Narrabri Mine

EXTRACTION PLAN
WATER MANAGEMENT PLAN LW107 to LW110

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Abbreviations

AHD	**Australian Height Datum**
ALS	**Aerial Laser Scanning**
ANZECC	**Australian and New Zealand Environment Control Council**
ARI	**Average Recurrence Interval**
CHPP	**Coal Handling and Processing Plant**
DGS	**Ditton Geotechnical Services Pty Ltd**
DP&E	**Department of Planning and Environment**
DPI Water	**Department of Primary Industries – Water**
EA	**Environmental Assessment**
EC	**Electrical Conductivity**
EPL	**Environment Protection Licence**
EP-WMP	**Extraction Plan Water Management Plan**
ESCP	**Erosion and Sediment Control Plan**
LW	**Longwall**
MHRDC	**Maximum Harvestable Right Dam Capacity**
NEPM	**National Environment Protection Measures**
NCMA	**Namoi Catchment Management Authority**
NCOPL	**Narrabri Coal Operations Pty Ltd**
OEH	**Office of Environment and Heritage**
Raffinate	Treated process water from the water conditioning plant
ROM	**Run-of-mine Coal**. Raw coal delivered to the Processing Facility with varying particle size and moisture content. ROM coal often contains contaminates introduced by the mining process.
SoC	**Statement of Commitments** from Section 5 of Surface Water Management Plan for the Narrabri Coal Mine Stage 2 Longwall Project Stage 2 Environmental Assessment.
TDS	**Total Dissolved Solids**
TSS	**Total Suspended Solids**
TOC	**Total Organic Content**
VWP	**Vibrating Wire Piezometer**
WMP	Stage 2 **Water Management Plan**

1 INTRODUCTION

1.1 Project Background

Narrabri Coal Operations Pty Ltd (NCOPL) (formerly Narrabri Coal Pty Ltd) was granted consent for Stage 1 of the development in 2007 (PA 05_0102). The Water Management Plan for the construction phase was subsequently replaced with an operational plan prior to the commencement of active mining.

Stage 2 of the development has been approved subject to the conditions listed in the modified approval document; PA 08_0144 (as modified), Narrabri Mine Stage 2 Project Approval. Stage 2 will result in the mine achieving full production by longwall mining techniques. The Stage 2 approval will enable ROM production to increase to 11 million tonnes per annum once the longwall is fully operational.

A number of documents are required to satisfy the conditions of approval of which an Extraction Plan is one. The Extraction Plan is required to contain a Water Management Plan (EP-WMP) that covers the operations involved in the longwall process. Specifically, this EP-WMP must consider the impacts of subsidence on the surface and ground water flows across the mine lease and beyond. This is in addition to the existing Water Management Plan (WMP) (URS, 2013) which covers the whole site and consequently significant overlaps exist.

This EP-WMP has been prepared to address secondary extraction (longwall mining) of Longwall (LW) 107 to LW110 only. An existing plan was developed by URS and related to the extraction of LW101 to LW105, as subsequently revised to incorporate LW106. The locations of the existing and proposed longwalls are presented in Figure 1-1.

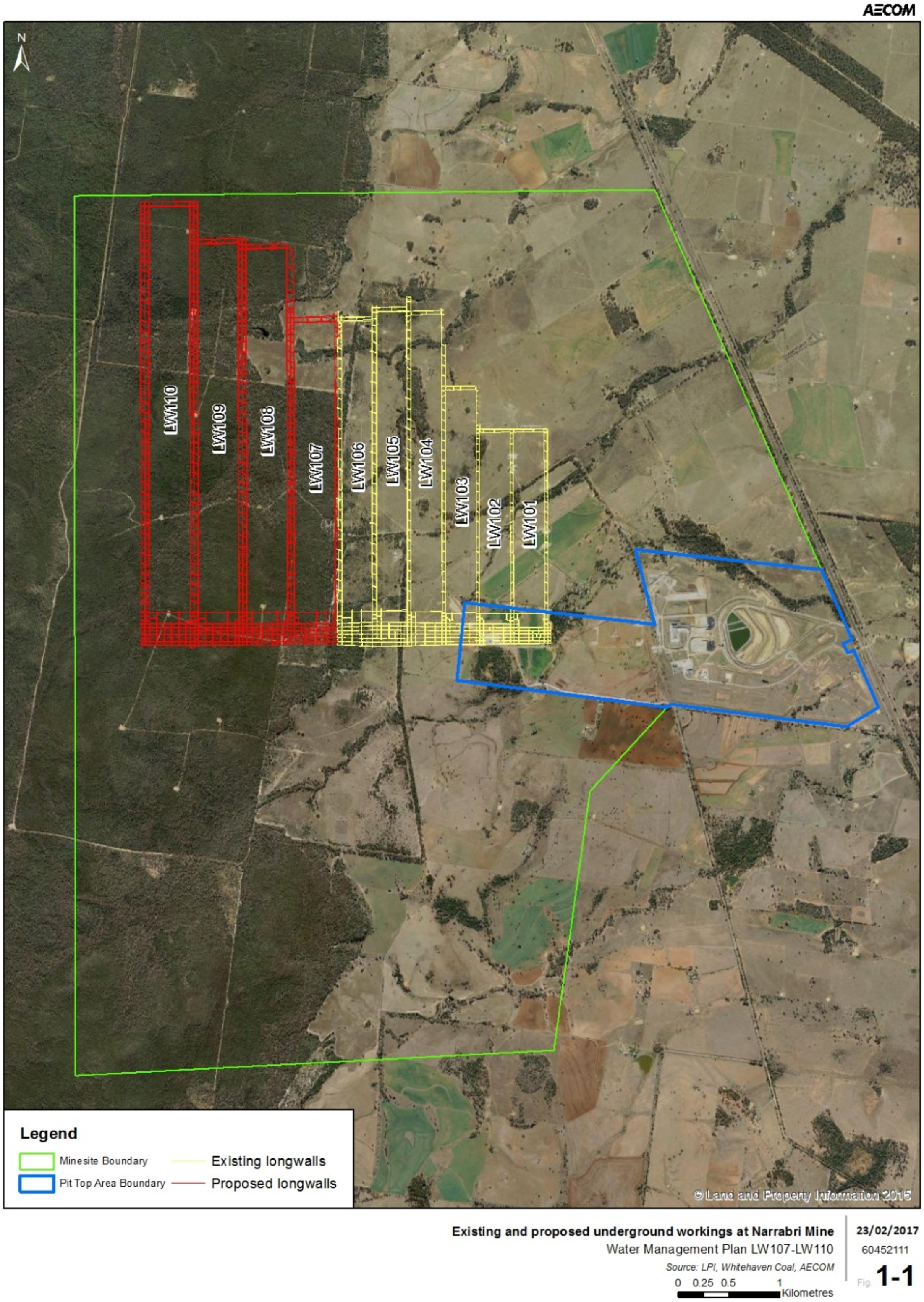

Figure 1-1 Existing and Proposed Underground Workings at the Narrabri Mine

1.2 Application Area

The Narrabri Mine is located approximately 30km southeast of Narrabri and approximately 10km northwest of Baan Baa in north-western New South Wales. Surface operations are located adjacent to, and accessed by, the Kamilaroi Highway across Lot 151-152 DP816020; Lot 60 &115 DP757124; and Lot 381-382 DP1028753.

The land above the proposed LW107 to LW110 (i.e. the application area) comprises private land holdings (project related) historically used primarily for livestock grazing with some cereal crop farming. The majority of areas are heavily vegetated. NCOPL owns the private land holdings above the proposed longwalls. Vegetation across the Extraction Plan area includes several stands of cypress pine and box gum forest with shrubs and grasses across the agricultural land use areas, and riparian zones along creeks.

The terrain is generally flat to gently undulating (2° - 5°) with moderate 10° - 15° slopes along Pine Creek and Pine Creek Tributary 3. The creeks are ephemeral watercourses that drain the mine site towards the north-east. There are a few ridges with steep slopes between 15° and 25° Topographic relief above the proposed longwalls ranges from 280 m AHD in the east to 340 m AHD in the west.

1.3 Management Plan Requirements

Schedule 3, Condition 4 of PA 08_0144, as modified, requires that Narrabri Mine prepare and implement a Water Management Plan, as part of an Extraction Plan. This is in addition to other subsidence related conditions within Schedule 3 which are considered by this report. Table 1-1 shows sections from Condition 4 that relate to the requirements for the EP-WMP (this document).

Table 1-1 Requirements of the EP-WMP

Condition	Refer to Sections
Schedule 3, Subsidence Impact Performance Measures	
1. The Proponent shall ensure that mine subsidence does not cause any exceedances of the performance measures in Table 1.	Section 6.1

Table 1: Subsidence Impact Performance Measures

Water Resources		
Great Artesian Basin	The Proponent shall ensure that, within 5 years of the date of this approval, any loss of water flow into the Great Artesian Basin aquifers (equal to the maximum predicted impact, or the measured impact of the project, whichever is greater), is managed, licensed or offset (including the possibility of injection of raffinate[1]) to the satisfaction of DPI Water.	
Schedule 3, Extraction Plan		
4. The Proponent shall prepare and implement Extraction Plans for any second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must: (h) include a: • Water Management Plan, which has been prepared in consultation with EPA and DPI Water, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on surface water resources, groundwater resources and flooding, and which includes:		
o surface and groundwater impact assessment including trigger levels for investigating any potentially adverse impacts on water resources or water quality;		Sections 3.3, 5.3 and 6.1
o a program to monitor and report groundwater inflows to underground workings; and		Section 6.3
o a program to manage and monitor impacts on groundwater bores on privately owned land;		Section 6.4.3
5. The Proponent shall ensure that the management plans required under condition 4(h) above include:		
(a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;		Section 5.2 and 6.2
(b) a detailed description of the measures that would be implemented to remediate predicted impacts; and		Section 8.1and 8.2
(c) a contingency plan that expressly provides for adaptive management.		Section 8.4
Schedule 6, Condition 2, Management Plan Requirements		
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:		
(a) detailed baseline data;		Section 5.2 and 6.2
(b) a description of:		

[1] Note that according to the Project Approval, a Raffinate Discharge and Transfer Control and Monitoring Plan does not need to be produced and approved until three months prior to the planned discharge or transfer from the site.

• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	
• any relevant limits or performance measures/criteria;	Section 5.3 and 6.3
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 8.1 and 8.2
(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 5.4and 6.4
(d) a program to monitor and report on the • impacts and environmental performance of the project; • effectiveness of any management measures (see (c) above);	Section 7
(e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 8
(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 7
(g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and	Section 7
(h) a protocol for periodic review of the plan.	Section 7

This EP-WMP is based on the Stage 2 WMP (URS, 2013), but focuses on the impact of longwall mining, especially subsidence. It references the Ditton Geotechnical Services (DGS) report: Mine Subsidence Assessment for the Proposed LW107 to LW110 Extraction Plan at the Narrabri Mine (DGS, 2016). The WMP is based on the Statement of Commitments (SoC) and the Environmental Assessment (EA) (R.W. Corkery & Co. Pty. Limited, 2009) for Stage 2 of the mining operations, including the following specialist technical reports:

- Narrabri Coal Mine Stage 2 Longwall Hydrogeological Assessment, Aquaterra Consulting Pty Ltd, November 2009
- Narrabri Coal Mine Stage 2 Longwall Project Surface Water Assessment, WRM Water & Environmental Pty Ltd, November 2009
- Narrabri Mine Modification 5 Environmental Assessment, Resource Strategies, September 2015

Any future refinements to water management or monitoring requirements will result in subsequent revisions of the WMP which will be submitted to the Secretary for endorsement. This may in turn require a possible review and update of this document.

1.4 Extraction Plan Water Management Plan Objectives

The EP-WMP aims to provide management approaches for the potential impacts from the longwall mining process (LW107 to LW110). These impacts may be on surface water resources, groundwater resources or flooding. Where there are overlaps with the existing WMP, those sections have been reproduced in this report.

