamental means of determining the magnitude of any subsidence impact and the need for further monitoring and/or remedial actions is based upon the Trigger Action Response Plan documented in **Table 3.11**. Management of impacts within predictions follow standard assessment review and response protocols. Contingent measures are included in this SMP to ensure the timely and adequate management of subsidence impacts outside of predicted levels. Where stated within each TARP table, the following notes apply:

Contract hydrogeologist/hydrologist investigations and reports will include:

- Scope of the study.
- Consider any relevant aspect from this plan.
- Analysis of trends.
- Assessment of any impacts against prediction.
- Cause analysis of any change or impact.
- Options for management and mitigation.
- Assessment for the need for contingent measures.
- Any recommended changes to this plan.
- Appropriate consultation.

Site specific mitigation/action plans will include:

- A description of the impact to be managed.

- Results of the hydrogeologist/hydrologist investigations.
- Aims and objections for the plan.
- Specific actions required to mitigate/manage.
- Timeframes for implementation.
- Roles and responsibilities.
- Identification of and gaining appropriate approvals from landholders and government agencies.
- Consultation and communication plan.

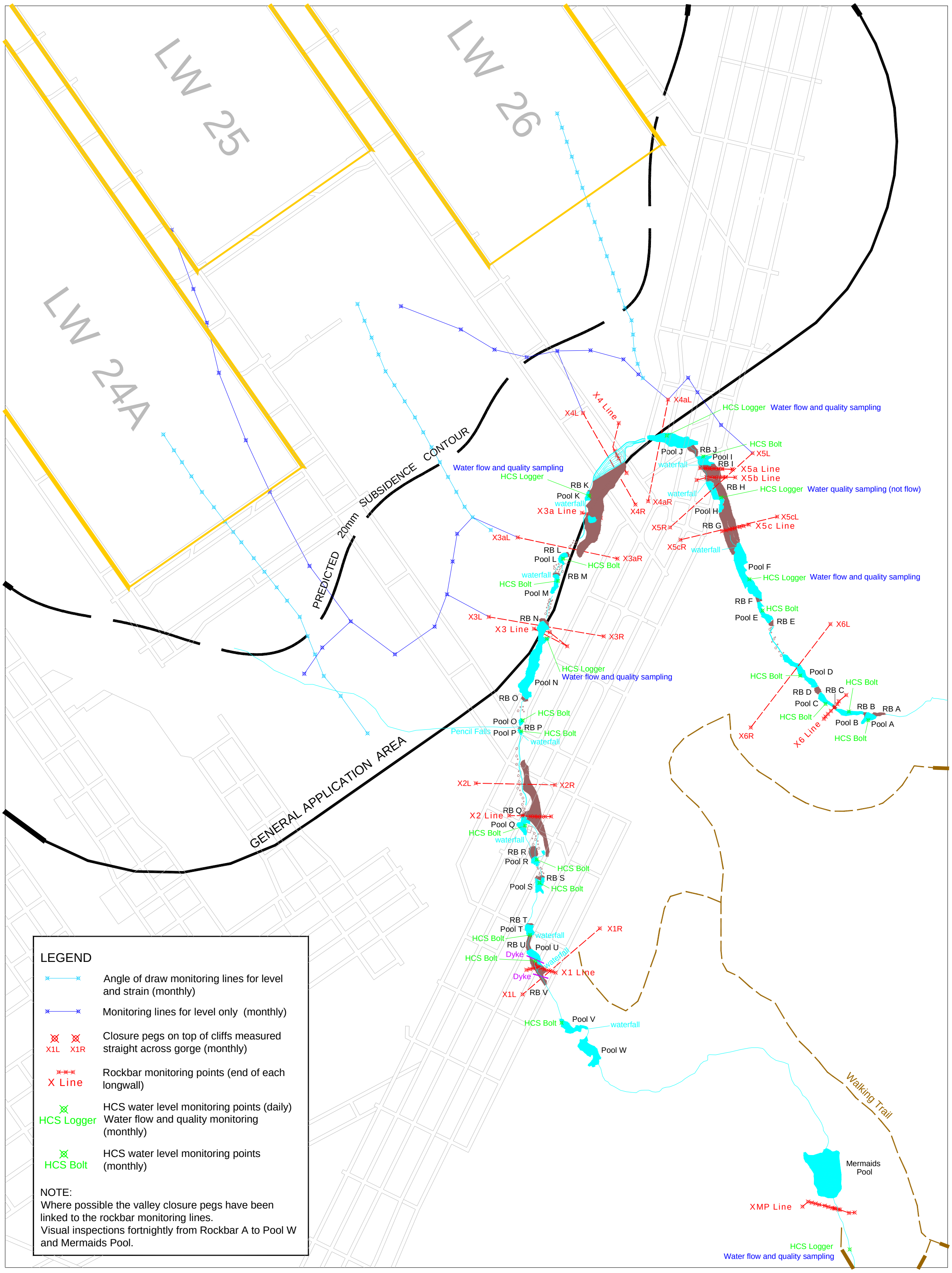


Fig. 3.2 Monitoring Locations in the Bargo River

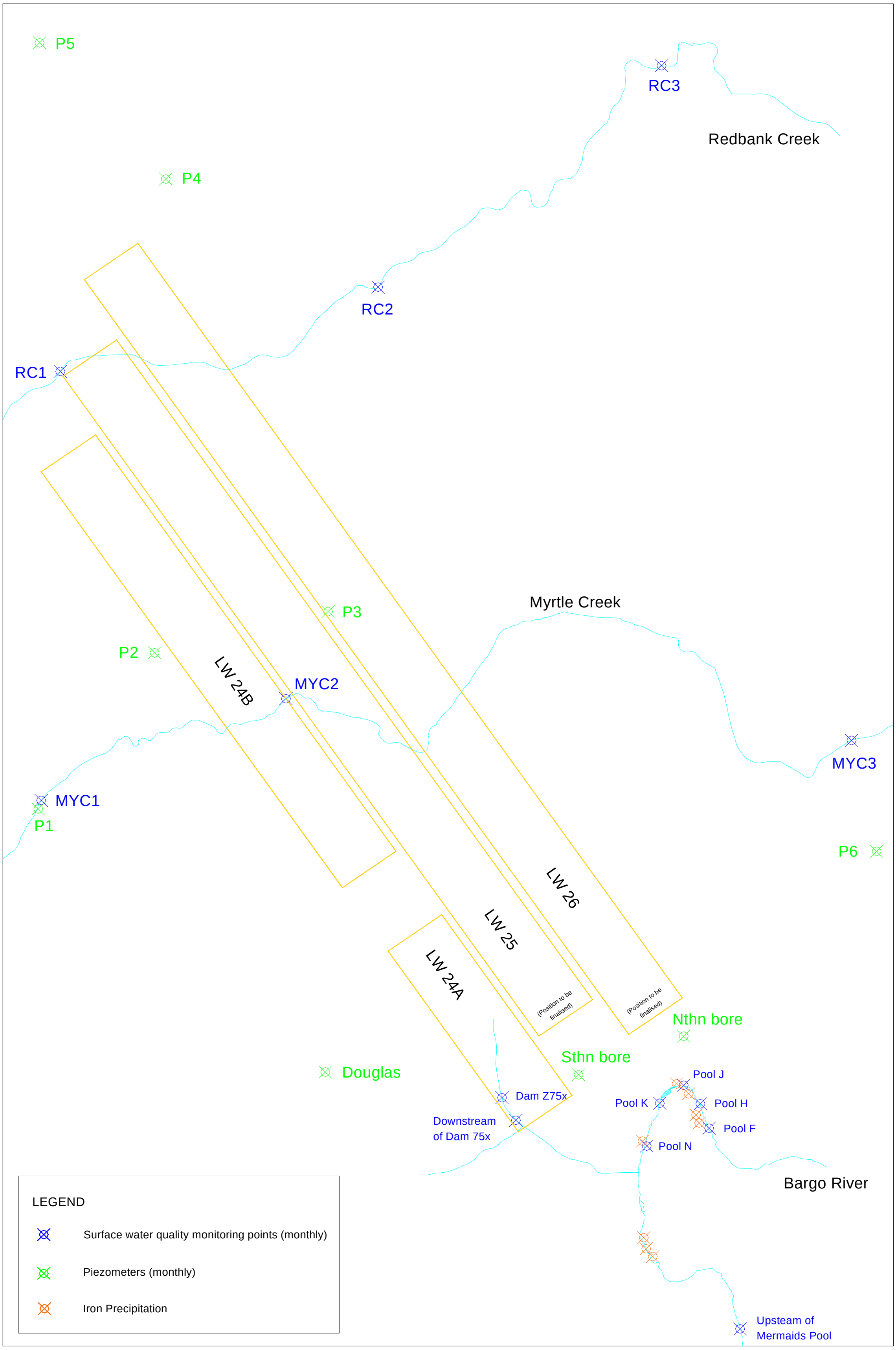
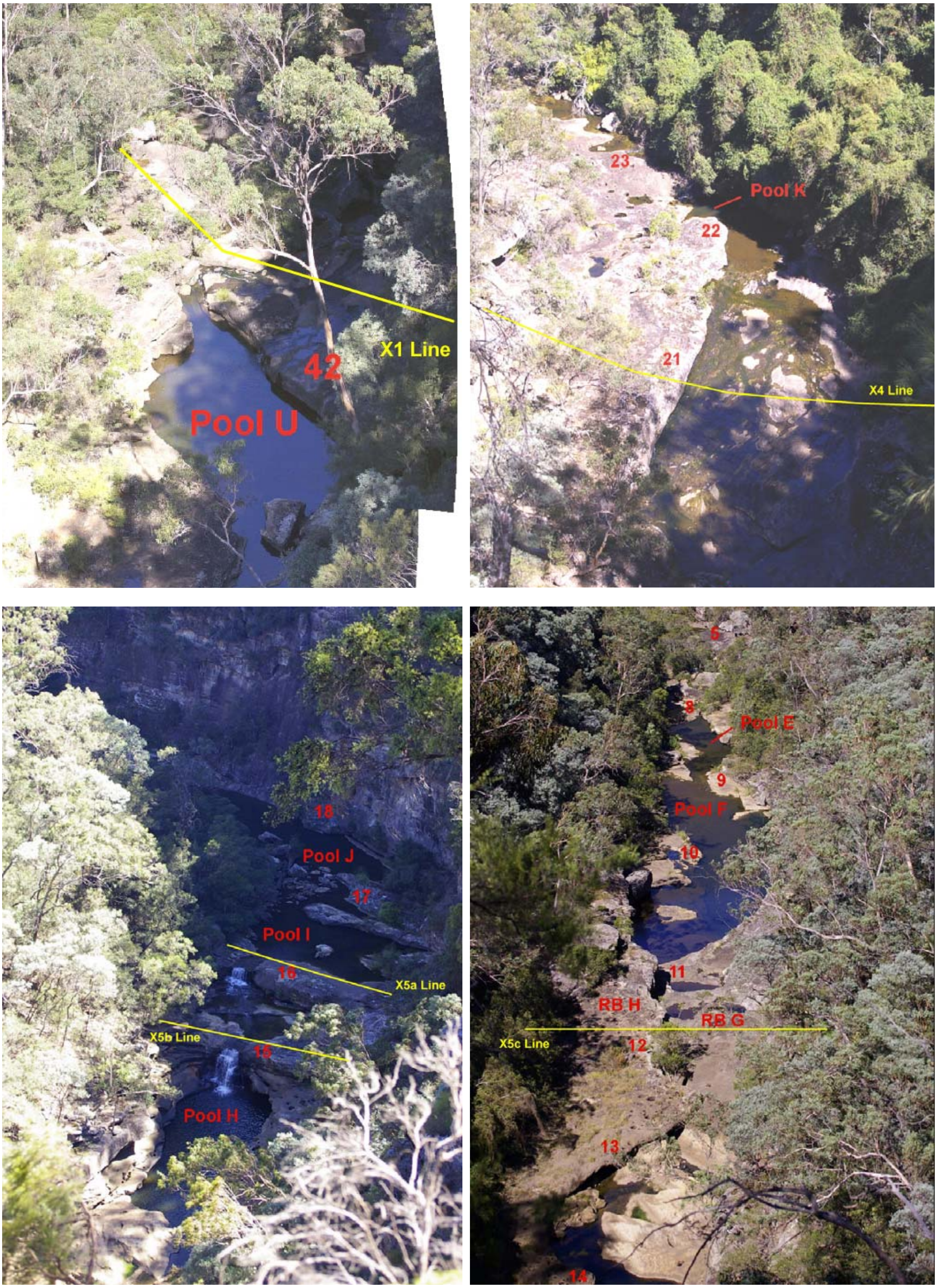


