GeoTerra

Appin Colliery

Longwall 707
End Of Panel
Surface Water and Groundwater
Monitoring Report

Sth32_707 R1B
11 October 2018

GeoTerra Pty Ltd ABN 82 117 674 941

PO Box 530 Newtown NSW 2042

Phone: 02 9519 2190 Mobile 0417 003 502 Email: geoterra@iinet.net.au

South 32 Illawarra Coal Holdings Pty Ltd
PO Box 514
UNANDERRA NSW 2526

Attention: Josh Carlon

Josh,

RE: Appin Colliery End of Longwall 707 Surface Water and Groundwater Monitoring Report

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)

Principal Hydrogeologist

Date	Rev	Comments
14/09/2018		Initial Draft
05/10/2018	A	Incorporate review comments
11/10/2018	B	Incorporate review comments

Distribution: Original GeoTerra Pty Ltd

1 electronic copy South32 Illawarra Coal Holdings Pty Ltd

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Appendix A Private Bore Water Chemistry

Executive Summary

The following table summarises the potential and observed effects on surface water and groundwater systems within the Longwall 707 subsidence area, with **Appendix A** outlining the monitored piezometer / bore groundwater chemistry.

Potential Impacts	Observed Impacts Due to Extraction of Longwall 707
Surface Water	
Bedrock cracking and loss of plateau stream flow not anticipated in plateau streams due to mitigating effects of stream sediment cover	*Stream bed cracking and loss of pool holding capacity has not been observed due to extraction of LW707*
No adverse ecological changes to plateau streams due to subsidence	*No adverse effect on plateau stream ecology has been observed due to extraction of LW707*
Possible localised ponding may occur in plateau streams	*No localised stream ponding due to subsidence has been observed due to extraction of LW707*
Plateau stream bed incision may occur	*No plateau stream bed incision has been observed due to extraction of LW707*
No adverse effects on plateau stream water quality anticipated	*No adverse effects on plateau stream water quality has been observed due to extraction of LW707*
Nepean River water level to remain essentially unchanged	*No adverse effects on the Nepean River were observed due to extraction of LW707*
Surface flow diversion from the Nepean River	*No adverse effects on the Nepean River were observed due to extraction of LW707*
Methane rich strata gas emissions into the river are likely, with reduced dissolved oxygen levels possible	*No new adverse effects on the Nepean River were observed due to extraction of LW707, although some pre-existing impacts at Gas Zones 14, 15, 17, 18 and AA7_LW706_001 were active during LW707 extraction. No gas releases have been observed in the AA7 Nepean River study area since January 2018.*
Low likelihood of ferruginous spring inducement with significant impacts from pH and iron not predicted	*No adverse effects on the Nepean River were observed due to extraction of LW707.*
Reduction in private dam water holding capacity and / or water quality, and / or strata gas discharge	*Dam E13d01, located on a private property, was observed to have bubbling strata gas along with a lower dam water level on 6th April 2016 (Impact AA7_LW707_001). No gas was observed in a post mining inspection on 16th May 2018, although the dam water level was still low*

Potential Impacts	Observed Impacts Due to Extraction of Longwall 707
Groundwater	
Adverse interconnection of aquifers and aquitards is not anticipated within 20 m of the surface	*No adverse interconnection between aquifers and aquitards observed within 20 m of the surface due to extraction of LW707*
Potential increased rate of recharge into the plateau	*No increased rate of recharge into the plateau was observed due to extraction of LW707*
Temporary lowering of regional phreatic water levels by up to 10 m which may stay at that level until maximum subsidence develops	*Significant depressurisation of the Bulli Seam (>200 m) and 50 -75 m reduction of the piezometric surface in the lower Bulgo and Scarborough Sandstones occurred due to subsidence in VWP EAW7. Moderate depressurisation in the lower Bulgo and Scarborough sandstones, and up to 38 m depressurisation occurred in the Bulli Seam at EAW5. Recovery of the water levels has not yet occurred.*
Groundwater levels should recover over a few months and no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops	*Continued depressurisation of the Bulli Seam, Lower Bulgo and Scarborough Sandstones in EAW5. All piezometer intakes except the Hawkesbury Sandstone (65 mbgl) sheared off in EAW7*
The yield and serviceability in registered bores may be affected by subsidence	*The pumping longevity of private bore GW105388 was reported by a landowner on 14th December 2016. Although no adverse impact on the bore yield was reported, the longevity of pumping was affected. South 32 have been supplying trucked tank water to the landholder since March 2017.*
Horizontal displacement may make private bores inaccessible	*No private bores reported to have been horizontally displaced due to Longwall 707 extraction*
Strata dilation and subsequent re-filling of secondary voids may temporarily lower standing water levels of private bores	*No private bore yields have been reportedly adversely affected due to extraction of LW707*
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 due to extraction of LW707*
Increased groundwater seepage inflow into the mine workings should not occur	*No notable increase in groundwater inflow to the mine has been observed due to extraction of LW707*
Strata gas discharge into private bores may occur	*Strata gas discharge (along with iron staining) in private bore GW102584 was observed on 7th March 2016. Combustible gas could be observed and heard within 0.5 m of the bore on 22nd April 2016. A second inactive bore on the property also had low levels of combustible gas and bubbling sounds (Impact AA9_LW707_002).*

1. INTRODUCTION

South32 Illawarra Coal Holdings Pty Ltd (Sth32-IC) and its predecessors, has extracted the Bulli Seam in Longwalls 701 to 707 at Appin Colliery by retreat longwall mining within the Appin Colliery lease area since October 2007.

The previous workings and the current panel (Longwall 708) are located to the north and west of the Nepean River, to the north east of Douglas Park village, south of Camden Park village and southwest of Campbelltown, as well as intervening semi-rural areas in the Southern Coalfields of NSW as shown in **Figure 1**.

This report provides a compilation of physical and geochemical groundwater and stream monitoring that has been conducted up to and after completion of Longwall 707, as well as observation of any subsidence related changes due to the extraction of Longwalls 701 to 707 within the Appin Area 7 study area (Area 7).

Surface water and groundwater features associated with, or in close proximity to, Longwall 707 include:

- the main channel and tributaries of the northerly flowing Nepean River;
- the headwaters of the southerly draining channel and tributaries of Harris Creek, which flows into the Nepean River;
- the headwaters of Foot Onslow Creek which flows into the Nepean River;
- two vibrating wire piezometer arrays in bores EAW5 and EAW7, and;
- ten DPI-W licensed private bores (GW102584, 104602, 104661, 105339, 105376, 105388, 105534, 106574, 108312 and GW112441).

The headwaters of Harris and Foot Onslow Creeks are 2nd order or less channels that overly Longwall 707.

Monitoring of the Nepean River and plateau streams has been conducted since October 2007 by assessing the;

- ephemeral or perennial nature and flow in streams over and adjacent to the panels;
- creek bed and bank erosion and channel bedload;
- stream and dam water quality, including ferruginous and gaseous seeps;
- stream bed and bank vegetation;
- nature of alluvial land along stream banks;
- presence, size and integrity of dams and their water levels, as well as;
- standing water levels and water quality in groundwater bores.

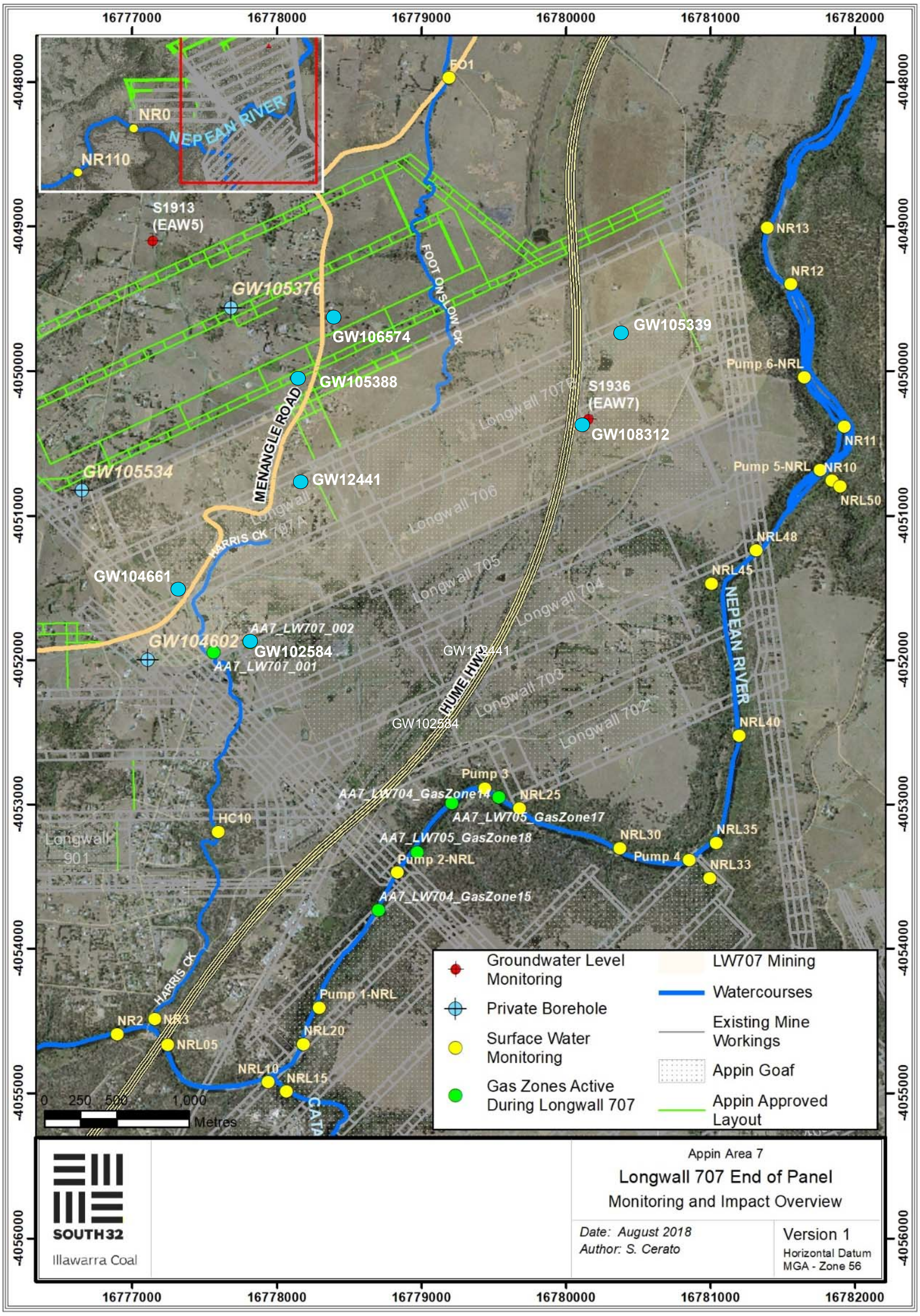


Figure 1 Area 7 Surface Water and Groundwater Monitoring Locations

2. GENERAL DESCRIPTION

2.1 Mine Layout and Progression

Appin Colliery extracted coal by mining Longwalls 701 to 707 to the south of the current Longwall 708.

Longwall 707 commenced on 7th January 2016 and was completed on 19th June 2018 as outlined in **Table 1**, with mining progressing up-dip in the Bulli Seam.