1.5 Responsibilities

During the operational phase of mine development, the Narrabri Mine is managed by the General Manager who has overall responsibility for ensuring contractors, employees and service providers comply with all laws, regulations, licences, approvals and conditions of the project approval. Table 1-2 below outlines the responsibilities of personnel at Narrabri Mine under this Management plan.

Table 1-2 Roles and Responsibilities

Role	Accountability
General Manager	Responsible for providing adequate resources to undertake the activities required by this plan.
Technical Services Manager	WMP and EP-WMP review.
Environment Superintendent	Responsible for ensuring that monitoring, periodic environmental inspections and inspections following high rainfall events are undertaken. Implementing this EP-WMP on a day to day basis. WMP and EP-WMP review. Carrying out monitoring program
Civil Services Coordinator	Periodic engineering inspections on dams

As part of their duty, the General Manager has the power to delegate resources and responsibility. The General Manager acts on the behalf of the mine and must fulfil the requirements of the Project Approval and commitments outlined in the Environmental Assessment. Implementation of these commitments is a requirement of the Project Approval and they contain a number of statements concerning the effects of subsidence.

Contingency and notification procedures in the event of an incident are presented in section 5.2 of the Extraction Plan.

2 MINE SITE WATER MANAGEMENT

2.1 Water Management Approach

The WMP (URS 2013) sets out the overall principles for the management of water at Narrabri Mine.

For the purposes of water management, the water generated at the Narrabri Mine is divided into four types based on water quality, as detailed below:

'Clean' – surface runoff from the mine site areas where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas and any fully rehabilitated areas;

'Dirty' – surface runoff water from the mine site areas that are disturbed by mining operations. This runoff may contain silt and sediment, but does not contain contaminated material. However, this runoff must be of sufficient quality prior to discharge into natural water courses, if required;

'Contaminated' – surface water from areas affected by mining operations and potentially containing chemicals of various types used in the mining operations. There are restrictions on the use and release of this water. Contaminated water areas include sumps, stockpile areas, service ponds and fuel storage areas. Rainfall and resulting runoff from these areas are also potentially contaminated and therefore must be managed to avoid discharge of potentially contaminated water into the natural water courses; and

'Saline' – water pumped from the underground workings containing concentrations of total dissolved solids (TDS) above that considered fresh water by ANZECC & ARMCANZ (2000) criteria. For the purpose of clarity, this water is referred to as 'dirty' in this document.

Catchment runoff from land overlying LW107 to LW110 is generally considered 'clean', however would generally contain a background level of silt and sediment due to natural erosion processes and agricultural activity. This runoff has the potential to be indirectly impacted by subsidence and become 'dirty' in that elevated levels of sediment or salinity result in comparison to the background water quality of the catchment runoff. The mechanisms for these impacts and proposed monitoring and mitigation measures are outlined in this EP-WMP.

There should be no contaminated water produced by the longwall, however groundwater inflows into the mine are typically saline and are pumped to the surface as part of normal operations. These flows are managed by the surface infrastructure on site. Monitoring of these mine inflow rates are documented in this EP-WMP as an indicator of subsidence behaviour in the overlying strata and associated consequences to the overlying groundwater and surface water resources.

A description of the strategies for monitoring and management of water impacts relating to secondary extraction of LW107 to LW110 are given below.

2.1.1 Clean Water Management

Pine Creek and its catchment are not located near the surface operations area of the mine; however it does pass over LW107 to LW110, as does Pine Creek Tributary No.3.

These are clean water catchments and will be potentially affected by the mine through subsidence and limited surface activities (i.e. installation of gas drainage and other associated infrastructure). Data gathered through the monitoring program documented in this EP-WMP will be used to assess the quality of these flows during mining and to regularly compare these values to the performance indicators, which include both the baseline water quality and ANZECC criteria. A Trigger Action Response Plan (TARP) has been developed to investigate and remedy issues, should a degradation of water quality be identified as a result of mining activities.

2.1.2 Saline Water Management

No saline water management is expected to be required at the LW107-110 operations. Any saline water management will be undertaken in accordance with the WMP (URS, 2013).

2.1.3 Contaminated Water Management

No contaminated water is expected to be produced from the longwall workings. Details of the contaminated water system are given in the WMP (URS, 2013).

2.2 Available Water Allocations

Table 2-1 shows the water allocation licences held by NCOPL. An Aquifer Access License was obtained to dewater the underground workings and the remaining allocations are off-site licences from either the Great Artesian Basin or the Namoi River.

Table 2-1 Narrabri Coal Mine Water Allocation Licences

Licence	Water Access Licence &/or Groundwater Works	Access Licence Category	Water Body	Nominal Allocation (ML/yr)
90AL822538, 90WA822539	WAL 29549	Mining	Gunnedah – Oxley Basin MDB Groundwater Source	818
90AL811346, 90CA811347	WAL15922, GW062433	Aquifer	Southern Recharge Groundwater Source	248
90AL812863, 90CA802130	WAL20152	Regulated River (General Security)	Lower Namoi Regulated River Water Source	600
90AL802212, 90CA802130	WAL2728	Regulated River (General Security)		10
90AL801995, 90CA802130	WAL2671	Regulated River (General Security)		48
90AL802129, 90CA802130	WAL6762	Regulated River (High Security)		20
90AL812858, 90WA812891	WAL20131, GW969667	Aquifer	Upper Namoi Zone 5 Namoi Valley (Gin's Leap To Narrabri) Groundwater Source	150
90AL807276	WAL12833	Aquifer		67

The off-site allocations will be used to meet site demands in years where sufficient water cannot be collected on site. It is anticipated that this will only be required in the first four years of the mine life.

2.3 Maximum Harvestable Right Dam Capacity

The maximum harvestable right dam capacity (MHRDC) is the total dam capacity allowed under the harvestable right for your property and takes into account rainfall and variations in rainfall pattern (DPI Water, 2017). The MHRDC is based on the contiguous area. The Harvestable Right for the site (6030 Ha) is 392 ML. The estimated Storage Capacity for the Stage 2 environmental assessment Farm Dams is 128 ML.

3 SUBSIDENCE ASSESSMENT AND IMPACTS

3.1 Application Area Analysis

The subsidence assessment by Ditton Geotechnical Services Pty Ltd (DGS, 2016) estimated the effects of the mining works. The mining lease is a 'Greenfields Site' (i.e. a mining area where no local prior knowledge of ground response to underground mining exists) and prior to the commencement of mining, it was necessary to make predictions using proven empirical modelling techniques developed in other coalfields with similar geological conditions. Engineering science was also applied in the form of established analytical models of overburden and chain pillar behaviour, to compare to the empirical model results.

The depth of cover above the Hoskissons Coal Seam over LW107 to LW110 ranges from 230 m to 350 m with the depth of weathering typically varying from about 15m to 35m from the surface. Through a review of the available exploration data, DGS determined that the potential subsidence reducing 'massive' units in the overburden are the conglomerate of the Digby Formation, the intrusive basalt sill in the Napperby Formation and basalt lava flows of the Garrawilla Volcanics. It was thought that these massive units might reduce subsidence through bridging behaviour. Following assessment of actual post mining subsidence, DGS have concluded that no bridging has occurred and future assessments should assume the same.

Planned mining has been completed in LW101 to 105 and monitoring of the subsidence effects continues. The subsidence monitoring data collected as longwall mining progresses will be used to inform and refine the site subsidence model over time.

3.2 Potential Subsidence

The maximum subsidence for the panels is predicted to range between 2.58m to 2.75 m (60% to 64% mining height). The maximum panel subsidence includes the subsidence above the chain pillars, which is estimated to range between 0.28 m and 0.69 m.

The recorded subsidence in LW101 toLW105 has a maximum measurement of 2.75 m. This occurred in LW104, however the other longwalls had similar figures. The measurements are less than 10% over the predicted maximum subsidence.

Maximum panel tilts are predicted to range between; 18 and 29 mm/m for a 'smooth' profile behaviour, and 27 and 44 mm/m for discontinuous movements. The concave and convex curvatures range from 0.3 to 1.6 km-1 (or radii of 3.33 km to 0.63 km). The maximum tensile strains are expected to range from 3 to 5 mm/m for a 'smooth' profile, and 7 to 13 mm/m for discontinuous movements. The compressive strains are estimated to range between 3 and 6 mm/m for a 'smooth' profile, and 8 to 16 mm/m for discontinuous movements.

The ground surface would tend to subside more towards the centre of the panel, ie. away from the chain pillars between the longwall panels.

3.3 Impacts of Subsidence

3.3.1 General

The DGS 2016 report suggested that the mining impacts are likely to include:

- surface cracks with widths of 30 mm to 130 mm and up to 260 mm;
- surface gradients are likely to increase or decrease by up to 3% (1.5°) with occasional increases of up to 6%;
- potential ponding depths of 0.1 to 2.6 m may develop above several of the longwalls and creeks in the flatter areas of the site.
- Discontinuous fracturing would be expected to occur, increasing rock mass storage capacity and horizontal permeability without direct hydraulic connection to the workings. Rock mass permeability is unlikely to increase significantly outside the limits of extraction;
- The various unsealed roads and tracks around the site are likely to be subject to cracking and heaving during mine subsidence development

The report acknowledged the uncertainties inherent in subsidence prediction and recognised that, in some cases, only worst case outcomes could be presented. Terms were used throughout the report to reflect the general probability of the impacts of subsidence. These terms and their meaning are detailed in Table 3-1 below.

Table 3-1 Qualitative Measures of Likelihood

Likelihood of Occurrence	Event implication	Indicative relative probability of a single event
Almost Certain	The event is expected to occur.	90-99%
Very Likely	The event is expected to occur, although not completely certain.	75-90%
Likely	The event will probably occur under normal conditions.	50-75%
Possible	The event may occur under normal conditions.	10-50%
Unlikely	The event is conceivable, but only if adverse conditions are present.	5-10%
Very Unlikely	The event probably will not occur, even if adverse conditions are present.	1-5%
Not Credible	The event is inconceivable or practically impossible, regardless of the conditions.	<1%

3.3.2 Surface Cracking

The DGS report further states that direct hydraulic connection to the surface, due to sub-surface fracturing above the panels, is considered unlikely to occur where cover depths are > 230 m (all proposed long walls have a minimum cover depth of at least 240 m). Subsurface aquifers within 174 m to 282 m above the proposed panels (i.e. 78 to 86 % of the cover depth) may be affected by direct hydraulic connection to the workings, with significant long-term increases to vertical permeability.

In-direct or discontinuous sub-surface fracturing could interact with surface cracks where cover depths are < 335 m. Creek flows could be re-routed to below-surface pathways. These could either re-surface down-stream of the mining extraction limits, or remain permanently underground. This could have a potentially negative impact on the surface features that are reliant on this water source.

While single surface cracks are unlikely to reach the mine workings, there is a possibility (though unlikely) that interaction of surface cracking with sub-surface fractures may link the surface water to the underground workings. The watercourses are all ephemeral and, therefore, this would only become an issue during periods of rain. If flow were able to quickly enter the mine workings from the surface, it may pose a safety risk and would also cause a significant input into the mine water system. However this scenario is considered unlikely and associated safety and operational issues are dealt with in the appropriate mine management plans (i.e. Inrush Hazard Management Plan).

There are a range of impact management strategies for surface cracking which will be implemented to further reduce the risk of surface water penetrating to mine workings. These include:

- Regular inspection of the surface during subsidence development above panels and mapping crack locations and widths.
- Repairing large surface cracks if they occur, but usually after subsidence development, including temporary fencing.
- Pumping ponded water downstream to reduce time for water to infiltrate to mine working.

Surface cracks were observed above LW101 to 105 with widths of typically 50 – 100 mm, but some were up to 200 mm. There are no reports on the depth of the cracks. Crack widths are expected to decrease with cover increases over LW107 to LW110.