Fig. 3.3 Map of Water Quality Monitoring Locations for Tahmoor North

Note: Red numbers refer to MSEC photographic survey stations.

Fig. 3.3 XMP, X2, X3, X3a and X6 Rockbar Monitoring Lines



Note: Red numbers refer to MSEC photographic survey stations.

Fig. 3.4 X1, X4, X5a, X5b, and X5c Rockbar Monitoring Lines

3.11. Trigger Action Response Plan for Longwall 24A

All Natural Feature Surface Areas									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Ground Monitoring	Angle of Draw Monitoring Lines Valley Closure Monitoring Points Vacant land areas	Subsidence Upsidence Closure Strain	Monthly until movements cease Weekly visual field observations.	To compare movements with predictions To assist in decisions on future mining, remediation and changes in other monitoring programs.	Angle of draw assessed to be equal to or less than predicted	Review observed movements and compare with predictions Compare results with observations on water flow, level and quality Consider addition of further monitoring lines Report in Subsidence Management Status Report End of Panel report	Tahmoor Colliery (SMP Coordinator)	Survey results sent to DPI within 48 hours of survey Review survey results within 3 days of survey Monthly updates of investigation progress EoP Report within 6 months of longwall completion	Inform stakeholders Assist in decisions on future mining, remediation and changes to monitoring programs
					Angle of Draw larger than that predicted	Installation of additional Subsidence lines in adjacent block to provide further information for investigation Investigation into the mechanisms relating to increased angle of draw in consultation with the DPI, DWE and appropriately qualified experts Review the proposed location of the end of the adjacent block to determine whether any modification is required Report in Subsidence Management Status Report End of Panel report	Tahmoor Colliery (SMP Coordinator)	Survey results sent to DPI within 48 hours of survey Review survey results within 3 days of survey Monthly updates of investigation progress EoP Report within 6 months of longwall completion	
					Valley closure or upsidence is greater than predicted maximum along Bargo River	Notify DPIM and DWE within 48 hours of survey Consider additional monitoring, investigations and reporting Consider implications on potential for impacts or further impacts to Bargo River Gorge If investigations show ongoing risk to	Tahmoor Colliery (SMP Coordinator)	Survey results sent to DPI within 48 hours of survey Review survey results within 3 days of survey	

All Natural Feature Surface Areas									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
						public safety then a site mitigation/action plan will be prepared and implemented in consultation with key agencies if deemed necessary. This may include prohibiting access to the affected area. Report in Subsidence Management Status Report End of Panel report		Monthly updates of investigation progress EoP Report within 6 months of longwall completion	
					Visual observations reveal land deformation impacts. i.e. surface crcks, compression humps etc..	Barricading, signage of unsafe areas Notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Within 1 week. Within 24hrs Commence preparation of mitigation/action plan within 1 week Monthly updates of progress EoP Report within 6 months of longwall completion	

NOTE: Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.
Access to any monitoring site on private land is subject to suitable landholder acceptance of access to the monitoring site.

Impacts to, flora, fauna, runoff water qualities, or landforms will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.

Bargo River

ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTNIG	RESPONSIBILITY	TIMING	PURPOSE
River Water Flow and Level	Mermaid Pool Pencil Falls (Turkey Ck) Pool K Pool J Pool H Pool F Identified in Figure 3.2	Measurement of water height and flow using loggers Flow connectivity between pools Areas of loss of overland observable flow Monitor flow Colliery licensed discharge points in Teatree Hollow Erosion of banks Photo points	Measurement of daily water level and flow via data loggers at monitoring sites, downloaded monthly Weekly field observations during active mining of Panel 24A, or until subsidence / uplift of gorge becomes static during Panel 24A extraction Measurement benchmarks / survey lines surveyed pre-mining, during and post mining Panel 24A	To provide pre-mining baseline pool water level data to compare to post-mining To identify any river flow impact from mining To identify pool connectivity impacts related to mining To identify any flow-on impacts from changes in river water level To provide data to any surface to mine connectivity investigation	> 3ML/day post Panel 24A loss of flow between Mermaid Pool and Pool F, compared to an equivalent low flow period.	Inform relevant agencies of change Repeat level / flow measurements and qualify if the results occurred following a storm event. Contract hydrologist to investigate and report on changes identified and options to address changes Inform relevant of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary. Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform within 24hrs Investigation initiated within 1 week Results of investigation reported within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	Identify, investigate and report on impacts to river water level, flow, pool depth and pool connectivity Investigate any mitigation measures required and implement in consultation with key agencies
					Observation of loss of flow connectivity between pools or pool levels compared to pre-mining observations	Inform relevant agencies of change. Repeat level / flow measurements and qualify if the results occurred following a storm event. Contract hydrologist to investigate and report on changes identified and options to address changes Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary. Report in Subsidence Management Status Report. Report in the End of Panel Report.	Tahmoor Colliery (SMP Coordinator)	Inform within 24hrs Investigation initiated within 1 week Results of investigation reported within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion.	