Table 1 Longwall Extraction Details

Longwall	Start	Finish	Width (m)	Length (m)	Depth of Cover (m)
701	27/10/2007	09/05/2008	315	527	500 - 515
702	18/09/2008	20/04/2009	313	973	490 - 535
703	22/10/2009	03/03/2011	313	2,326	505 - 555
704	7/05/2011	29/07/2012	313	2,316	490 - 595
705	7/09/2012	27/03/2014	313	2,828	510 - 600
706	23/04/2014	28/11/2015	313	3,044	500 - 615
707A	07/01/2016	16/08/2016	313	1,035	475 - 600
707B	26/09/2016	19/06/2018	313	2,070	475 - 600

Extraction of Longwall 707A and 707B occurred from east to west, with the depth of cover increasing to the western end of the panel.

The longwall was subdivided into two sections due a block of coal left behind to avoid mining through a zone of geological structure.

Seam thickness varies from 2.8– 3.4 m, with 45 m wide chain pillars as shown in **Figure 1**.

2.2 Topography and Drainage

Area 7 is generally undulating on the plateau and is incised by the Nepean River gorge which can be up to 70 m high, with vertical cliff faces up to 30 m. The gorge is steep sided with sandstone cliffs and steep slopes.

The Nepean is part of the Hawkesbury-Nepean River system which originates in the uplands west of Wollongong and flows northward past Camden to its junction with the Warragamba River near Wallacia.

River water level in the study area is regulated by Menangle Weir, which is 4.8 km downstream, and Douglas Park Weir at 1.9 km upstream, of the Area 7 longwalls.

The weirs, which are outside the subsidence area of Longwalls 701 to 707, have transformed the natural free flowing regime of the river and have generated a sequence of stationary, regulated water bodies.

Water levels fall by 260 mm over the 14 km between Douglas Park and Menangle Weir.

The catchments overlying the subject longwalls comprise up to 2nd order streams draining from the plateau to the Nepean River which usually contain earthen wall farm dams which regulate runoff to the gorge.

Harris Creek drains to the Nepean River in the south and lies over Longwall 707, whilst Foot Onslow Creek headwaters also lie over Longwall 707, and drains north into the Nepean River.

2.2.1 Nepean Gorge and River Bed Geomorphology

The river has dissected the plateau, forming significant scarps and discrete cliffs on either side of the gorge.

Where the channel is close to the systematic joint direction, the cliff line is usually close to the channel. Cliffs are usually formed under competent sandstone which contain stratigraphically controlled cavernous zones with ephemeral seeps.

Sandy alluvium is dominantly located in the base of the gorge and on the alluvial flanks.

The Nepean River gorge increases from approximately 28 m to 46 m wide in the study area and the river is deeper where erosion is greatest at the outside of river bends.

The river generally becomes deeper with distance downstream with a depth range of less than 0.25 m over sand bars to over 8 m in deeper rock based pools (GeoTerra, 2005).

2.2.2 Harris Creek

The headwaters of Harris Creek overlie Longwall 707, and flows directly south-south west into the Nepean River, and it has been undermined by Longwall 707.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

No DPI-W registered water extraction is listed within the creek.

2.2.3 Foot Onslow Creek

The headwaters of Foot Onslow Creek overlie Longwall 707, and flows to the north into the Nepean River, and it also has been undermined by Longwall 707.

The stream bed and banks are generally well vegetated, and do not show significant erosion or bank instability.

No DPI-W registered water extraction is listed within the creek.

2.3 Streamflow and Water Levels

2.3.1 Nepean River Flow

The following section is an excerpt from Ecoengineers (2014).

Water flows in the Nepean River are derived from a number of sources, including;

- flows from catchment areas,
- flows from licensed discharges, including Appin Colliery and Tahmoor Colliery (the latter located adjacent to Bargo River), and
- stormwater runoff from agricultural and urban areas.

Excess flows from the Lake Nepean and Lake Avon catchment areas released over Pheasants Nest Weir contribute the majority of flows into the River.

The major tributaries upstream of Area 7 below Pheasants Nest Weir are the Bargo, Cordeaux and Cataract Rivers.

Minor amounts of water are directly drawn from the river by licensed water pumps and there are several of these close to Area 7 as shown in **Figure 1**. It is understood that the total of seven licensed extraction allocations adjacent to Area 7 is about 9 – 10 ML/day.

Runoff is also retained or retarded by small farm dams both within and outside the study area.

Flow varies greatly and is largely dependent on rainfall within the catchment. Regular monitoring is not conducted within the SMP area as it is difficult to measure flow in deep, wide channels, although river depths are measured.

The closest flow gauging station upstream of Appin Area 7 is at Maldon Weir, located approximately 14 km upriver from Longwall 705. The closest flow gauging station downstream of the SMP Area is Menangle Weir, located approximately 5 km downriver of Longwall 705.

Menangle Weir ensures that the River remains fully charged at all times, even when there is little flow in it.

The Maldon Weir has a nominal catchment of 865 km^2 when Water NSW is spilling water over Pheasants Nest Weir (about 25 km upriver of Longwall 705) on the Upper Nepean River. For the approximately 50 percentile (median) and lower flows, when Water NSW is not spilling water over Pheasants Nest Weir, the Maldon Weir catchment is comprised primarily of the Bargo River catchment (approx. 181 km^2).

Relatively consistent discharges to the Nepean River below Maldon Weir come from Stone Quarry Creek (Picton), Allen's Creek (Wilton), and the Cataract River over Broughton's Pass Weir, as well as irregular flow inputs from creeks such as Harris Creek, together with approximately 1 ML/day from Allen's Creek via the Appin West Pit Top licensed discharge (GeoTerra, 2006).

The flow at Menangle Weir is considered to be far more representative of flows adjacent to Area 7 than the flow rate at Maldon Weir but it is still biased by flows from tributaries in the River between Maldon and Menangle Weirs, the largest contributor of which is by far the Cataract River catchment below Broughton's Pass Weir but also including Water NSW releases and/or 'natural' spills over the Weir.

Measured daily mean water flows at Maldon, Menangle and Broughton's Pass Weirs have been provided by Water NSW up to 1st January 2016, however there are some gaps and lesser quality data in the record.

No data is available from Water NSW for the monitored sites after 1st January 2016.

Cessation of flow events have been recorded by Water NSW, which reflect periods where more water is extracted from the river than is supplied from upstream, with maximum falls below the weir spill point of 36 mm at Maldon Weir and 295 mm at Menangle Weir.

Subtraction of daily Maldon and Broughton's Pass Weir flows from Menangle Weir flows sometimes gave negative values either because of flow gauging errors or the effect of licensed extractions.

Water flows in the Nepean River:

- vary greatly and are highly responsive to rain events due to the significant areas of upriver catchment involved;
- reach very high levels during sustained storm events, while minimum flow is rarely likely to be less than 13 ML/day (approx. a 5 percentile flow at Menangle Weir);
- cease on a small number of occasions, usually only when the rate of pumping out of the river exceeds the rate of inflow under low flow/drought conditions; and
- are characterised by median flow rates in the Nepean River adjacent to Area 7 that are likely to be much higher than the median flow rate at Maldon Weir (33.01 ML/day), and about 15% less than median flow at Menangle Weir (105.4 ML/day).

Interpolation between Maldon and Menangle Weir post millennium drought flow records suggests a median (50 percentile) flow rate adjacent to Area 7 of roughly 86 ML/day.

Water levels along the Nepean River fall slightly from a point immediately downstream of Douglas Park Weir (RL 61.10 AHD) to a point immediately upstream of Menangle Weir (RL 60.84 AHD), which represents a gradual fall of approximately 260 mm over a length of approximately 14 km. This slight fall in water level most likely represents friction and head losses occurring along the river.

The bed profile changes considerably along the river's length and the river is typically between 2 m and 7 m deep.

The river is generally deeper where erosion is greatest on the outside of bends. It also becomes generally deeper as it travels downstream with a depth range from less than 0.25 m over sand bars to greater than 8 m in deeper rock based sections (GeoTerra, 2006).

The minimum river level between Douglas Park Weir and Menangle Weir is controlled by the spill height of Menangle Weir, which maintains the depth of water through extended dry periods, whilst rises of up to at least 9 m have been recorded at Maldon Weir after significant storms.

The maximum water level in the study area is not known due to the safety limitations of measuring during flood flow, however it is clear that extreme rainfall events result in large-scale flooding of the gorge.

2.4 Nepean River Water Chemistry

The following section is an excerpt from Ecoengineers (2014).

Baseline water qualities in the Nepean River, especially under the ecologically more critical low flow conditions (<50 percentile), are clearly dominated by the following processes:

- inputs of more acidic water from Cataract River;
- low flow inputs of more saline water from Harris, Elladale and Ousedale Creeks which have negligible to minor bulk effect on overall river salinity;
- consistent inputs of low DO water from Cataract River (and Elladale Creek) which is the primary driver of DO in the Nepean River immediately downstream of the Cataract River confluence;
- a relatively low rate of re-aeration downriver of the Cataract River confluence (the flooded geomorphology of the River is such that it has a low re-aeration coefficient adjacent to Area 7; and
- consistent inputs of Fe and Mn to the river from Cataract River and Elladale Creek.

Analysis of the baseline water quality database, including water quality analyses at depth, showed that the Nepean River near the confluence and downstream of Cataract River, typically exhibits distinctive temperature/dissolved oxygen (DO) stratification, and to a lesser degree, salinity stratification between surface and deeper waters.

Oxygen stratification is most apparent in summer months or during low flow periods when turbulent mixing is limited, with deeper stretches showing low to very low DO (Ecoengineers, 2014).

Past data also show that during dry weather, when conditions are warm and sunny and flows in the Nepean River remain relatively constant (due to controlled or no release from Maldon Weir), then pH values in the river may occasionally occur naturally in the 8.2 – 9.5 pH range. This applies particularly where the Nepean River passes through an area dominated by farmland and there are pre-existing nutrient inputs (total phosphorus and nitrogen) from fertilizing and livestock waste contaminating small catchments draining into the river.

These nutrient inputs were detected in the large number of sampling campaigns conducted since July 2002. They are especially evident from sites NR11 and others further downriver, especially following significant rain.

Algal primary productivity in river pools is maximized under those circumstances. Algae absorb dissolved CO_2 and bicarbonate ions from water and produce oxygen, thereby driving pH up (when CO_2 and bicarbonate ion concentrations decrease). It is common to observe pH levels in the river rising to maximal levels as high as 9.5 during warm, sunny conditions.

Runoff into the Nepean River is dominated by a Cumberland Plain (Lowlands) landscape dominated by a mixture of Hawkesbury Sandstone and Wianamatta Shale outcrops. Even taking into account the Appin West Colliery licensed discharge to Allen's Creek, salinity of the river water (expressed in Electrical Conductivity (EC) units) is unlikely to ever exceed 1000 µS/cm and chloride and sulfate ion concentrations are unlikely to frequently exceed about 20 mg/L and 100 mg/L, respectively.

