Illawarra Coal

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Appin Area 7
Longwall 705
End of Panel Report

July 2014

Executive Summary

This End of Panel (EoP) report has been prepared in accordance with Condition 18 of the Appin Area 7 Longwalls 705 and 706 Subsidence Management Plan (SMP) Approval, granted on the 28th February 2012. This EoP report outlines the measured and observed impacts during the extraction of Longwall 705 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP.

Longwall 705 is located within Consolidated Coal Lease No. 767 (CCL767) and was extracted using conventional longwall techniques and equipment during the period from 7th September 2012 to 27th March 2014.

Economic Effects

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. Longwall 705 generated $26.09 Million in royalty payments to the NSW Government. BHP Billiton Illawarra Coal was granted consent for the Bulli Seam Operations Project in 2011, which outlines the Company's plans for its Appin and West Cliff Mines for the next 30 years. The Company provides local jobs for approximately 2000 direct employees and contractors throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 small to medium local businesses provide their goods and services to the company. The company is a major contributor to the economy of the local region and New South Wales. When flow-on effects are taken into account, Illawarra Coal contributes 4.7 per cent of household income and 5.3 per cent of industry value added to the Illawarra/Wollondilly region (IRIS, 2011). As of 10th July 2014 there were 521 full time employees and 42 contractors and fixed term employees engaged by Appin Colliery. These jobs are reliant on maintaining continuity of longwall coal extraction.

Subsidence

Subsidence movements resulting from the extraction of Longwall 705 were monitored at various lines and points within the SMP area. Monitoring was conducted to measure subsidence associated with the Nepean River, Moreton Park Road, Hume Highway (HW2), Main Southern Railway (ARTC) and Sydney Catchment Authority infrastructure.

The maximum observed incremental and total upsidence and closure movements at the Nepean River Cross Lines K, L, M, N, O and P after the completion of Longwall 705 were generally equal or less than the maxima predicted.

The maximum observed incremental and total subsidence after the completion of Longwall 705 along the Moreton Park Road Line and Telstra infrastructure were similar to or less than those predicted.

The total observed subsidence measured on the HW2 East and West Lines represented 103% and 91 %, respectively, of the maximum predicted subsidence. Similarly, the maximum observed incremental tilts along the HW2 East and HW2 West Lines of 7.4mm/m and 6.0mm/m, respectively, were greater than the maximum predicted systematic tilts of 4.7mm/m and 5.7mm/m, respectively.

The maximum observed incremental subsidence along the ARTC Line of 764mm was less than the maxima predicted of 950mm. The maximum observed subsidence represented around 80 % of the

maximum predicted subsidence. The maximum observed incremental tilt of 2.9mm/m was slightly more than the maximum predicted systematic tilt of 2.4mm/m.

A summary of the maximum observed incremental net subsidence, net uplift and closure at the Ousedale Creek, Mallaty Creek, Leafs Gully and Nepean Creek Aqueducts and Bridges, during the extraction of Longwall 705 showed that the maximum observed incremental net subsidence was similar to or less than survey tolerance.

Impacts on Man-made Features

The observed impacts on the surface infrastructure, after the extraction of Longwall 705, are similar to or less than the predicted impacts.

There were no reported impacts to the Upper Canal, Devines Tunnels and associated infrastructure, Douglas Park Twin Bridges, low voltage powerlines, copper telecommunications cables, optical fibre cable, groundwater bores, water tanks, farm dams, pools or fences.

Impacts to man-made features due to Longwall 705 were observed along the Hume Highway and included humps forming on both carriageways, these were remediated by re-shaping of the pavement surface and installation of additional slots as part of Management Plan responses. Along the Main Southern Railway changes in track geometry were recorded and remediated in accordance with the established Management Plan, there were no adverse impacts to safety and serviceability. Along Moreton Park Road, minor localised heaving was observed, reported and remediated by the asset owner.

Building structures remained in safe and serviceable condition during mining. To date, no new claims to the MSB for impacts to building structures due to the mining of Longwall 705 have been made. One claim to the MSB for subsidence impact to pavement was made and one claim for impact to an irrigation pipe due to the extraction of Longwall 705 was made.

Impacts on Natural Features

Impacts observed on natural features from Longwall 705 were within the predictions outlined in the SMP.

Impacts to the Nepean River included three gas releases. These impacts were within prediction and categorised as a Level 1 impact in the SMP.

No significant water quality, water levels or flow impacts have been observed or measured within the Nepean River as a result of mining Longwall 705. No significant impacts on the water quality of first and second order streams were identified (Ecoengineers, 2014). No significant water level or water quality effects for groundwater were identified (Geoterra, 2014).

The results from the latest survey indicate that there have been no significant changes to the aquatic and riparian habitat in the Nepean River since monitoring commenced (CEL, 2014). The gas releases identified in the Nepean River associated with the extraction of Longwall 705 do not appear to have had any effect on macroinvertebrates, fish or macrophytes in the Nepean River. This is not surprising given that no impacts to water quality, flow and levels, or impacts to physical features have been observed in the Nepean River during extraction of Longwall 705 (MSEC 2014, Ecoengineers 2014).

With regards to terrestrial ecology, inspections of the Nepean River area on a weekly basis show that there has been no change to habitat features within either the Nepean River gorge or its tributaries

and no impacts to cliffs or steep slopes as a result of the extraction of Longwall 705. It is therefore concluded that there has been negligible impact on threatened fauna or their habitats in these areas.

One Aboriginal shelter with deposit (52-2-2095), two open camp sites (52-2-3842 and 52-2-3845) and one scarred tree (52-2-2096) are located within close proximity to Longwall 705. Inability to access these sites precluded an assessment of any possible impacts. However, given the lack of major movement and the predictions of low impact to Aboriginal sites within this area, subsidence was considered to have a negligible impact on cultural heritage values.

Trigger Action Response Plans (TARPs)

Impacts associated with roads and highways were minor, and have been reported, rehabilitated and monitored in accordance with agreed actions of the Management Plan and TARP.

In response to impacts associated with the Nepean River, no remediation of impacts for Longwall 705 is proposed.

Conclusion

All impacts to man-made and natural features observed during monitoring associated with the extraction of Longwall 705 have been within prediction. Monitoring of man-made and natural features will continue as part of post-mining monitoring and during mining monitoring (for Longwall 706) in accordance with the SMP and relevant Management Plans.

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Attachment B: End of Panel Subsidence Monitoring Report for Appin Colliery Longwall 705, Revision B (MSEC686). MSEC, June 2014.

Attachment C: Longwall 705 End of Panel Landscape Monitoring Report. Illawarra Coal Environmental Field Team, May 2014.

Attachment C2: Longwall 705 Impact Reports. Illawarra Coal Environmental Field Team (ICEFT).

Attachment D: End of Panel Assessment of Water Flow and Quality Effects, Appin Colliery Longwall 705. Ecoengineers, Revision 1. June 2014.

Attachment E: Appin Longwalls 701-704 and 705-710 Aquatic Ecology Monitoring, 2003 – 2013. Cardno Ecology Lab, July 2014.

Attachment F: Terrestrial Ecology Assessment for Longwall 705 – Appin Colliery Area 7 End of Panel Report. Niche Environment and Heritage, June 2014.

Attachment G: Aboriginal and European Heritage Assessment for Appin Colliery – Longwall 705 End of Panel Report. Niche Environment and Heritage, June 2014

Attachment H: Appin Area 7 End of Longwall 705 Groundwater Monitoring Report. Geoterra, July 2014.

1. Introduction

1.1. Background

Appin Area 7 Longwall 705 is located within Consolidated Coal Lease No.767 (CCL767). The extraction of Longwall 705 commenced on the 7th September 2012 and was completed on the 27th March 2014, using conventional longwall techniques and equipment.

This End of Panel (EoP) Report has been prepared, in accordance with Condition 18 of the Appin Area 7 Longwalls 705 and 706 Subsidence Management Plan (SMP) Approval, granted on the 28th February 2012. The EoP Report outlines the measured and observed impacts of Longwall 705 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports for Longwall 705.

Information in this report is based on monitoring and reports undertaken by BHP Billiton Illawarra Coal (BHPBIC) and specialist consultants that have been involved with the monitoring and analysis of data relating to the Longwall 705 to 706 SMP Area.

1.2. Approval and Legislative Requirements

The Appin Area 7 SMP for Longwalls 705 to 706 was approved by the Director General of the Department of Trade and Investment, Regional Infrastructure and Services, NSW on the 28th February 2012. The SMP approval is provided as **Attachment A**.

In September 2009, BHPBIC submitted an Environmental Assessment (EA) for its Bulli Seam Operations Project (BSOP) to the NSW Department of Planning and Infrastructure, now the Department of Planning and Environment (DoPE) for the continuation of underground mining operations for both Appin and West Cliff Mines. The BSOP was approved 22nd December 2011 by the NSW Planning Assessment Commission (PAC) under delegation of the NSW Minister for Planning under Part 3A of the NSW Environmental Planning and Assessment Act (EP&A Act). The Environmental Performance measures for the BSOP approval relating to Appin Area 7 are shown below in Table 1-1.

Table 1-1: Bulli Seam Operations Project Approval – Environmental Performance Measures

BSOP Approval Condition		Relevant Section in EoP Report
Condition 1, Schedule 3 The Proponent shall ensure that the project does not cause any exceedance of the performance measures in Table 1, to the satisfaction of the Director-General		
Nepean River	Negligible environmental consequences including: · negligible diversion of flows or changes in the natural drainage behaviour of pools; · negligible gas releases and iron staining; and · negligible increase in water cloudiness	*Section 6.1 and 6.2*
Other watercourses	No greater subsidence impact or environmental consequences than predicted in the EA and PPR	*Section 6.1 and 6.2*

Condition 18 of the SMP Approval is provided in Table 1-2.

Table 1-2: Longwalls 705 to 706 SMP Approval Condition for End of Panel Reporting

SMP Approval Condition	Relevant Section in EoP Report
Condition 18 Within 4 months of the completion of each longwall panel, an end of panel report must be prepared to the satisfaction of the Director Environmental Sustainability. The end of panel report must: a) include a summary of the subsidence and environmental monitoring results for the applicable longwall panel; b) include an analysis of these monitoring results against the relevant; - impact assessment criteria; - monitoring results from previous panels; - predictions in the SMP; and - performance measures specified in Table 1 and Table 2; c) identify any trends in the monitoring results over the life of the activity; and d) describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining	*Sections 4 to 6, Attachments B to G* *Section 8*

1.3. Reports and Management Plans

The impact predictions associated with Longwall 705 are described in the following reports:

- Cardno Forbes Rigby Pty Ltd, June 2008. *Appin Colliery Area 7 Longwalls 705 to 710 Subsidence Management Plan Application.*
  This plan includes specialist reports on subsidence, water quality, aquatic ecology, flora and fauna and cultural heritage predictions as follows:
    - Biosis Research (2008). Appin Colliery Area 7 – Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna.
    - Biosis Research (2008) Archaeological and Cultural Heritage Assessment of Proposed Longwalls 705-710, West Appin, NSW.
    - Ecoengineers (2008) Assessment of Water Flow and Quality Effects Appin Colliery Longwalls 705-710.
    - Geoterra (2008) Appin Area 7 Longwalls 705-710 Groundwater Assessment Douglas Park NSW.
    - MSEC (2007) The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Longwalls 705 to 710 in Area 7 at Appin Colliery, in support of the SMP application, MSEC326.

1.4. Report Outline

Observed impacts have been described by the Illawarra Coal Environmental Field team (ICEFT) and specialist consultants during and following the mining of Longwall 705.

Economic effects associated with the longwall extraction are discussed in Section 2. An Overview of the consultation involved with Appin mining operations is provided in Section 3. Subsidence movement predictions and measurements are in Section 4. Predicted and observed impacts of Longwall 705 on man-made features and natural features are provided in Sections 5 and 6 respectively. The Longwall 705 monitoring program and proposed future monitoring in the SMP Area, and summary of the Trigger Action Response Plans (TARPs) including any remediation measures, are outlined in Sections 7 and 8.

2. Economic Effects

The extraction of underground coal reserves from Area 7 provides benefits at international, national, state and local levels. BHPBIC provides 70% of BlueScope Steel's coking coal requirements. Mining operations at Appin Colliery represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue. During the mining of Longwall 705, Illawarra Coal paid approximately $26.09 Million in Royalties to the government and had a Clean Coal production of 3,107,619 Tonnes. BHPBIC was granted consent of the Bulli Seam Operations Project in 2011, which outlines the Company's plans for its Appin and West Cliff Mines for the next 30 years. The Company provides local jobs for approximately 2000 direct employees and contractors throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 small to medium local businesses provide their goods and services to the company. The company is a major contributor to the economy of the local region, contributing 4.7 per cent of household income and 5.3 per cent of industry value added. In terms of Appin Colliery, as of 11th July 2014 there were 521 full time employees and 42 contractor and fixed term employees at the site. These jobs are reliant on maintaining continuity of longwall coal extraction.

3. Stakeholder Consultation

Impact monitoring and provision of ongoing information to the community has been undertaken by BHPBIC during the extraction of Appin Area 7 longwalls.

Information on BHPBIC operations is provided to the community through the following mechanisms:

- Community information sheets and letter box drops;
- Media releases and other media activities;
-
- General community surveys and reports;
- Coal News – an Illawarra Coal publication for employees;
- Coalition News – a quarterly Illawarra Coal publication distributed to the community;
- Internet site www.bhpbilliton.com/regulatoryinformation
- Illawarra Coal Community Consultative Committee Meetings for BSOP (meeting minutes provided on the BHPB website and emailed direct to interested stakeholders);
- Landholder relations program; and
- Information days.

BHPBIC aims to mitigate the potential impacts subsidence may cause on individuals through various means outlined in Table 3-1.

Table 3-1: Social Impact Variables Associated with Subsidence

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	- Level of community concern relating to subsidence - Awareness of subsidence and its effects and management - Level of perceived community risk associated with subsidence effects - Level of satisfaction with the company's subsidence management practices - The extent to which the community	- - Notice boards where progress of the longwalls is displayed - The Illawarra Coal Community Consultative Committee meetings for BSOP (one meeting included a presentation on the technical parameters and explanations of how and why subsidence occurs, and its potential impacts)

	attributes environmental, social and economic change occurring within the community to mining activities	- A biennial random telephone survey of residents in the communities in which Illawarra Coal operates. The survey aims to determine the community's perception of the company's overall performance - Development of Built Feature Management Plans (BFMPs) in consultation with landowners - Meetings and on-going consultation with landowners during mining and in accordance with individual BFMPs

The management of subsidence impacts on private properties is addressed in Built Feature Management Plans (BFMPs). The BFMPs have been prepared in consultation with each property owner. For any impacts to properties in relation to Longwall 705, landholders have been encouraged to make claims with the Mine Subsidence Board (MSB). BHPBIC is available to assist landholders throughout the process of making a claim and is continuing to assist in the management of the social impacts of the mining operations associated with Appin Area 7.

4. Predicted and Observed Subsidence

Subsidence movements resulting from the extraction of Appin Longwall 705 were monitored along various lines and points within the SMP Area. A comparison of the observed and predicted movements resulting from the extraction of Longwall 705 has been prepared by MSEC (MSEC686, 2014) and is included as **Attachment B**. The results from MSEC686 are summarised below.

Monitoring points and lines associated with Longwall 705 include:

- The Nepean River Cross Lines,
- Moreton Park Road Line,
- HW2 East and West Lines,
- FBG monitoring along the HW2 Hume Highway,
- Slot closure monitoring along the HW2 Hume Highway,
- ARTC monitoring line, strain gauges and tilt sensors,
- ARTC Embankment Points,
- Highway and Railway Cutting Points,
- Absolute far-field 3D monitoring points adjacent to the Nepean Twin Bridges and Moreton Park Road Bridge (South),
- Relative 3D monitoring points on the Nepean Twin Bridges and Moreton Park Road Bridge (South),
- Inclinometer monitoring near the Douglas Park Twin Bridges,
- Bridge joint monitoring on the Douglas Park Twin Bridges,
- Visual monitoring of the HW2 Hume Highway, Moreton Park Road, the Nepean Twin Bridges and Moreton Park Road Bridge (South), and
- Monitoring lines at Sydney Catchment Authority infrastructure.