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTNIG	RESPONSIBILITY	TIMING	PURPOSE
					Observing changes in premining dry / low water and/or throughflow sections of the river to post mining observations	Inform relevant agencies of change Repeat level / flow measurements and qualify if the results occurred following a storm event. Contract hydrologist to investigate and report on changes identified and options to address changes Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary. Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform relevant agencies within 24hrs Investigation initiated within 1 week Results of investigation reported within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress and EoP Report within 6 months of longwall completion	
					Observation of changes in erosion of bed / banks compared to pre-mining state	Inform relevant agencies of change Contract hydrologist to investigate and report on changes identified and options to address changes Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary. Report in Subsidence Management Status Report. Report in the End of Panel Report.	Tahmoor Colliery (SMP Coordinator)	Inform relevant agencies within 24hrs Investigation initiated within 1 week Results of investigation reported within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress . EoP Report within 6 months of longwall completion.	

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTNIG	RESPONSIBILITY	TIMING	PURPOSE
	XMP, X1, X2, X3, X3a, X4, X5a, X5b, X5c, and X6. See Figure 3.2.	Rockbar monitoring lines	Monthly	To provide measurement of valley closure and upsidence within the gorge.	Monitoring results show upsidence above predictions, evidence of cracking	Inform relevant agencies of change Repeat level / flow measurements and qualify if the results occurred following a storm event. Contract hydrologist to investigate and report on changes identified and options to address changes Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary. Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform relevant agencies within 24hrs Investigation initiated within 1 week Results of investigation reported within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress and EoP Report within 6 months of longwall completion	

NOTE: Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

The trigger flow of 3ML/day of the apparent loss of flow between Mermaid Pool and Pool F was generated from pre Panel 24A stream flow data collected during an extended dry, low flow period between 2/5/06 and 10/2/07. It should be noted that higher flow differentials have occurred during storm runoff and higher flow events monitored since 10/2/07, therefore the trigger of 3ML/day does not apply following storm or extended high runoff periods in the Bargo River catchment

Impacts to water quality, water level, water flow, river accessibility or use within the Bargo River will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Immediate barricading and signage to reduce exposure to unsafe areas such as vigorous gas release, areas of shallow water or rock fall areas.
- Immediate notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified.
- Regular monitoring of safety aspects at the site.
- Grouting and rehabilitation of areas of river where required, with appropriate government approvals. This would be triggered by identification of surface water flow identified being lost from the Bargo River system to deep storage or the mine workings.
- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.
- Active preservation of life such as relocation of stranded fish and watering of exposed aquatic vegetation where this is practical.

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
River Water Quality	Mermaid Pool Pool N Pool K Pool J Pool H Pool F 1 sampling site in tributaries (Turkey Ck – Pencil Falls) Note, additional observation points are monitored upstream of Mermaid Pool but are not included in the Panel 24A suite Identified in Figure 3.2.	Observable iron or salinity staining Photo points Laboratory/field analysis of: EC, Eh, pH, temp, TDS, TSS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, DOC, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Cs, Rb, Sr (filtered)	Laboratory sampling monthly Field analysis monthly Weekly Visual Observations	To compare pre and post Panel 24A water quality To identify any water quality impacts from mining 24A	Observable increase in iron or salinity staining compared to pre Panel 24A data , based on photographs and field inspection	Increase sampling frequency to fortnightly Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Within 1 week. Monthly updates of investigation progress and EoP Report within 6 months of longwall completion	Identify, investigate and report on impacts to river water quality Investigate any mitigation measures required and implement in consultation with key agencies
					Water quality parameter exceeds historical (Pre Panel 24) maximum concentration in flow bands (0-6, 6-10, >10ML/day) at a specific site.	Contract hydrologist to investigate and report on changes identified Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with relevant agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week Results of investigation reported within 1 week of completion to DPI. Commence preparation of mitigation/action plan as agreed with relevant agencies Monthly updates of investigation progress to DPI. EoP Report within 6 months of longwall completion	
					Consistent trend of water quality trigger exceedance over at least 3 monitoring events at a specific site	Contract hydrologist to investigate and report on changes identified Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with relevant agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week Results of investigation reported within 1 week of completion to DPI. Commence preparation of mitigation/action plan as agreed with relevant agencies Monthly updates of investigation progress to DPI. EoP Report within 6 months of longwall completion	

NOTE: Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to water quality, water level, water flow, river accessibility or use within the Bargo River will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Immediate barricading and signage to reduce exposure to unsafe areas such as vigorous gas release, areas of shallow water or rock fall areas.
- Immediate notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified.
- Regular monitoring of safety aspects at the site.
- Grouting and rehabilitation of areas of river where required, with appropriate government approvals. This would be triggered by identification of surface water flow identified being lost from the Bargo River system to deep storage or the mine workings.
- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.
- Active preservation of life such as relocation of stranded fish and watering of exposed aquatic vegetation where this is practical.

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Seep Water (Bed and Cliff) Quality and Flow	8 observed seeps in Bargo River bed between Mermaid Pool and Pool F 1 cliff seep identified upstream of pool w. Further regular observations Mermaid Pools to Pool W, to Pool F Refer to Figure 3.2.	Observable increase iron or salinity staining Observable increase in seepage rate Observe new seeps Photo points Where able, laboratory/field analysis of: EC, Eh, pH, temp, TDS, TSS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, DOC, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Cs, Rb, Sr (filtered)	Weekly visual observations Field / laboratory analysis if increased seepage rate observed	To provide comparison between pre and post Panel 24A To identify the development of any new, or loss of existing seeps To identify any water quality or seepage rate changes due to 24A	Visual identification of new ferruginous seep/s or increase / decrease in flow of existing seeps based on comparison of pre and post Panel 24A field observations and photographs	Collect samples to assess change, and contract hydrologist engaged to investigate and report on changes identified Report in Subsidence Management Status Report .Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week an results reported within 1 week of completion Monthly updates of investigation progress to DPI. EoP Report within 6 months of longwall completion	Identify, investigate and report on impacts to seep flow and water quality, as well as effects on river water quality Investigate any mitigation measures required and implement in consultation with key agencies
					River water quality indicators exceed historical maximum concentrations (pre Panel 24A data) as a result of seep discharge.	Inform relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with relevant agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform relevant agencies within 24hrs Commence preparation of mitigation/action plan within timeframes agreed with relevant agencies. Monthly updates of investigation progress to DPI. EoP Report within 6 months of longwall completion	