3.3.3 Surface Uplift

Valley closure and uplift movements are strongly dependent on the level of 'locked-in' horizontal stress immediately below the floor of the gullies. It is also dependant on the bedding thickness of the floor strata (i.e. thin to medium bedded sandstone is more likely to buckle than thicker beds). The influence of the aspect ratio (i.e. valley width/depth) is also recognised as an important factor, with deep, narrow valleys having greater ‘upsidence’ than broad, rounded ones, due to higher stress concentrations.

The valleys across Narrabri Mine’s mining lease are very broad between crests and this would suggest uplift to be a minor factor. There is also a lack of thick, massive beds of conglomerate and sandstone units along the valleys which further suggests that the development of ‘upsidence’ above the mine workings is likely to be negligible.

Survey measurements across Pine Creek Tributary 1 in October 2014 have indicated maximum closure of 148 mm between the 30 m wide creek bank crests at Line F, with compressive strain of 6.2 mm/m and uplift of 64 mm. Lines E and G did not detect any Valley Closure or Uplift movements in the creek above the chain pillars due to LW101 to LW104. The measured movements are within the predicted range previously presented in the approved 2012 EP.Land Slip and Erosion

The DGS report has suggested that there is a 'barely credible' chance that *en-masse* sliding might occur in the ground surface above the mine. Instead it is more likely that only minor changes in gradient will occur; however this may also have undesirable effects. It is possible that gradient changes along creek paths may increase erosion and, therefore, increase the sediment load being carried downstream. This may also cause instability in the banks of the creeks, at locations where erosion is increased.

Monitoring in LW104 and LW105 has shown a gradient change of up to 3.5% the predicted range by up to ± -.0%.

3.3.4 Surface Depression and Ponding

The predicted maximum panel subsidence of 2.75 m could therefore result in closed form depressions forming in the central areas of the panels and disrupt natural drainage pathways to the water courses.

The potential maximum ponding depths, affected area and volume above the proposed panels after mining have been updated with the re-calibrated prediction are summarised in Table 2.

Table 2-1 Predicted surface depression and ponding

Longwall	Max Pond RL (AHD)	Max. Depth h (m)	Ponded Area Increase After Mining# (m^2)	Ponded Volume Increase After Mining# (ML)
107	274.0	1.0	9,805	4.90
108	280.5	2.6	7,096	9.23
	279.0	0.5	2,682	0.67
	280.4	0.1	7,502	0.38
109	284.0	0.8	3,503	1.40
110	288.5	0.7	6,126	2.14
108	285	0.4	622	0.12

The maximum pond depths for LW107 to LW110 range from 0.1 m to 2.6 m with pond volumes ranging from 0.12 ML to 9.23 ML. The majority of potential ponding areas will develop along the watercourses and are likely to remain in channel.

It should also be noted that the actual ponding depths, areas and volumes would still depend upon several other factors, such as rain duration, surface cracking and effective percolation rates of the surface soils.

It should be noted that ponded water is likely to have increased salinity from sitting on saline soils for an increased length of time. The ponding may also affect local farming, flora and fauna; however, there may be both positive and negative impacts. Ponding may take up land that has other uses; however, it may also act as an additional water source.

The monitoring to date shows that water ponds in the subsidence depressions and that this is focussed on the most upstream depression.

3.3.5 Water Storage Dams and Soil Conservation (Contour) Banks

There are a total of five farm dams of various size located across the potential subsistence area above LW107 to LW110. Non-engineered farm dams and water storages will be susceptible to surface cracking and tilting (i.e. storage level changes) due to mine subsidence. The tolerable tilt and strain values for the dams would depend upon the materials used, construction techniques, foundation type and likely repair costs to re-establish the dam's function and pre-mining storage capacity (if necessary).

The expected phases of tensile and compressive strain development may result in breaching of the dam walls or water losses through the floor of the dam storage area. Loss or increase of storage areas may also occur due to the predicted tilting. Maximum tensile crack widths across dam wall or storage areas are estimated to range between 30 mm and 130 mm. Surface 'steps' or humps due to compressive shear failures are estimated to range between 30 mm and 130 mm. Damage to windmills and fences near the dams and soil conservation (contour) banks may also occur and require repairing.

As noted above, the water in the storage dams is likely to have increased salinity from sitting on saline soils for an increased length of time. Therefore, its sudden release in to the watercourse system may have detrimental effects on the environment. These effects will be diluted as the flow moves through the catchment.

The management of water storage dams stability and function is addressed in the Built Features Management Plan, which makes up part of the Extraction Plan.

Monitoring to date has shown that several small farm dams have been subsided by LW101 to LW105 but have not required any remedial works to be implemented.

4 ENVIRONMENTAL CONSEQUENCES

This section outlines the environmental consequences that longwall mining can have on surface water and groundwater.

4.1 Surface Water

4.1.1 General Principles

Surface water, in terms of the EP-WMP, relates to any above ground water directly affected by the longwall mining process. In the case of the Narrabri Mine LW107 to LW110, the water bodies that may be impacted are; the ephemeral Pine Creek and Pine Creek Tributary 3 that traverse some of the proposed longwall panels; and adjacent farm dams.

Surface water quantity and quality of these water bodies may be impacted by subsidence caused by the longwall mining process. Subsidence development mechanisms are explained in detail in Section 4.2 of the Environmental Assessment for Narrabri Mine Modification 5 and recent subsidence assessment by DGS (2016) as summarised in Section 10.

This EP-WMP considers management strategies to minimise the effects of any subsidence that may be caused by the longwall mining process. This will be achieved by a combination of regular monitoring and reactive works. The surface water quantity and quality of the ephemeral Pine Creek, that traverses some of the proposed longwall panels and adjacent farm dams, may be impacted upon by the following:

- Surface cracking
- Slope instability and erosion
- Surface uplift
- Ponded water
- Breach or alteration of farm dams and soil conservation (contour) banks
- Ground disturbance above longwall panels.

4.1.2 Surface Cracking

Surface water quantity may be affected by surface cracking. Surface cracking may lead to water in Pine Creek and its tributaries (when they are flowing) leaving the creek via surface cracks and flowing into aquifers or into the mine. Water entering aquifers within the mine site boundary may resurface again further downstream thus resulting in no net loss in water for Pine Creek and its tributaries. However, water flowing into the mine may lead to a decrease in water flowing down Pine Creek and its tributaries and would be dealt with as stated in Section 6.

4.1.3 Slope Instability and Erosion

Increased erosion and sediment transport may occur as a result of localised increases in the bed gradient of local watercourses due to differential ground movement or creek bank instability. Localised increases in bed gradient are most likely to occur immediately downstream of each chain pillar (where flow direction is perpendicular to the panel orientation) and would result in increased flow velocity and erosive potential of surface flows. Current and predicted profiles of Pine Creek are presented in the Mine Subsidence Assessments (DGS 2016). Localised creek bank instability would provide a potential sediment load source for transportation downstream and associated degradation of water quality.

Areas of the overbank areas will also experience an increase in slope, which may in turn lead to an increase in erosion thus affecting surface water quality. Erosion and sediment transport would result in a degradation of water quality which may impact downstream water bodies and users. Changes in water quality as a result of erosion are generally observed as an increase in total suspended solids (TSS) and turbidity.

4.1.4 Surface Uplift

Surface uplift affects surface water in a similar manner to surface cracking and slope stability and erosion. Water may be diverted underground and an increase in erosion thus decrease in water quality may occur due to the change in slope.

4.1.5 Ponded Water

Surface water flowing to the creeks may pond in areas where it currently does not pond as a result of surface gradients changing due to the above mechanisms. Both the quantity and quality of surface water is affected should areas of ponded water develop. There may be a decrease in the quantity of water reaching the creeks as it ponds and evaporates rather than flowing to the creeks. There may be a change in water quality as salinity may increase if water ponds over saline soils.

4.1.6 Farm Dams and Soil Conservation (Contour) Banks

Water quality of farm dams may be affected by ponding water and redirection of flows with higher sediment loads due to erosion. This is due to the additional salts absorbed by the stationary water stored in the dam. The effects will have a short duration due to the limited capacity of the dams when compared to the catchment size for the downstream areas. The environmental impact is therefore secondary to the impact on the utility of the dam. This may result in a social and /or economic impact due to the effect on livestock

It should be noted that dams similar to those across ML1609 have been undermined by longwalls elsewhere in Australia and any damage and water supply impacts have been effectively managed. The dams were repaired and reinstated in a timely manner and an alternative supply of water was provided by the mine during the interim period.

4.1.7 Ground disturbance above longwall panels

Surface water may also be impacted upon by ground disturbance above the longwall panels associated with works to enable mining such as the installation of drainage (gas and water) boreholes. At this stage it is anticipated that boreholes will be required at approximately 50m intervals along the longwall development. Borehole installation will require:

- construction of access tracks to access the drill sites: this will involve the use of machinery to construct the track and may require the import of fill and implementation of temporary drainage crossings;
- clearing and ground disturbance (i.e. cut and fill) required to construct the drill pads: the drill rig will require a minimum area of 5m x 5m for each borehole;
- ongoing access to the installed boreholes for monitoring and maintenance purposes: which will involve vehicular traffic with consequent wear and maintenance.

The above activities have the potential to exacerbate erosion and have a direct impact on runoff quality from the disturbed areas.

These bores will also require licencing by DPI Water and the water extracted will make up part of the mines 818 unit shares in the Gunnedah-Oxley Basin MDB Groundwater Source. Narrabri Mine will submit licence applications with as much notice as possible guided by the findings from future revisions of the Stage 2WMP or this EP-WMP.

4.1.8 Effects on Harvestable Right

As presented in section 2.3, Harvestable Right for the NCOPL land holdings is 392 ML. The subsidence ponded volume is estimated to be 207 ML in total. This results in a total dam capacity of 335 ML, which is less than the MHRDC.

4.2 Groundwater

4.2.1 Predicted Impacts on Groundwater

The main potential impact of proposed longwall mining on the hydrogeological environment was considered to be on near-surface groundwater, including the alluvial groundwater system of the Namoi Valley, and groundwater baseflow contributions to the Namoi River and other surface drainages

DGS (2016) predicts that discontinuous sub-surface fracturing could interact with surface cracks where cover depths are < 335 m, as is the case with LW107 to LW110. Creek flows could be rerouted to below-surface pathways and re-surfacing down-stream of the mining extraction limits in these areas.

Discontinuous fracturing would be expected to occur above these limits and increase rock mass storage capacity and horizontal permeability without direct hydraulic connection to the workings.

Numerical groundwater modelling has been used to predict mine inflows and impacts on groundwater levels and baseflows, both locally and regionally. Principal findings of the modelling after all 20 longwall panels (LW101 to LW120) have been mined include the following:

- Large drawdowns are predicted to occur within the target Permian coal measures (Hoskissons Seam) close to the mine, as a result of groundwater flows into the mine workings. The drawdown cone is predicted to be relatively steep, and drawdowns exceeding 10 m would be limited to around 6 km to 7 km to the west, north and south, and around 2 km to the east of the underground workings. The Permian drawdown impact would extend much less to the east, where it would be limited by the truncation of the coal seam by an overlying unconformity. The region of predicted drawdown greater than 1 m in the Hoskissons Seam extends approximately 20 km to the west, 10km from the mined areas to the south and to the north, but not to the east where the seam is absent.
- Predicted groundwater level impacts in the overlying Triassic Napperby Formation are much less pronounced. Drawdowns of 1m or more are predicted to extend a maximum of approximately 10km to the west of the Mine Site.
- Impacts on Jurassic Pilliga strata would be extremely small, and there will be effectively no measurable impact above the Purlawaugh Formation aquitard (i.e. in the Great Artesian Basin (GAB) intake beds).
- Predicted impact of all Longwalls under the entire MOD5 approval from that already approved indicates that the maximum change to the net water take is approximately 0.5ML/day at the end of mining. This is less than the approved mining loss due to shorter duration of mining in the modifications.