In contrast, Elladale and Simpson Creeks arise in Cumberland Plain landscape almost exclusively dominated by Wianamatta Shale. These shale-derived soils are such that salinities in the middle and lower sections of these creeks frequently exceed 3000 µS/cm, and chloride and sulfate ion concentrations are likely to frequently exceed 500 mg/L and 20 mg/L respectively.

The salinity of waters discharged from these shale catchment creeks into the Nepean River is principally based upon the cation sodium (Na+) and the anion bicarbonate ($HCO3^-$).

The anion bicarbonate is the principal and most variable driver of salinity-based ecotoxicity in such waters. It is important to note that as the pH of the river water is lowered, the ratio of bicarbonate to carbonate anion concentrations (i.e. [$HCO3^-$]/[$CO3^{2-}$]) rises, causing ecotoxicity due to salinity alone to increase (per unit of salinity). Here decreased pH is due principally to inputs of dissolved Fe and Mn and their oxidation and precipitation as hydrous oxides, and/or the addition of dissolved CO_2 from exogenous sources such as CO_2 in decomposition of natural organic matter.

The Nepean River is a lowland river where the default EC trigger value in the NWQG is 2200 µS/cm (ANZECC/ARMCANZ, 2000a & b). This conclusion is based on:

- studies which have shown that below Bargo River, the river has long been affected not only by discharges from Bargo River, the township of Picton and from Appin West Colliery, but also by agricultural land uses; and the fact that
- large areas of the River catchment are dominated by Wianamatta Shale-derived soils, the Shale being a marine sediment (Hazelton and Tille, 1990). Such marine sediments continue to provide salinity to runoff and groundwater seepages (interflow, through-flow, etc.) up to the present day.

A number of tributaries of the Upper Nepean River naturally contribute relatively saline water to the River. For example, the long term mean salinity of lower Elladale Creek at site NR8 is 3028 ± 1763 µS/cm at the one standard deviation level. This catchment is largely mantled by Wianamatta Shale-derived soils and drains to Nepean River. The creek salinity is not only highly variable but most of the time significantly exceeds the default trigger value (2200 µS/cm) even for lowland rivers for south eastern Australia in the NWQG (ANZECC/ARMCANZ, 2000a & b).

2.5 Geology

The study area is underlain by the Hawkesbury Sandstone in the Nepean River gorge. The upper edge of the gorge contains the Ashfield Shale, whilst lithologies progressively further away from the gorge include the Minchinbury Sandstone and Bringelly Shales within the Wianamatta Group.

2.6 Soils

Soils in the study area catchment predominantly comprise the Hawkesbury Landscape (ha) in the Nepean River gorge and the Blacktown Landscape (bt) developed over sandstone basement (Hazelton, P.A,. and Tille, P.J 1990). The distribution of soil landscapes is illustrated in **Figure 2**.

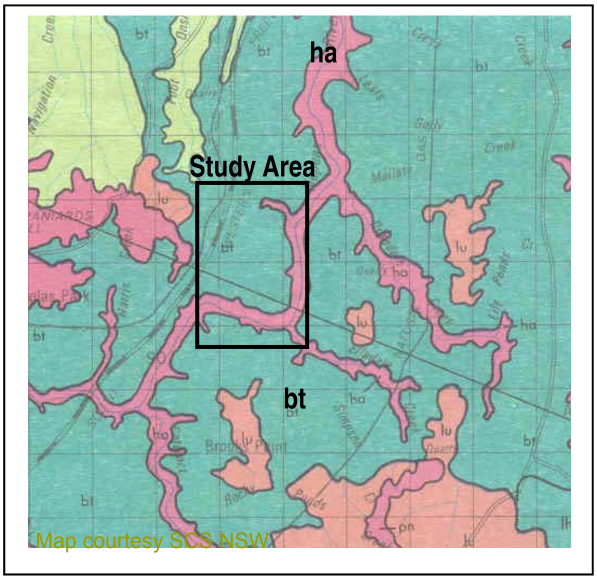


Figure 2 Area 7 Soil Landscapes

2.6.1 Hawkesbury Landscape

The Hawkesbury alluvial / colluvial landscape is developed primarily on Hawkesbury Sandstone within the Nepean River gorge. It has a local relief of 50-80 m, with slopes of 5-20%.

Crests and ridges are convex with moderately inclined to precipitous slopes. Valleys are narrow (20-100 m) and incised with common rock outcrops occurring as horizontal benches and broken scarps up to 10m high. Rock outcrops, surface boulders and cobbles cover up to 50% of the ground surface.

Ironstone fragments are present in the profile, which would be a source of dissolved iron into receiving streams.

2.6.2 Blacktown Landscape

The Blacktown residual landscape consists of gently undulating rises developed over Wianamatta Shale with local relief to 30 m and slopes <5%, with broad rounded crests and ridges with gently inclined slopes.

Shallow to moderately deep (<150 cm) red podzolic and brown podzolic soils develop on crests, upper slopes and well drained areas, with deep (<300 cm) yellow podzolic and soloths on lower slopes and drainage lines.

It is a shallow, low permeability soil with high erodibility, and is strongly acid with minimal exposed rock.

2.7 Hydrogeology

The Nepean River is a 'gaining' system, where groundwater flows from the plateau under a regional hydraulic gradient to the river, with groundwater flow being dominantly horizontal within confined flow along discrete layers that are underlain by fine grained or relatively impermeable strata.

The Hawkesbury Sandstone within the study area generally provides low-yielding aquifers with low hydraulic conductivities.

2.7.1 Surface Water / Groundwater Interaction

Surface water drainage on the plateau is mainly within ephemeral first and second order gullies and streams.

The smaller gullies generally discharge into the Nepean from elevated stream beds which cascade down the cliffs after sufficient rain, whilst the majority of rainfall in the small ephemeral catchments would infiltrate into the plateau soils.

Recharge to the groundwater system would occur over an extended delay after meteoric water has soaked through the plateau's soil, Wianamatta Shale and Hawkesbury Sandstone, with the majority of water discharging from temporary seeps in the cliff face due to the significantly preferential horizontal rather than vertical flow regime in the sandstone.

The predominantly horizontal flow regime and restricted vertical recharge is essentially determined by the;

- horizontally bedded strata under both sides of the plateau with preferential flow along bedded zones with coarser grain size;
- claystone/mudstone banding at the base and tops of sedimentary facies which restrict vertical migration and enhance horizontal flow at the base of the unit;
- fracture zones enhancing horizontal flow through the strata; and
- bedding planes or unconformities located immediately above finer grained sediments or iron rich zones.

DPI-W (ex DNR) data (GeoTerra, 2006) indicates that the shallowest aquifer was intersected during drilling over Longwall 703 at 116 m to 119 m below the plateau, whilst the shallowest aquifer was generally intersected between 40 m and 78 m below surface in the vicinity of Longwall 17.

The intersected aquifer depth is generally deeper than the standing water level, as once the aquifer is drilled through, the formation water generally tends to rise up the bore due to head pressure in the overlying strata. Accordingly, standing water levels monitored in the Illawarra Coal piezometers (GeoTerra, 2006) could be interpreted to show the intersected aquifers as being located above the base of the gorge, however the majority of aquifer intersections over the proposed mining area are below the relative height of the river.

As the Nepean River is the largest regional river in the catchment, all drainage from surrounding groundwater systems and tributary streams is toward the base of the gorge, with the river then flowing under gravity along the gorge to Menangle Weir, and subsequently along the Nepean River downstream of Warragamba Dam to the Hawkesbury River.

2.7.2 Private Bores and Colliery Piezometers

Eight open standpipe piezometers (NGW3, 4, 5, 6, 7, 9, 10 and 11) were installed by Illawarra Coal over, or in the vicinity of, Longwalls 701 – 703.

Groundwater level and water quality monitoring within the Hawkesbury Sandstone to 10m below the base of the Nepean River gorge began in June 2004 in the NGW suite of piezometers, with their details outlined in **Table 2**.

Due to the advancement of mining to the west, and the age of the installed equipment, no additional monitoring data was available for the NGW piezometer suite during Longwall 707 extraction, and they are therefore not discussed further in this assessment. Discussion of this suite is contained in (GeoTerra, 2016)

Fully cemented, sealed vibrating wire piezometer arrays were also installed by Illawarra Coal in bores EAW5 (S1913) and EAW7 (S1936) as shown in **Figure 1**.

Ten DPI-W registered private bores are located within the Longwall 701 - 707, 20 mm subsidence area as shown in **Figure 1** and **Table 2**:

- GW102584, 104602, 104661, 105339, 105376, 105388, 105534, 106574, 108312 and GW112441

All DPI-W registered private bores in the region are located on the western plateau of the Nepean River gorge. They were drilled between 70 – 294 m below surface, with water obtained primarily from sandstone aquifers, however some thin, perched horizons encountered water in the Wianamatta Shale (GW103161 at 17-18 m and GW104602 at 30 m).

Reported yields range up to 1.3L/sec from inflow zones ranging from 9 - 225 m below surface. DPI-W bore data within the Longwall 701 to 707 (20 mm) subsidence zone indicates regionally significant aquifers are generally intersected beneath 100 m below surface from sandstone aquifers.

According to available records, private bore groundwater intersections as shallow as 9 m may be present in perched aquifers with limited extent, as well as in limited, perched horizons within the Wianamatta Shale.

The actual intersected aquifer horizon is generally deeper than the measured piezometric surface of a bore because when a confined aquifer is drilled into, formation water rises up the bore due to a combination of lithostatic and hydrostatic pressures.

Based on this principle, and on assessment of the DPI-W data, the majority of aquifer intersections over the Longwall 701 to 707 mining area lie at or below the relative height of the Nepean River, even though the bore water levels may rise under pressure to higher elevations in a bore.

The piezometer and bore monitoring data has been used to determine the pre Longwall 707 baseline status and groundwater level and water quality variations within the regional Hawkesbury Sandstone aquifer to a maximum depth of 10 m below the relative level of the Nepean River bed.

Groundwater levels are logged hourly using vibrating wire piezometers in the EAW series piezometers and are downloaded at the completion of longwall panels (or as required).

Table 2 Private Bore and Sth32 Piezometer Summary

GW	N	E	SWL (m)	Depth (m)	Drilled	Aquifer	Lithology	YIELD (L/s)	EC (mg/L)	Purpose
Registered Bores in the Longwall 701 - 707 20mm subsidence area										
34425	6215425	289085	14.6	70	1972	9 – 69.4	sandstone	0.63	good	Waste disposal
101437	6216406	291651	75	128	1997	119 - 121	sandstone	0.7	2500	Farming
102584	6216445	289626	60	186	1999	54 – 60 64 - 70 108 – 112 144 – 150 177 - 179	sandstone	0.1 – 0.9	1300	Dom / Stock
104154	6216080	291240	74	165	2000	116 - 161	shale / sandstone	1.3	2200	Dom / Stock
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
105339	6218356	291919	-	238	2003	139 – 140 183 - 184	sandstone	0.25	-	Dom / Stock / Irrig
105388	6217892	289888	69	230	2002	104-104.1 191 – 191.2 219 – 219.2	Sandstone / shale	0.13	fresh	Dom / Stock
105534	6217297	288655	92	207	2003	113 – 113.1 161 – 161.1 188 – 188.1 197 – 197.1	sandstone	0.43	fresh	Dom / Stock
106574	6218350	290123	_	238	2002	115 – 116 133 - 134	sandstone	0.57	_	Domestic
108312	6217750	291534	84	175	2004	119 – 120 156 - 157	sandstone	0.16	500	Test
112441	6217284	289940	70	294	2010	113 – 113.1 136 – 136.05 140 – 140.05 225 – 225.01	sandstone	0.1	400	Dom / Stock
Sth32 Piezometers in the vicinity of Longwall 701 - 707										
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.
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	-	various	-	-	Monit.
EAW7	6217767.8	291547.3	various	556.1	2008	-	various	-	-	Monit.