NOTE: Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

All identified bed seeps have been located within the base of the gorge, within or on the edge of the river high water mark. As a result, these seeps are submereged during high flow events, or extended periods of high flow following storms, which significantly dilutes the actual seep water quality and masks the seep flow rate, as they are under water. Therefore assessment of seep changes can only be conducted following extended low flow periods where the seep outflow can be separated from the river flow. The one observed cliff seep has not been observed to flow since baseline monitoring began.

Impacts to water quality, water level, water flow, river accessibility or use within the Bargo River will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Immediate barricading and signage to reduce exposure to unsafe areas such as vigorous gas release, areas of shallow water or rock fall areas.
- Immediate notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified.
- Grouting and rehabilitation of areas of river where required, with appropriate government approvals. This would be triggered by identification of surface water flow identified being lost from the Bargo River system to deep storage or the mine workings.
- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.
- Active preservation of life such as relocation of stranded fish and watering of exposed aquatic vegetation where this is practical.

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Strata Gas	Mermaid Pool Pool N Pool K Pool J Pool H Pool F Length of Bargo River between Pool W and Pool F. Refer to Figure 3.2.	Strata gas observed Strata gas smell	Weekly visual observations. As required by any report from the community/landholders.	To identify potential impacts to water quality due to strata gas. To identify any safety hazards.	Strata gas observed to be released from river or banks – from visual or audible signs e.g. hissing, bubbling, plumeor strata gas smell detected within gorge.	Take gas sample and measure release rate where applicable. Collect water quality sample in vicinity of release Inform relevant landholders and agencies. If deemed necessary make area safe with barriers and signage as required. Prepare and implement a site mitigation/action plan in consultation with relevant agencies if deemed necessary. Report in Subsidence Management Status Report. Report in the End of Panel Report.	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week an results reported within 1 week of completion. Report to relevant agencies and adjacent landholder within 24 hours. Secure site safety and report to landholder and agencies immediately. Commence preparation of mitigation/action plan within timeframe agreed with relevant agencies. Monthly updates of investigation progress to DPI. EoP Report within 6 months of longwall completion.	Identify and report on gas releases in Bargo River. To manage any safety hazards.

NOTE: Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to water quality, water level, water flow, river accessibility or use within the Bargo River will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Immediate barricading and signage to reduce exposure to unsafe areas such as vigorous gas release, areas of shallow water or rock fall areas.
- Immediate notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified.
- Regular monitoring of safety aspects at the site.
- Provision of a safety officer as deemed necessary in areas of public exposure to safety concerns.
- Grouting and rehabilitation of areas of river where required, with appropriate government approvals. This would be triggered by identification of surface water flow identified being lost from the Bargo River system to deep storage or the mine workings.
- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.
- Active preservation of life such as relocation of stranded fish and watering of exposed aquatic vegetation where this is practical.

Bargo River									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Surface to Mine Connectivity	Active mining areas – longwall 24A face and roadway development Mined goaf areas – LW24A	Groundwater make increasing as measured by mine dewatering monitoring Inflow event from mining area Water sample of any inflow event (Laboratory Analysis for major Cations & Anions as well as Stable Isotopes) for comparison to surface waters	Daily statutory mine inspections Mine dewatering monitored throughout the mining process by flow meter of water pumped into and discharged from workings.	To identify potential connectivity to the surface or large groundwater make To provide data for surface impact investigations To establish baseline information for groundwater make	Notable increases in water make from longwall 24A which is suspected to be as a result of mine subsidence.	Contract hydro-geologist engaged to investigate and report on changes identified Inform relevant agencies of results of investigation Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week Results of investigation reported within 1 week of completion Monthly updates of investigation progress EoP Report within 6 months of longwall completion	Identify, report and respond to surface to mine connectivity
					Inflow event from mining area requiring notification to the mining inspectorate	Contract hydro-geologist engaged to investigate and report on changes identified Inform relevant agencies of results of investigation Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week Results of investigation reported within 1 week of completion Monthly updates of investigation progress EoP Report within 6 months of longwall completion	
					Water Chemistry or age indicates connectivity to the surface	Inform relevant agencies of change Commence preparation of mitigation/action plan within the timeframe agreed with relevant government agencies Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform relevant agencies within 24hrs Commence preparation of mitigation/action plan within timeframe agreed with relevant agencies. Monthly updates of investigation progress EoP Report within 6 months of longwall completion	

NOTE: Due to the lack of accurate mine inlow data, longwall 24A will be used to establish baseline flows to establish suitable % variation triggers for subsequent longwall panels. Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Cliff Lines and steep slopes									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Rockfall. **Slope instability**	Bargo River Gorge	Site Inspections Photographic record. Aerial Photographs	In conjunction with weekly river visual inspections.	To identify risks to public safety. To identify aesthetic impacts. To identify impacts to flora and fauna.	Pre-mining conditions	Conduct pre-mining photographic survey of cliffs. Erect warning signs along public access tracks, warning of the risks of falling rocks Advise landowners adjacent to the cliffs of risks of cliff instabilities.	Tahmoor Colliery (SMP Coordinator)	Prior to commencemt of LW24A	Identify potential risk areas. Provide information to persons entering the gorge area.
					Extraction of LW24A	Work with local and regional bushwalking clubs to advertise the risks of cliff instabilities Include warning of risks of cliff instabilities in monthly community newspaper update Include warning of risks of cliff instabilities in weekly community email update Include warning of risks of cliff instabilities in weekly community update at Tahmoor Town Centre and Tahmoor Community Centre Include warning of risks of cliff instabilities on Tahmoor Colliery website.	Tahmoor Colliery (SMP Coordinator)	During Extraction of LW24A	Provide information to persons entering the gorge area.
					Viisual observations reveal rockfall, or landslip on steep slope.	Barricading, signage of unsafe areas Notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Within 1 week. Within 24hrs Commence preparation of mitigation/action plan within 1 week Monthly updates of progress EoP Report within 6 months of longwall completion	Identify, report and respond to rockfalls and/or slope instability To manage any safety hazards