The locations of these monitoring lines and points are shown in Figure 4-3 (Drawing No. MSEC686-01).

4.1. The Nepean River Cross Lines

Differential movements across the Nepean River valley were measured by BHPBIC along 7 monitoring lines, NEPX K-Line through to the NEPX Q-Line, during Longwall 705 (refer to Figure 4-3).

The maximum observed incremental and total upsidence and closure movements at the Nepean River Cross Lines K, L, M, N, O and P after the completion of Longwall 705 were generally less than the maxima predicted. Q Line observed closure equalling the predicted closure of 10mm.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.2. Moreton Park Road Lines

The mine subsidence movements along Moreton Park Road were measured by BHPBIC using a 3D monitoring line. The location of the Moreton Park Road Line is shown in Figure 4-3.

The maximum observed incremental subsidence along the road, due to the extraction of Longwall 705, of 845mm was less than the maximum predicted of 1015mm. The maximum observed incremental tilt of 7.2mm/m was greater than the maximum predicted systematic tilt of 4.0mm/m, however, this occurred in the location of valley closure related non-conventional movement.

The maximum predicted conventional total tensile and compressive strains along the monitoring line, based on applying a factor of 15 to the maximum predicted curvatures, were 1.1mm/m and 1.8mm/m, respectively. The maximum observed incremental and total tensile strain of 1.0mm/m was, therefore, similar to the maximum predicted based on conventional movements. The maximum observed incremental and total compressive strains of 3.5mm/m and 4.8mm/m, respectively, were, however, greater than the maxima predicted based on conventional movements only. The compressive strain above Longwall 705 was localised between Marks MPR119 and MPR120 and appears to be the result of valley closure related non-conventional movement. Minor localised heaving on Moreton Park Road was observed, reported and remediated by the asset owner.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as Attachment B.

4.3. HW2 Hume Highway

The HW2 Hume Highway crosses directly above Longwall 705 as shown in Figure 4-3. The monitoring associated with the highway, during the extraction of Longwall 705, included the following:

- HW2 East and West Lines,
- Highway Cutting Points, and
- FBG and slot closure monitoring.

The monitoring results and discussions were provided in the weekly subsidence monitoring review reports for the highway (MSEC578-01 to MSEC578-39), which were issued during the extraction of Longwall 705 between the 6th February 2013 and the 26th November 2013.

A summary of the monitoring results for the HW2 Hume Highway are provided in the following sections. For further details of specific measured movements refer to the report by MSEC (MSEC686), included as **Attachment B**.

4.3.1. HW2 East and HW2 West Lines

The mine subsidence movements along the HW2 Hume Highway were measured by BHPBIC using two 3D monitoring lines, being the HW2 East and HW2 West Lines. The locations of these monitoring lines are shown in Figure 4-3.

The maximum observed incremental subsidence along the HW2 East and HW2 West Lines of 1030mm and 941mm, respectively, were slightly greater than and slightly less than the predicted maximum subsidence of 1000mm. The maximum observed subsidence along the HW2 East and HW2 West Lines, therefore, represented 103% and 91 %, respectively, of the maximum predicted subsidence. Similarly, the maximum observed incremental tilts along the HW2 East and HW2 West Lines of 7.4mm/m and 6.0mm/m, respectively, were greater than the maximum predicted of 4.7mm/m and 5.7mm/m, respectively.

The maximum observed incremental tensile strains along the HW2 East Line and HW2 West Line were 1.3mm/m and 1.4mm/m, respectively. The maximum predicted incremental and total conventional tensile strain along the monitoring lines, based on applying a factor of 15 to the maximum predicted curvatures, was 0.5mm/m. Whilst the maximum observed tensile strain along the HW2 East Line exceeded the predicted maxima, based on conventional movements, the observed tensile strains were similar to those typically observed elsewhere in the Southern Coalfield.

The maximum observed incremental compressive strains along the HW2 East Line and HW2 West Line were 2.8mm/m and 2.5mm/m, respectively. The maximum predicted total conventional compressive strain along the monitoring lines, based on applying a factor of 15 to the maximum predicted curvatures, was 1.0mm/m.

The observed peak compressive strains were localised between Marks E121R to E122R along the East Line and between Marks W113 to W117 along the West Line with an associated bump in the observed subsidence profile, which indicates that non-conventional movement has developed at this location. The magnitudes of the compressive strains between Marks E121R to E122R and between Marks W113 to W116 were similar to those for the non-conventional movements which developed during the previous extraction of Longwalls 703 and 704. Also, the rates of development of these compressive strains were similar to the maximum rates of development for the non-conventional movements during the previous extraction of Longwalls 703 and 704.

4.3.2.FBG Monitoring

A total of 480 temperature and 480 strain FBG sensors were installed in the top 50mm of asphalt along each carriageway within the outside shoulder. The sensors are spaced every 10 m and the temperature and strain were measured every 15 minutes during the mining of Longwall 705.

The temperature compensated FBG strains exceeded the trigger levels in the management plan twice during the mining of Longwall 705. A blue alarm was received on the 29th May 2013 for an exceedance of the average strain at a single FBG 126.2 on the Northbound Carriageway. Upon inspection at the trigger point, a hump, which had been previously detected the week before, was found to have grown. A smaller hump was observed on the Southbound Carriageway opposite the site. Observed pavement strains were found to correspond with observed increased compressive ground strains on both the East and West monitoring lines in this area.

A number of additional management measures were undertaken in response to this event between May and August 2013. The measures were undertaken during and after the period of most active changes in differential ground movements and FBG strains, which was between May and late June 2013.

The additional management measures included re-profiling of the pavement and the installation of additional slots. The highway remained safe and serviceable during the event period, though temporary speed restrictions were imposed for short durations during this time. A small number of additional blue alarms were received during this period.

4.3.3. Slot Displacement Monitoring

Displacement sensors were installed in each pavement slot and were measured every 5 minutes during the mining of Longwall 705. The slot displacements did not exceed the management plan trigger levels for closure at any stage during the mining of Longwall 705. The maximum observed closure of the slots located directly above Longwall 705 was 38mm at SB103 and 58mm at NB126.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.4. The Main Southern Railway

The Main Southern Railway crosses directly above Longwall 705 as shown in Drawings Nos. MSEC686-01 and MSEC686-03, in **Attachment B**. The monitoring associated with the railway, during the extraction of Longwall 705, included the following:

- *ARTC Line*

The maximum observed incremental subsidence along the ARTC Line of 764mm was less than the maxima predicted of 950mm. The maximum observed subsidence represented around 80 % of the maximum predicted subsidence. The maximum observed incremental tilt of 2.9mm/m was slightly more than the maximum predicted of 2.4mm/m.

The maximum observed incremental tensile and compressive strains along the ARTC Line were 0.7mm/m and 2.0mm/m, respectively. The maximum predicted incremental conventional tensile and compressive strains along this monitoring line, based on applying a factor of 15 to the maximum predicted curvatures, were both 0.6mm/m.

The observed peak compressive strains were localised between Marks ARTC1085 to ARTC1086 with an associated bump in the observed subsidence profile, which indicates that non-conventional movement has developed at this location. The compressive strain between Marks ARTC1085 to ARTC1086 was similar to those for the non-conventional movements which developed during the extraction of Longwalls 703 and 704.

- *Railway Cutting Points*

These will be discussed in **Section 4.5**.

- *Automated Track Monitoring*

Automated track monitoring was conducted using a combination of Tilt Sensors, Rail Stress Transducers and Expansion Switch Displacement Sensors. Measurements from these sensors did not exceed any trigger levels during or following the mining of Longwall 705.

- *Embankment Monitoring*

The maximum observed incremental subsidence along the embankment of 751mm was less than the maxima predicted of 950mm. The maximum observed subsidence represented around 80 % of the maximum predicted subsidence. The maximum observed incremental tilt of 3.4mm/m was more than the maximum predicted of 2.4mm/m.

- *Culverts*

The mine subsidence movements along a particular railway culvert were measured by IC using a 3D ground monitoring line, referred to as the ARTC 70.5km Culvert. The locations of the monitoring points are shown in Drawing No. MSEC686-01 (Figure 4-3) and the measured changes in horizontal distance along the culvert invert are shown in Figure 4-1.

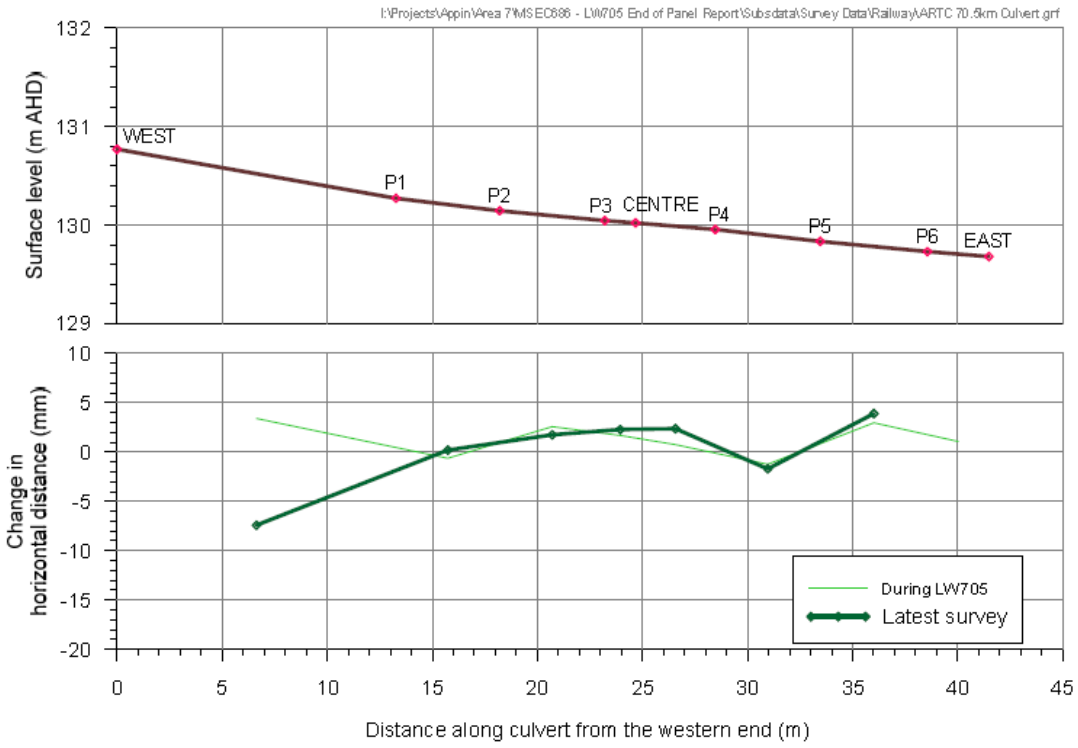

Figure 4-1: Changes in Horizontal Distance along the ARTC 70.5km Culvert Invert during the Extraction of Longwall 705

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.5. Highway and Railway Cutting Points

The observed incremental horizontal movements at the highway and railway cutting points were within the range of those observed along the highway and railway monitoring lines, and less than those typically observed elsewhere in the Southern Coalfield.

During the mining of Longwall 704, a fixed-in-place inclinometer detected very early small deflections at 8 m depth, where the borehole intersects a fault zone. Deflection of the B-Axis (parallel to the strike of the fault) at 8 m depth increased as mining progressed, with the rate of change accelerating when the longwall face had passed the inclinometer by approximately 150 m. The maximum deflection at the 8 m sensor B-Axis was 147mm on 4th June, when it reached the limit of its monitoring tolerance and ceased to record. A new fixed-in-place inclinometer was installed at this time and the readings showed continued deflection where the new borehole intersects the fault at 6 m depth during the mining of Longwall 705. Approximately 50% of the additional differential movements developed during the mining of Longwall 705.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.6. Far Field 3D Marks

The observed incremental horizontal movements at the far-field marks, due to the extraction of Longwall 705, were within the range of those previously observed in the Southern Coalfield as shown in Figure 4-2 below.

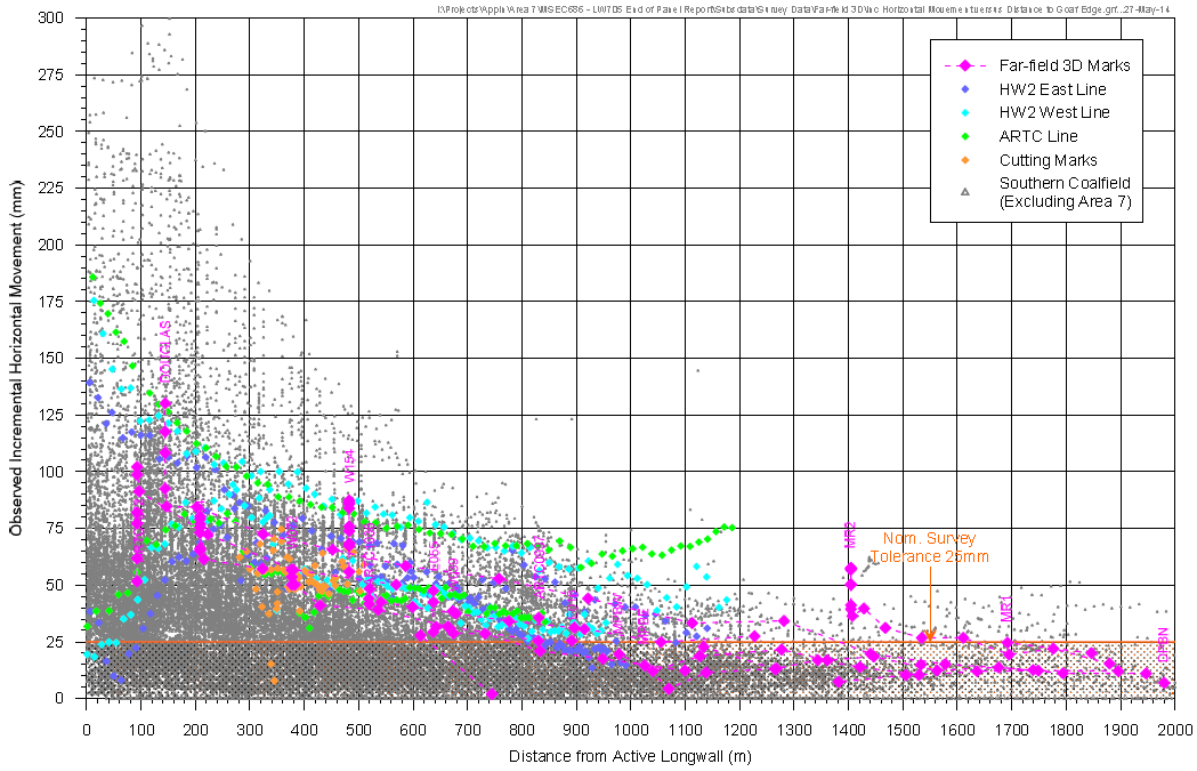

Figure 4-2: Observed Absolute Incremental Horizontal Movements versus Distance to Nearest Longwall Goaf Edge with Solid Coal between Mark and Extracted Longwall, with Longwall 705 results overlaid.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.7. Douglas Park Twin Bridges

The Douglas Park Twin Bridges are located approximately 1.9 kilometres south-west of the finishing (western) end of Longwall 705. The monitoring associated with the Nepean Twin Bridges, during the extraction of Longwall 705, included the following:

- *Absolute 3D bridge monitoring points*

The absolute 3D horizontal movements at the Douglas Park Twin Bridges were monitored by BHPBIC at Points DPBN and DPBS, which are located adjacent to the northern and southern ends, respectively, of the bridges. The observed incremental horizontal movements for these marks show that the bridge has moved towards the north-east as the result of the extraction of Longwall 705.