The groundwater take from the GAB is replenished rapidly following cessation of mining with a sustained loss of less than 0.1 ML/day. Losses for LW106 to LW110 alone will be less than that for the entire MOD5.

- Predicted impacts on river baseflows to the Namoi River to the east are very small. Baseflow in this reach is predicted to be less than 0.3 ML/d.

Overall, these results indicate that the following impacts on water resources may occur due to the mining of longwall panels LW107 to LW110:

- There will be negligible impact on groundwater within the Pilliga Sandstone beyond the mine plan, and hence a negligible impact on recharge to the GAB.
- Negligible impacts on groundwater levels in the Namoi Valley alluvium are predicted beyond the mine plan, and existing groundwater users will not be affected.
- Continuous/connected fracturing induced by longwall mining has the potential to significantly impact groundwater stored in the fractured rock aquifers above the mine (up to the Garrawilla Volcanics). The potential for impact on other local groundwater users is mitigated by NCOPL's acquisition of several properties within the anticipated zone of impact.

The groundwater assessment undertaken from MOD5 (HydroSolutions, 2015) concluded that there would be negligible impact on water quality from the underground mine workings. The average water quality of mine inflows would be a composite blend of the water qualities from all groundwater sources contributing to inflows. The inflow water quality would initially be dominated by the groundwater from the Hoskissons Coal Seam and the underlying Arkarula Formation. Over time, as proportionally more groundwater flows from the higher units and from more distant parts of the area of predicted drawdown impact, the groundwater quality would change to reflect an increased contribution from those areas. This suggests that the groundwater quality of the Mining Area would be generally improved as lower salinity water is drawn from the units higher in the geological sequence into the void space of the underground mine.

Predicted annual inflow volumes from groundwater sources for the entire MOD5 mine plan is presented in Table 4-1 below (Hydrosolutions, 2015). Table 4-1 includes the allocated value previously presented in in Table 2-1. As indicated in Table 4-1, the predicted inflow volumes are significantly less than the allocation amount except for the Gunnedah-Oxley Basin MDB Groundwater Source which is exceeded by 191 ML/year. A revised access license will need to be secured for that water source should monitoring indicate that take is from the Gunnedah Oxley Basin MDB groundwater source is likely to be exceeded. It is unlikely that this will be required for the LW107 to 110 panels as there will only be a portion of the take predicted for the entire MOD5 as presented in Table 4-1.

Table 4-1 Predicted Narrabri Coal Mine Water Allocation Licences

Water Body	Predicted Inflow volume (ML/yr) (Hydrosimulations 2015)	Nominal Allocation (ML/yr)
Gunnedah – Oxley Basin MDB Groundwater Source	1009	818
Southern Recharge Groundwater Source	179	248
Lower Namoi Regulated River Water Source	78	678
Upper Namoi Zone 5 Namoi Valley (Gin's Leap To Narrabri) Groundwater Source	110	217

5 SURFACE WATER MONITORING AND MANAGEMENT

5.1 Surface Water Monitoring

The surface water monitoring system is discussed in detail in the site WMP (URS, 2013) and summarised in Figure 5-1.

5.2 Baseline Water Quality

Baseline water quality is discussed in detail in the Site WMP (URS 2013).

5.2.1 Water Quality Criteria and Triggers

Surface water compliance criteria are as prescribed by the Catchment Action Plan for the Namoi River (NCMA, 2007) which includes the ANZECC (2000) guidelines for

- Irrigation water – EC range of 650-1300µS/cm; and
- Aquatic Ecosystem Protection – mean values of Total Endosulphan <0.03µS/L and Atrazine <0.7µS/L.
- River Salinity of <550µS/cm 50% of the time and <1000 µS/cm 80% of the time

The ANZECC (2000) water quality trigger values for upland rivers are shown in Table 5-1. These triggers will be used, should it not be possible to establish baseline levels or a correlation between monitoring up and downstream of the underground workings.

Table 5-1 ANZECC (2000) trigger values for upland rivers

Parameter	ANZECC (2000) Upland Trigger Value	Local Creek Background Concentration	
		Median	80th %ile
pH	6.5 – 8.0	7.2	7.8
Electrical Conductivity (µS/cm)	30 – 350	126	235
Total Suspended Solids (mg/L)	–	84	179
Oil & Grease (mg/L)	–	10	27.4
Turbidity (NTU)	2 – 25		
Phosphorus (µg/L)	20		

ANZECC & ARMCANZ (2000) does not specify trigger values for oils and greases or total suspended solids (TSS). The range of default trigger values given for turbidity of between 2 and 25 NTU (ANZECC & ARMCANZ, 2000) can be used to indicate likely acceptable TSS values. At present, insufficient data is available to draw a correlation between TSS and turbidity. Both parameters would be measured in the future to allow a correlation to be made. Nutrients, such as phosphorus, are not currently monitored because the surrounding agricultural areas are likely to generate significantly higher nutrient levels in comparison to the mine.

The proponent proposes to work within the framework outlined in the NCMA (which incorporate the ANZECC 2000 trigger values) and the NSW Salinity Strategy for the longwall project to ensure that the ability to achieve these targets is not compromised.

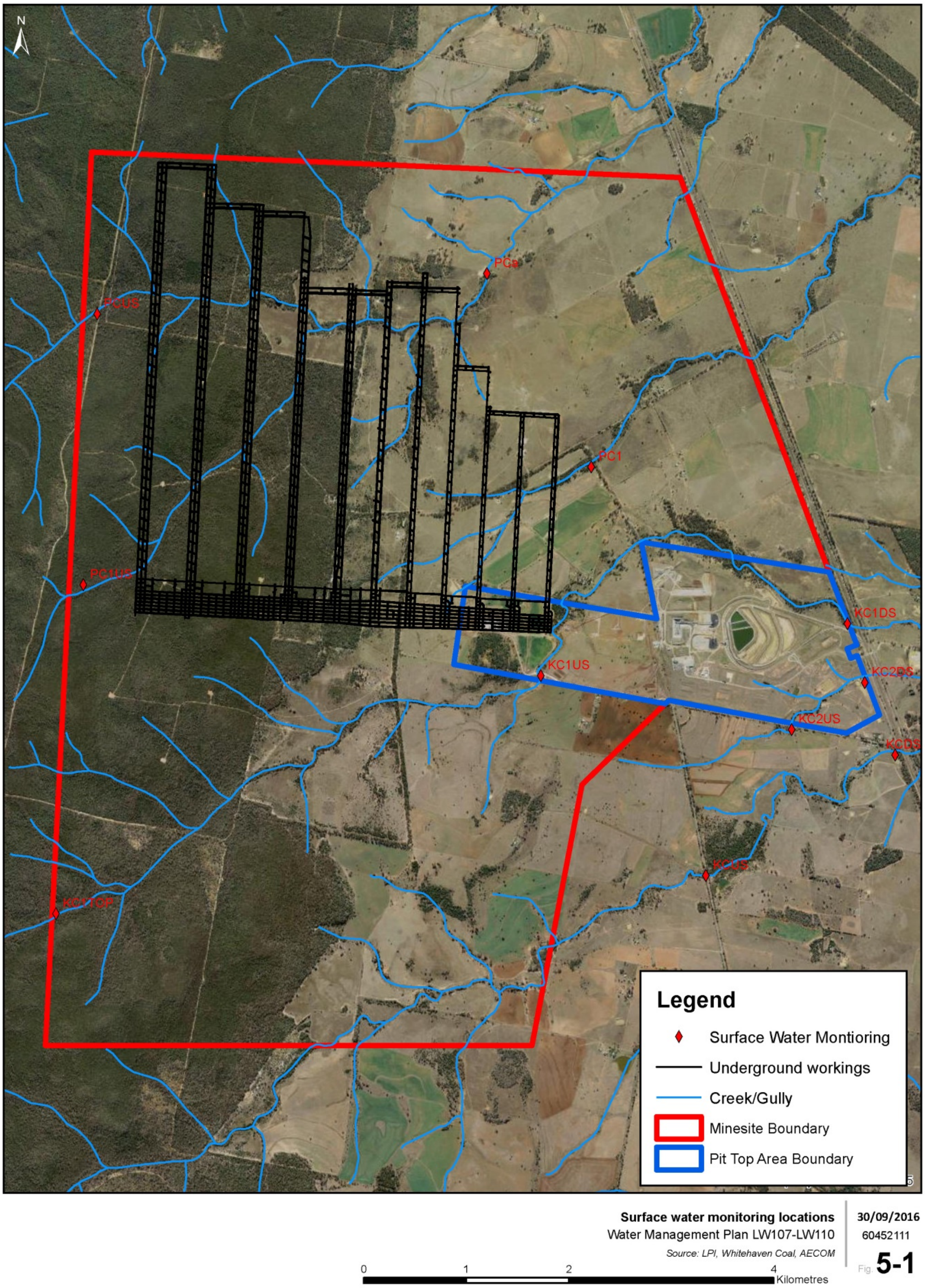

Figure 5-1 Surface Water Monitoring Locations

5.3 Surface Water Monitoring Parameters and Schedule

5.3.1 Water Quality Monitoring Schedule

Current monitoring locations together with the additional monitoring locations will continue to be monitored in accordance with the sampling parameters and sampling frequencies set out in Table 5-2. Due to the ephemeral nature of the watercourses, sampling will be undertaken on an event-basis. The water quality monitoring program provides for the assessment of background (upstream) data for flow events in the various creeks and comparison to samples taken downstream of the mining impact area which should enable water quality changes as a result of mining to be identified.

Monitoring is the responsibility of the Environmental Superintendent and is conducted by a suitably qualified professional in accordance with the relevant Australian Standards. The frequency of monitoring and range of parameters analysed during flow and routine monitoring is reviewed after the first two years of operations.

Table 5-2 Water Quality Monitoring Schedule

Location	Parameters	Frequency
Site (Meteorological Monitoring)	Rainfall Wind speed and direction Temperature Relative Humidity Solar Radiation	Recording every 15 minutes
Ponding areas when Identified	EC	Monthly (adjusting frequency when trends are understood)
PCUS, PC1US, PC, PC1	EC Oil and grease pH TSS TOC Turbidity	Quarterly during flow events (samples can only be taken during runoff events as the creeks are ephemeral)

Areas of ponding that are identified will be sampled on a monthly basis to test how water salinity changes. This monitoring frequency can then be adjusted, as dictated by the results. Over time, regular water testing will build up a general trend for the condition of the water being collected. Further investigation can then be started, should these trends change during the mining operations.

5.3.2 Inspection Monitoring Schedule

The water quality data will need to be complimented with a programme of visual inspection. The existing monitoring program would be extended to include the monitoring of the impact of mining on the watercourses that traverse the proposed longwalls. The inspection monitoring would include the following components.

- Each Creek traversing a longwall will be surveyed at regular intervals to determine the ultimate level of the area. Monitoring will be undertaken:
  - Immediately pre- and post-longwall mining
  - Monthly during mining of the long wall and for three months following cessation of longwall mining with visual inspections undertaken following significant rainfall events (defined as a 5 day 95th%ile rainfall event which is 38.4mm over 5 consecutive days).
  - Quarterly inspection for two years following cessation of mining.
- Photographs of the creek would be taken prior to mine subsidence and for 1 year after significant mine subsidence has ended (as defined in DGS 2016). These photographs would be taken following rainfall events of 38.4mm over a consecutive 5-day period, to assess whether erosion has occurred. This requirement is to be re-evaluated at the end of the monitoring period.
- A log of when inspections occur (and photographs taken) would be kept together with an assessment of the changes in erosion.