Cliff Lines and steep slopes									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
					Visual observations reveal cracking occurrences on steep slope and/or debris scouring as a result.	Barricading, signage of unsafe areas Notification of relevant stakeholders including landholders, government agencies and the community where safety issues are identified Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Within 1 week. Within 24hrs Commence preparation of mitigation/action plan within 1 week Monthly updates of progress EoP Report within 6 months of longwall completion	

NOTE: Access to any monitoring site on private land is subject to suitable landholder acceptance of access to the monitoring site. Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to, flora, fauna, runoff water qualities, river accessibility or use within the Bargo River will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.

Private Bores									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Borehole Data **Water Quality** **Water Level**	***NO private bores in the Panel 24A SMP Area)*** 1 inaccessible registered bore approx. 450m west, and outside of, Panel 24A (Douglas – *bore is currently inaccessible due to the placement of a welded plate over the hole.*) Refer to Figure 3.3	Available water supply and iron precipitation	Prior to and after extraction of 24A if access is possible	To provide pre-mining baseline comparison with post-mining To identify any impact from mining	Reduction in the ability of owner to obtain bore water or increase in iron precipitation above current levels	Investigation of possible mitigation measures in consultaion with the landowner and DWE.	Tahmoor Colliery (SMP Coordinator)	Inform DPI and other relevant agencies within 24hrs Investigation initiated within 1 week	Identify, investigate and report on impacts to private bore water supply and bore condition
						Prepare and implement a site mitigation/action plan in consultation with key agencies if deemed necessary Report in Subsidence Management Status Report Report in EoP Report.	Tahmoor Colliery (SMP Coordinator	Commence preparation of mitigation/action plan within 1 week End of Panel 24A update of investigations Report within 6 months of longwall completion	

NOTE: Access to private bores for water level and quality sampling may be difficult due to bore installation and wellhead configuration. Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to private bore or dam water quality, water level, accessibility or landholder use will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Provision of alternate water supply through regular delivery to tank, dam or other vessel.
- Provision of alternate water supply through modification, repair or replacement of existing water supply e.g. deepening a bore, alternate bore drilled, deepening a dam or construction of a new dam.
- Provision of water treatment facilities to address any water quality impacts e.g. dosing or filtration.
- Repair of any subsidence impacts to water infrastructure eg. pipes and pumps.

Xstrata Monitoring Bores									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Borehole Data **Water Quality** **Water Level**	6 bores in Tahmoor / Thirlmere Area (P1-P6). Continuation of baseline program for LW25-26. Refer to Figure 3.3.	Location Water level Depth /date drilled Permeability data Lithology Purpose Laboratory/ field analysis: EC, Eh, pH, temp, TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Cs, Rb, Sr (filtered) Groundwater level using pressure transducr – 12hr recording.	Pre mining baseline assessment prior to mining Panels 25 and 26 (ongoing) for underlying or immediately adjacent bores to longwalls 25 / 26 End of panel , following full development of subsidence for each bore As required, provide additional data for any landholder bore impact investigation or if physical impacts to bore identified	To provide pre-mining baseline water quality and groundwater level data to compare with post-mining To identify physical and/or chemical water quality and water level impacts related to mining	2 std deviation change in pre-mining water quality parameters – using all available data from private and Xstrata bores for statistical analysis	Repeat water quality sampling of impacted and adjacent bores as required Contract hydro-geologist engaged to investigate and report on any identified adverse changes Inform landholders with adjacent bores and DPI/DWE investigation outcomes. Investigation of possible mitigation measures in consultaion with the landowner and DPI/DWE. Prepare and implement a site mitigation/action plan in consultation with the landowner and DPI/DWE. if deemed necessary Report in Subsidence Management Status Report Report in SMP / End of Panel reports ongoing to inform relevant agencies of results of monitoring	Tahmoor Colliery (SMP Coordinator)	Results of investigation reported within 1 week of completion Inform relevant landholders and agencies within 24hrs Investigation initiated within 1 week Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	Inform stakeholders of baseline assessment and monitoring Identify, investigate and report on impacts to groundwater quality and levels
					>5m water level reduction over 2 month period	Contract hydro-geologist engaged to investigate and report on any identified adverse changes Inform landholders with adjacent bores and DPI/DWE investigation outcomes. Investigation of possible mitigation measures in consultaion with the landowner and DPI/DWE. Prepare and implement a site mitigation/action plan in consultation with the landowner and DPI/DWE. if deemed necessary Report in Subsidence Management Status Report Report in SMP / End of Panel reports ongoing to inform relevant agencies of results of monitoring	Tahmoor Colliery (SMP Coordinator)	Results of investigation reported within 1 week of completion Inform relevant landholders and agencies within 24hrs Investigation initiated within 1 week Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	