Note: - no data available

3. MONITORING RESULTS AND DISCUSSION

3.1 Subsidence

The maximum monitored subsidence, tilt and strain following the completion of extraction of Longwall 707 is shown in **Table 3**.

Table 3 Maximum Subsidence at the Completion of Longwall 707

Component	Observed Total Movement	Subsidence Line Where Maximum Occurred
Vertical subsidence	1036 mm	Main Southern Railway
Tilt	7.7 mm/m	Moreton Park Road
Tensile / Compressive Strain	-1.6 / 6.0 mm/m	Hume Motorway / Main Southern Railway
Nepean Gorge Closure	182mm 65mm	NEPX-C Line after LW704 NEPX-Q Line after LW707B

Source: MSEC (2018)

3.2 Rainfall

Daily rainfall recorded at Douglas Park (St Marys Towers BOM Station 68200) since June 2004 is shown in **Figure 3**.

Mean annual potential evapotranspiration on the plateau averages around 1617 ±64 mm/year, whilst annual evapotranspiration is estimated at around 660 ±111 mm/year for the 2007 to 2013 period (Ecoengineers, 2014).

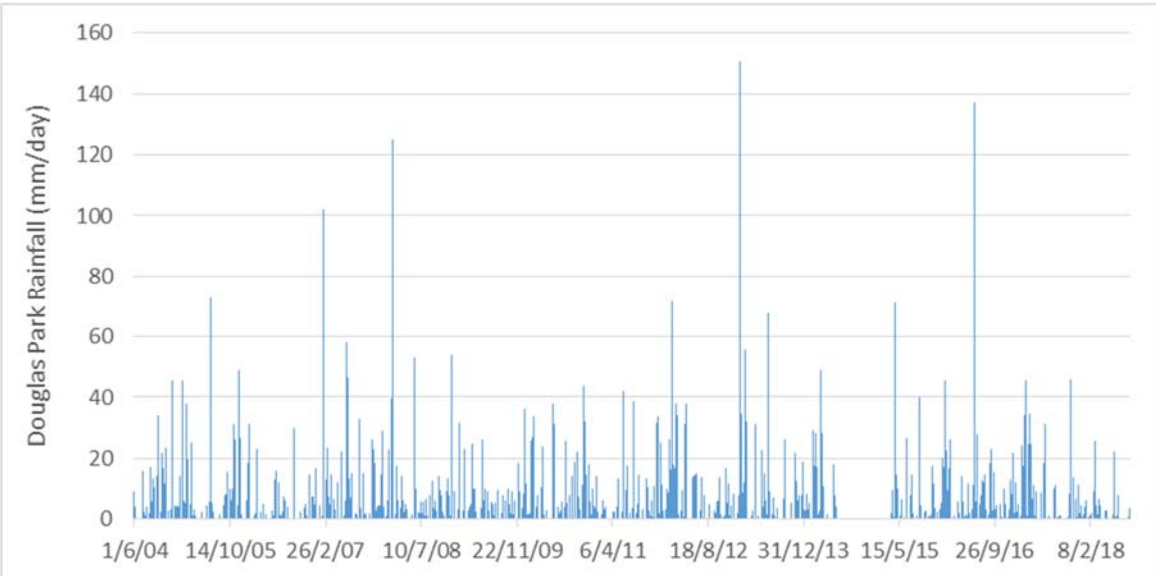


Figure 3 Douglas Park (St Marys Towers) Rainfall

3.3 Nepean River

Stream water level as well as field chemistry and laboratory analysis of river water samples has been conducted by the Illawarra Coal Environmental Field Team (ICEFT) in the Nepean River since July 2002 at sites shown in **Figure 1.**

3.3.1 Nepean River Height and Flow

River level with nail reference monitoring commenced in 2007 for the selected sites as shown in **Figure 4** at locations shown in **Figure 1**.

According to the Longwall 707 to 710 Environmental Management Plan Trigger Action Remediation Action Plan requirements, and focussing on the relevant sites for the extraction of Longwall 707, this report outlines the Nepean River monitoring sites Pump 5 – NRL, Pump 6 – NRL and NR13 / NRL13.

Pump 5 – NRL and Pump 6 are upstream, whilst NR13 / NRL13 is downstream of Longwall 707.

Based on the monitoring conducted by the ICEFT and, supported by **Figure 4,** there have been no periods in the Nepean River where dry and / or flooded areas of riverbed were observed during the extraction of Longwall 707.

During Longwall 707, no TARP trigger levels were attained for water level or flow in comparison to baseline observations and flows

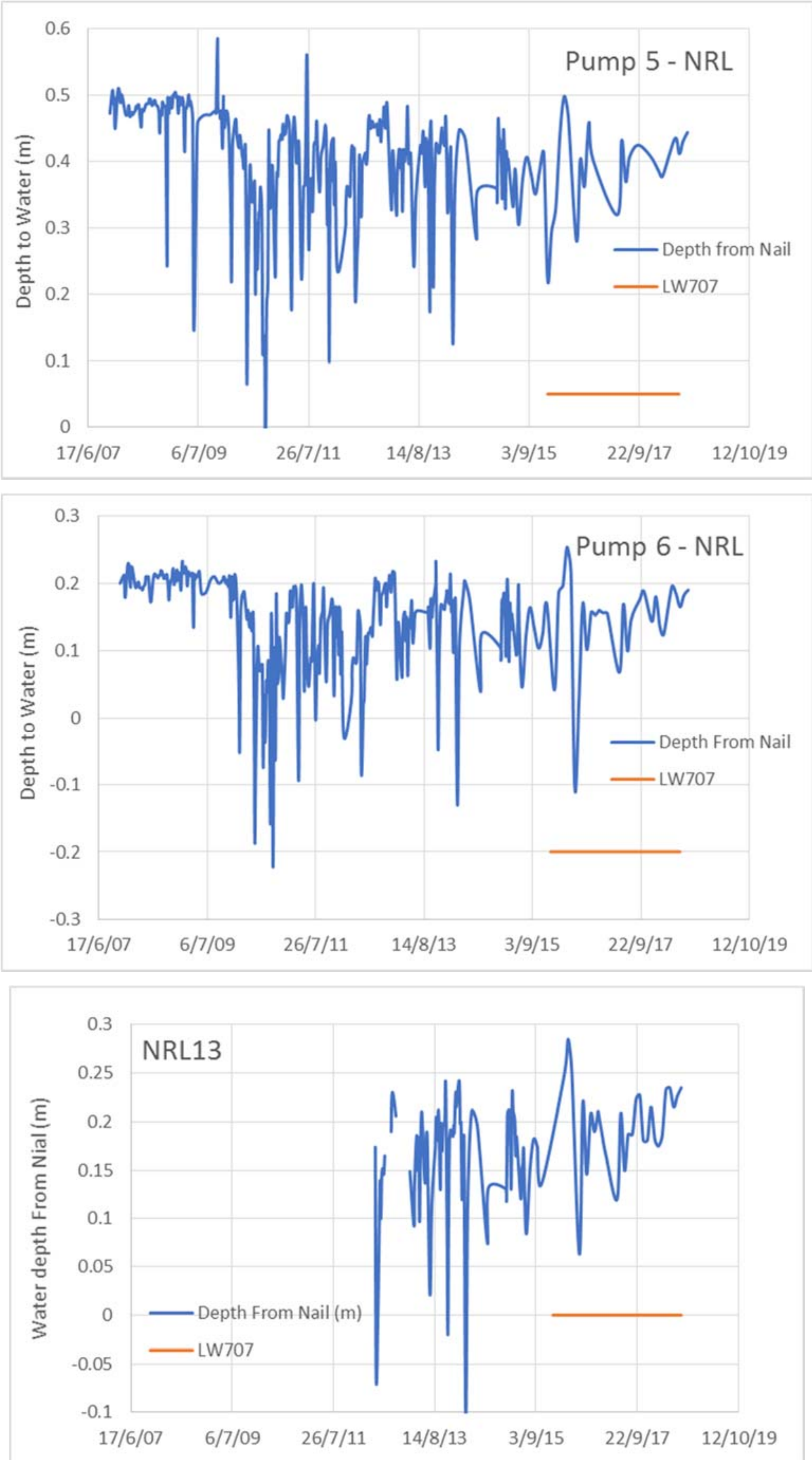


Figure 4 River Depth Monitoring at Selected Nail Reference Locations

3.3.2 Nepean River Pre Longwall 707 Water Quality Observations

Prior to extraction of Longwall 707, the Nepean River was observed to have undergone subsidence associated water chemistry effects (Ecoengineers, 2014) such as;

- Iron Stain Zone One in Elladale Creek, activated during the mining of Longwall 701, was short-lived in duration and no staining was observed after October 2009.
- Iron Stain Zone Two along the bank of the Nepean River currently comprises a spring with iron staining over an approximate 2 x 2 m area. No changes to this zone were observed over numerous monitoring visits during and since mining of Longwall 705.

3.3.3 Nepean River pH and Salinity

According to the Longwall 707 to 710 Environmental Management Plan Trigger Action Remediation Action Plan requirements, and focussing on the relevant sites for the extraction of Longwall 707, this report focusses on the Nepean River monitoring sites NR11 and NR13. NR11 is upstream, whilst NR13 is downstream of Longwall 707.

For the selected monitoring sites, based on historical data at the selected sites, the Nepean River has an EC and pH range as shown in **Table 4**.

For the period of extraction of Longwall 707, the trigger levels for a 1 and 2 standard deviation (compared to pre Longwall 707 mean) reduction in water quality for pH and salinity are also shown in **Table 4**.

Table 4 Nepean River Water Quality Statistics (pH and Salinity)

pH	NR11	NR13
Pre 707 mean	7.68	7.42
Pre 707 SD	0.39	0.34
1SD trigger	8.08	7.77
2SD trigger	8.47	8.11

EC	NR11	NR13
Pre 707 mean	302	178
Pre 707 SD	184	49
1SD trigger	487	227
2SD trigger	671	275

During the Longwall 707 extraction period, the Nepean River pH and salinity maintained a similar pre Longwall 707 variability, with no significant change to the observed ranges as a result of its extraction.

As shown in **Figures 5** and **6**, during the Longwall 707 extraction period, no significant change in trend or extended adverse changes occurred for pH and salinity.

During Longwall 707, no TARP trigger levels were attained for pH or salinity as the 2 standard deviation value reduction for pH or exceedance for EC at NR13 did not persist for longer than 2 months.