The TARP for the Douglas Park Twin Bridges, which was developed by the RMS chaired Technical Committee, provided triggers for absolute and relative horizontal movements of the far-field 3D Points DPBN and DPBS adjacent to the bridges. The results of the monitoring program show that the maximum observed absolute and relative horizontal movements at the far-field 3D monitoring Points DPBN and DPBS did not exceed the Level 1 Triggers.

- *Relative 3D bridge monitoring points*

The mine subsidence movements at the Douglas Park Twin Bridges were measured by BHPBIC using relative 3D marks fixed directly to the bridge structure.

The survey result on 6th May found very little differential lateral movement of the bridge, other than changes in the length of the bridge deck due to temperature effects. A small extension was detected along the length of the bridge, though high accuracy horizontal distance check surveys found very little difference in horizontal distances since 2007 (less than 2mm).

Whilst a small 7mm relative lateral shift was measured at the base of the central piers 2 and 3, it is noted that the survey of the piers is not linked directly to the deck and no lateral shift is evident in the bases of the piers and abutments on either side of the bridges. The survey result also does not correlate with inclinometer readings. The small measured movement is considered to be a result of very difficult surveying conditions at the base of the bridges. Future surveys will be examined to confirm the accuracy of the results.

- *Inclinometer monitoring*

The differential movements at two inclinometers near the Douglas Park Twin Bridges were monitored during the extraction of Longwall 705, being PSM2 and PSM6. The maximum observed differential movement at PSM2 was 3.1mm and PSM6 was 1.4mm. No triggers were exceeded during the extraction of Longwall 705.

- *Bridge joint monitoring*

The differential movements across the movement joints in the Douglas Park Twin Bridges were measured by PSM during the extraction of Longwall 705. The bridge movement joints are referred to as Joint 1 (adjacent to Pier 1), Joint 2 (adjacent to Pier 2) and Joint 3 (main expansion joint adjacent to Pier 3). The maximum observed differential movement across the bridge joints we all well below the Level 1 Triggers.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B.**

4.8. Moreton Park Road Bridge (South)

Moreton Park Road Bridge (South) is located approximately 980 metres south of the finishing (western) end of Longwall 705. The monitoring associated with Moreton Park Road Bridge (South), during the extraction of Longwall 705, included the following:

- *Absolute 3D bridge monitoring points*

The absolute 3D horizontal movements at the Moreton Park Road Bridge (South) were monitored by BHPBIC at Points MPBE and MPBW, which are located adjacent to the eastern and western ends, respectively, of the bridge. The maximum observed absolute incremental horizontal movements at Points MPBE and MPBW, at any time during or after the extraction of Longwall 705, were 17mm and 22mm, respectively. No triggers were reached during or after the extraction of Longwall 705.

- *Relative 3D bridge monitoring points*

The mine subsidence movements of the Moreton Park Road Bridge (South) were measured by BHPBIC using relative 3D marks fixed directly to the bridge structure.

The observed total changes in the horizontal distance between the abutments, during the extraction of Longwalls 701 to 705, show that there has been a small amount of abutment spreading, in the order of 5mm, which primarily developed during the extraction of the previous Longwalls 703 and 704. The results vary slightly between surveys and the cause is thought to be related to changes in moisture and/or temperature.

Relative 3D surveys have also detected a horizontal rotation of the deck. The deck movements are not considered to be due to subsidence as the deck is moving independently of the abutment and bases of the column supports.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.9. SCA Infrastructure

The Sydney Catchment Authority (SCA) infrastructure in the vicinity of Longwall 705 includes the Upper Canal, Devines Tunnels, wrought iron aqueducts, bridges and concrete aqueducts. The movements at the Ousedale Creek, Mallaty Creek, Leafs Gully and Nepean Creek Aqueducts and Bridges were monitored by BHPBIC using local 3D surveys.

A summary of the maximum observed incremental net subsidence, net uplift and closure at the Ousedale Creek, Mallaty Creek, Leafs Gully and Nepean Creek Aqueducts and Bridges, during the extraction of Longwall 705 showed that the maximum observed incremental net subsidence was similar to or less than the survey tolerance.

The movements at Concrete Aqueducts C and D were monitored by BHPBIC using local 3D surveys. The maximum observed incremental net vertical and horizontal movements at the Concrete Aqueducts C and D, during the extraction of Longwall 705, were all less than 3mm, which are similar to the order of survey tolerance.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

4.10. Telstra Infrastructure

The mine subsidence movements along the Telstra optical fibre line were measured by BHPBIC using a 3D ground monitoring line, referred to as the Telstra Line. Maximum incremental subsidence was measured at 222mm compared to a predicted 275mm and the maximum incremental tilt was 1.6mm/m compared to predicted 2.2mm/m.

The observed profiles of incremental subsidence, tilt and strain along the Telstra Line, resulting from the extraction of Longwall 705, show that the observed profiles of subsidence and tilt were reasonably similar to the profiles predicted.

For further details of the observed and predicted movements, including specific measurements, refer to MSEC686, provided as **Attachment B**.

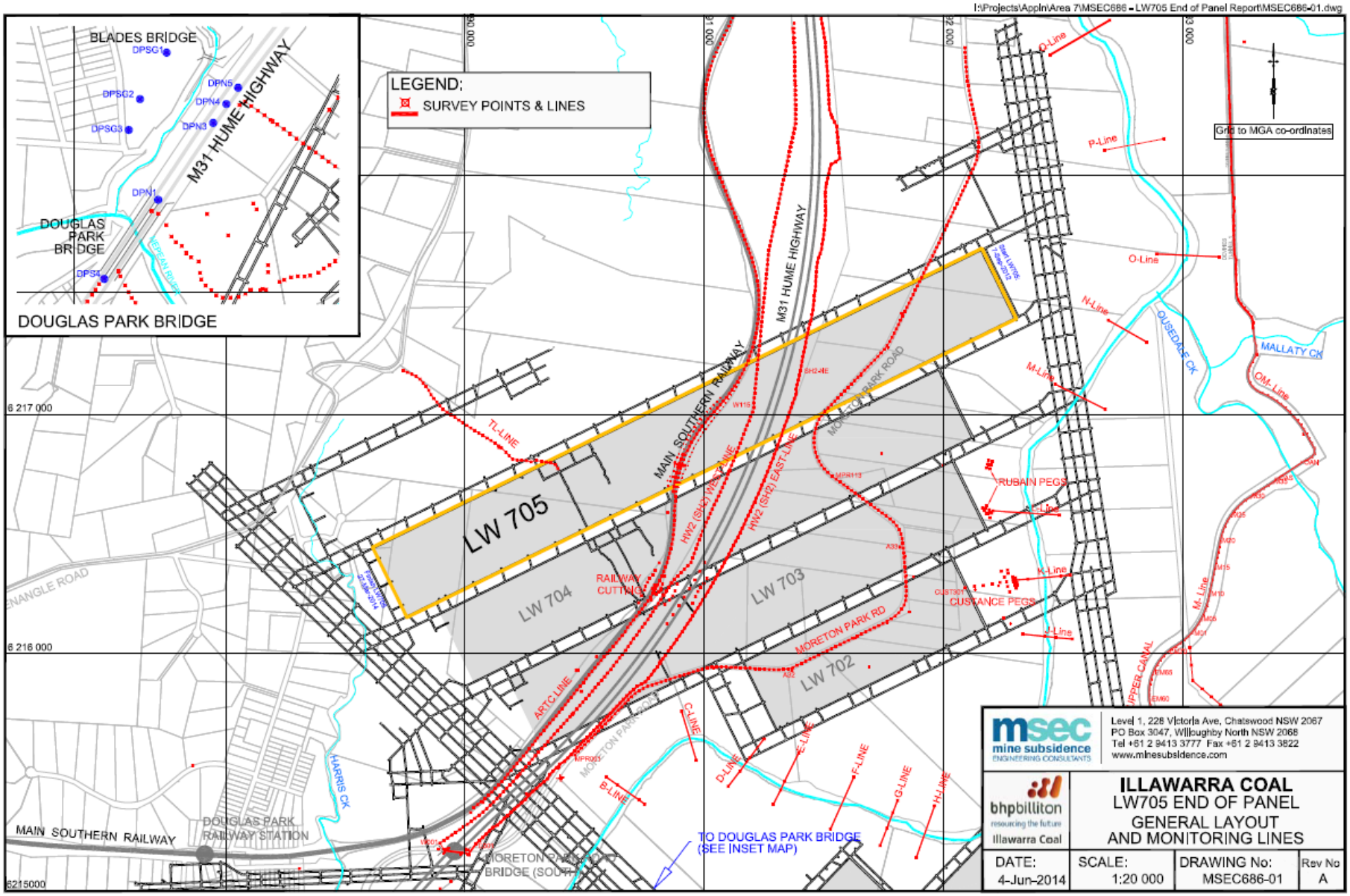

Figure 4-3: Longwall 705 Subsidence Monitoring Lines (MSEC686-01)

5. Impacts to Man-Made Features

The built features in the vicinity of Longwall 705 are shown in Drawing Number MSEC686-03, in **Attachment B**. The features which are located within the predicted 20mm incremental subsidence contour, due to the extraction of Longwall 705, or which may be sensitive to far-field or valley related movements include:

- Moreton Park Road and drainage culverts,
- HW2 Hume Highway and associated infrastructure,
- Main Southern Railway and associated infrastructure,
- The Douglas Park Twin Bridges,
- Moreton Park Road Bridge (South),
- Low voltage powerlines,
- Copper telecommunications cables,
- Optical fibre cables – Telstra (2), Optus, NextGen and Powertel,
- Building structures, pools, tanks and farm dams,
- Heritage structures (including the Mountbatten Group),
- Groundwater bores (including GW101437 and GW104154),
- Pumps in the Nepean River,
- The Upper Canal, Cataract Tunnel and associated infrastructure, and
- Survey control marks.

The MSEC assessments for the built features, resulting from the extraction of Appin Longwalls 701 to 705, were provided in Report No. MSEC342. Comparisons between the assessed and observed impacts for the built features located within either the 35 degree angle of draw line from Longwall 705, or within the predicted incremental 20mm subsidence contour due to Longwall 705, are provided in Table 3.2. The built features in the vicinity of Longwall 705, which have been considered sensitive to far-field or valley related movements, have also been included in this table.

Table 5-1: Summary of the Assessed and Observed Impacts for Surface Infrastructure Resulting from the Extraction of Longwall 705

Built Feature	Predicted Impacts	Observed Impacts
Moreton Park Road	Minor cracking and localised heaving of the road surface may occur in some locations above the longwalls	Minor localised heaving observed, reported and remediated by the Asset owner
HW2 Hume Highway	No impacts on the safety or serviceability of the highway after the implementation of the management strategies	No adverse impacts to safety or serviceability. Humps formed on both carriageways and these were remediated by re-shaping of the pavement surface and installation of additional slots as part of Management Plan responses
Main Southern Railway	No impacts on the safety or serviceability of the railway after the implementation of the management strategies	Changes in track geometry recorded and remediated in accordance with the established Management Plan. No adverse impacts to safety and serviceability
Douglas Park Twin Bridges	Impacts unlikely after the implementation of the TARP	No adverse impacts observed
Moreton Park Road Bridge (South)	Impacts unlikely after the detailed investigation, analysis and implementation of the TARP	No adverse impacts observed
Low voltage powerlines	Impacts unlikely, but minor mitigation measures may be required	No reported impacts

Copper telecommunications cables	Impacts unlikely	No reported impacts
Optical fibre cables	Impacts unlikely with the implementation of the management strategies including OTDR monitoring and mitigation	No reported impacts
Building structures	Typically Category A Tilt Impacts, with 1 x Category B Tilt Impact Typically Category 0 Strain Impacts, with 6 x Category 1 Strain Impacts 4 x Category 2 Strain Impacts	*Houses and Non-Residential Structures* Building structures remained in safe and serviceable condition during mining. To date, no new claims to the MSB for impacts to building structures due to the mining of Longwall 705 *Other Features* One claim to the MSB for impact to pavement and one claim for impact to an irrigation pipe due to the mining of Longwall 705
Pools	In ground pools could be more susceptible to ground strains	No reported impacts
Water tanks	Impacts unlikely	No reported impacts
Farm dams	Potential for minor cracking or leakage	One property reported cracking and water loss from dam. MSB claim was made. Water provided by IC until dam was repaired
Heritage structures	Impacts unlikely	No reported impacts
Groundwater bores	Potential for blockage or reduction in the capacity of the groundwater bores	No blockage of bores reported. No triggers exceeded on groundwater yield or bore serviceability and no ameliorative actions are required
Pumps in the Nepean River	Impacts unlikely	No reported impacts
The Upper Canal, Cataract Tunnel and associated infrastructure	Impacts unlikely	No reported impacts

It can be seen from Table 5.1, that the observed impacts on the surface infrastructure, after the extraction of Longwall 705, were similar to or less than the predicted impacts.

6. Impacts to Natural Features

The natural features in the vicinity of Longwall 705 are shown in Drawing No. MSEC686-02, in **Attachment B**, which include:

- The Nepean River,
- Creeks,
- Cliffs and rock outcrops,
- Steep slopes, and
- Archaeological sites.

The MSEC assessments for the natural features, resulting from the extraction of Appin Longwalls 705 to 710 were provided in Report No. MSEC342. More detailed assessments for some natural features were also provided in other consultants reports.

Monitoring activities for natural features within the Longwall 705 SMP Area relate to the following categories:

- Water flow, pool water levels and water quality monitoring;
- Photographic and observational monitoring to identify mining-induced fractures, strata gas releases, iron staining and rock falls;
- Aquatic ecology monitoring;
- Terrestrial flora and fauna monitoring; and
- Aboriginal and European heritage items.

The information below has been provided by the ICEFT and relevant specialist consultants. The ICEFT undertook detailed monitoring of watercourses potentially impacted by Longwall 705, before, during and after mining. Water quality and flow data have been reviewed by Ecoengineers. Groundwater data has been reviewed by GeoTerra. Niche has undertaken a review of the terrestrial flora and fauna and of cultural heritage. Cardno Ecology Lab (CEL) was responsible for the aquatic ecology monitoring and assessment.

The results of these monitoring programs and assessments are discussed below. For details on the monitoring program refer to **Section 7**.

6.1. Landscape Features

The ICEFT undertook monitoring of landscape features in the vicinity of Longwall 705. Their findings are provided in Attachment C and C2 and summarised below. The key watercourse in the SMP Area is the Nepean River, as shown in Figure 6-1.

Monitoring sites along the Nepean River are shown in Figure 6-2. The monitoring includes water quality, water flow, water levels, photographic and observational records, impact monitoring (i.e. mining-induced fractures, strata gas and iron staining) and also cliff lines and steep slope assessments.

There are no significant tributaries of the Nepean River in the vicinity of Longwall 705. The water level within the River is predominantly regulated by the downstream weir at Menangle, which acts as a dam.

The monitoring program for Longwall 705 is undertaken in accordance with SMP requirements for Appin Longwalls 705 to 706. The monitoring program is outlined in Section 7, Table 7-2.