The above will be supplemented with aerial photography and Aerial Laser Scanning (ALS) survey data when they are made available on the existing monitoring schedule. These visual inspections coupled with survey will be able to easily identify changes in creek beds and erosion that may be attributed to mining activities rather than natural phenomena. For further detail of monitoring of surface cracking and erosion refer to the Land Management Plan.

NCOPL will review the frequency of monitoring and range of parameters analysed after the first two years of the Longwall Project.

5.4 Proposed Management Actions

The following management strategies will be employed to address the predicted impacts of longwall mining on surface water. Contingency measures are also presented should they be required. The presented actions focus on visual inspection as these can be easily conducted on a regular basis.

All works in the catchment will be carried out with due regard to erosion protection and sediment control. The mine currently has an Erosion and Sediment Control Plan (ESCP) that would be suitable for the intended works. The main reference material in NSW is 'The Blue Book' (Landcom, 2004), but other references include guidelines produced by the Australian arm of the International Erosion Control

Association (IECA, 2009) and the 'Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries' (OEH, 2008). These reference documents provide methods for assessing the potential for erosion and sedimentation as well as describing methods and systems for controlling negative impacts.

Given the variable nature of impact, mitigation strategies would be tailored to each individual location, considering the geomorphic characteristics, vegetation and soil types of each location.

5.4.1 Surface Cracking

Narrabri Mine will monitor areas above the underground workings that are likely to be affected by surface cracking on a monthly basis and significant rain events (defined as a 5 day 95th%ile rainfall event which is 38.4mm over 5 consecutive days). This would involve inspection of the areas on foot, or where access is available, by vehicle.

When cracks are identified, the location will be noted but no immediate action will be taken. It is expected that natural erosive forces will fill smaller cracks naturally. For larger cracks (>100mm) or those persisting without being naturally filled in, remedial works will be required. This will involve the scarification or light ripping of ground over, and on both sides of, the crack.

If these remedial works are insufficient to fill in a deeper or wider crack, a different approach will be required. Narrabri Mine will excavate the required volume of subsoil from stockpiles located at nearby gas drainage sites, ventilation sites or footprint of the Reject Emplacement Area, transfer it to the crack site and fill it in.

Creeks traversing a longwall panel will be inspected within 6 months of being crossed.

5.4.2 Slope Stability and Erosion

Given the ephemeral nature of the creeks, bed changes and erosion would be expected to occur as part of naturally occurring phenomena. Therefore the creeks are expected to naturally re-adjust to any changes in gradient and short term increase in erosion as a result of subsidence.

Part of the monitoring of the surface above the mine workings will include an assessment of the area's most susceptible to post mining surface gradient changes (as identified in the DGS (2016) report Figures 20, 21a, 21b, 22A, and 22b). This assessment will focus on the potential for accelerated erosion in creek beds and slopes with exposed soil. Creeks will be monitored for erosion following 38.4mm over a consecutive 5-day period. Any "non-natural" or erosion deemed to be in excess of natural rates of erosion will be repaired and remedial measures, such as check dams or drop structures, would be constructed, if necessary.

While considered unlikely, should large-scale slope instability be identified after mining, mitigation works will be required. Stabilisation works will be carried out, such as the installation of deep sub-surface drainage trenches (to reduce pore pressures) and the construction of strategic catch drains to improve surface run-off. In the event that erosion is identified, especially along the creek channels, the sections of damaged or steeply eroded banks would be stabilised.

5.4.3 Surface Uplift

The monitoring and remediation for uplift is very similar to that of surface cracking. The surface above the mining operations should be inspected for signs of uplift and associated cracking. If found, then the cracks should be filled in as previously described. Where uplift is identified, this should be reviewed to allow improved predictions after the completion of each longwall panel.

5.4.4 Ponded Water

Inspection of the watercourses over the subsidence zone of the mine site will occur on a monthly basis and following rainfall events. If ponding (as identified in the WRM report Figure 7.1) is identified, Narrabri Mine will implement the following mitigation strategy.

- If little vegetation of significance is impacted and water quality analysis confirms no increase in salinity, the ponding would be left to “self-correct” over time. The WRM report suggests that the continual action of erosion and sedimentation without mitigation measures is likely to ‘self-correct’ the geomorphic characteristics of the waterways over time.
- If important environmental features are impacted (i.e. riparian vegetation, Endangered Ecological Community or archaeological deposits) OR water quality analysis indicates an increase in salinity, the ponding will be assessed and remediation options will be developed to protect the affected environmental features and prevent saline water discharging downstream. The remediation will consider the requirements of the Biodiversity Management Plan and Heritage Management Plan.
- Should modification of any watercourses be required a suitably qualified geomorphologist shall be consulted and DPI Water shall be notified.

5.4.5 Farm Dams and Soil Conservation (Contour) Banks

Appropriate impact management strategies are described in the Built Features Management Plan which makes up part of the Extraction Plan. As all farm dams are owned by NCOPL no testing of farm dams is proposed.

5.4.6 Ground disturbance above longwall panels

Appropriate management strategies during construction of access tracks and clearing will be implemented as per the approved ESCP. A ground disturbance protocol outlining the standard practices to control soil erosion and sedimentation will be prepared ahead of the planned disturbance. Strategies to control the impacts may include:

- Limit clearing to a designated path whilst seeking to disturb the minimum amount of vegetation (i.e. avoid mature trees, etc);
- Avoid drainage lines wherever possible;
- Implement erosion control measures for roadways, e.g. drainage socks along table drains, rock check dams to slow down runoff, etc;
- Implement erosion control measures for disturbed slopes, e.g. silt fences along contours;
- Schedule construction in the dry wherever possible.

For the drill pads, rehabilitate using fast growing pasture grasses once wells have been installed.

5.4.7 Contingency measures

In the event that; significant erosion; ponding which inundates significant areas of vegetation; or increased surface water salinity or pH outside the target range of ANZECC (2000) is identified an impact mitigation strategy would be developed. The impact mitigation strategy may include the following approaches.

- Undertake a more detailed survey of watercourses based on the principles of the Index of Diversion Condition (IDC) developed for creek diversions as part of the ACARP program 'Monitoring and Evaluation Program for Bowen Basin Diversions' (ID&A 2000). IDC provides a rapid assessment of the condition of diversions and adjoining stream reaches. The purpose of the IDC is to flag potential management issues rather than provide a scientific assessment of a diversion or stream. It is an integrated suite of indicators that measures the geomorphic and riparian condition of a diversion and its upstream control and downstream reaches hence it could be adapted to monitor significant changes in surface morphology as a result of subsidence.
- Visible crack in the bed of the creek will be in-filled.
- Contour banks that cross chain pillars would be removed and reconstructed if appropriate for the ongoing land use (noting that the Proponent owns all of the land over LW107 to LW110 and as such is being managed to achieve

lower stocking rates and higher vegetation cover than has been historically the case).

- If significant areas of ponding are identified, i.e. above the predicted levels, an assessment will be made.

6 GROUNDWATER MONITORING AND MANAGEMENT

6.1 Groundwater monitoring

Narrabri Mine has a groundwater monitoring program in place across the mine site that incorporates the collection of water quality and water level data from groundwater monitoring and local production bores. This groundwater monitoring network will be augmented by the installation of additional groundwater monitoring bores and vibrating wire piezometers to monitor and compare actual to predicted impacts. The groundwater monitoring network is presented in Table 7-1 of the site WMP. Locations of the monitoring network are shown in Figure 6-1 and Figure 6-2. Indicating the locations of bores across the mine lease and surrounds.

6.2 Baseline data

Preliminary baseline groundwater level and water quality information has been collected periodically between 2007 and commencement of mining and is presented in the Site WMP (URS 2016).