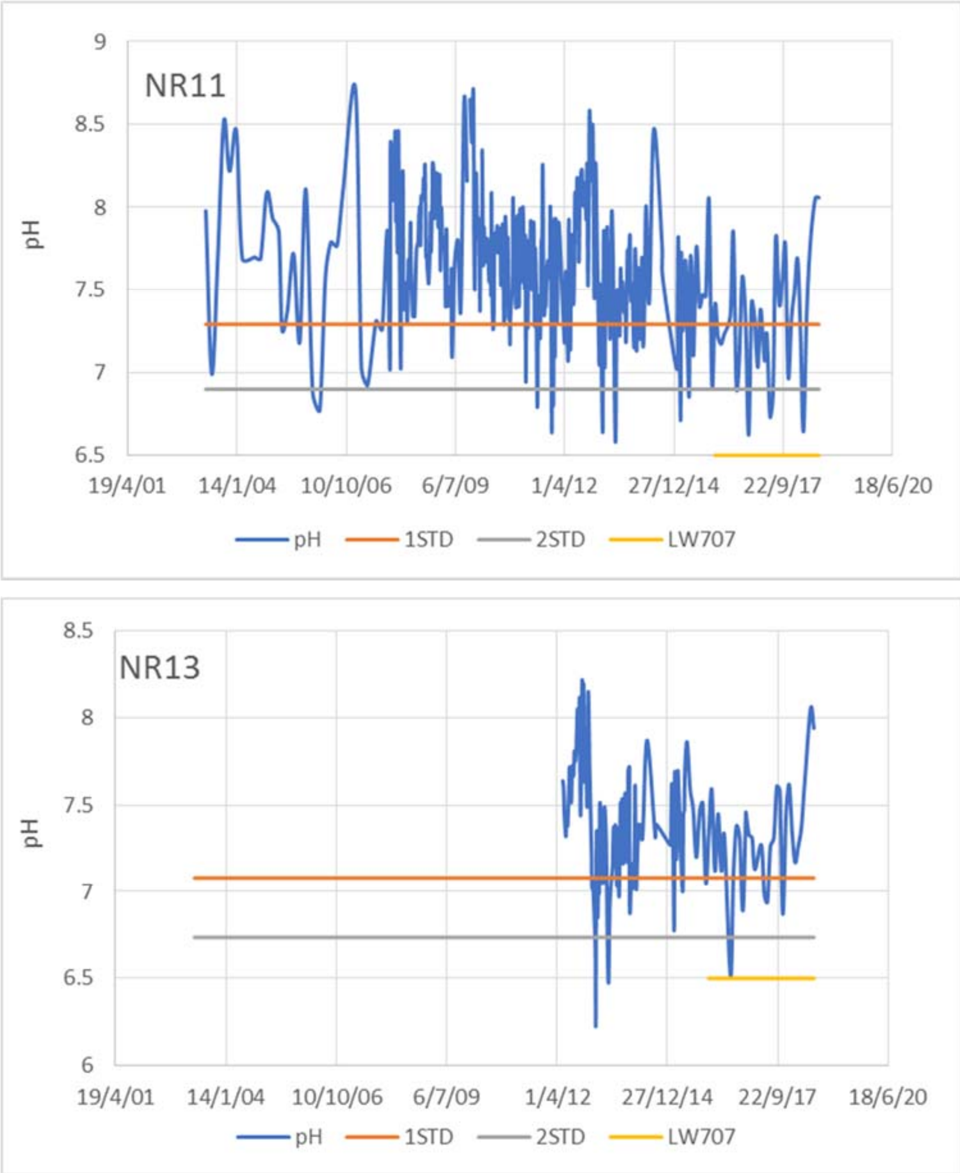


Figure 5 Nepean River pH

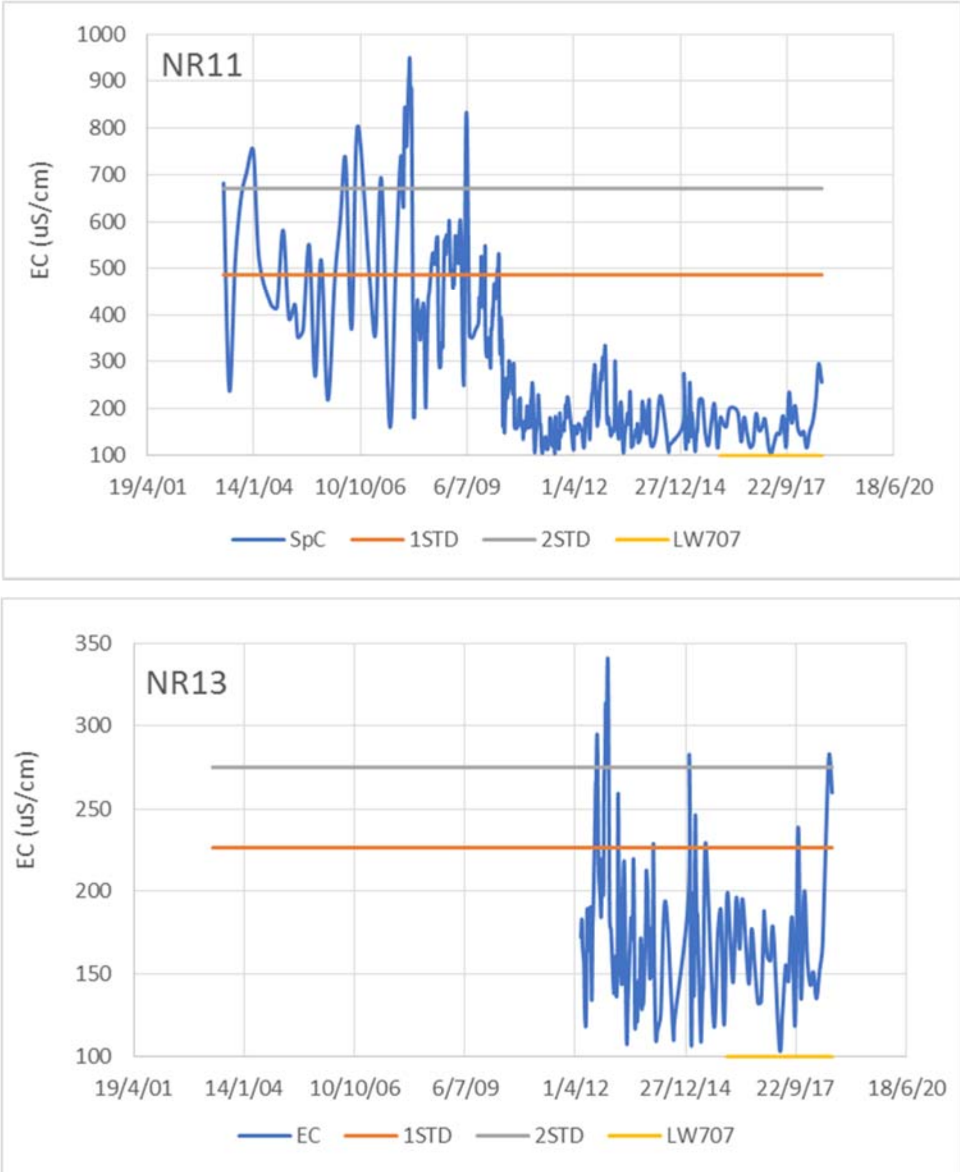


Figure 6 Nepean River Electrical Conductivity

3.3.4 Nepean River Dissolved Oxygen

For the selected monitoring sites, based on historical data at the selected sites, the Nepean River has a dissolved oxygen range as shown in **Table 5**.

For the period of extraction of Longwall 707, the trigger levels for a 1 and 2 standard deviation (compared to pre Longwall 707 mean) reduction in water quality for dissolved oxygen are also shown in **Table 5**.

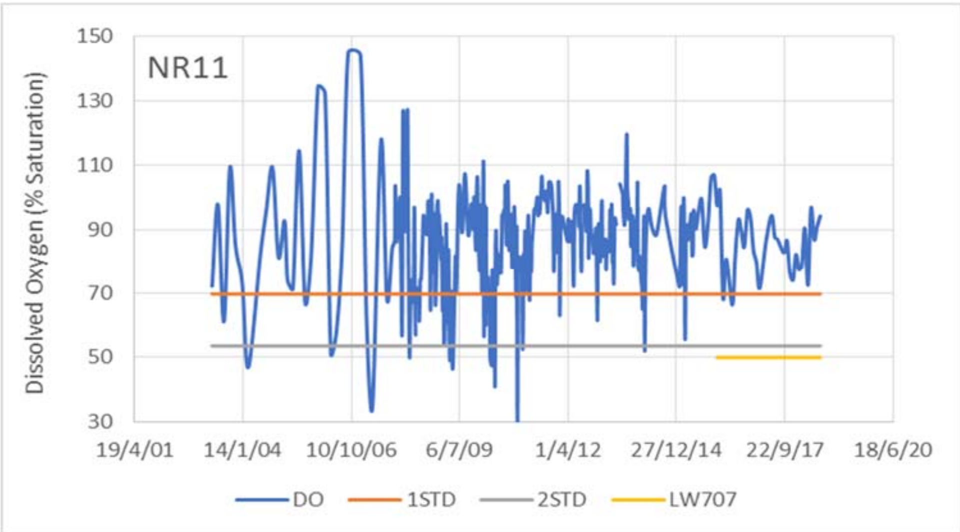
Table 5 Nepean River Water Quality Statistics (Dissolved Oxygen)

DO (% Sat'n)	NR11	NR13
Pre 707 mean	85.9	86.9
Pre 707 SD	16.1	13.5
1SD trigger	102.1	100.4
2SD trigger	118.2	113.9

During the Longwall 707 extraction period, the Nepean River dissolved oxygen maintained a similar pre Longwall 707 variability, with no significant change to the observed ranges as a result of its extraction.

As shown in **Figure 7**, during the Longwall 707 extraction period, no significant change in trend or extended adverse changes occurred for dissolved oxygen.

During Longwall 707, no TARP trigger levels were attained for dissolved oxygen.



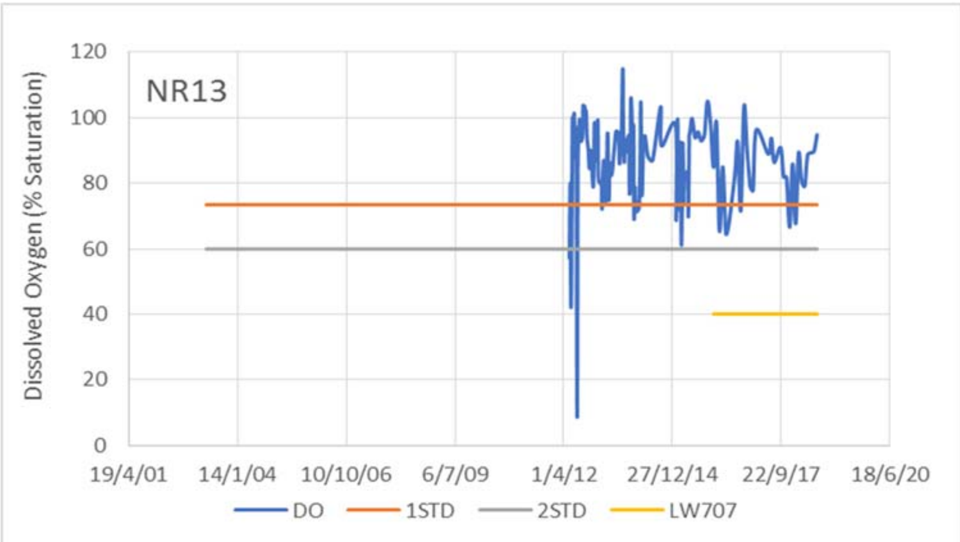


Figure 7 Nepean River Dissolved Oxygen

3.3.5 Nepean River Iron and Manganese

For the selected monitoring sites, based on historical data at the sites, the Nepean River has a total iron and manganese range as shown in **Tables 6** and **7**.