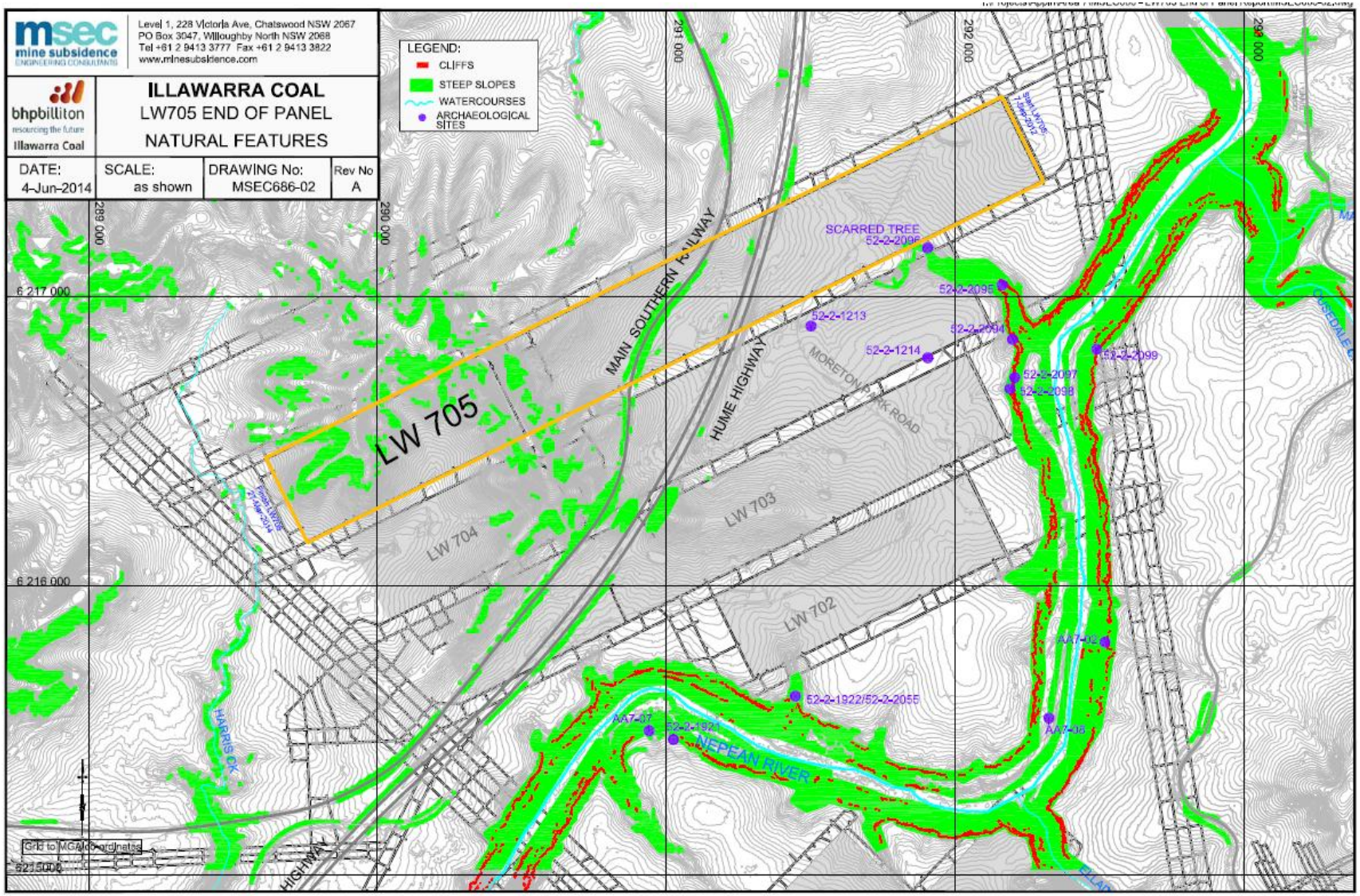

Figure 6-1: Natural Surface Features associated with Longwall 705 (MSEC686-02)

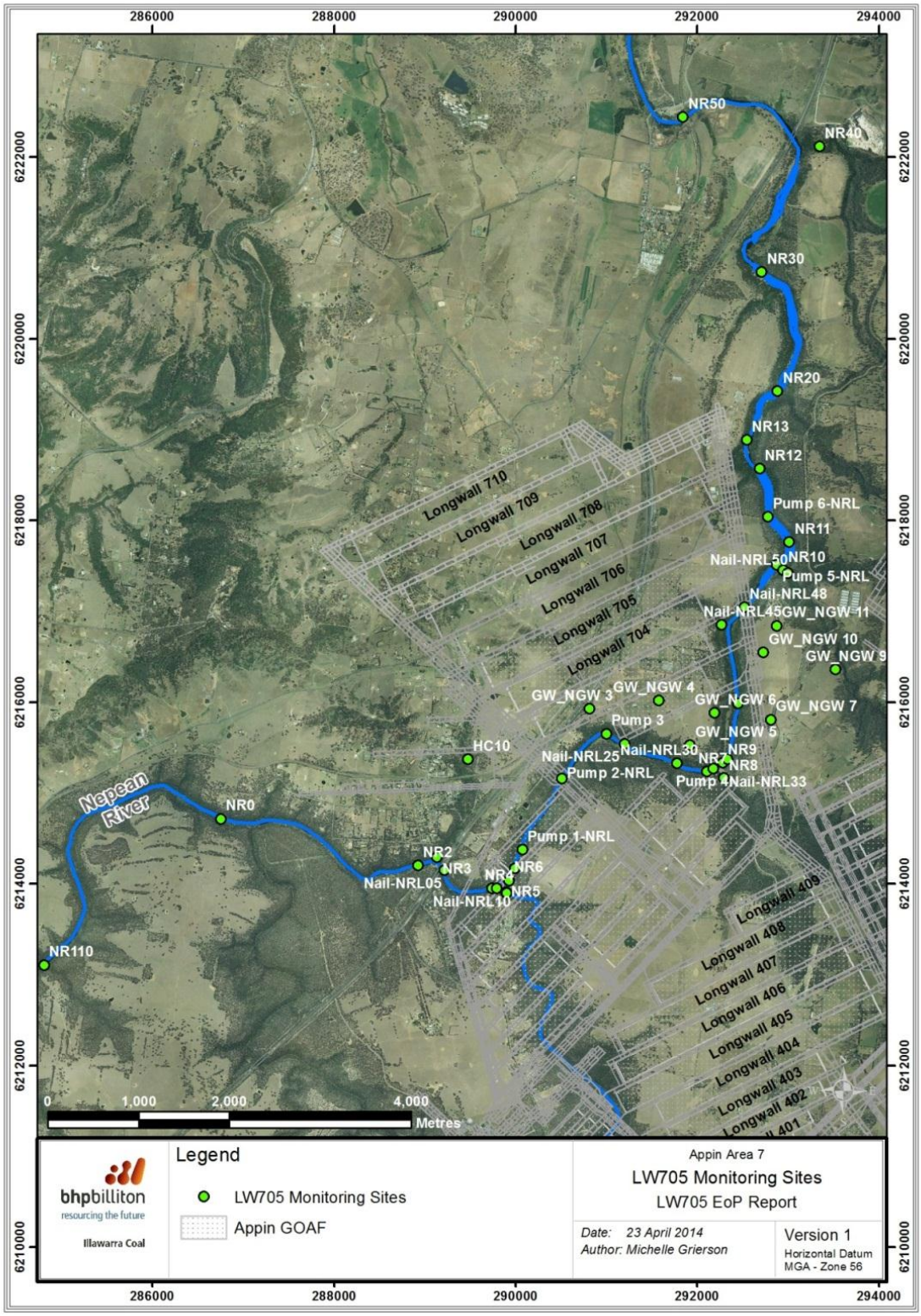

Figure 6-2: Monitoring Sites along the Nepean River (ICEFT sites)

6.1.1.Predicted and Observed Impacts on Landscape Features

All impacts observed in relation to Longwall 705 were within levels predicted in the SMP for Longwalls 705 to 706. A summary of the observed and predicted landscape impacts for Longwall 705 is provided in Table 6-1. Further descriptions of the impacts identified are provided in the section below.

Table 6-1: Predicted and Observed Landscape Impacts for Longwall 705

Aspect	Predicted Impact	Observed Impact
Water Quality	Any pH reduction from mining is likely to be less than 2 standard deviations from pre-mining mean Any DO reduction from mining is likely to be less than 2 standard deviation from pre-mining mean Any EC, total Fe and total Mn increases from mining are likely to be less than 2 standard deviation from pre-mining mean Strata gas plume are likely to have a flow rate < 3000 L/min(2)	*For pH, DO and EC please refer to Surface Water Section 6.2* *Identification of three gas zones, all are Level 1 Impacts according to the TARPs*
Water levels/flow	There may be areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for more than 2 consecutive months	*No impacts observed*
Appearance	There may be iron staining greater than baseline monitoring resulting from the mining There may be water cloudiness greater than baseline monitoring resulting from the mining	*No impacts observed*
Landscape Features (cliffs, steep slopes, fire trails & watercourses)	Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining are likely to represent less than 0.3% of the total cliff line face area of the mining domain Erosion resulting from mining likely to naturally stabilise within the monitoring period Surface movement or rock displacement resulting from mining with no more than minor soil surface exposed	*No impacts observed*
Other watercourses Upper Harris Creek (HC10) Foot Onslow Creek (FO1) Navigation Creek (NAV1)	Fracturing resulting in loss of surface flow in some creeks or tributary Fracturing resulting in water loss from some permanent pools Reduced water retention time in pools Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	*No impacts observed*

6.1.2.Observed Impacts to the Nepean River

As of the 5th May 2014, the ICEFT had identified three impacts along the Nepean River relating to the extraction of Longwall 705. All three impacts are gas release zones in the Nepean River and are summarised in Table 6-2. A detailed description of these impacts can be found in the relevant impact reports provided as an attachment to the Longwall 705 EoP Report.

All impacts observed have been within prediction and categorised as Level 1 on the SMP TARPs. Examples of these impacts are provided in the photographs below. For further detail on the impacts refer to **Attachments C** and **C2**.

Table 6-2: Summary of Impacts to Nepean River

Site ID	Easting	Northing	Impact	First Obs	Last Obs	Description	Feature Affected	TARP Level Triggered	Impact Report/s Dated
AA7LW705 Gas Zone 16	288878	6192060	Gas Zone	4/10/12	17/01/14	Multiple releases on western side of river with one main constant release. This gas zone is spread variably over approximately 280m^2	Nepean River	Level 1	5th October 2012
AA7LW705 Gas Zone 17	290815	6215562	Gas Zone	12/02/13	19/02/14	Up to 7 intermittent releases	Nepean River	Level 1	14th February 2013
AA7LW705 Gas Zone 18	290623	6215275	Gas Zone	18/03/13	16/04/14	Up to 20 intermittent releases	Nepean River	Level 1	18th March 2013 & 6th May 2013

Photo 1: AA7LW705 Gas Zone 16 looking downstream. Taken on 04/10/2012.

Photo 2: AA7LW705 Gas Zone 16 looking downstream. Taken on 23/10/2012.

Photo 3: AA7LW705 Gas Zone 16 looking down stream. Gas zone not active. Taken on 17/01/2014.

Photo 4: AA7LW705 Gas Zone 17 looking across stream. Taken on 18/03/2013.

Photo 5: AA7LW705 Gas Zone 17 looking across stream. Gas zone not active. Taken on 19/02/2014.

Photo 6: AA7LW705 Gas Zone 18 looking downstream. Taken on 18/03/13.

Photo 7: AA7LW705 Gas Zone 18 looking downstream across stream. Taken on 18/03/13.

6.2. Surface Water

Assessment of the water quality and flow of watercourses associated with Longwall 705 extraction was undertaken by Ecoengineers for BHPBIC. A summary of the assessment by Ecoengineers is provided below, and the full report is provided as **Attachment D**.

Water flows in the Nepean River are derived from a number of sources, which include flows from catchment areas, flows from licensed discharges, including Appin Colliery and Tahmoor Colliery (the latter located adjacent to Bargo River), and flows from stormwater runoff from agricultural and urban areas. Releases from Pheasants Nest Weir contribute the majority of flows into the River.

There are no significant tributaries of the Nepean River in the vicinity of Longwall 705. A small, first order tributary locally called Lyrebird Creek crosses the north-eastern end of the longwall. Another small tributary, Harris Creek, runs south to Nepean River to the immediate west of Longwall 705.

Ecoengineers assessment of surface water flow and quality is based upon past experience in the assessment of water quality effects induced by mining in the Illawarra Region generally, and specifically from hydrologic and water quality monitoring studies conducted in Nepean River.

6.2.1. Nepean River Water Quality Monitoring

The monitoring program for Longwall 705 was undertaken in accordance with the SMP requirements for Appin Longwalls 705 – 710 and the approved Appin Area 7 Water Management Plan.

River-related inspections, undertaken by the ICEFT, occurred between Douglas Park Weir (NR2) and Menangle Weir (NR50). The monitoring included: water level monitoring, photographic records, impact monitoring (i.e. strata gas and iron staining), and cliff stability and steep slopes assessments.

Data for pH, EC, DO, Total Fe and Total Mn at the baseline upriver (of Longwall 705) site NR2, and the downriver sites NR11, NR12, NR13, NR20 and NR30 were compared in order to identify any significant change in water quality that may have resulted from the mining of Longwall 705.

Assessment of data from 2002 to April 2014 for the parameters pH, EC, DO, Total Fe and Total Mn showed that no water quality TARP monitoring level was reached at the monitoring sites NR11, NR12, NR13, NR20 and NR30 as a result of mining of Longwall 705.

Emissions of strata gas into the Nepean River were observed during the extraction of Longwall 705. While it is possible that emission of strata gas into the Nepean River gave rise to some reduction in dissolved oxygen in the River due to microbiological consumption of dissolved methane by natural aerobic bacteria (‘obligate aerobes’) within the water column, the magnitude and riverine extent of any reduction in DO during the period of mining Longwall 705 was well within the bounds of DO measured during the pre-mining baseline period for similar flow rates in the river.

The assessment undertaken by Ecoengineers on the effects of Longwall 705 on water quality in the Nepean River has shown that no significant water quality impacts have been observed or measured.

6.2.2. Nepean River Flow Monitoring

Daily flow data records for Maldon, Menangle and Broughtons Pass weirs from 1990 have been assessed in order to improve the study of dry weather recessions in the Nepean River adjacent to Appin Area 7. All dry weather recessional flow periods in the Menangle minus Maldon minus

Broughtons Pass flow record were identified and plotted to identify log-linear recession curves and provide their R2 values.

This study showed that there is a very strong correlation, with a strong R2 of 0.88, between the starting flow rates of recessional periods and subsequent rate of recession. There are hydrodynamic reasons associated with the typical topography of the basal part of the Nepean River gorge why such a correlation might be expected.

This relationship was then used to check the recessions identified from the period of mining of Longwall 705. Analyses showed that rates of recession during the mining period of Longwall 705 were closely similar and only marginally lower (shallower) than the mean rate and range estimated by the study of 55 baseline dry weather recessions between 1990 and 2007, indicating that there has been no observable loss or diversion of water from the Nepean River as a result of the mining of Longwall 705.

6.2.3. Predicted and Observed Impacts to Nepean River and Harris Creek

The following table describes the predicted versus observed impacts for both the Nepean River and Harris Creek.

Table 6-3: Predicted Versus Observed Impacts

Feature	Predicted Impacts	Observed Impacts
Nepean River	Water level to remain essentially unchanged	No mining-induced water level change has been observed – natural fluctuations with rainfall and SCA dam water releases
	Potential for surface water flow diversion is very low	No surface water flow diversion has been observed
	Strata gas emissions into the river likely, with some associated reduction in dissolved oxygen possible	Three new gas zones were observed during the mining of Longwall 705, one of which is still active. No associated reduction in riverine dissolved oxygen has been observed
	Low likelihood of inducement of ferruginous springs. Significant impacts on Nepean River pH and iron and dissolved oxygen concentrations not predicted	No new iron staining or iron seeps resulting from the extraction of Longwall 705 were identified
Harris Creek	Mine subsidence induced ferruginous springs possible, with potential impacts on water quality	No subsidence induced fracturing or iron staining has been observed in Harris Creek

For further detail on the assessment of water quality for Nepean River, refer to **Attachment D**.

6.3. Hydrogeology

GeoTerra was commissioned by BHPBIC to report on the predicted and any observed groundwater changes resulting from extraction of Longwall 705. The information in this section has been drawn from the GeoTerra report which is provided in full as **Attachment H**.