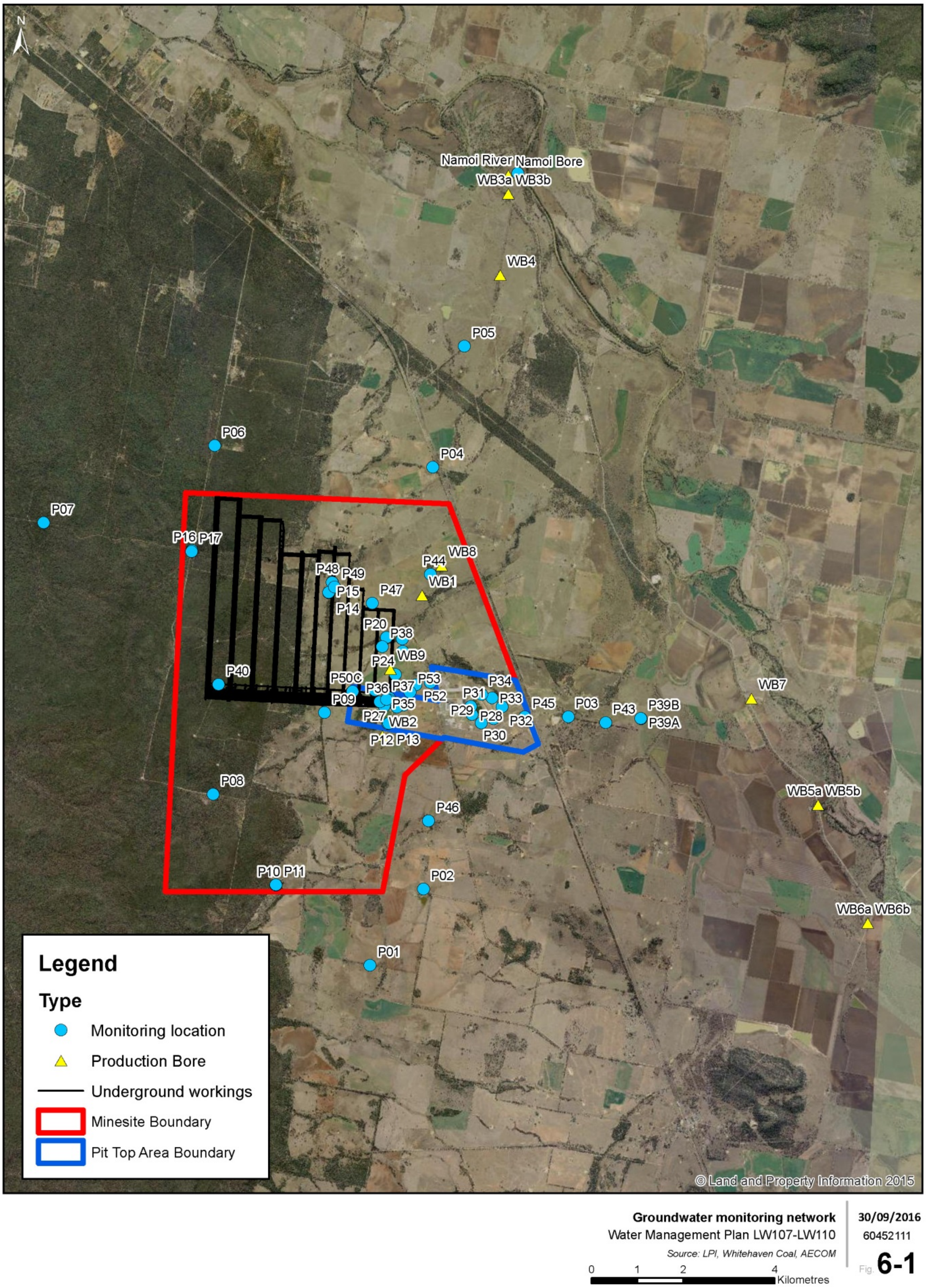

Figure 6-1 Groundwater Monitoring Network

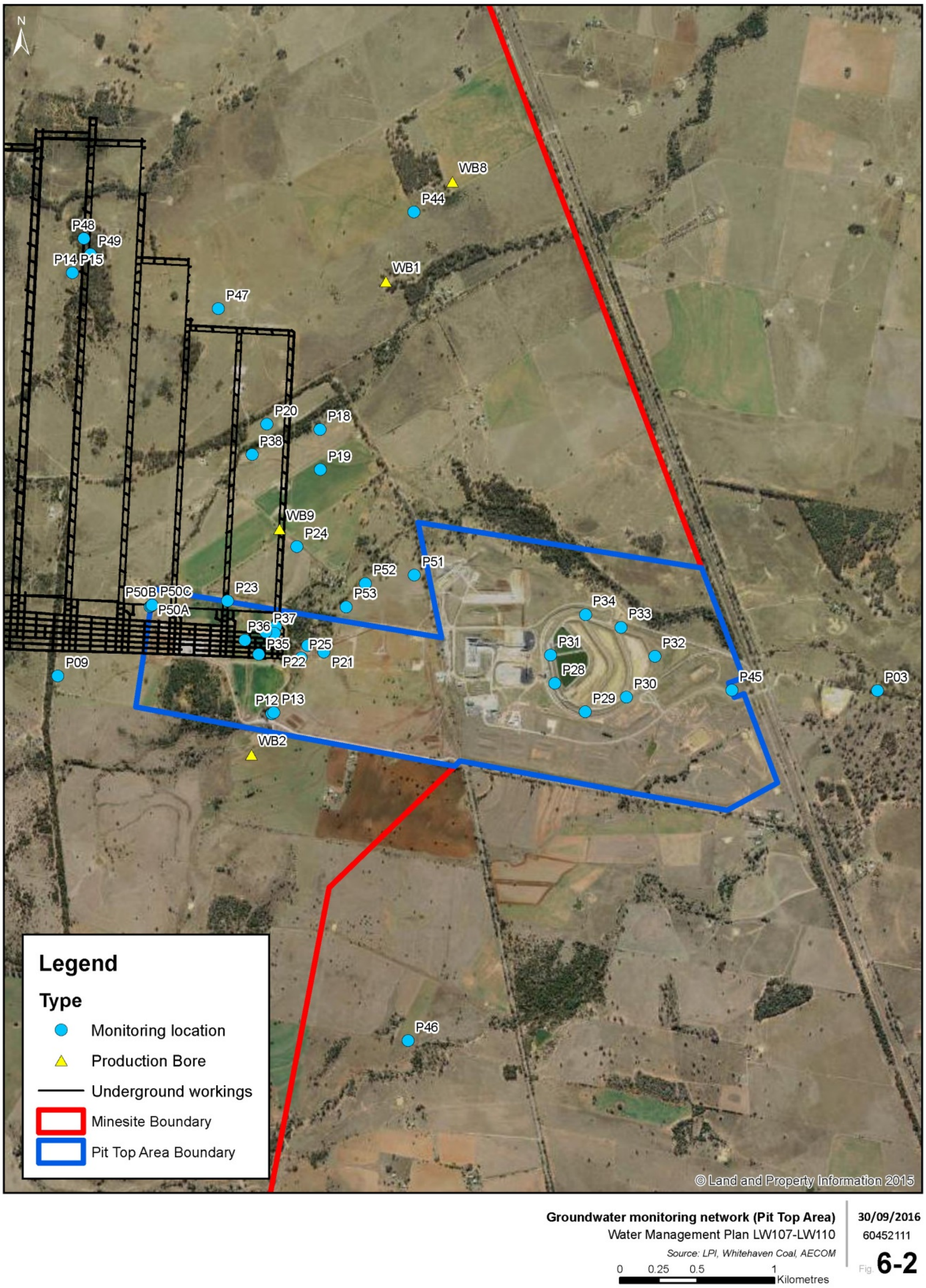

Figure 6-2 Groundwater Monitoring Network (Pit Top Area)

6.3 Groundwater Monitoring Schedule

6.3.1 Requirements for Subsidence Impact Monitoring

Narrabri Mine has implemented a comprehensive monitoring program to investigate the subsidence impacts as they develop above longwall panels LW107 to LW110. Several multi-level vibrating wire piezometers have been installed to enable ongoing groundwater level monitoring for the life of the operation.

Groundwater monitoring bores and vibrating wire piezometers have been installed between the mine site and the Namoi River alluvium in order to detect groundwater level (and hence base flow) impacts on the Namoi River. Baseline groundwater level data has been monitored at Narrabri Mine since 2007. Monitored data collected during and following mining of LW106 to 110 will be compared to baseline data. Where monitored seasonal levels vary significantly from baseline levels and modelled levels in the environmental assessment, the groundwater model will be used to determine the likely source of the discrepancy and to what extent longwall mining is influencing groundwater levels.

Data on mine water inflows and outflows is collected via:

- Metering of water pumped into the mine (for dust suppression, machinery operation etc);
- Metering of water pumped from sumps to the surface;
- Ventilation (rate and humidity); and
- Coal moisture content.

The groundwater level and quality information collected, together with the mine water inflows and outflows, would show changes in surface or groundwater flow entering the mine for comparison to and updating of the groundwater model. Hydrogeological data is reviewed annually and included in the annual monitoring report.

6.3.2 General Monitoring Schedule

Table 6-1 and Table 6-2 defines the parameters and sampling frequency for each sampling location. The groundwater quality monitoring program allows for the collection of additional baseline data information and ongoing operational data.

Table 6-1 Groundwater Monitoring Schedule

Location	Parameters	Frequency
All standpipes	Water level Water quality (see Table 6-2)	Water level monthly Annually (full water quality)

Representative Bores	Water level EC pH TDS Metals Anions and Cations	Annually
Spring discharges (including Mayfield Spring)	Flow rate and water quality (pH, EC, TDS)	Monthly
Vibrating Wire Piezometers	Water level	Daily (data logger)
Mine water pumped into and out of the mine	Water quality (see Table 6-2) and discharge rate	Daily (flow rate) Monthly (EC pH,) Quarterly (Full water quality)

* As groundwater response is understood, can become monthly

Data collected from the vibrating wire piezometers will be compared against initial groundwater and subsidence modelling predictions.

The increased frequency of water level monitoring as the longwall operations begin will allow a greater understanding of the groundwater response. This can then be used to refine the groundwater model and refine future predictions.

Table 6-2 Laboratory Analysis Suite for Groundwater

Class	Parameter
Physical parameters	EC, TDS, TSS and pH
Major cations	Calcium, magnesium, sodium and potassium
Major anions	Carbonate, bicarbonate, sulphate and chloride
Dissolved metals	Aluminium, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, selenium, zinc
Nutrients	Ammonia, nitrate, phosphorus, reactive phosphorus

6.3.3 Groundwater Sampling Procedure

The groundwater sampling procedure is detailed in the WMP (URS, 2013).

6.3.4 Monitoring bores impacted by subsidence

Where groundwater monitoring points are identified as having been impacting by subsidence NCOPL will undertake to reinstate or correct the monitoring point. DPI Water will be notified within two weeks of identification of detection of the impacted bore. A determination of the appropriate action for reinstatement or correction of the groundwater bore will be determined in consultation DPI Water. Impacted monitoring locations will be rectified within three months of detection.

6.4 Groundwater Impact Assessment Criteria

Impact assessment criteria have been adopted for:

- Mine inflow rate;
- Mine inflow water quality;
- Near surface groundwater levels, in particular groundwater levels within the Garrawilla Volcanics;
- Water levels in the Namoi River alluvium
- Impacts on surficial groundwater levels and creek base flows; and
- Impacts on existing licensed users.

The basis for and development of these adopted impact assessment criteria are discussed below.

6.4.1 Mine Inflow Rates

Daily recording of mine water inflows and outflows will be conducted to record potential sudden inflows as subsidence develops (as a result of groundwater inflow or connection to surface water flows). In consideration of the sensitivity analysis conducted on the groundwater model (Aquaterra, 2009) and the potential variability of mine inflows (on a daily basis compared to the weighted average annual inflow of the model), an observed inflow rate 100% in excess[2] of the predicted base case mean monthly inflow rate at any stage during the mine life sustained for 3 consecutive months would trigger an investigation and preparation of a response plan as detailed in Section 8 of this report.

The volumes extracted from the mine workings are passed through the box cut sump and flows pumped from here are measured. These volumes are included as part of the monitoring network and are reported in the Annual Review. This forms the largest portion of flow that contributes to Narrabri Mine's licenced groundwater extraction volume.

6.4.2 Bore and Gas Drainage Water Extraction

The groundwater volumes extracted from bores and gas drainage activities will be measured using flow meters on the pumping equipment. This water contributes to Narrabri Mine's total licenced extraction volume. The volumes extracted from each location will be recorded and included in the Annual Review.

[2] 'Day to day inflow rates may be highly variable as the longwall retreats and subsidence develops. A fracture zone may be intercepted which contributes increased inflow for a short period of time (days to weeks), but then inflow would be expected to return to the long term average. The groundwater model also assessed variability in parameters, including hydraulic conductivity, to examine potential variability in impact on groundwater (groundwater level drawdown and inflow rate) compared to the base case. The adoption of a 100% trigger level for variation in inflow rates is based on these two considerations.'

6.4.3 Impacts to Licensed Users

Due to the generally high groundwater salinities and low bore yields, there is very limited existing groundwater abstraction in the immediate mining area other than for coal mine dewatering.

Occasional small stock water supplies are drawn from near surface groundwater. Aquaterra (2009) considered that an impact on surrounding registered groundwater users should be treated as significant if it exceeds 15% of predicted drawdown (taking into account groundwater model sensitivity) as per the Statement of Commitments within the Project Approval.

The greatest impact during extraction of all longwall panels is predicted to occur within the Hoskissons Coal Seam, exceeding 10 m to around 6 km to 7 km to the west, north and south, and around 2 km to the east of the underground workings.. Drawdown to the east is limited by the truncation of the Hoskisson Coal Seam in sub-crop.

The MOD 5 Groundwater Assessment indicated that for the whole life of mine, no alluvial bores have a drawdown of more than 2 m. Within the Pilliga Sandstone there are no bores with a predicted drawdown of greater than 2 m. One bore in the Purlawaugh formation is expected to have a drawdown of more than 2 m (Bore No. GW067626; Private Owner). One bore in the Garrawilla Volcanics formation is expected to have a drawdown in excess of 2 m, (Bore No. GW966836; owned by NCOPL).

An observed drawdown in licensed bores which exceeds predicted drawdown would require a response action as detailed in Table 8-1.

6.4.4 Mine Inflow Water Quality

Mine inflow water quality is presented in the Site WMP (URS, 2013).

6.4.5 Groundwater Quality Criteria

Groundwater quality criteria is presented in the Site WMP (URS, 2013).

6.4.6 Further Development of the Groundwater Model

The SoC within the approval conditions proposed recalibrating the groundwater model 2 years after the commencement of longwall extraction, and every 5 years thereafter, Following the first review, if necessary, the groundwater model will be recalibrated and revised forward impact predictions made.

It is proposed to calibrate this model with ongoing monitoring data from the site. Other circumstances which may trigger further development or refinement of the groundwater model include:

- A significant change to the mine plan or operations that would have the potential to alter subsidence behaviour/predictions, particularly in relation to (an increased) extent, or altered longwall caving and fracturing behaviour;
- Acquisition of new hydrogeological information, such as groundwater levels and aquifer properties (i.e. hydraulic conductivity) which are different to calibrated values used in the model; and
- Groundwater drawdown and inflows which significantly exceed model predictions for that stage of mining (refer to TARP in Section 8.3).

7 REPORTING AND REVIEW

Reporting and review of surface water and groundwater impacts, incidents and non-conformances will be carried out as per Schedule 6 – Environmental Management, Monitoring and Reporting. This will be made available in the Annual Review for the site.

7.1 Surface Water

The Environmental Superintendent for the mine site retains an active database of monitoring results which will be updated on a regular basis. This will cover both catchment flows crossing the mine lease and water flowing or stored in the surface operating area. Any runoff event within affected surface watercourses will result in the triggering of a sampling event.