					Consistent trend toward water level trigger as measured over time (using at least 3 data points with trend to reach trigger within the mining period)	Contract hydro-geologist engaged to investigate and report on any identified adverse changes Inform landholders with adjacent bores and DPI/DWE investigation outcomes. Investigation of possible mitigation measures in consultaion with the landowner and DPI/DWE. Prepare and implement a site mitigation/action plan in consultation with the landowner and DPI/DWE. if deemed necessary Report in Subsidence Management Status Report Report in SMP / End of Panel reports ongoing to inform relevant agencies of results of monitoring	Tahmoor Colliery (SMP Coordinator)	Results of investigation reported within 1 week of completion Inform relevant landholders and agencies within 24hrs Investigation initiated within 1 week Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	
					Relate changes to saturated thickness of the monitored aquifer	Contract hydro-geologist engaged to investigate and report on any identified adverse changes Inform landholders with adjacent bores and DPI/DWE investigation outcomes. Investigation of possible mitigation measures in consultaion with the landowner and DPI/DWE. Prepare and implement a site mitigation/action plan in consultation with the landowner and DPI/DWE. if deemed necessary Report in Subsidence Management Status Report Report in SMP / End of Panel reports ongoing to inform relevant agencies of results of monitoring	Tahmoor Colliery (SMP Coordinator)	Results of investigation reported within 1 week of completion Inform relevant landholders and agencies within 24hrs Investigation initiated within 1 week Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	
					Any of above triggers reported by landholders.	Contract hydro-geologist engaged to investigate and report on any identified adverse changes	Tahmoor Colliery (SMP Coordinator)	Results of investigation reported within 1 week of completion	

						Inform landholders with adjacent bores and DPI/DWE investigation outcomes. Investigation of possible mitigation measures in consultaion with the landowner and DPI/DWE. Prepare and implement a site mitigation/action plan in consultation with the landowner and DPI/DWE. if deemed necessary Report in Subsidence Management Status Report Report in SMP / End of Panel reports ongoing to inform relevant agencies of results of monitoring		Inform relevant landholders and agencies within 24hrs Investigation initiated within 1 week Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress EoP Report within 6 months of longwall completion	

NOTE: Access to private bores for water level and quality sampling may be difficult due to bore installation and wellhead configuration. Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to private bore or dam water quality, water level, accessibility or landholder use will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Provision of alternate water supply through regular delivery to tank, dam or other vessel.
- Provision of alternate water supply through modification, repair or replacement of existing water supply e.g. deepening a bore, alternate bore drilled, deepening a dam or construction of a new dam.
- Provision of water treatment facilities to address any water quality impacts e.g. dosing or filtration.
- Repair of any subsidence impacts to water infrastructure eg. pipes and pumps.

Upland Streams

ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
Upland Stream Water Quality and Flow	1 unnamed first order stream in Panel 24A SMP Area Dam Z75X , below dam Z75X and Pencil Falls Refer to Figure 3.3.	Observable iron or salinity staining Photo points Interview with landholder Field analysis of: EC, Eh, pH, temp, DO Water flow in creek Areas of increased flooding Erosion of stream banks	Prior to undermining the stream End of panel, following development of full subsidence under the stream As requested by landholder or if physical impacts to stream identified (Inghams SSSMP) Contract hydrologist to observe stream (Inghams SSSMP) Opportunistic monitoring of flow in ephemeral stream after rain	To provide pre-mining baseline water quality and stream flow data to compare with post-mining To identify any water quality or stream flow impact due to mining To identify water quality, stream flow or stream stability impacts related to mining To identify any flow-on impacts from changes in dam or stream water level	Observable increase from baseline in iron staining or salinity (e.g. orange or white staining in water or on banks/bed) in excess of pre-mining conditions determined from comparison of pre-mining and post-mining monitoring and photographs. EC exceeds 2500uS/cm (Myrtle Ck) and 2000uS/cm (Redbank Creek) pH outside 5-8.5 (Myrtle Creek) and 3-7.5 (Redbank Creek) Dissolved oxygen / Eh / temperature (see notes)	Repeat water quality sampling and initiate laboratory water quality sampling on a monthly basis Contract hydrologist investigate and report on changes identified Inform landholders and relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform landholder and relevant agencies within 24 hours Investigation initiated within 1 week Results of investigation reported to DPI/DWE and relevant landholders within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress Report within 6 months of longwall completion	Ensure adequate water supplies for landholder or flow to Bargo River Identify, investigate and report on impacts to ephemeral stream water quality and flow Investigate any mitigation measures required and implement in consultation with key agencies and landholders
					Observation of loss of flow connectivity within a flowing ephemeral stream	Repeat water quality sampling and initiate laboratory water quality sampling on a monthly basis Contract hydrologist investigate and report on changes identified Inform landholders and relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act Report in Subsidence Management Status Report	Tahmoor Colliery (SMP Coordinator)	Inform landholder and relevant agencies within 24 hours Investigation initiated within 1 week Results of investigation reported to DPI/DWE and relevant landholders within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress	

Upland Streams									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION / REPORTING	RESPONSIBILITY	TIMING	PURPOSE
						Report in the End of Panel Report		Report within 6 months of longwall completion	
					Observation of areas of flooded stream in excess of baseline conditions – identified by extended flooding within a terrestrial habitat and from comparison of pre-mining and post-mining photographs	Survey area to identify whether earthworks are required. Contract hydrologist investigate and report on changes identified Inform landholders and relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Inform landholder and relevant agencies within 24 hours Investigation initiated within 1 week Results of investigation reported to DPI/DWE and relevant landholders within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress Report within 6 months of longwall completion	
					Observation of erosion of stream and dam banks in excess of baseline conditions identified from comparison of pre-mining and post-mining photographs	Contract hydrologist investigate and report on changes identified Inform landholders and relevant agencies of results of investigation Prepare and implement a site mitigation/action plan in consultation with key agencies and in accordance with Section 54 of the Water Management Act Report in Subsidence Management Status Report Report in the End of Panel Report	Tahmoor Colliery (SMP Coordinator)	Investigation initiated within 1 week Results of investigation reported to DPI/DWE and relevant landholders within 1 week of completion Commence preparation of mitigation/action plan within 1 week Monthly updates of investigation progress Report within 6 months of longwall completion	

NOTE:

Access to any monitoring site on private land is subject to suitable landholder acceptance of access to the monitoring site. Stated notification and investigation timeframes are from when triggers have been confirmed by the SMP Coordinator.