6.3.1. Potentially Affected Bores and Piezometers

Eight open standpipe piezometers (NGW3, 4, 5, 6, 7, 9, 10 and 11) were installed by BHPBIC over, or in the vicinity of, Longwalls 701 to 705.

Groundwater level and water quality monitoring within the Hawkesbury Sandstone to 10m below the base of the Nepean River gorge began in June 2004.

Due to the advance of mining to the west, monitoring of piezometers on both the eastern and western side of the gorge was discontinued for the following piezometers:

- NGW7 (18/10/2012)
- NGW8 (not drilled)
- NGE9 (28/11/2012)
- NGW10 (5/6/2013)
- NGW11 (5/6/2013)
- NGW3 (31/3/2014)

Fully cemented, sealed vibrating wire piezometer arrays were also installed by BHPBIC in bores EAW5 (S1913) and EAW7 (S1936) in the Area 7 monitoring region.

Three NOW registered private bores are located within the Longwall 701 to 705 SMP area (Boustani – GW101437, Nahkle – GW104154 and Zampiron – GW102584), whilst four private bores are outside, although in the vicinity of, the Longwall 701 to 705 SMP area as shown in Table 6-4.

Table 6-4: Private Bore and BHPB Piezometer Summary

GW	Northing	Easting	SWL (m)	Depth (m)	Drilled	Aquifer	Lithology	YIELD (L/s)	EC (mg/L)	Purpose
Private Registered Bores in the Longwall 701 to 705 SMP Area										
Boustani 101437	6216406	291651	75	128	1997	119 - 121	sandstone	0.7	2500	Farming
Nahkle 104154	6216080	291240	74	165	2000	116 - 161	shale / sandstone	1.3	2200	Dom / Stock
Zampiron 102584	6216255	289480	60	186	1999	54 - 179	sandstone	0.9	1300	Dom / Stock
Private Registered Bores in the Vicinity of Longwalls 701 to 705										
34425	6215425	289085	14.6	70	1972	9 – 69.4	sandstone	0.63	good	Waste disposal
104602	6216148	288909	42	231	2002	30 - 213	sandstone	0.75	2500	Stock
104661	6216470	288973	68	219	2003	113 - 212	sandstone	1.05	fresh	Dom / Stock
BHPB Registered Piezometers in the Longwall 701 to 705 SMP Area										
NGW3	6216749.5	275027.4	1.4*	72.1	2004	-	shale / sandstone	-	-	Monit.
NGW4	6216826.2	275789.9	58	78.75	2004	-	sandstone	-	-	Monit.

NGW5	6216327.4	276124	44.3	66.45	2004	-	sandstone	-	-	Monit.
NGW6	6216680.5	276403.3	51.1	66.75	2004	-	sandstone	-	-	Monit.
EAW7	6217767.8	291547.3	various	556.1	2008	n/a	various	n/a	n/a	Monit.
BHPB NOW Registered Piezometers in the Vicinity of Longwall 701 to 705										
NGW7	6216591.4	277026.7	50.5	69.18	2004	-	sandstone	-	-	Monit.
NGW9	6217131.4	277736.9	24.8	69.19	2004	-	sandstone	-	-	Monit.
NGW10	6217333.4	276952.2	52.9	69.5	2004	-	sandstone	-	-	Monit.
NGW11	6217624.6	277104.8	48	72.15	2004	-	sandstone	-	-	Monit.
EAW5	6218729	289027	various	612	2008	n/a	various	n/a	n/a	Monit.

Groundwater levels are logged hourly using vibrating wire piezometers in the NGW and EAW series piezometers and are downloaded once every two months.

Water levels in the Nahkle bore were automatically measured twice daily and downloaded approximately every 2 months between February 2009 and May 2013, when the logger was removed and no further water level or water quality monitoring was conducted.

No water level monitoring was conducted in the Boustani or Zampiron bores as the wellheads are sealed. No piezometers or private bores were directly undermined during extraction of Longwall 705, however the Zampiron bore (GW102584), which overlies the Longwall 705 maingate chain, was within the 20mm subsidence zone of Longwall 705.

6.3.2. Predicted and Observed Groundwater Impacts

Following the extraction of Longwall 705, monitoring has been conducted to document any observed impacts relating to BHPB "NGW" piezometers to the north-west of the Nepean River gorge, as well as three private boreholes (GW101437 – Boustani, GW102584 – Zampiron and GW104154 – Nahkle).

This monitoring is summarised below along with the predicted impacts for Longwall 705 (Geoterra 2006).

6.3.2.1. Aquifer/Aquitard Interconnection under the Plateau

Predicted Impacts

- No adverse interconnection of aquifers and aquitards anticipated within 20m of the plateau surface.
- Potential increase in the rate of groundwater recharge into the plateau following rainfall due to the increased porosity and permeability of the fractured strata.

Observed Impacts

Based on the limited data available over Longwalls 704 and 705, no adverse interconnection of aquifers and aquitards has been observed within 20m of the plateau surface and no increased rate of groundwater recharge into the plateau has been observed as a result of Longwall 705 extraction.

No TARP trigger levels related to aquifer / aquitard interconnection or changes in recharge have been observed to have been reached or exceeded as a result of Longwall 705 extraction.

6.3.2.2. Groundwater Levels

Predicted Impacts

- Temporary lowering of the piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity.
- Groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location.
- Groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall sourced water.
- No permanent post mining reduction in water level in bores on the plateau unless a new outflow path develops.
- No permanent reduction in groundwater levels underneath the Nepean River.

TARP Criteria

The triggers outlined below are from the Appin Area 7 Longwall 705-706 TARPs.

Level 1

- Up to an additional 2.5m reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months.

Level 2

- Between 2.5m and 5m additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months.

Level 3

- Greater than 5m of additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months.
- Privately owned water supply adversely impacted from the mining, other than impact that is negligible.

Observed Impacts

A summary of the pre-longwall starting water levels in the suite of open standpipe piezometers that continued to be monitored throughout Longwall 705 extraction, as well as groundwater level changes during the extraction of Longwall 705 are summarised in Table 6-5**.**

Table 6-5: Longwall 705 Groundwater Level Changes

Piezometer	LW701 start (27/10/07) (mAHD)	LW702 start (18/9/08) (mAHD)	LW703 start (22/10/09) (mAHD)	LW704 start (22/10/09) (mAHD)	LW705 start (07/09/12) (mAHD)	Lowest RL During LW705 (mAHD)	Max. Change During LW705 (m)
Nepean River	61	61	61	61	61	61	No change
NGW3	76.93	77.34	76.78	81.72	85.0	85.42	0.42 rise
NGW4	68.17	68.82	65.78	70.75	72.65	72.15	0.50 fall
NGW5	66.19	66.69	65.78	65.65	65.82	65.68	0.14 fall
NGW6	66.12	66.26	62.58	63.67	65.54	63.33	2.21 fall

NOTES: ** mbgl = metres below ground level n/a = not available

NGW4

NGW4 was not undermined by Longwall 705 and fell by up to 0.5m during extraction of the longwall. No adverse subsidence effect on groundwater levels in NGW4 due to extraction of Longwall 705 was observed.

NGW5

NGW5 was not undermined by Longwall 705 and fell by up to 0.14m during extraction of the longwall. No adverse subsidence effect on groundwater levels in NGW5 due to extraction of Longwall 705 was observed.

NGW6

NGW6 was not undermined by Longwall 704 or Longwall 705, however a definitive response comprising an up to 2.21m fall in groundwater level occurred after Longwall 704 was completed and before Longwall 705 extraction occurred.

The Nepean River water surface averages 61.10mAHD at Douglas Park weir and 60.84mAHD at Menangle, and as a result, the NGW6 water level varied from 2.33 – 4.75m higher in elevation than the river during the Longwall 704 and Longwall 705 monitoring period as shown in Figure 3.

The decline in water level occurred just after Longwall 704 was completed and then erratically rose, fell, and then continued to rise until the logger trace cut out on 03/09/12. Prior to re-establishment of the logger in a rising limb of the water level trace, the water level had previously fallen by 1.02m.

The water level rise significantly flattened out around mid-October 2012, then continued to fall at a lower rate after that time until early October 2013, then rose and fell a minor amount after that time to the end of the monitoring period.

Boustani and Nahkle Bores

The Boustani and Nahkle bores were not undermined by Longwall 704 or Longwall 705 and no adverse effect on their water levels was observed due to extraction of Longwall 705.

Due to lack of access inside the casing, no water level data is available for the Zampiron bore which overlies the Longwall 705 maingate chain pillar.

6.3.2.3. Groundwater Quality

Predicted Impacts

- Potential increased iron and manganese hydroxide precipitation in discharged bore water.
- Potential lowering of pH in discharged bore water.

TARP Criteria

Level 1

- Groundwater quality reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months.

Level 2

- Groundwater quality reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months.

Level 3

- Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months.

Observed Impacts

Groundwater sampling and laboratory analyses since December 2007 in the "NGW" series piezometers and the private bores is shown in Appendix A and plotted in Figures 5 and 6.

NGW Piezometers

The groundwater quality in NGW3 is generally fresh (344 - 434 mg/L) with circum-neutral to slightly alkaline pH (7.1 – 7.7), however as the piezometer is regularly inundated with rainwater recharge down the bore annulus, the data does not represent the actual formation water quality and is not further considered.

NGW4 may also be affected by rainwater recharge, although it does not show in the water level trace after significant storms as it also has a low salinity (434 – 458mg/L) and circum-neutral to slightly alkaline pH (7.5 – 8.0).

NGW 5, 6 and 10 generally exceed the ANZECC 2000 irrigation water quality for chloride and sodium, whilst NGW7, 9 and 11 are relatively fresh with a circum-neutral to slightly acidic pH.

Since December 2007, on-going monitoring indicates that:

- NGW5 salinity has remained essentially unchanged, and its pH has reduced from 7.9 to 6.3, whilst;
- NGW6 salinity has reduced from 5,180 to 729µS/cm, and its pH has reduced from 7.5 to 7.0.

No additional monitoring of the NGW piezometers to the west of the Nepean River occurred during extraction of Longwall 705.

Boustani and Nahkle Bores

Limited additional water quality monitoring occurred in the Nahkle and Boustani Bores during extraction of Longwall 705 as outlined in Appendix A, and no significant change in water quality was observed with the limited data available.

Discussion of further details regarding the private bore water quality is contained in Geoterra (2012).

Zampiron Bore

The NOW database indicates the Zampiron 1999 installation water salinity was 1300mg/L. Monitoring by BHPB during Longwall 705 extraction on the 11th October 2013 and after Longwall 705 on 14th May 2015 indicate a salinity of 3990 – 4010µS/cm (2300 - 1960mg/L) and pH between 7.17 and 7.50 as shown in Appendix A.

Laboratory analysis indicates the bore has no monitored metals outside of the ANZECC 200 criteria. The Zampiron bore increased its pre-subsidence salinity of 1,3000mg/L to 2,300mg/L in October 2013. However, no pre Longwall 705 controlled water quality sampling was conducted and the installation water quality reported from 1999 is probably affected by injected fresh water during the drill hole cleaning process.

No bore water quality TARP triggers were exceeded during or after the extraction of Longwall 705.

6.3.2.4. Well Yield and Bore Serviceability

Predicted Impacts

- Four registered bores within or near the Longwall 702 to 705 (20mm) subsidence zone may have been affected by subsidence. Two are located over Longwall 703 (GW101437 - Boustani and GW104154 - Nahkle) and two are located on the edge of the 20mm subsidence zone, northwest of the proposed Longwall 705 (GW102584 and GW103161).
- Horizontal displacement of strata may make some bores inaccessible.
- Strata dilation and subsequent refilling of the secondary voids may temporarily lower standing water levels, whilst increasing the potential yield of a bore through enhanced permeability and secondary porosity.

Observed Impacts

No adverse effects on groundwater supply, well yield or bore serviceability have been monitored or reported during and following extraction of Longwall 705 within the Longwall 702 to 705 (20mm) subsidence area.

No well yield or bore serviceability TARP triggers were exceeded during or following the extraction of Longwall 705.

6.3.2.5. Potential Inflow to Mine Workings

Predicted Impacts

- No observable increase in mine workings groundwater inflow.

TARP Criteria

Level 1

- Abnormal rise in water flow from the goaf between 2.7 and 3ML/day (over 20 day average).

Level 2

- Abnormal rise in water flow from the goaf between 3 and 3.4ML/day (over 20 day average).

Level 3

- Abnormal rise in water flow from the goaf >3.4ML/day (over 20 day average).

Observed Impacts

No increased inflow to the Appin mine workings following extraction of Longwall 705 has occurred and no TARP trigger levels have been reached or exceeded, based on statutory inspection data.

6.3.2.6. Gas

Predicted Impacts

There is a potential for discharge of strata gas into private bores.

Observed Impacts

No discharge of strata gas has been observed or reported in private bores or BHPB piezometers following extraction of Longwall 704 and no TARP trigger levels have been reached or exceeded.

6.3.3. Groundwater TARPs

As outlined in the various groundwater sections above, no groundwater TARP triggers were exceeded during extraction of Longwall 705 and therefore no associated ameliorative actions were required.

6.3.4. Conclusion and Summary

No groundwater TARP triggers were exceeded during extraction of Longwall 705. Table 6-6 summarises the predicted and observed effects on the groundwater system in relation to the extraction period for Longwalls 701 to 705.

Table 6-6: Predicted Versus Observed Impacts to Groundwater in Relation to LW705

Predicted Impacts	Observed Impacts Due to Extraction of Longwalls 701 to 705
- Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	- Interconnection between aquifers and aquitards has been observed within 20m of the surface over Longwall 703 in the Boustani and Nahkle bores
- Potential increased rate of recharge into the plateau	- An increased rate of recharge into the western plateau has been observed in both BHPB piezometers and the Nahkle bore
- Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops	- Lowering of the piezometric surface by up to 14m has been observed in NGW4 over LW702, which recovered to above its pre LW702 level. Up to 6m reduction and subsequent recovery occurred in NGW6, and is interpreted to be due to enhanced recharge responsiveness from mining LW702
- Groundwater levels should recover over a few months	- The piezometric surface recovered to pre LW702 levels in 4 to 5 months, and to pre LW703 levels in approximately 4 months. Ongoing groundwater level recovery is being observed during extraction of LW704
- No permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	- No permanent lowering of piezometric surface has been observed
- No permanent reduction in groundwater levels under the Nepean River	- No permanent reduction in groundwater levels in the vicinity of the Nepean River has been observed
- The well yield and bore serviceability in four NOW registered bores (GW101437, 102584, 103161, 104154,) may be affected by subsidence	- One complaint regarding reduced bore yield was received from the Boustani property. After removing the bore pump and conducting onsite maintenance, the bore yield is not reduced due to subsidence related effects
- Horizontal displacement may make the four private bores inaccessible	- No private bores have been made inaccessible by subsidence related effects, although minor lateral displacement was observed in the Nahkle and Boustani bores
- Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels and increase the potential private bore well yields	- Standing water levels have increased by 2.3m (Boustani) to 31m (Nahkle), with no monitored increase in yield in the private bores
- Private bore groundwater may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	- No private bores have been affected by adverse subsidence related increases in iron / manganese hydroxide precipitation or lower pH
- Lowering of perched ephemeral seeps along the Nepean River gorge cliffs may occur	- No lowering of perched ephemeral seeps along the

	Nepean River gorge cliffs has been observed
- Interface drainage, ferruginous, brackish seeps may be generated in streams on the plateau	- No interface drainage, ferruginous, brackish seeps have been generated in streams on the plateau
- Ferruginous seeps may develop in the Nepean River	- The EoP report for LW703 assessed that ferruginous seeps had developed in the Nepean River, upstream of Elladale Creek (Ecoengineers, 2008B). No additional seeps observed during LW704 extraction
- Increased groundwater seepage inflow into the Bulli Seam workings should not occur	- No increased rate of groundwater seepage into the Bulli Seam workings has occurred due to extraction of LW701 to 704
- Strata gas discharge into private bores may occur	- No strata gas discharge into private bores has occurred

6.4. Aquatic Ecology

Cardno Ecology Lab (CEL) was commissioned by BHPBIC to assess the potential impact of longwall mining-related subsidence on the aquatic ecology of the Nepean River and other nearby watercourses within the Appin Area 7 SMP Area through the implementation of an aquatic ecology monitoring programme. The latest round of aquatic ecology monitoring was undertaken between December 2013 and January 2014, as part of the ongoing aquatic ecology monitoring programme. The assessment focussed on the effects of extraction of Longwalls 701 to 706 on aquatic habitats and biota in nearby sections of the Nepean River, comparing results from surveys undertaken since 2002 (CEL, 2013). The findings of their investigation are summarised below and provided as **Attachment E**. The monitoring sites associated with the aquatic ecology programme are shown in Figure 6-3.