7.2 Groundwater

An active database of monitoring results, to be retained by the Environmental Superintendent, will be updated on a regular basis. The Annual Review will present an overview of the performance of the groundwater monitoring network during the preceding 12 months and identify the proposed extraction, processing and rehabilitation activities and environmental management planned for the following 12 months.

As part of annual monitoring, it is the responsibility of Narrabri Mine to commission an experienced hydrogeologist to collate and review the monitoring data collected. This review will assess the impacts of the project on the groundwater environment, and to compare any observed impacts with those predicted from groundwater modelling. If significant variation is found between predicted impacts and observed operational monitoring data then notification of remediation will be required. Refer to Section 1.5 Responsibilities for details.

The ongoing monitoring program and collation of relevant data will provide the basis for continuing improvement in groundwater management across the site.

8 SURFACE AND GROUNDWATER RESPONSE PLAN

The surface and ground water response plan includes a protocol for managing and reporting any:

- incidents;
- complaints;
- non-compliances with statutory requirements; and
- exceedances of the impact assessment criteria and or performance criteria.

Records of any of these items along with the data collected as outlined in this section are to be maintained and available for review by the appropriate agency/authorities.

8.1 Surface Water

Monitoring will involve both the sediment and chemical content of the surface water and the physical movement of the flow. If these elements are altered significantly, then remediation will be required. The monitoring will be as described in Section 5.1.

8.1.1 Contingency Measures

The methods used to correct or compensate for the various changes in the surface water flow are described in Section 5.4. While there are no specific triggers, the general aim is to minimise the effect of subsidence to the surface water flow routes. There are performance indicators for the quality of the water and these may indicate the presence of subsidence; however visual inspection of the area is essential. The corrective action may not always be immediate, but this is intended to allow the majority of subsidence effects to occur before any action is taken.

8.1.2 Response Action

If an exceedance of the performance indicators within Pine Creek is observed (detailed in Section 5.1), then Narrabri Mine will follow the procedure listed below:

- Record the timing, location, environmental conditions and any potential contributing factors to the exceedance;
- Issue advice of the apparent exceedance to relevant agencies immediately;
- Sampling point and areas upstream inspected to ascertain cause of exceedance;
- Operational practices reviewed to determine if any current operational practice contributed to the exceedance;

- Implementation of ameliorative measures on site to minimise the potential for future exceedance. May include: alteration to operational practice, or maintenance for subsidence effects.
- Written advice to relevant agencies identifying actions undertaken to reduce future risk of exceedance within 14 days;
- Where specific cause of exceedance cannot be identified, external advice may be sought; and
- Ongoing future monitoring to ensure ameliorative measures have been successful with concentration criteria being met.

All other surface water monitoring will be discussed in the Annual Review with reference to relevant guidelines, such as the Australian and New Zealand Environment Control Council (ANZECC) guidelines.

In the event of any exceedance in concentration criteria, Narrabri Mine will advise DPI Water and other relevant agencies within 24 hours of detecting the exceedance in accordance with consent Condition 3 of Schedule 4. Narrabri Mine will also provide a written report within 7 days of the event to the relevant agencies which will:

- Describe the date, time and nature of the exceedance/incident;
- Identify the cause (or likely cause) of the exceedance/incident;
- Describe what action has been taken to date; and
- Describe the proposed measures to address the exceedance/incident.

The ongoing monitoring program and collation of relevant data will provide the basis for continuing improvement in surface water management across the site.

A Trigger Action Response Plan (TARP) is presented as Table 8-1. The TARP was initially developed for responses to groundwater triggers; however the surface water triggers have been included.

8.2 Groundwater

If adverse impacts or groundwater quality degradation are beyond predictions in the EA and this is caused by mine operations, contingency measures will be required. Narrabri Mine will: commission an assessment of the causes; develop a staged response program satisfactory to DPI Water to mitigate the adverse impacts; and establish and implement measures to manage further impact.

8.2.1 Contingency Measures

The identification process and response protocol to adverse outcomes are provided in the TARP (refer **Section 8.3**). The responses proposed incorporate a staged assessment and development of management measures deemed appropriate for each individual event should it occur.

Specific trigger levels have been designed to alert Narrabri Mine to observed parameter responses which are outside of normal variation and predicted responses, or where observed parameter values do not follow anticipated trends.

The triggers for instigation of response actions would occur when observed changes to monitored parameters exceed specified levels. Such changes in observed parameters or conditions include:

- Sudden in-rush of groundwater into the mine or measured flows in exceedance of predicted inflows;
- Significant change in observed water quality or groundwater levels between sampling rounds;
- Changes in trends over an extended period for groundwater levels and quality that are not consistent with the prediction models; and
- A significant increase or variation from predicted models.

8.2.2 Response Action

In the event of any exceedance detailed in Section 6.4, the following response action may be initiated:

- Narrabri Mine assessment to determine the reason for the exceedance which may include resampling or increasing monitoring frequency to confirm trend / exceedance or identify sampling anomaly.
- Refer the matter to an independent hydrogeologist for review if Narrabri Mine investigation is unable to identify reason for exceedance. Any such investigation (depending on nature of trigger) may include:
  - Review monitoring data
  - Review groundwater model
  - Review site water balance
  - Assessment of potential causes and consequences. Key considerations of the assessment may include:
    - Does the monitoring and investigation indicate that a performance measure, development consent condition or water licensing limit has been exceeded, (or is likely to be exceeded in the immediate future)
    - What are the implications of the exceedence (other water users, mine water balance, Namoi River alluvium, GAB)

  - What are the potential factors that may have contributed to the exceedence
  - What actions, if any are required, to mitigate or minimise the potential for future impacts
  - Develop recommendations and report.
- If assessed as being caused by the mining operation, and it is further assessed to be likely to cause an adverse impact on an existing beneficial or environmental use of surface water or groundwater, then an appropriate preventative or remedial strategy would be recommended, which may comprise:
  - Additional monitoring;
  - Modification to mine plans;
  - Provision of alternative water supply or other agreed compensation; or
  - (If appropriate) no change to operations.

The above response program would be carried out in consultation with OEH and DPI Water.

Should any review or post-audit indicate a significant variance (refer Section 4.2) from the model predictions with respect to either water quality or groundwater levels, then the implications of such variance will be assessed, and appropriate response actions implemented in consultation with the DPI Water and other departments as appropriate.

If inflows deviate significantly (refer Section 4.2) from predictions, regular review of the groundwater model predictions against monitoring data will be carried out. Should the re-calibrated model show groundwater inflows beyond these cases described in the Environmental Assessment (EA), a separate detailed impact assessment will be conducted and mitigating measures determined.

8.3 Trigger Action Response Plan (TARP)

The Trigger Action Response Plan (TARP) has been developed to focus upon appropriate trigger and response actions for mitigation of impacts to the natural environment as a result of mining.

Monitoring serves to advise of changes to groundwater levels or quality that occur or to raise alert that an abnormal condition relating to mining has developed.

Each monitoring program has established trigger levels of particular impacts at which a response is needed, and to help define an appropriate response (Table 8-1). Management of impacts within predictions follows standard assessment review and response protocols.

The TARP has been designed to reference the risks that mining poses to the environmental receptors both within the mining area and beyond. Aspects assessed to be at risk are summarised in Section 4 and 6.4 of this report. These include both predicted and unpredicted impacts, and include:

- Groundwater level;
- Groundwater quality;
- Hydraulic connection to alluvium associated with the Namoi River;
- Discharges;
- Pumping bores/underground pumping stations;
- Groundwater users (Private Bores);
- Surface water quality; and
- Ponding etc.

Table 8-1 Trigger Action Response Plan (TARP)

Monitoring	Trigger	Action
Surface Water		
Water Quality (Pine Creek)		
To identify potential surface water quality impacts as a result of mining activities (e.g. via subsidence cracking, ponding, erosion). **Sites:** PCUS, PC1US, PC, PC1, (see Figure 5-1). **Parameters:** EC, oil and grease, pH, TSS, TOC, Turbidity. **Analysis:** Comparison of upstream and downstream results as well as to ANZECC water quality trigger levels. Review of water quality trends over time. Current monitoring suggests baseline data is within ANZECC guidelines however there are no discernible trends at this stage. **Frequency:** During runoff events (as practical).	**Level 1** Long term upwards trend towards ANZECC water quality guideline limit (for six consecutive months).	• Repeat sampling to confirm results exceed trigger level. • Hydrologist (or similar specialist) to review sampling and climate data and confirm likely mining impact or otherwise. If mine-related, undertake physical inspection of affected surface and creeks to identify potential source of water quality degradation. Implement appropriate management or contingency response (i.e. repair of subsidence cracking, remediation of ponding, erosion control works and rehabilitation).
	Level 2 Exceedance of ANZECC water quality guideline limit for three consecutive monitoring results	• Actions stated for Level 1 • Implement contingency and notification measures as per Section 5.2 of the Extraction Plan
Water Quality (Ponding)		
To monitor potential salinity increases in water ponding over potential saline soils. To ensure that surface water ponding does not provide a potential source of salinity for downstream watercourses (Namoi River). **Sites:** Longwall panels LW107-110.	**Level 1** Long term upwards trend towards ANZECC quality guidelines (for six consecutive months) or identified changes in topography either by visual inspection during an event or via survey information	• Ecological benefits of ponded water should be considered before any action is taken. • If little vegetation of significance is impacted and water quality analysis confirms no increase in salinity, the ponding would be left to “self-correct” over time.

Parameters: Water quality sampling (EC) of surface water ponding in overbank areas. Identification of changes in topography that leads to ponding. **Analysis:** Comparison to ANZECC trigger levels and observing trend in quality over time. Identification of potential ponding areas via changes in topography. Identified via visual inspection and ALS survey. **Frequency:** Following formation of surface ponding and monthly during ponding occurrence. Monthly visual inspection and three yearly ALS survey.		• Should vegetation of significance be at risk or there is an exceedance of salinity, construct drainage (i.e. open channel / drain) works to ensure area is able to drain freely once substantial subsidence has ended. Rehabilitate and stabilise. • Should vegetation of significance be at risk or there is an exceedance of salinity, construct drainage (i.e. open channel / drain) works to ensure area is able to drain freely once substantial subsidence has ended. Rehabilitate and stabilise.
	Level 2 Exceedance of ANZECC water quality guideline limit for three consecutive monitoring results	• Actions stated for Level 1 • Implement contingency and notification measures as per section 5.2 of the Extraction Plan
Changes in water course morphology		
To determine if subsidence due to mining is impacting on the morphology of Pine Creek and Pine Creek Tributary 3. This can appear as changes in; planform, creek grade, bank erosion and sedimentation which effects water quality. This may occur in the channel and the wider floodplain. **Sites:** Where Pine Creek and Pine Creek Tributary 3 traverse longwall panels LW107-110. **Parameters:** Water quality – use results from 'water quality' section above. Identification of changes in planform, creek grade,	**Level 1** Water quality triggers as described above may indicate changes in channel morphology.	• Identified changes in topography should be allowed to "self-correct" unless there is evidence of significant erosion. (or variation from predicted model results see figures 20 to 23b of the Subsidence Assessment for LWs 107 – LW110 (DGS 2016).
	Level 2 Identified changes in topography either by visual inspection during an event or via survey information	• Actions stated for Level1 • If erosion and deposition is identified as being significant, a qualified geomorphologist will be consulted to develop action plan which may involve further monitoring or remediation. - Monitoring may involve use of

bank erosion and sedimentation. **Analysis:** Identified via visual inspection and subsidence monitoring survey. **Frequency:** Water quality - during runoff events (as practical). Morphology - monthly visual inspection and 3 yearly ALS survey.		‘Index of Diversion Condition’ principles as per ACARP. - Remediation works will be identified; these may include erosion protection works, removal of sedimentation and realignment of the watercourse. • Implement contingency and notification measures as per section 5.2 of the Extraction Plan including contact with DPI Water.
Ground disturbance above longwall panels		
To determine if activities above longwall panels required to enable mining is impacting on surface erosion and in turn impact on water quality. **Sites:** Areas that traverse the long wall panels. **Parameters:** Water quality – use results from ‘water quality’ section above. **Analysis:** Identified via visual inspection. **Frequency:** Water quality - during runoff events (as practical).	**Level 1** Water quality triggers as described above may indicate increased rates of erosion.	• Continued monitoring of erosion; control measures as described in the mine site erosion and sediment control plan.
	Level 2 Visual inspection revealing excessive erosion or ineffective control measures.	• Actions stated for Level 1: • If implemented erosion control measures are found to be failing, review causes and replace with like or better. Continue monitoring.
Groundwater		
Groundwater levels (Namoi River alluvial aquifer)		
To provide water level data and to identify water level impacts. To verify that impacts in base flows to Namoi River Alluvium are consistent with model predictions.	**Level 1** Drawdown greater than maximum predicted impact in sensitivity analysis of groundwater model.	• Engage hydrogeologist to undertake investigation and report on any identified changes/likely causes and recommendations in accordance with Section 8.2.2.