For the period of extraction of Longwall 707, the trigger levels for a 1 and 2 standard deviation (compared to pre Longwall 707 mean) reduction in water quality for iron and manganese are shown in **Tables 6** and **7**.

Table 6 Nepean River Water Quality Statistics (Iron)

Fe	NR11	NR13
Pre 707 mean	0.21	0.26
Pre 707 SD	0.14	0.09
1SD trigger	0.35	0.35
2SD trigger	0.49	0.44

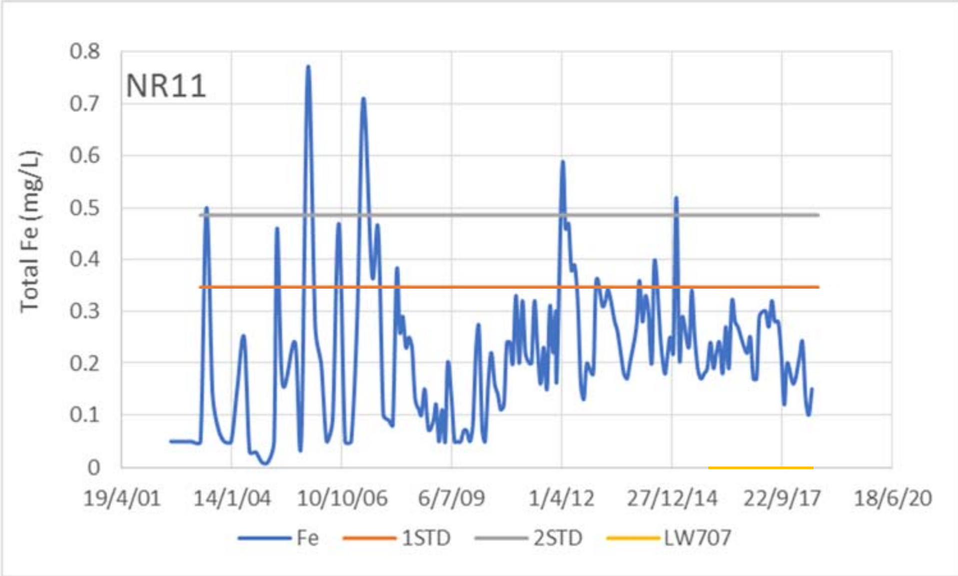
Table 7 Nepean River Water Quality Statistics (Manganese)

Mn	NR11	NR13
Pre 707 mean	0.017	0.016
Pre 707 SD	0.041	0.012
1SD trigger	0.059	0.028
2SD trigger	0.100	0.041

During the Longwall 707 extraction period, the Nepean River iron and manganese maintained a similar pre Longwall 707 variability, with no significant change to the observed ranges as a result of extraction of Longwall 707.

As shown in **Figures 8** and **9**, during the Longwall 707 extraction period, no significant change in trend or extended adverse changes occurred for iron and manganese.

During Longwall 707, no TARP trigger levels were attained for iron and manganese as both the iron and manganese 2 standard deviation exceedances that occurred at NR13 did not persist for more than 2 months.



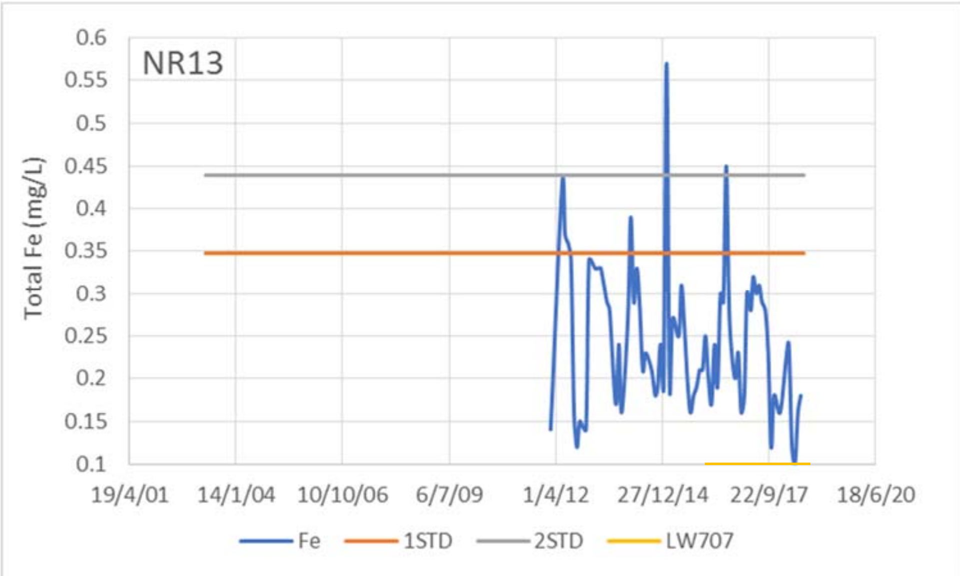


Figure 8 Nepean River Total Iron

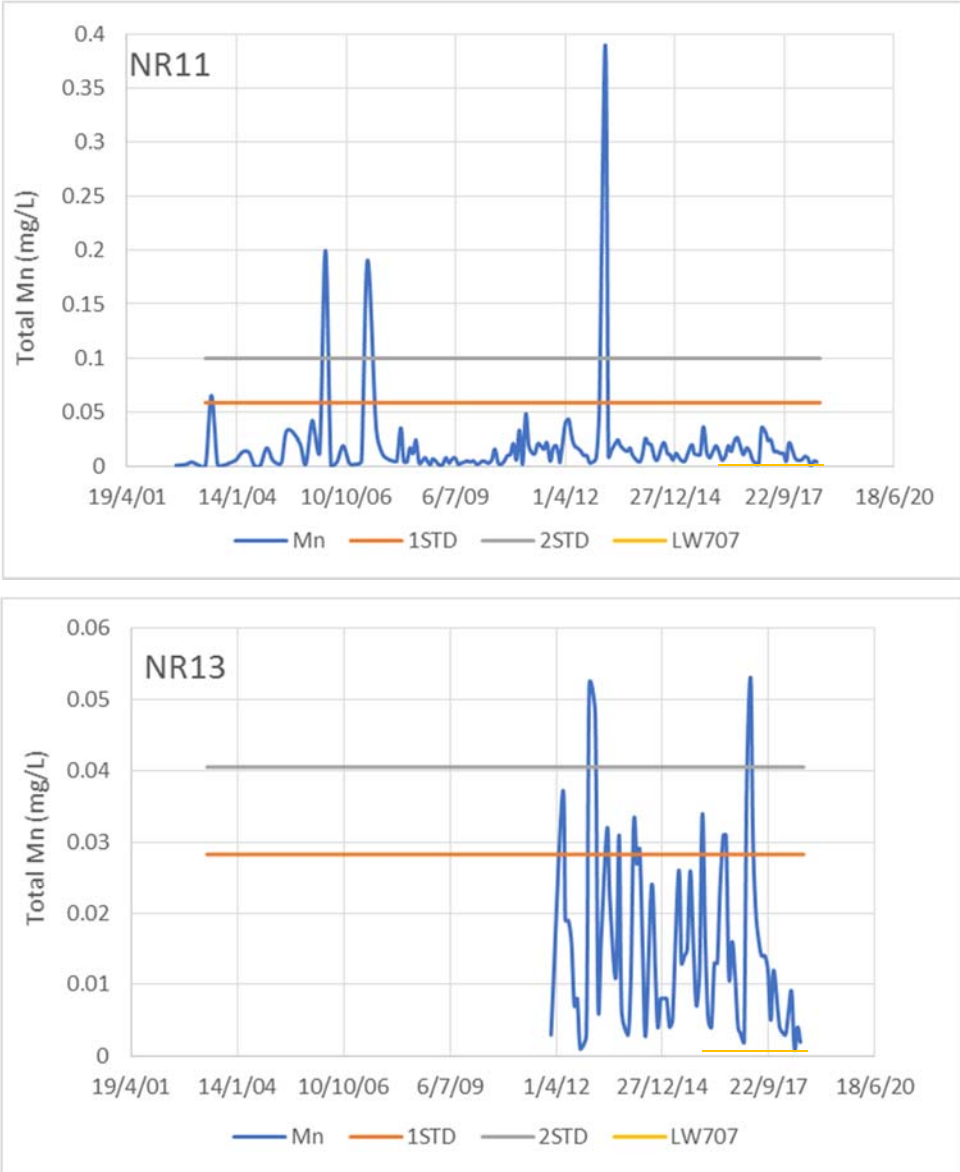


Figure 9 Nepean River Total Manganese

3.3.6 Gas Seeps in the Nepean River

Gas seepage was observed in the Nepean River prior to Longwall 707 extraction period at numerous locations in the Nepean River with three new gas zones (16, 17 and 18) identified during Longwall 705 extraction.

No new zones were observed during extraction of Longwall 707.

Only Zone 18 remained active at the end of the Longwall 705 extraction period. The highest gas zone flow rate was Zone 16, at an estimated rate of 200 L/min, which is a Level 1 Impact.

During Longwall 706 extraction, an area of four gas release sites in two 2 m x 1 m zones were observed approximately 6 m part, approximately 925 m upstream of Gas Zone 15 on 13th August 2014. The site overlaid the previously extracted Longwall 16 of the Tower Mine, which was extracted between October 1998 and August 1999. The ICEFT interpreted it as a re-activated gas release from the mining of Longwall 16.

At the time of inspection Gas Zones 5 and 14 were low intensity single point gas release sites.

Existing Gas Zones 14, 15, 17, 18 and *AA7_LW706_001* were active during the Longwall 707 extraction period, however they were activated by previous longwalls (704, 705 and 706).

The following Gas Zones were last observed to be active;

- Gas Zone 14 – 6th July 2016;
- Gas Zone 15 – 3rd December 2016;
- Gas Zone 17 – 29th August 2016;
- Gas Zone 18 – 17th July 2017, and;
- *AA7_LW706_001* - 18th January 2018.

No gas releases have been observed on the Nepean River as a result of Appin Area 7 since January 2018.

3.3.7 Dam or Private Property Gas Seeps

One new gas release was observed during extraction of Longwall 707.

Impact *AA7_LW707_001* consisted of four small gas releases observed in a private property dam E13d01 on the 6th April 2016. The gas release has since ceased.

During Longwall 707, no TARP trigger level exceedances for gas seepage in the Nepean River, private dams or bores were observed.

3.4 Groundwater

Monitoring has previously been conducted in the study area to document any observed impacts relating to the "NGW" piezometers to the north-west of the Nepean River gorge, as outlined in (GeoTerra, 2016).