The assessment of impacts on aquatic ecology in relation to the Longwall 705 EoP Report will draw on findings from the report provided by The Ecology Lab (2004), the EoP assessment on surface and shallow groundwater impacts from Longwall 705 and the landscape report summarising the observed impacts from Longwall 705.

Figure 6-3: Aerial photograph of the study area showing aquatic ecology monitoring sites and gas release zones identified during extraction of Longwall 705, CEL (2014).

6.4.1.Predicted and Observed Impacts on Aquatic Ecology

Mine subsidence predictions for the project indicated the reach of the Nepean River within the SMP Area would experience a combination of subsidence, upsidence and valley closure effects that could result in a net vertical uplift (<300mm) of the river bed.

It was predicted that reductions in water depth and wetted width could have minor effects on components of aquatic ecology including flow, connectivity and water quality and could also reduce the availability of aquatic habitat.

The results from the latest survey undertaken by CEL indicate that there have been no significant changes to the aquatic and riparian habitat in the Nepean River since monitoring commenced (CEL, 2014). The gas releases identified in the Nepean River associated with the extraction of Longwall 705 do not appear to have had any effect on macroinvertebrates, fish and macrophytes in the Nepean River. This is not surprising given that no impacts to water quality, flow and levels, or impacts to physical features have been observed in the Nepean River during extraction of Longwall 705 (MSEC 2014, Ecoengineers 2014).

Details of potential impacts on aquatic ecology due to predicted subsidence associated with the extraction of Longwalls 701 to 705 identified by The Ecology Lab (2008) are listed in Table 6-7, along with the observed effects.

Table 6-7: Predicted and Observed Impacts on Aquatic Ecology Associated with Longwall 705 Extraction

Predicted Impacts	Observed Impacts
- Exposure of wetted substrata in some limited shallow areas of the river, potentially arising due to minor reductions in water depth caused by net uplift of the river bed	- No reported change in water level apart from the normal fluctuations associated with rainfall and Sydney Catchment Authority releases. No exposed wetted substrata observed
- Potential water loss or reduced flow due to fracturing of the river bed. However, this was not expected to result in significant water loss or reduced flow due to the flooded nature of this reach	- No visible fracturing observed in the Nepean River and no water loss observed
- Components of aquatic ecology such as flow characteristics, connectivity and water quality should not be impacted by any predicted subsidence	- No reported surface water flow diversions, impacts on water quality or connectivity of aquatic habitat components
- Alterations to the composition of macrophyte beds due to small reductions in water depth. However, this is not expected to have a significant impact on the overall habitat in the survey area	- No signs of desiccation or die-back of Macrophyte were observed. The water visibility (1 to 2 m) may have resulted in some macrophyte species being obscured from view - No mining induced vegetation dieback has been observed
- Possible that gas emissions may have impacts on water quality	- No evidence of impacts on water quality due to gas releases
- Potential impacts on fish and macroinvertebrates due to mine subsidence are considered unlikely in the SMP Area	- No evidence of any mining induced impact on either fish or macroinvertebrates

Although mining has previously resulted in rock fractures, flow diversions and short periods of reduced water levels, iron staining and gas releases, no significant changes to the aquatic or riparian habitat of the Nepean River have been observed since the commencement of the monitoring program (CEL, 2014), which began in 2002. No aquatic ecology TARPs have therefore been triggered to date from Longwall 705 extraction.

6.4.2. Recommendations

Two years of post-extraction data has been collected at potential impact sites relevant to Longwalls 701-704. However, as these sites may experience cumulative impacts associated with the extraction of Longwalls 701 to 704 and 705 to 710, monitoring should continue here during extraction of Longwall 706. The next sampling event should take place in spring 2014 at these sites and sites relevant to Longwalls 705 to 710 to provide further pre, during and post-mining data for these Longwalls CEL (2014).

6.5. Terrestrial Ecology

The assessment of the effects of Longwall 705 on terrestrial flora and fauna was undertaken by Niche Environment and Heritage (Niche). The full report is provided as **Attachment F**, the summary of the report is provided below.

6.5.1. Predicted and Observed Impacts on Terrestrial Ecology

A monitoring program of the Nepean River, riparian vegetation, steep slopes and cliffs has been undertaken for Longwall 705 by the ICEFT. Niche prepared a report of the impacts on terrestrial ecology within the Longwall 705 area based on the ICEFT monitoring program and previous assessments of the Study Area. A comparison is made between the findings of the pre-mining ecological assessment conducted in April 2006 (Biosis Research 2006) and the results of the post mining inspections. The results of their investigation are summarised below and provided in **Attachment F.**

A summary of the predicted and observed impacts to terrestrial flora and fauna is provided in Table 6-8.

6.5.2. Endangered (Threatened) Ecological Communities

Two Endangered Ecological Communities (EEC's) occur within the limit of subsidence for Longwall 705 (Biosis Research 2008):

- Cumberland Plain Woodland: listed as Critically Endangered under both the TSC and EPBC Act; and
- Shale Sandstone Transition Forest: listed under both the TSC and EPBC Act.

Moist Shale Woodland and River Flat Eucalypt Forest, both listed as EECs under the TSC Act have also been mapped by NPWS (2002) as occurring within proximity to the limit of subsidence. Biosis Research (2008) predicted it was unlikely that Longwall 705 and associated subsidence impacts would have a significant impact on any plant community within the study area. Potential surface fracturing and gas emissions were considered unlikely to result in the broad scale alteration of species composition or distribution of plant communities within the study area.

There have been no reported impacts to vegetation as a result of Longwall 705 (BHPBIC 2014). Mechanisms of subsidence that could potentially result in impacts to native vegetation, such as vegetation die-off due to surface cracking or gas releases, were not observed by the ICEFT within these vegetation communities during monitoring inspections. It is therefore concluded that there were negligible impacts on Endangered Ecological Communities due to Longwall 705.

6.5.3.Threatened Species

No threatened plant or fauna species were recorded in the study area (Biosis Research 2008). However, three threatened plant species (*Eucalyptus benthamii, Pomaderris brunnea and Pterostylis saxicola*) and four threatened fauna species (Giant Burrowing Frog, Little John's Tree Frog, Red-crowned Toadlet and Large Footed Myotis) were considered to have potential habitat within the study area that could potentially be impacted by the mechanisms of subsidence (Biosis Research 2008). Further, the Spotted- tailed Quoll, Brush-tailed Rock Wallaby, Yellow bellied Sheathtail Bat, Large-eared Pied Bat, Eastern Bentwing Bat, Large-footed Myotis, Broad-headed Snake, and Rosenbergs Goanna were considered likely to have potential habitat within caves and crevices of cliff and steep slopes within the study area (Biosis Research 2008).

Impact assessments under the TSC and/or EPBC Act were conducted for the three threatened plant species. It was considered unlikely that any of the threatened flora listed on the TSC Act or EPBC Act or any other significant flora that have been recorded or have potential habitat within the study area, would be significantly impacted by subsidence resulting from the proposed mining (Biosis Research 2008).

No vegetation die-off or other vegetation impacts were observed within the Nepean River area by the ICEFT. It is therefore concluded that the extraction of Longwall 705 has had negligible impact on potential habitat for threatened plants.

Biosis Research (2008) concluded that predicted subsidence impacts on the Nepean River were unlikely to have a significant impact on species dependent on the Nepean River. Biosis Research also concluded that threatened species dependant on caves and crevices within cliffs and steep slopes were unlikely to be significantly impacted by predicted subsidence to these habitats. The remaining threatened fauna species known to occur or with potential habitat within the study area were considered unlikely to be significantly impacted by subsidence as habitat for these species occurs within woodland, or other habitats that are unlikely to be impacted by subsidence.

As there has been no noticeable change to habitat features within either the Nepean River gorge or its tributaries and no impacts to cliff and steep slopes as a result of the extraction of Longwall 705, it is concluded that there has been negligible impact on threatened fauna or their habitats in these areas (Table 6-8).

Biosis (2014) concludes it is unlikely that impacts to any threatened flora and/or fauna species have occurred as a result of Longwall 705 extraction.

Table 6-8: Predicted and Observed Impacts to Terrestrial Ecology Resulting from Longwall 705

Ecological Values	Predicted Impacts	Observed Impacts	Within Prediction
Endangered Ecological Communities (and other vegetation)	Potential gas emissions may result in small, isolated areas of vegetation dieback in the Nepean River gorge. Potential surface fracturing and gas emissions considered unlikely to result in alteration of species composition or distribution	Gas release observed at three sites restricted to the Nepean River. No surface fracturing observed	Yes
	Unlikely to have a significant impact on any plant communities	No significant impacts to plant communities	
Threatened Flora	Volume of water available for plant use is unlikely to be significantly impacted. It is considered unlikely that subsidence impacts would result in a broad change in the floristic composition of the riparian zone. No significant impact to threatened flora	No significant vegetation impacts No significant impacts to flora and flora habitat	Yes
Threatened Fauna and Fauna Habitat	Changed surface water conditions, such as effects to pools and streams. Impacts to steep slopes and cliffs. Impacts of gas emissions on water quality and riparian vegetation	No observed rock falls, rock collapses or rock fracturing. No noticeable change to habitats. No significant vegetation impacts. No significant impacts to fauna and fauna habitat	Yes
	Unlikely to result in a significant impact to threatened fauna		

6.6. Cultural Heritage

The assessment of cultural heritage and archaeological sites potentially impacted by Longwall 705 was conducted by Niche.

Nineteen registered Aboriginal archaeological sites were located within the Longwalls 705 to 710 SMP Area. Of these sites four registered Aboriginal archaeological sites occur in close proximity to Longwall 705. Those sites are identified in Table 6-9 and have been considered further in this assessment. Two further sites 52-2-3671 and 52-2-3674 which are present within the SMP Area were not assessed as part of this assessment due to their distance from the impact zone of Longwall 705. There were no European heritage sites identified as being potentially affected by the extraction of Longwall 705. Hence, no sites were included in the assessment undertaken by Niche (2013).

The full report by Niche is provided as **Attachment G**, and a summary is provided below. The results of the inspection undertaken by Niche are provided in Table 6-10.

Table 6-9: Summary the Aboriginal Heritage Sites in Proximity to Longwall 705

AHIMS Site Number	Site Name	Site Description
52-2-3842	Moreton Park Road 2	Open Camp Site
52-2-3845	Moreton Park Road 5	Open Camp Site
52-2-2096	Nepean River 7	Scarred Tree
52-2-2095	Nepean River 6	Shelter with Deposit

Table 6-10: Cultural Heritage Impacts

Subsidence Monitoring Areas with Potential to Impact Heritage Values	Correlation to Cultural Heritage Values	Heritage Impacts Due to Longwall 705
Cliff instabilities	Cultural heritage values including sites such as overhangs containing art or deposit are located within the cliff line landscape feature. One such site occurs within the limit of subsidence of Longwall 705	No overhang sites have been reported as becoming unstable due to the extraction of Longwall 705 therefore no impacts to sites are likely in cliff areas*.
Slope slippage	Cultural heritage values of sites containing archaeological deposits such as Nepean River 6 (52-2-2095) is located within or may be influenced by impacts to the steep slope landscape feature	No slope slippage has occurred therefore it is considered unlikely that there are any impacts on sites due to slope slippage*
Fracturing	MSEC (2006) predicted that minor fracturing could occur in overhang sites Nepean River 6 (52-2-2095)	There has been no fracturing recorded as a result of the extraction of Longwall 705; it is unlikely that impacts have occurred at this site*

***Once access has been granted for a detailed assessment, any impacts to the site will be confirmed.**

6.6.1. Recommendations

Based on the reported observations of MSEC and the ICEFT, large landscape changes which may affect the overhang sites and scarred tree site have not occurred. A detailed archaeological assessment is planned for all of these sites when access to the area has been legally granted. Given the lack of major movement and the predictions of low impact to aboriginal sites, subsidence is considered to have a negligible impact on cultural heritage values.

7. Longwall 705 Monitoring Program

A comprehensive monitoring program for Longwall 705 is in place as required by the Longwall 705 – 706 SMP Approval.

The monitoring commitments outlined in the Longwall 705 - 706 SMP is shown in Table 7-1 (Man-Made Features) and Table 7-2 (Surface Features).

Table 7-1: Monitoring Program for Man-Made Features Associated with Longwall 705

Monitoring Commitment	Monitoring to Date Associated with LW705	Future Monitoring	Monitoring Undertaken by
Subsidence Monitoring			
During Active Mining	***During Active Mining***	***During Active Mining***	BHPBIC
• Nepean River Cross Lines • Douglas Park Bridges - 3D monitoring - inclinometer monitoring - joint monitoring - visual monitoring - monitoring line • Moreton Park Road Bridge - 3D monitoring - monitoring line	• Nepean River Cross Lines • Douglas Park Bridges - 3D monitoring - inclinometer monitoring - joint monitoring - visual monitoring - monitoring line • Moreton Park Road Bridge - 3D monitoring - monitoring line • HW2 Hume Highway • Main Southern Railway • Far-field 3D monitoring points • Nepean Gorge properties	• Nepean River Cross Lines • Douglas Park Bridges - 3D monitoring - inclinometer monitoring - joint monitoring - visual monitoring - monitoring line • Moreton Park Road Bridge - 3D monitoring - monitoring line • HW2 Hume Highway • Main Southern Railway • Far-field 3D monitoring points • Nepean Gorge Properties	
Farm Dams and Infrastructure			
During Active Mining	***During Active Mining***	***During Active Mining***	BHPBIC
• Inspections as outlined in individual PSMPs	• Inspections as outlined in individual PSMPs	• Inspections as outlined in individual PSMPs	
Nepean River Water Pumps			
During Active Mining	***During Active Mining***	***During Active Mining***	BHPBIC
• Weekly visual inspections of six pumps in Nepean River within the SMP Area • Observations along entire length of Nepean River between Cataract River and Ousedale Creek	• Visual inspections undertaken weekly • Observations conducted weekly	• Visual inspections undertaken Monthly • Observations conducted Monthly	