To re-calibrate and validate model with additional data. **Sites:** Up-gradient background reference bores. Groundwater bores in alluvium. Vibrating wire piezometers and groundwater bores in Permian between mine site and alluvium. **Parameters:** Water level. **Analysis:** Comparison to predicted drawdown taking into account natural variations observed in background reference sites. Determine potential baseflow impacts during model review. **Frequency:** Manual monitoring of groundwater bores monthly and automatic groundwater level monitoring of VWPs daily		• Notify agencies when exceedance becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at conclusion of assessment. • Implement contingency responses (See Extraction Plan section 5.2) as agreed with government agencies and in accordance with hydrogeologist recommendations.
Groundwater levels (Permian to Jurassic hard rock aquifers)		
For comparison to baseline water level data and to identify water level impacts. To verify that impacts on GAB aquifers are consistent with model predictions. To re-calibrate and validate model with additional data.	**Level 1** Drawdown greater than 15% above predicted trend in VWPs, monitoring bores, and private landholder bores (not pumping affected).	• Engage hydrogeologist to undertake investigation and report on any identified changes /likely causes and recommendations in accordance with Section 8.2.2. • Notify agencies when exceedance becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at

Sites: Vibrating wire piezometers and groundwater bores in Permian. Private landholder bores (including identified springs to the south of the mine). **Parameters:** Water level. **Analysis:** Comparison to predicted drawdown taking into account natural variations. **Frequency:** Manual monitoring of groundwater bores monthly and automatic groundwater level monitoring of VWPs daily		conclusion of assessment. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.
Hydraulic connectivity		
To identify changes (pre and post mining) in permeability and provide data for on-going review and recalibration of groundwater predictive models. To obtain site-specific data on fracturing behaviour and extent in overlying strata. **Sites:** Vibrating wire piezometers (existing and others as constructed at ends of panels, over panels and over chain pillars). Monitoring bores (existing and others as constructed at ends of panels, over panels and over chain pillars).	**Level 1** Drawdown greater than 15% above predicted trend in VWPs and monitoring bores, or permeability greater than upper limits used in sensitivity analysis in groundwater model, or fracturing extends above Garrawilla Volcanics.	• Engage hydrogeologist and/or subsidence specialist to undertake investigation and report on any identified changes/likely causes and recommendations in accordance with Section 8.2.2. • Notify agencies when exceedance becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at conclusion of assessment. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.

Extenseometers to be constructed at ends of panels, over panels and over chain pillars. **Parameters:** Water level **Analysis:** Comparison to predicted drawdown taking into account natural variations. Horizontal and vertical permeability compared to values used in groundwater model. **Frequency:** Manual monitoring of groundwater bores monthly. Automatic groundwater level monitoring of VWPs daily (downloaded monthly) from commencement of adjacent longwall continuing until 6 months of longwall pass, otherwise as for 'Groundwater Levels – Permian to Jurassic hard rock aquifers'. Annual review by an experienced hydrogeologist to collate and review monitoring data collected.		
Mine water inflows – volume/rate		
To verify that impacts of subsidence and groundwater drawdown are consistent with model predictions. To re-calibrate and validate model with additional data. **Sites:** Surface to in seam extraction bores, sumps/pumps, water entry to mine.	**Level 1** An observed inflow rate 100% in excess of the predicted base case mean monthly inflow rate at any stage during the mine life sustained for 3 consecutive months or inflow rate for a 3 month period 100% greater than the predicted base case total for that 3 month period.	• Engage hydrogeologist or subsidence specialist to undertake investigation and report on any identified changes /likely causes and recommendations in accordance with Section 8.2.2. • Notify agencies when exceedance becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at conclusion of assessment.

Parameters: Volume. **Analysis:** Comparison to predicted volumes in mine water management and groundwater models. **Frequency:** Daily recording of volumes.		• Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.
Mine water inflows – quality		
To verify that impacts of subsidence and groundwater drawdown are consistent with model predictions. To re-calibrate and validate model with additional data. **Sites:** Underground sumps/pumps, water entry to mine. **Parameters:** Water quality – full laboratory analysis suite (See Table 6 4). **Analysis:** Comparison to predicted water quality in mine water management and groundwater models. **Frequency:** Monthly for EC and pH. Quarterly (full water quality).	**Level 1** Should the TDS of the mine inflows or dewatering discharge indicate an inflow salinity of more than 20% above that predicted by modelling at any stage during the mine life sustained for three consecutive months (or the 3-month rolling average exceeds the criteria)	• Engage hydrogeologist or subsidence specialist to undertake investigation and report on any identified changes /likely causes and recommendations in accordance with Section 8.2.2. • Notify agencies when exceedance becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at conclusion of assessment. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.
Groundwater quality		
For comparison to baseline water quality data and to identify water quality impacts.	**Level 1** Water quality exceeds NEPM guideline or exceeds	• Engage hydrogeologist to undertake investigation and report on any identified

Sites: As per the WMP. **Parameters:** Water quality – full laboratory analysis suite (See Table 6 4). **Analysis:** Comparison to NEPM and baseline water quality (groundwater quality conducted up to and including the first two years of mining). **Frequency:** Quarterly for EC and pH. Annually for other water quality.	baseline water quality (97.5th percentile of baseline data).	changes /likely causes and recommendations in accordance with Section 8.2.2. • Notify agencies when exceedence becomes known (as per section 5.2 of the Extraction Plan), and provide updates throughout investigation above, and at conclusion of assessment. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.

NOTE: All actions for the Environmental Superintendent

* Note 1 – If quarterly groundwater monitoring identifies that the groundwater level trigger has been exceeded, the water level in the affected piezometer will be measured within one month of the initial measurement. If the water level no longer exceeds the trigger level, the groundwater level measurements will continue as per the quarterly monitoring program. If the SWL still exceeds the trigger level, and Narrabri Mine is unable to ascertain the cause of the exceedance (eg. windmill in operation) the matter will be referred to relevant agencies and an independent hydrogeologist for review.

8.4 Unforeseen Impacts Protocol

Table 8-2 outlines the procedure to be followed (in general accordance with the criteria exceedance protocols detailed in **Section** 5 and **Section** 6) in the event that any unforseen surface or groundwater impacts are detected. This is in addition to the procedures already described and is intended to allow an initial response that can be tailored for similar future occurrences.

Table 8-2 Unforeseen Impact Procedure

Stage	Procedure
1	Review the unforeseen impact including consideration of: • Any relevant monitoring data; and • Current mine activities and land management practices in the relevant catchment
2	Commission an investigation by an appropriate specialist into the unforeseen impact, if considered appropriate by the Environmental Specialist.
3	Develop appropriate ameliorative measures based on the results of the above investigations, in consultation with the relevant authorities.
4	Implement additional monitoring where relevant to measure the effectiveness of the improvement measures.

9 REFERENCES

ACARP (2001) — *Monitoring & evaluation program for Bowen Basin river diversions*, report prepared by ID&A (2001)

ANZECC and ARMCANZ (2000) — '*Australian and New Zealand Guidelines for Fresh and Marine Water Quality'*, Australian and New Zealand Environment Control Council and Agricultural and Resource Management Council of Australia and New Zealand, Australia.

Aquaterra (2009) — *Narrabri Coal Project Hydrogeological Assessment of the, prepared* on behalf of Narrabri Coal Operations *Pty Ltd (Part 2 of the Specialist Consultant Studies Compendium).*

Coffey (2008) — '*Narrabri Coal Project Water Management Plan*, Report prepared by Coffey Geotechnics Pty Ltd for Narrabri Coal Pty Ltd

DPI Water (2017) — Harvestable Right – Dams *http://www.water.nsw.gov.au/water-licensing/basic-water-rights/harvesting-runoff*

DGS (2016) — *Mine Subsidence Assessment for the Proposed LW 107 to LW110 Extraction Plan at the Narrabri Mine*, prepared on behalf of Narrabri Coal Operations Pty Ltd

DGS (2011) — *Mine Subsidence Effect Predictions and Impact Assessment for the Proposed Longwalls 1 to 5 at the Narrabri Coal Mine, Narrabri,* Report prepared by Ditton Geotechnical Services Pty Ltd.

EPA (2007) — "*EPA Guidelines. Bunding and Spill Management*" EPA 080/07 Updated June 2007

GHD (2007) — *'Groundwater Assessment of the Narrabri Coal Project',* Report prepared by GHD Pty Ltd for Narrabri Coal Pty Ltd (Part 2 of the *Specialist Consultant Studies Compendium*).

Landcom (2006) — *The Blue Book - Managing Urban Stormwater (MUS): Soils and Construction*

HydroSimulations (August 2015) — *Narrabri Mine Modification Groundwater Assessment,* Report prepared by HydroSimulations for Narrabri Coal Pty Ltd.

IECA, (2009) — *Best Practice Erosion and Sediment Control*, produced by the Australasian arm of the International Erosion Control Association (IECA, 2009)

NCMA (2007) — *Catchment Action Plan 2010-2020,* produced by the Namoi Catchment Management Authority for the Namoi River

NEPC (1999) — *National Environment Protection (Assessment of Site Contamination)* Measure, NEPC, Adelaide.

OEH, 2008	*Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries*
R.W. Corkery & Co. (2009)	*'Environmental Assessment for the Narrabri Coal Mine Stage 2 Longwall Project'* Report prepared by R.W. Corkery & Co. Pty. Limited
Resource Strategies (2015)	'*Narrabri Mine Modification 5 Environmental Assessment*' Report prepared by Resource Strategies Pty Ltd
URS (2007)	*'Report for Evaporation and Storage Dams, Narrabri Coal Pit Top Infrastructure'*, Report prepared by URS Pty Ltd for Narrabri Coal Pty Ltd.
URS (2013)	*'Narrabri Mine Water Management Plan'*, Report prepared by URS Pty Ltd for Narrabri Coal Pty Ltd.
WRM (2008)	*'Narrabri Coal Project Surface Water Management Plan'* prepared by WRM Water & Environment Pty Ltd for Narrabri Coal Pty Ltd
WRM (2009)	*'Narrabri Coal Mine Stage 2 Longwall Project Surface Water Assessment' Prepared by: WRM Water & Environment Pty Ltd November 2009 (Environmental Assessment (R.W. Corkery & Co. 2009) Specialist Consultant Studies Compendium Volume 1, Part 3)*
WRM (2015)	*Modification 5 Surface Water Assessment,* Prepared by WRM Water & Environment Pty LTd or Narrabri Coal Pty Ltd.

Note:

Reference has been made throughout this report to the Office of Environment and Heritage (OEH) which is the new name for the Department of Environment and Climate Change (DECC). All reference material and guidance is still applicable to the new department.

10 LIMITATIONS

AECOM Services Pty Limited (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Narrabri Coal Operations Pty LTd and only those third parties who have been authorised in writing by AECOM to rely on this Report.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.