The following private boreholes within the Longwall 702 to 707 subsidence area were monitored during the extraction of Longwall 707, or have previously been monitored:

- GW102584, 104602, 104661, 105339, 105376, 105388, 105534, 106574, 108312 and GW112441

As outlined in **Section 2.7**, monitoring of all NGW piezometers was sequentially discontinued, due to either land access issues or deterioration of the equipment prior to or during extraction of Longwall 706.

The observed effects during extraction of Longwall 707 are outlined in the following sections.

3.4.1 Aquifer / Aquitard Interconnection

No adverse interconnection of aquifers and aquitards has been observed within 20 m of the plateau surface and no increased rate of groundwater recharge into the plateau has been observed as a result of Longwall 702 - 707 extraction.

Strata fracturing, with associated bore displacement and reduction in bore water quality was previously observed in the private bores GW104154, GW101437 and GW102584 (GeoTerra, 2015).

No other strata dewatering or adverse aquifer / aquitard interconnections were observed during extraction of Longwall 707.

No TARP trigger levels related to aquifer / aquitard interconnection or changes in recharge have been reached or exceeded as a result of Longwall 707 extraction.

3.4.2 Groundwater Levels

Bore EAW5 [S1913] is located approximately 2.2 km north to northwest of Longwall 707.

Head declines linearly at EAW5 in the Hawkesbury Sandstone and there is a clear difference in the behaviour of groundwater pressures above and below the Bald Hill Claystone as shown in **Figure 10**.

This is evidence of the contiguous nature of the claystone across the Appin Area 7 region, and evidence of the pre-mining separation between shallow and deep aquifer heads.

Within the upper Bulgo Sandstone the heads become artesian (at or above ground level), except for a slightly lower head in the Bulli Seam. The vertical profiles between the September 2008 and June 2012 data are quite consistent, although the Bulli Seam water level rose from September 2008 to June 2012 to an artesian level, unlike the September 2008 data, which is sub-artesian (HydroSimulations, 2013).

The EAW5 water levels showed a notable change in the water level trend with depressurisation evident in the;

- Hawkesbury Sandstone (Piezo 1, 2 and 3).
- Scarborough Sandstone (Piezo 7 and 9), and previously in the;
- Bulli Seam.

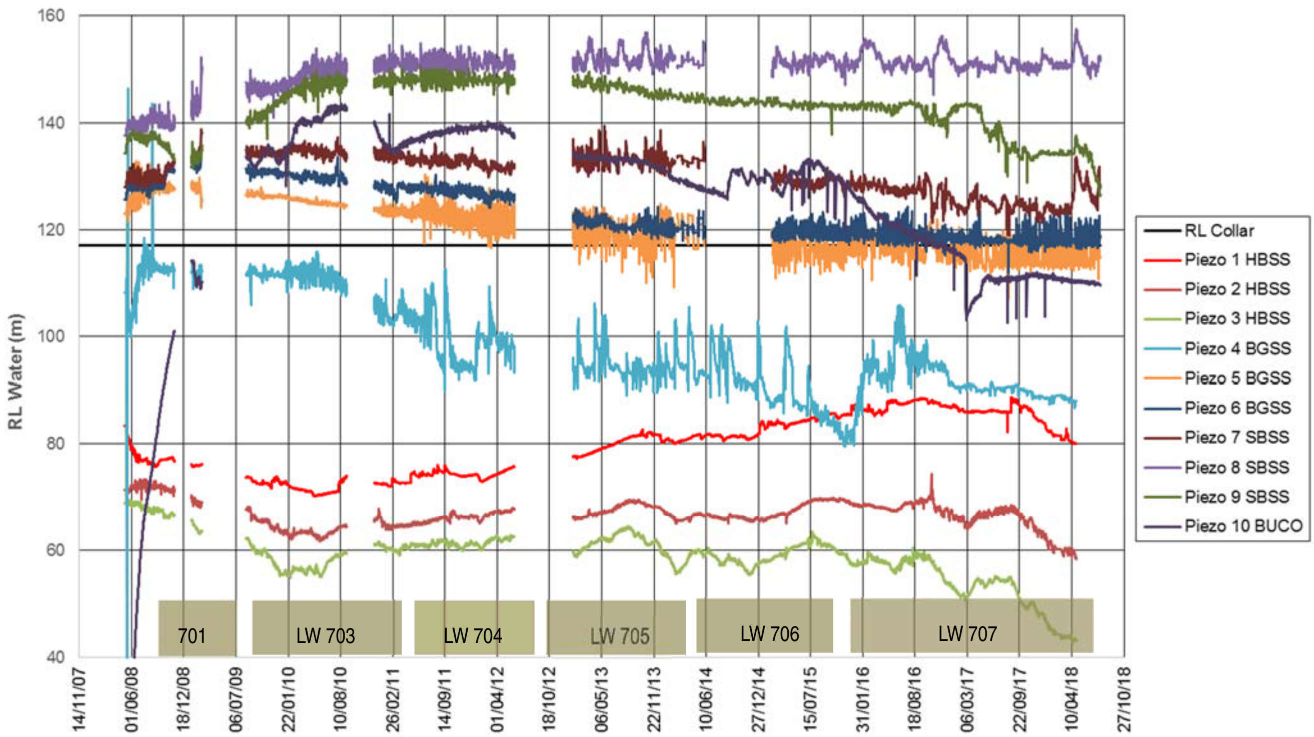


Figure 10 EAW5 Water Levels

EAW7 (S1936) is located over Longwall 707.

The deeper heads are sub-artesian at EAW7, although were generally higher than the Hawkesbury Sandstone levels at June 2012 and lower at June 2013.

The head profile patterns at June 2012 and June 2013 are similar, although there is clearly more variation between 2009, 2012 and 2013 in the deeper water levels than in the Hawkesbury Sandstone. For example, within the Bulgo Sandstone, there was a decline in levels of about 6 – 17 m between June 2012 and June 2013 in the middle and lower Bulgo Sandstone respectively as shown in **Figure 11**.

The decline was greater at around 30 m in the Scarborough Sandstone, which is a clear mining effect due to Longwall 705. There is minimal difference in the lower Hawkesbury Sandstone water levels between 2012 and 2013 and no change was observed in the upper Hawkesbury Sandstone (HydroSimulations, 2013).

A definitive sharp fall in water levels occurred around late April 2014 in the Scarborough Sandstone at 456.2, 462.1 and 468 mbgl, along with a continued enhanced reduction in water levels in the Bulgo Sandstone at 347.8 and 422.5 mbgl and a distinctive pressure reduction in the Bulli Seam since the start of monitoring.

The Bulli Seam intake stopped recording data around June 2012, whilst all other intakes, except for the 65 m deep Hawkesbury Sandstone monitor, stopped recording data between July and August 2014.

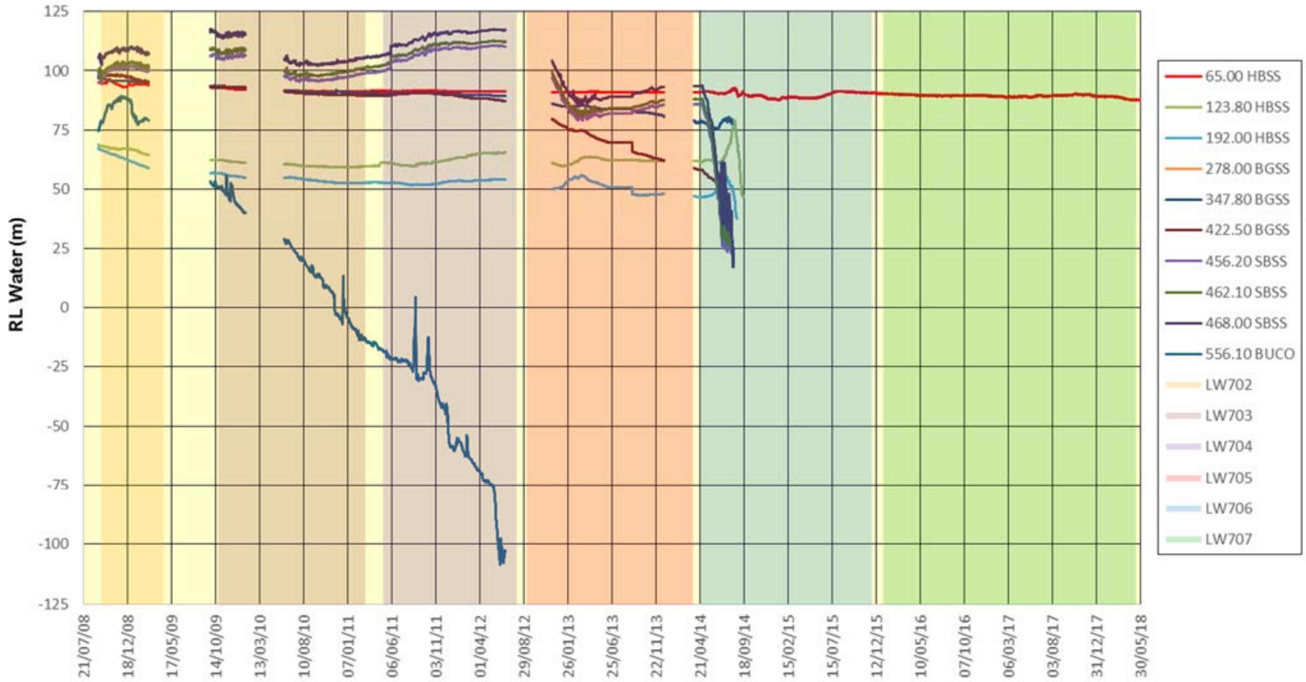


Figure 11 EAW7 Water Levels

No groundwater level reduction TARP triggers were exceeded during extraction of Longwall 707 in any private bores and no changes outside of predictions for the VWP monitoring bores occurred.

3.4.3 Well Yield and Bore Serviceability

Bore GW105388, which is located approximately 500m from the Appin Colliery Longwall 707, was reported to have been affected by adverse impacts to the longevity of pumping times on 14th December 2016. This impacted on the serviceability of the bore as the pumping duration was reduced due to subsidence effects.

No adverse effect on bore yield was reported.

South 32 have been supplying trucked tank water to the landholder since March 2017.

Outside of the gas seepage effect discussed in Section 3.4.5, no well yield or bore serviceability TARP triggers were exceeded during or following the extraction of Longwall 707.

3.4.4 Groundwater Quality

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 – 458 mg/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 729 µS/cm, and its pH has reduced from 7.5 to 7.0.

No monitoring of the NGW piezometers groundwater quality occurred during extraction of Longwall 707. A summary of the sampled private bore water chemistry is contained in **Appendix A**.

No groundwater quality TARP triggers were exceeded during or following the extraction of Longwall 707.

3.4.5 Gas Seepage

Monitoring by ICEFT of GW112441 during Longwall 707 extraction on 15/07/2015, identified water cloudiness and a gaseous smell in the extracted bore water, with laboratory analysis confirming the presence of methane, along with lesser ethane, propane, butane and other hydrocarbons. Laboratory analysis indicated no post-Longwall 707 change to pH, salinity or metals.

The landowner ceased to use the bore and the area around the wellhead was fenced off and a 10,000 Litre tank was provided by Sth32-IC for livestock watering, which is topped up as required by Illawarra Coal.

At this stage, a replacement bore is planned to be drilled after completion of Longwall 708 unless an alternative arrangement is agreed to by the landowner.