Table 7-2: Monitoring Program for Surface Features Associated with Longwall 705

MONITORING SITE	SITE TYPE	MONITORING FREQUENCY	MONITORED SITES ASSOCIATED WITH LONGWALL 705	RECOMMENDED FUTURE MONITORING
WATER QUALITY				
Nepean River Baseline upriver sites for cross- checking for upriver perturbations: • NR0 • NR2 (pre Area 9 mining) • NR110 (New site - post Area 9 mining) • NR4 • NR5 • NR6 Impact monitoring sites adjacent to each longwall: • NR11 • NR12 • NR13 • NR20 • NR30 Other sites • NR7 • NR9 • NR50	Grab Sample and field measurements	• Monthly baseline prior to mining (data has been recorded for most sites since 2003) • Weekly observations and field analysis during mining • Monthly detailed laboratory analysis during mining • Monthly monitoring for 2 years post mining (or as otherwise required/approved) • If required as a result of assessment of mining impacts	**Nepean River** Baseline upriver sites for cross- checking for upriver perturbations: • NR0 • NR2 (pre Area 9 mining) • NR110 (New site - post Area 9 mining) • NR4 • NR5 • NR6 Impact monitoring sites adjacent to each longwall: • NR11 • NR12 • NR13 • NR20 • NR30 Other sites • NR7 • NR9 • NR50	• Monthly observations and field analysis due to distance from mining • Removal of NR20 and NR30 due to distance from mining and adequate location of NR12, NR13 and NR50
Other Watercourses • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (FO1) • Navigation Creek (NAV1)	Grab sample and field measurements	• Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall. • Monthly detailed laboratory analysis during mining • Following the development of incremental subsidence for each longwall that will impact on the feature	**Other Watercourses** • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10)	• As per the monitoring program
LEVEL AND FLOW				
Nepean River At benchmark sites and water pump sites: • NRL05 • NRL10 • NRL12 • NRL13 • NRL15 • NRL20 • Pump 1 NRL • Pump 2 NRL • NRL25 • NRL30 • NRL33 • NRL35 • NRL40 • NRL45	Water Level Water flow (measured at SCA weirs)	• Monthly baseline prior to mining (data has been recorded for most sites since 2007) • Weekly manual monitoring at nails during mining • Flow monitoring at weirs (data supplied by SCA) • Ongoing monthly monitoring for 2 years post mining (or as otherwise required/approved)	**Nepean River** At benchmark sites and water pump sites: • NRL05 • NRL10 • NRL12 • NRL13 • NRL15 • NRL20 • Pump 1 NRL • Pump 2 NRL • NRL25 • NRL30 • NRL33 • NRL35 • NRL40 • NRL45	• Monthly measurement of benchmark sites due to distance from mining

• NRL48 • NRL50 • Pump 5 NRL • Pump 6 NRL			• NRL48 • NRL50 • Pump 5 NRL • Pump 6 NRL	
Other Watercourses • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10) • Foot Onslow Creek (F01) • Navigation Creek (NAV1)	Water Level	• Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall • Following the development of incremental subsidence for each longwall that will impact on the feature	**Other Watercourses** • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek (HC10)	• As per the monitoring program
APPEARANCE				
Nepean River • Visual observations along the length of the Nepean River within the active mining area	Observational and photographic monitoring	• Monthly baseline prior to mining (data has been recorded for most sites since 2003) • Weekly observations and field analysis during mining • Monthly monitoring for 2 years post mining (or as otherwise required/approved) • If required as a result of assessment of mining impacts	**Nepean River** • Visual observations along the length of the Nepean River within the active mining area	• Monthly observations and field analysis due to distance from mining
Other Watercourses • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek • Foot Onslow Creek • Navigation Creek	Observational and photographic monitoring	• Prior to mining of longwall underlying watercourse or mining of any immediately adjacent longwall. • Following the development of incremental subsidence for each longwall that will impact on the feature	**Other Watercourses** • Lower Harris Creek (NR3) • Elladale Creek (NR8) • Ousedale Creek (NR10) • Menangle Creek (NR40) • Upper Harris Creek	• As per the monitoring program
Water Pumps • Pump 1 NRL • Pump 2 NRL • Pump 3 • Pump 4 • Pump 5 NRL • Pump 6 NRL	Observational and photographic monitoring	• Pre mining photographs • Weekly visual inspection during mining • If required as a result of assessment of mining impacts	**Water Pumps** • Pump 1 NRL • Pump 2 NRL • Pump 3 • Pump 4 • Pump 5 NRL • Pump 6 NRL	• Monthly inspection due to distance from mining
GROUNDWATER				
Water Level IC monitoring bores • NGW3 • NGW4 • NGW6 • NGW5 • NGW7 • NGW9 • NGW10 • NGW11	Groundwater level	IC Bores • Pre-mining (data has been recorded since September 2004 for some sites) • Water level logged hourly • Post-mining – following the development of incremental subsidence for each longwall that will potentially impact on the borehole	**Water Level** IC monitoring bores • No IC monitoring bores associated with Longwall 705 Private bores • 1 registered bore monitored for Longwall 705 (see main report "Property Inspections" section for details on Private bore impacts)	IC monitored bores • S1936 Cease regular monitoring of IC boreholes as mining has been outside the area of influence for at least 12 months: - NGW3 - NGW4 - NGW5

• EAW5 • EAW7 (S1936) • S1584 • S1809 • S1853 • S1854 Private bores • 10 registered bores within the SMP area (refer to Built Feature Management Plans for monitoring/management)		• Monitoring to continue for at least 12 months post mining Private Bores - Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder) - Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder) - As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore		- NGW6 - NGW7 - NGW9 - NGW10 - NGW11 Private bores Monitoring of private boreholes prior-to and post-mining of Longwall 706 - GW104661 - GW104602 - GW102584 - GW108312
Water Quality IC monitoring bores • NGW6 • NGW5 Private bores • 10 registered bores within the SMP area (refer to Built Feature Management Plans for monitoring/management)	Grab Sample	IC Bores • Pre-mining – prior to mining of longwall underlying bore or mining of any immediately adjacent longwall • Post-mining – following the development of incremental subsidence for each longwall that will impact on the feature (i.e. each longwall) • As required to provide additional data for any bore impact investigation or if physical impacts to bore identified Private Bores • Prior to mining of longwall underlying bore or mining of any immediately adjacent longwall (if in agreement with landholder) • Post-mining – following the development of incremental subsidence for each longwall that will impact on the borehole (if in agreement with landholder) • As requested by landholder or if physical impacts to bore identified (landholder to observe during use of bore)	**Water Quality** IC monitoring bores • No IC monitoring bores associated with Longwall 705 Private bores • 1 registered bore monitored for Longwall 705 (see main report "Property Inspections" section for details on Private bore impacts)	IC monitored bores Cease regular monitoring of following IC boreholes as mining has been outside the area of influence for at least 12 months: - NGW3 - NGW4 - NGW5 - NGW6 - NGW7 - NGW9 - NGW10 - NGW11 Private bores Monitoring of private boreholes prior-to and post-mining of Longwall 706: - GW104661 - GW102584 - GW108312
LANDSCAPE FEATURES				
Cliffs • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated tributaries	Observational and photographic monitoring	• Once prior to mining. Photographic records taken • During mining, monthly visual inspections, increased to weekly inspections during critical periods	**Cliffs** • Along Nepean Gorge **Steep Slopes** • Along Nepean Gorge, associated	• Monthly inspections due to distance from mining

and above western end of the proposed longwalls		(for cliffs and steep slopes along the Nepean Gorge and associated tributaries) • Monitoring to continue 6 monthly for 2 years following the completion of mining (or as otherwise required/approved) • As required when specific impacts are identified or when concern is raised by a landowner • As required, in accordance with Built Feature Management Plans and landholder agreement	tributaries and above western end of the proposed longwalls	
Terrestrial Ecology				
Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and landscape.	Observational and photographic monitoring	• If required as a result of assessment of mining impacts. • General observation of active mining areas during all other monitoring.	• Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and landscape.	• As per the monitoring program.
Aboriginal Heritage				
• Nepean River 4 (52-2-2098) • Nepean River 5 (52-2-2097) • Nepean River 6 (52-2-2095) • Nepean River 7 (52-2-2096) • Nepean River 8 (52-2-2239) • Upper Nepean Hand Stencils • Bulli Site 40 (BS 40) Refer to Figure 5-22 of Bulli Seam Operations EA and Figure 3 Bulli Seam Operations Appendix G (Aboriginal Cultural Heritage Assessment)	Observational and photographic monitoring	• Baseline archival recording prior to longwall mining. • Final impact assessment recording 12 months after undermining or final subsidence movement at the site.	• Macro and micro recording using digital photography • Detailed elevation plans of shelter walls recording structural and surface features including but not limited to the art itself, graffiti, joints, bedding planes, exfoliation scars, cracks, mineral and micro-organism growth, drip line and water seepage locations	• As per the monitoring program.
Historic Heritage				
• Buildings or structures of identified heritage significance Note: Detailed Heritage Management Plans to be developed prior to any heritage item being influence by mining	Observational, photographic monitoring and structural inspections.	• Baseline assessment recording prior to longwall mining. • Monitoring during subsidence (if in agreement with landholder) • Final assessment recording 12 months after undermining or final subsidence movement at the site.	• Building/structure condition • Heritage value	• As per the monitoring program.

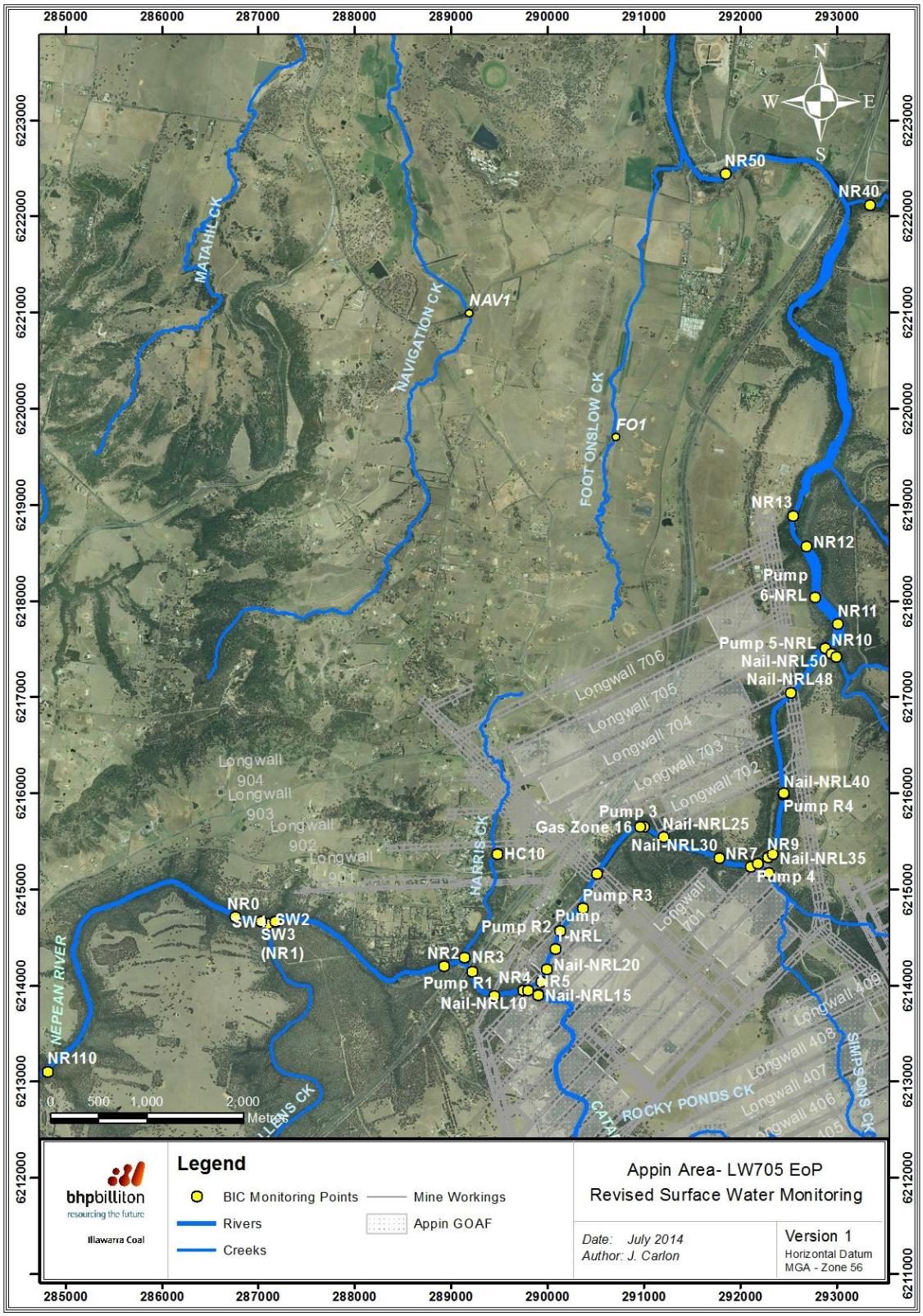

Figure 7-1: Revised Surface Water Monitoring

8. Management of Impacts and Remediation

8.1. Management and Rehabilitation

Management Plans have been prepared to ensure the mining area is adequately monitored and managed. Management plans relevant to Longwall 705 include those associated with natural features (Condition 13 of the 28/02/2012 approval) and infrastructure (Condition 14 of the 28/02/2012 approval) and are noted below:

SMP Application:

- Volume 1 – Written Report and Reduced Plans
- Volume 2 - Longwalls 705-710 Proposed Subsidence Management Plan (SMP)
- Appendix A: Longwalls 705-710 Prediction and Assessment of Mine Subsidence Impacts
- Appendix B: Longwalls 705-710 Assessment of Surface Water Flow and Quality Effects
- Appendix C: Longwalls 705-710 Effects of Mine Subsidence on Aquatic Habitat and Biota
- Appendix D: Longwalls 705-710 Impacts of Subsidence on Terrestrial Flora and Fauna
- Appendix E: Longwalls 705-710 Archaeological and Cultural Heritage Impact Assessment
- Appendix G: Longwalls 705-710 Risk Assessment
- Appendix H: Longwalls 705-710 Groundwater Assessment Management Plans

Management Plans:

- Appin Area 7 Longwalls 701-706 Nepean River Cliff and Steep Slopes Management Plan
- Appin Area 7 Longwalls 705-706 Environmental Management Plan
- Appin Area 7 Longwalls 705-706 Public Safety Management Plan

8.2. Remediation Associated with Longwall 705

8.2.1. Nepean River

Impacts associated with Longwall 705 have not required rehabilitation works to date. Where impacts have occurred, these have been within prediction. Ongoing monitoring and assessments will confirm whether or not remediation works will be required.

8.2.2. Infrastructure

Remediation associated with Longwall 705 impacts to infrastructure has occurred in relation to the HW2 Hume Highway, Moreton Park Road and the Main Southern Railway. These are discussed further in Table 8-1 below.

Table 8-1: Remediation of Impacts to Infrastructure.

Built Feature	Impact	Remediation
Moreton Park Road	Minor localised heaving observed	Remediated through smoothing of the road surface. No impact to the safety or serviceability of the road
HW2 Hume Highway	Humps formed within the road surface on both carriageways	Remediated by re-shaping of the pavement surface and installation of additional slots as part of Management Plan responses. No impacts on the safety or serviceability of the highway after the implementation of the management strategies
Main Southern Railway	Changes in track geometry	Remediated with expansion switch adjustments in accordance with the Management Plan. No impacts on the safety or serviceability of the railway after the implementation of the management strategies

8.3. Trigger Action Response Plans (TARPs)

The TARPs for Longwalls 705 to 706 are provided in Table 8 2. This table describes the monitoring required, the triggers and actions required, and whether any impacts were observed.

Table 8-2: Appin Area 7 TARP

Refer to Table 7-2 of this report for monitoring sites.