Impacts to vegetation, water quality, flow or pool level to upland streams will be addressed through the development of site specific mitigation and management plans which could include the following actions:

- Grouting and rehabilitation of areas where required, with appropriate government approvals. This would be triggered by identification of surface water flow being lost from the catchment to deep storage or the mine workings or loss of a significant permanent pool.
- Minor earthworks to prevent erosions such as overland flow diversion works, establishment of banks, smoothing and re-contouring, with appropriate government approvals.
- Revegetation works such as planting, seeding, mulching, weed control and plant maintenance, with appropriate government approvals.
- The field monitoring parameters of dissolved oxygen and Eh are highly variable due to the upland streams being ephemeral, and can have very low dissolved oxygen and low to negative Eh values purely due to anaerobic ponding of water after extended dry periods. As such, no triggers have been specified for these values
- Field monitored water temperature varies significantly with the season and climatic conditions at any one time as well as the highly variable nature of the ephemeral flow in the upland streams, so notrigger level is specified

Private Dams									
ASPECT	MONITORING				TRIGGER				
	SITES	PARAMETERS	FREQUENCY	PURPOSE	LEVEL	ACTION	RESPONSIBILITY	TIMING	PURPOSE
Dam Water Level and Quality	***<u>NO private dams within Panel 24A SMP Area (apart from Inghams dams)</u>*** 6 Inghams dams previously addressed in Inghams SSSMP								

CHAPTER 4. RESOURCES

The Risk Control Procedures indicate which party is responsible for each risk control procedure. Please refer to each individual management plan in relation to resources allocated for each procedure.

CHAPTER 5. CONSULTATION

The current version of this plan has been developed in consultation with a number of government agencies, including:

The NSW Department of Water and Energy (DWE)

Meetings were held on the 6th and 26th of Novemeber with Fergus Hancock to assist with understanding the DWE's requirements of the plan and to review the draft plan prior to submission to NSW Department of Primary Industries

The NSW Department of Primary Industries – Mineral Resources. (DPI –MR)

A meeting was held 8th of November with Greg cole Clarke, Elise Newberry, Gang Li and Jonathon Smith to discuss the conditons of approval 04/3389 – 02 dated 31 October and in particular the modifications required for this plan.

CHAPTER 6. MANAGEMENT PLAN REVIEW MEETINGS

The monitoring of natural surface features will be carried out by Tahmoor Colliery. Management Plan Review Meetings will be held between Tahmoor Colliery, stakeholders, and / or the Department of Primary Industries for discussion and resolution of issues raised in the operation of the SSSMP. The frequency of the Plan Review Meetings will be at the end of each longwall unless agreed otherwise between representatives of each Plan Review Meeting.

A secretary will be appointed at the Plan Review Meeting. All documentation, distribution of meeting minutes and organising of meeting times will be undertaken by the secretary.

Plan Review Meetings will discuss any incidents reported in relation to the relevant surface feature, the progress of mining, the degree of mine subsidence that has occurred, and comparisons between observed and predicted ground movements.

It will be the responsibility of the meeting representatives to determine whether the incidents reported are due to the impacts of mine subsidence, and what action will be taken in response.

In the event that a significant risk is identified for a particular surface feature, any party may call an emergency Plan Review Meeting, with one day's notice, to discuss proposed actions and to keep other parties informed of developments in the monitoring of the surface feature.

CHAPTER 7. AUDIT AND REVIEW

Should an audit of the SSSMP be required during that period, an auditor shall be appointed by Tahmoor Colliery to review the operation of the SSSMP and report at the next scheduled Plan Review Meeting.

Other factors that may require a review of the SSSMP are:-

- Observation of greater impacts on surface features due to mine subsidence than was previously expected.

- Observation of fewer impacts or no impacts on surface features due to mine subsidence than was previously expected.
- Observation of significant variation between observed and predicted subsidence.

CHAPTER 8. RECORD KEEPING

The secretary will keep and distribute regular minutes of each Plan Review Meeting for each surface feature. The minutes will include reports on the condition of the relevant surface feature, the progress of mining, the degree of mine subsidence that has occurred, comparisons between observed and predicted ground movements, agreements reached between parties, and a log of incidents that have occurred on the surface feature.

CHAPTER 9. CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
Department Primary Industries (Mineral Resources Division)	Phil Steuart	(02) 4931 6648	phil.steuart@dpi.nsw.gov.au	(02) 4931 6790
Department Primary Industries (Mineral Resources Division)	Gang Li	(02) 4931 6644 0409 227 986	gang.li@dpi.nsw.gov.au	(02) 4931 6790
Department Primary Industries (Mineral Resources Division)	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@dpi.nsw.gov.au	(02) 4931 6790
Department Primary Industries (Mineral Resources Division)	Judith Egan	(02) 4222 8310	judith.egan@dpi.nsw.gov.au	
GHD Geotechnics	Andrew Leventhal	(02) 94624700	Andrew.Leventhal@ghd.com.au	
GHD Geotechnics	Greg Kotze	(02) 94624700	Greg.Kotze@ghd.com.au	
EcoEngineers	Steve Short	(02) 42274174	steve@ecoengineers.com	
Geoterra	Andrew Dawkins	(02) 9560 6583	geoterra@iinet.net.au	(02) 9560 6584
Hydrometric Consulting Services (HCS)	Steve Swanbury	(02) 4889 5102	steves@mitmania.net.au	
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay	(02) 9413 3777	daryl@minesubsidence.com	(02) 9413 3822
Sunrise Building and Property Services (SBPS)	John Schwarz	(02) 4883 9030 0400 390 058	sunbuilding@bigpond.com.au	(02) 4883 9738
Tahmoor Colliery (SMP Coordinator)	David Clarkson	(02) 4640 0133	dclarkson@xstratacoal.com.au	(02) 4640 0140
Tahmoor Colliery (Senior Mine Surveyor)	Mark Rundle	(02) 4640 0155	mrundle@xstratacoal.com.au	(02) 4640 0140

APPENDIX A. Glossary of Terms and Definitions

Glossary of Terms and Definitions

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections.
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Face length	The width of the coalface measured across the longwall panel.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

APPENDIX B. Specification for Ground Monitoring