Monitoring	Trigger	Actions Undertaken if Impact was Observed	Impacts Observed	Impacts within prediction?	Further Actions or Recommendations
WATER QUALITY					
Nepean River Impact monitoring sites adjacent to each Longwall: ▪ NR11 ▪ NR12 ▪ NR13 ▪ NR20 ▪ NR30 Refer Figure 1a ***Notes:*** *Baseline upriver sites will be used for cross- checking for upriver perturbations(3)* *Baseline Upriver site NR2 data to be updated at end of panel following completion of each longwall, subject to checks-for, and discard-of upriver perturbed data*	***Level 1 (Within Prediction)(1)*** Impact monitoring sites: ▪ pH reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months ▪ DO reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months ▪ Identification of strata gas plume of flow rate < 3000 L/min (2)	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	Three Gas Zones in the Nepean River with flow rate <3000L/min ▪ AA7LW705 Gas Zone 15 ▪ AA7LW705 Gas Zone 16 ▪ AA7LW705 Gas Zone 17	Yes	Continue Monitoring Program
	Level 2 (Within Prediction – CMAs may be required)(1) Impact monitoring sites: ▪ pH reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months ▪ DO reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months ▪ EC, total Fe and total Mn increases greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months ▪ Identification of strata gas plume of flow rate > 3000 L/min(2)	▪ Actions as stated for Level 1 plus: ▪ Review monitoring program ▪ Notify relevant specialists (BHPBIC) and develop and implement remedial action if necessary *Strata Gas Emission Plume:* ▪ Estimate gas emission flow rates. Re-estimate should significant change be observed ▪ Take sample of plume (if possible) for: - chemical composition - dissolved methane from exactly above gas plume and at established downriver monitoring sites - dissolved sulfide and total phenols from exactly above gas plume and at nearest downriver monitoring site(s)	*No such impacts observed*	N/A	N/A

	Level 3 (CMAs likely to be required)[1] Impact monitoring sites: ▪ Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months	▪ Actions as stated for Level 2 plus: ▪ Immediately notify OEH, D&PI, NoW & DRE and any other relevant specialist. ▪ Consultation with stakeholders. ▪ Collect laboratory samples and analyse for: - pH, EC, Total Fe and Mn - Suite of Filterable metals. - Dissolved methane, sulfide and total phenols (if relevant). ▪ Develop site management measures as soon as practically possible (pending stakeholder availability) and seek any approvals required to implement	*No such impacts observed*	NA	N/A
	Exceeding Prediction ▪ More than negligible gas releases	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
WATER LEVEL AND FLOW					
Nepean River ▪ Visual observations along the length of the Nepean River within the active mining area	***Level 1 (Within Prediction)***[1] ▪ Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for less than 2 consecutive months.	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed*	N/A	N/A
	Level 2 (Within Prediction – CMAs may be required)[1] ▪ Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for more than 2 consecutive months.	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required)[1] ▪ Observation of areas of dry and/or flooded riverbed in comparison to pre-mining baseline observations and flows, for more than 6 consecutive months.	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1	*No such impacts observed*	N/A	N/A

		month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders			
APPEARANCE					
Nepean River ▪ Visual observations along the length of the Nepean River within the active mining area	***Level 1 (Within Prediction)*** [1] ▪ Identified iron staining resulting from the mining for two consecutive months ▪ Identified water cloudiness resulting from the mining for two consecutive months	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed*	N/A	N/A
	Level 2 (Within Prediction – CMAs may be required) [1] ▪ Iron staining greater than baseline monitoring resulting from the mining for two consecutive months ▪ Water cloudiness greater than baseline monitoring resulting from the mining for two consecutive months	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [1] ▪ Iron staining greater than baseline monitoring resulting from the mining for six consecutive months ▪ Water cloudiness greater than baseline monitoring resulting from the mining for six consecutive months	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if	*No such impacts observed*	N/A	N/A

		required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders			
	Exceeding Prediction ▪ More than negligible iron staining resulting from the mining ▪ More than negligible increase in water cloudiness resulting from the mining	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
Ephemeral Watercourses ▪ Upper Harris Creek (HC10) ▪ Foot Onslow Creek (FO1) ▪ Navigation Creek (NAV1) Visual observations at water quality monitoring sites and along the length of the stream within the active mining area where landholder access is granted	***Level 1 (Within Prediction)*** [(1)] ▪ Fracturing with no observable loss of surface water flow ▪ Fracturing with no reduction in pool water level when compared to similar environmental conditions in baseline period ▪ Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed*	N/A	N/A
	Level 2 (Within Prediction – CMAs may be required) [(1)] ▪ Fracturing resulting in loss of surface flow in some creeks or tributary ▪ Fracturing resulting in water loss from some permanent pools ▪ Reduced water retention time in pools ▪ Increase in turbidity, iron staining, algal growth, or other visible water quality parameters resulting from the mining for two consecutive months determined by comparing baseline photos with photos during the mining period	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [(1)] ▪ Fracturing resulting in total loss of surface flow in all sections of a creek or tributary ▪ Fracturing resulting in total water loss from all permanent pools in the mining area ▪ Reduced water retention time in all pools in the mining area	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1	*No such impacts observed*	N/A	N/A

		month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders			
	Exceeding Prediction ▪ Fracturing of controlling rockbars and/or stream bed, resulting in the diversion of all stream flow in the mining area ▪ Increased leakage from all pools in the mining area	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
Water Pumps ▪ There are six pumps in the Nepean River which will be monitored for the effects from subsidence: - Pump 1 - Pump 2 - Pump 3 - Pump 4 - Pump 5 - Pump 6	▪ Pump not functioning due to physical disturbance from subsidence	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record ▪ Develop and implement CMA (if required) in consultation with key stakeholders	*No such impacts observed*	N/A	N/A
AQUATIC ECOLOGY					
Nepean River ▪ Sites 5 and 6 (located adjacent to Longwalls 705 and 706 downstream of the confluences with Mallaty and Ousedale Creeks) ▪ Sites 7 and 8 (located downstream of all proposed Longwalls 701-710)	***Level 1 (Within Prediction)*** [1] ▪ 1 season reduction in aquatic habitat resulting from the mining when comparing to baseline condition	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed. Refer to Longwall 705 End of Panel specialist report on Aquatic Ecology for more information.*	N/A	N/A

Ephemeral Watercourses ▪ Sites F1 and F2 (located on Foot Onslow Creek, over Longwalls 708 and 710) ▪ Site N1 (located on Navigator Creek northeast of Longwall 710) ▪ General observation of all other watercourses in active mining areas Refer Figure 20.1 in LW705-710 SMP	***Level 2 (Within Prediction – CMAs may be required)*** [(1)] ▪ 2 consecutive season reduction in aquatic habitat resulting from the mining when comparing to baseline condition	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [(1)] ▪Reduction in aquatic habitat resulting from the mining for > 2 consecutive seasons or complete loss of habitat	▪ Actions as stated for Level 2 ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders	*No such impacts observed*	N/A	N/A
	Exceeding Prediction ▪ More than negligible environmental consequences for a threatened species, threatened population or endangered ecological community	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
GROUNDWATER					
Water Level IC monitoring bores: ▪ NGW3 ▪ NGW4 ▪ NGW6 ▪ NGW5 ▪ EAW5 ▪ EAW7 (S1936)	***Level 1 (Within Prediction)*** [(1)] ▪ Up to an additional 2.5m reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed. Refer to Longwall 705 End of Panel specialist report on Groundwater for more information.*		
	Level 2 (Within Prediction – CMAs may be	▪ *Actions as stated for Level 1* ▪ Review monitoring program			

Private Bores ▪ Registered bores and any new bores within the SMP area	***required)*** [1] ▪ Between 2.5m and 5m additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months	▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved			
Notes: *Impact monitoring data during longwall mining is compared to predicted groundwater levels from the BSOP (or later updates) groundwater model, during preparation of the End of Panel Report* *Privately owned water supplies are monitored as agreed with landowners in the Built Feature Management Plans* Refer Figure 1a	***Level 3 (CMAs likely to be required)*** [1] ▪ Greater than 5m of additional reduction from the predicted standing water level or pressure (outside of pumping influences) over 2 consecutive months ▪ Privately owned water supply adversely impacted from the mining (other than impact that is negligible)	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders ▪ Compensatory water supply measures must be provided as an alternative long-term supply that is equivalent to the loss attributed to the mining impact, and be provided (at least on an interim basis) within 24 hours of the loss being identified.			
Water Quality IC monitoring bores ▪ NGW6 ▪ NGW5 Private Bores ▪ Registered bores and any new bores within the SMP area (where water quality samples can be taken)	***Level 1 (Within Prediction)*** [1] ▪ Groundwater quality reduction greater than 1 standard deviation but less than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed. Refer to Longwall 705 End of Panel specialist report on Surface Water and Shallow Groundwater for more information.*		
	Level 2 (Within Prediction – CMAs may	▪ *Actions as stated for Level 1*			

	be required) [1] ▪ Groundwater quality reduction greater than 2 standard deviation from pre-mining mean resulting from the mining for two consecutive months	▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved			
	Level 3 (CMAs likely to be required) [1] ▪ Level 2-type reduction in water quality resulting from the mining observed for more than 6 consecutive months	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders ▪ Compensatory water supply measures must be provided as an alternative long-term supply that is equivalent to the loss attributed to the mining impact, and be provided (at least on an interim basis) within 24 hours of the loss being identified			
LANDSCAPE FEATURES					
Cliffs ▪ Along Nepean Gorge **Steep Slopes** ▪ Along Nepean Gorge, associated tributaries and above western end of the proposed Longwalls	***Level 1 (Within Prediction)*** [1] ▪ Any rock fall, displacement, dislodgement of boulders or slabs or fracturing of a cliff line flanking the Nepean River resulting from mining ▪ Erosion resulting from mining localised to a small area that should naturally stabilise within the monitoring period	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed*	N/A	N/A

Refer Figure 19.1 in LW705-710 SMP ▪ Cliffs flanking the Nepean River	▪ Surface movement resulting from mining with no more than negligible soil surface exposed				
	Level 2 (Within Prediction – CMAs may be required) [(1)] ▪ Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts 0.3% of the total cliff line face area of the mining domain. ▪ Erosion resulting from mining likely to naturally stabilise within the monitoring period. ▪ Surface movement or rock displacement resulting from mining with no more than minor soil surface exposed	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [(1)] ▪ Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliff line(s) flanking the Nepean River resulting from mining that in total impacts up to 0.5% of the total cliffline face area of the mining domain. ▪ Any rock falls, displacements, dislodgements of boulders or slabs or fracturing of a cliffline(s) flanking the Nepean River resulting from mining that in total impacts 0.4% of the total cliffline face area of the mining domain after 1 longwall. ▪ Mass movement of a slope causing large areas of exposed soil ▪ Any form of rockfall or erosion that poses a threat to public safety	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders	*No such impacts observed*	N/A	N/A
	Exceeding Prediction ▪ More than negligible environmental consequences (that is occasional rockfalls, displacement or dislodgement of boulders or slabs, or fracturing, that in total impacts more than 0.5% of the	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A

	total face area of such cliffs within the Longwall mining domain) ▪ Rockfall or erosion that poses more than a negligible increased risk to public safety				
TERRESTRIAL ECOLOGY					
Monitored in conjunction with general observational monitoring for the Nepean River, ephemeral watercourses and active mining area	***Level 1 (Within Prediction)*** [1] ▪ Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is likely to naturally regenerate within the monitoring period	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record	*No such impacts observed. Refer to Longwall 705 End of Panel specialist report on Terrestrial Ecology for more information.*	N/A	N/A
	Level 2 (Within Prediction – CMAs may be required) [1] ▪ Vegetation impacted by mining (by rockfalls, soil slippage, gas emissions) that is unlikely to naturally regenerate within the monitoring period	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [1] ▪ Vegetation impacted by mining that is not responding to CMAs	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders	*No such impacts observed*	N/A	N/A

	Exceeding Prediction ▪ More than negligible environmental consequences on threatened species, threatened populations, or endangered ecological communities	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
ABORIGINAL ARCHAEOLOGY					
▪ Nepean River 4 (52-2-2098) ▪ Nepean River 5 (52-2-2097) ▪ Nepean River 6 (52-2-2095) ▪ Nepean River 7 (52-2-2096) ▪ Nepean River 8 (52-2-2239) ▪ Upper Nepean Hand Stencils ▪ Bulli Site 40 (BS 40) Any other newly identified Aboriginal Archaeology sites Refer to Figure 5-22 of Bulli Seam Operations EA and Figure 3 Bulli Seam Operations Appendix G (Aboriginal Cultural Heritage Assessment)	***Level 1 (Within Prediction)*** [1] ▪ Change in shelter conditions not attributable to natural weathering or preservation – mineral growth or micro-organism growth (as observed by comparing pre-mining photographs with post-subsidence/mining photographs) ▪ Changes external to the shelter that affect the site context – ground cracking, boulder slumping, rock and/or tree falls	▪ Continue monitoring program ▪ Report impacts to key stakeholders Summarise impacts and record	*No such impacts observed. Refer to Longwall 705 End of Panel specialist report on Aboriginal Archaeology for more information.*	N/A	N/A
	Level 2 (Within Prediction – CMAs may be required) [1] ▪ Change in shelter conditions not attributable to natural weathering or preservation – change in drip line or seepage, cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints at panel, block fall within shelter or overhang	▪ *Actions as stated for Level 1* ▪ Review monitoring program ▪ Notify relevant technical specialists and seek advice on any CMA required ▪ Implement agreed CMAs as approved	*No such impacts observed*	N/A	N/A
	Level 3 (CMAs likely to be required) [1] ▪ Shelter or overhang collapse not attributable to natural weathering ▪ Level 2 impacts at greater frequency than predicted ▪ Level 2 impacts attributable to mining	▪ *Actions as stated for Level 2* ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1	*No such impacts observed*	N/A	N/A

	remote from the mining area	month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders			
▪ Sites determined to hold high or moderate significance as a result of studies required for Extraction Plans ▪ Other Aboriginal heritage sites	***Exceeding Prediction*** ▪ More than 10% of such sites across the mining area are affected by subsidence impacts (other than negligible impacts or environmental consequence) ▪ Less than 10% of such sites (or 1 such site, whichever is the greater) within any longwall mining domain are/is affected by subsidence impacts (other than minor impacts or environmental consequence)	▪ *Actions as stated for Level 3* ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A
HISTORIC HERITAGE					

▪ Buildings or structures of identified heritage significance. Note: *Detailed Heritage Management Plans to be developed prior to any heritage item being influence by mining.*	***Exceeding Prediction*** ▪ Loss of heritage value greater than predicted under the Heritage Management Plan	▪ Continue monitoring program ▪ Report impacts to key stakeholders ▪ Summarise impacts and record ▪ Immediately notify relevant government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. ▪ Site visits with stakeholders if required ▪ Develop site CMA in consultation with key stakeholders within 1 month. ▪ Completion of works following approvals ▪ Issue CMA report within 1 month of works completion ▪ Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required ▪ Review the relevant TARP and Management Plan in consultation with key stakeholders ▪ Investigate reasons for the exceedance ▪ Update future predictions based on the outcomes of the investigation	*No such impacts observed*	N/A	N/A

(1) These may be revised in consultation with DoPI and DPI and other key stakeholders

(2) If strata gas emission plumes are detected – particularly coinciding with low river flow and significant gas evolution

(3) Baseline upriver sites for cross-checking for upriver perturbations impacting Area 7 monitoring sites:

- NR0 - possible perturbations from Allens Creek (>2 standard deviation)
- NR2 - upstream perturbations (>2 standard deviations) pre-Area 9 mining
- New site NR110 - possible perturbations from Area 9 (>2 standard deviations) post-Area 9 mining commencement
- Checks at Upriver sites NR4, NR5 and NR6 for possible Cataract River-based perturbations (>2 standard deviation)

Current values:

Level 1

NR11

- pH>6.93;<7.33
- DO>47.8%;<66.0%
- EC>561 uS/cm;<758 uS/cm
- Total Fe>0.589;<0.866mg/L
- Total Mn>0.044;<0.074 mg/L

NR2 upstream normality checks

- pH>7.01
- DO>55.3%
- EC<890 uS/cm
- Total Fe<1.220 mg/L
- Total Mn<0.090 mg/L

Level 2 and 3

NR11

- pH<6.93
- DO<47.8%
- EC>758 uS/cm
- Total Fe>0.866
- Total Mn>0.074

NR2 upstream normality checks

- pH>7.01
- DO>55.3%
- EC<890 uS/cm
- Total Fe<1.220 mg/L
- Total Mn<0.090 mg/L

9. References

Appin Area 7 Longwalls 705 to 706 Subsidence Management Plan Approval

Biosis, 2012. *Bulli Seam Operations Project Heritage Management Plan*, October 2012. Prepared for BHP Billiton Illawarra Coal.

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