One additional report of an adverse effect involving a gas release and increased iron staining, titled as site impact *AA7_LW707_002*, was observed in GW102584 on 22nd April 2016. The bore was capped on the 22nd June 2016 during extraction of Longwall 707.

No bore water quality TARP triggers were exceeded during or after the extraction of Longwall 707 as there are no specified criteria for bore water gaseous emissions.

3.4.6 Private Bore Inspections

Five private property inspections were conducted during and before extraction of Longwall 707 to assess the baseline status and potential subsidence impacts on private bores, where requested by landowners.

Three properties have no observed impact (GW101986, 105376 and 105534), one property had a confirmed impact of increased iron staining and gas discharge in the bore water (GW102584) and one possible impact of decreased bore pressure and yield was reported by a landowner (GW104602).

Subsidence impacts, where present, are summarised in **Table 8**.

The full property reports can be viewed as outlined in the references within Section 5.0.

Table 8 Private Bore Inspections

Borehole ID	Observation	Subsidence Impact Status
GW101986	No observed changes	No Impact
GW102584	Iron staining, gas odour and bubbling reported by landowner	Confirmed Impact
GW104602	Decrease in flow pressure and yield reported by landowner	Possible
GW105376	No observed changes	No Impact
GW105534	No observed changes	No Impact

3.4.7 Mine Workings Inflow

Daily mine groundwater inflow data for the Appin Area 7 workings are available between 31st July 2017 and 30th May 2018.

In that time, with the available data, the mine groundwater make did not reach or exceed any TARP trigger levels as shown in **Figure 12**.

No increased groundwater inflow to the Appin mine workings following extraction of Longwall 707, compared to the previous longwall periods, has occurred, and no TARP trigger levels have been reached or exceeded, based on statutory inspection data as shown in ***Figure 12****.*

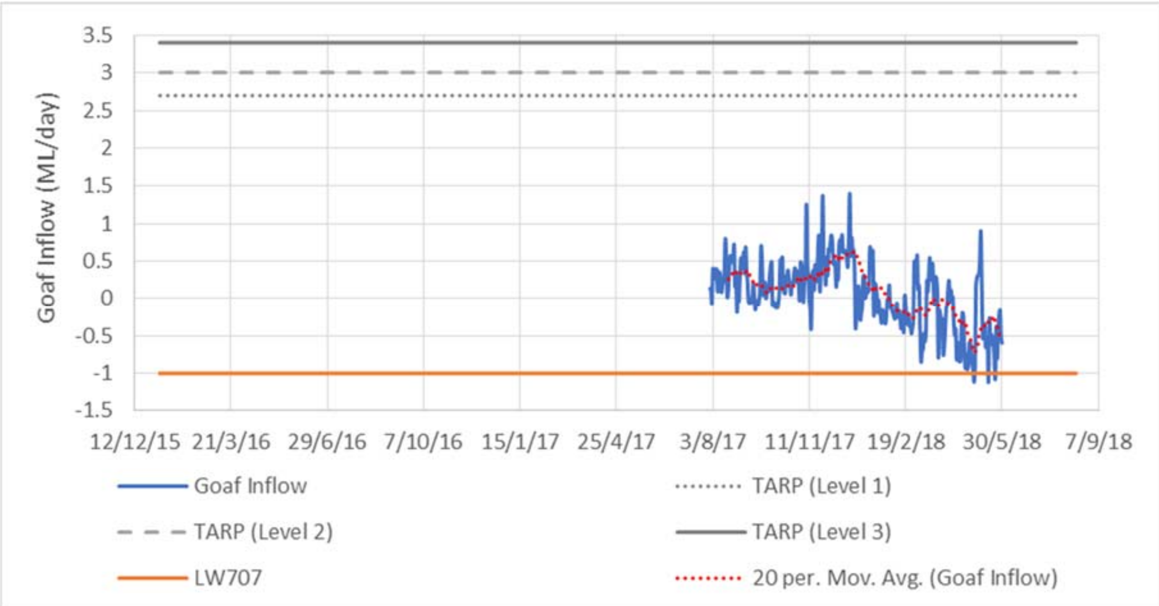


Figure 12 Appin Mine Groundwater Inflow

4. CONCLUSIONS

Based on monitoring of the Nepean River, plateau streams, dams and groundwater conducted prior to, during and after extraction of Longwall 707, the following conclusions can be made:

- No significant stream bed cracking, or associated with a reduction in stream flow and pool desiccation has been observed in the plateau streams;
- No observable loss, diversion of water, flooding or dry reaches were observed in the Nepean River;
- Emissions from Gas Zones 14, 15, 17, 18 and *AA7_LW706_001 ceased on or before* 18th of January 2018, with no associated reduction in dissolved oxygen due to microbiological consumption of oxygen observed;
- No new ferruginous springs were observed in the Nepean River;
- Significant depressurisation of the Bulli Seam, Scarborough Sandstone and lower Bulgo Sandstone has been observed in the vibrating wire piezometer bore EAW7 that overlies Longwall 706, and to a lesser degree, in EAW5;
- Impact *AA7_LW707_001* consisted of a small gas release zone to dam E13d01 on Lot 8 DP804133. A post Longwall 707 inspection indicated the gas release had ceased;
- Impact *AA7_LW707_002* consisted of gas release from borehole GW102584. Iron staining was also observed in water extracted from the bore. The bore was capped on 22nd June 2016.
- Bore GW105388 was reported to have been affected by an adverse impact to the longevity of pumping times on 14th December 2016. No adverse effect on bore yield was reported. South 32 have been supplying trucked tank water since March 2017.

5. REFERENCES

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South 32, 2018G Longwall 707 Post Mining Property Inspection, Lot 900, DP1072947

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Mine Subsidence Engineering Consultants, 2008 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 at Appin Colliery in Support of the SMP Application

Mine Subsidence Engineering Consultants, 2011 Appin Colliery Longwall 703 End of Panel Subsidence Monitoring Report For Appin Longwall 703

Mine Subsidence Engineering Consultants, 2012 End of Panel Subsidence Monitoring Report For Appin Longwall 704

Mine Subsidence Engineering Consultants, 2014 End of Panel Subsidence Monitoring Report For Appin Longwall 705

Mine Subsidence Engineering Consultants, 2018 End of Panel Subsidence Monitoring Report For Appin Longwall 707

LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between GeoTerra Pty Ltd (GeoTerra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the client's requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

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The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of GeoTerra.

APPENDIX A
Private Bore Water Quality

Parameter	ANZECC 2000 Livestock Drinking Water (mg/L)	GW101986 Pre LW707 22/02/2018	GW101986 Post LW707 06/08/2018
EC (uS/cm)		5650	3570
TDS	2000 (poultry) 5000 (sheep)	2900	1900
pH		7.76	7.34
Total Alkalinity as CaCO3		722	612
Hydroxide Alkalinity as CaCO3		<1	<1
Bicarbonate Alkalinity as CaCO3		722	612
Carbonate Alkalinity as CaCO3		<1	<1
Chloride		1460	804
Dissolved Sodium		879	453
Dissolved Calcium	1000	118	144
Dissolved Magnesium	2000	122	80
Dissolved Potassium		29	12
Dissolved Sulfate as SO4 2-	1000	47	28
Sulfate as SO4 - Turbidimetric	1000		
Total Aluminium	5	<0.01	<0.01
Dissolved Aluminium	5	<0.01	<0.01
Dissolved Arsenic	0.5	<0.001	
Dissolved Barium			0.298
Dissolved Bromine		3	
Dissolved Copper	0.4 (sheep) 5 (poultry)	0.001	<0.001
Dissolved Iodine		<0.1	
Total Iron		0.29	0.82
Dissolved Iron		0.14	0.72
Dissolved Lead	0.1	<0.001	
Dissolved Lithium			0.134
Total Manganese		0.007	0.006
Dissolved Manganese		0.008	0.008
Dissolved Nickel	1	<0.001	<0.001
Dissolved Selenium	0.02	<0.01	
Dissolved Silicon			4.27
Dissolved Strontium			2.7
Dissolved Zinc	20	0.011	0.008
Total Nitrogen as N			
Ammonia as N		1.76	1.67
Nitrate as N	400		
Nitrite as N	30		
Nitrite + Nitrate as N		0.12	0.06
Total Kjeldahl Nitrogen as N		1.6	1.7
Total Phosphorus as P		<0.01	<0.01
Reactive Phosphorus as P		<0.01	<0.01
Dissolved Organic Carbon		2	10

Parameter	ANZECC 2000 Livestock Drinking Water (mg/L)	GW102584 Baseline 11/10/2013	GW102584 Post LW705 14/05/2014	GW102584 Post LW706 07/03/2016	GW102584 Post LW706 22/04/2016
EC (uS/cm)		3990	4010	3770	3970
TDS	2000 (poultry) 5000 (sheep)	2300	1960	2060	2040
pH		7.5	7.17	7.61	7.53
Total Alkalinity as CaCO3		651	823	728	685
Hydroxide Alkalinity as CaCO3		<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3		651	823	728	685
Carbonate Alkalinity as CaCO3		<1	<1	<1	<1
Chloride		856	777	777	851
Dissolved Sodium		450	430	457	491
Dissolved Calcium	1000	150	163	121	139
Dissolved Magnesium	2000	148	152	139	155
Dissolved Potassium		13	16	11	12
Dissolved Sulfate as SO4 2-	1000	84	62		
Sulfate as SO4 - Turbidimetric	1000			49	33
Total Aluminium	5	<0.01	0.11	0.02	0.02
Dissolved Aluminium	5	0.02	<0.01	<0.01	<0.01
Dissolved Arsenic	0.5	<0.001	<0.001	0.004	0.003
Dissolved Bromine		2.1	2	2	2
Dissolved Copper	0.4 (sheep) 5 (poultry)	<0.001	<0.001	<0.001	<0.001
Dissolved Iodine		<0.1	<0.1	<0.1	<0.1
Total Iron		<0.05	0.92	7.26	9.18
Dissolved Iron		<0.05	0.57	6.56	8.33
Dissolved Lead	0.1	<0.001	<0.001	<0.001	<0.001
Total Manganese		0.151	0.252	1.07	1.6
Dissolved Manganese		0.147	0.239	1.09	1.53
Dissolved Nickel	1	0.002	0.002	0.003	0.002
Dissolved Selenium	0.02	<0.01	<0.01	<0.01	<0.01
Dissolved Zinc	20	0.059	0.011	0.008	<0.005
Total Nitrogen as N				0.3	0.3
Ammonia as N		0.35	0.6	0.26	0.24
Nitrate as N	400			0.03	0.01
Nitrite as N	30			<0.01	<0.01
Nitrite + Nitrate as N		0.05	<0.01	0.03	0.01
Total Kjeldahl Nitrogen as N		0.5	0.8	0.3	0.3
Total Phosphorus as P		<0.01	<0.01	0.02	<0.01
Reactive Phosphorus as P		<0.01	<0.01	0.01	<0.01
Dissolved Organic Carbon		9	4	2	4

	ANZECC 2000	GW102584 Holding Tank	GW102584 Holding Tank
	Livestock	Post LW706	Post LW706
Parameter	**Drinking Water (mg/L)**	**07/03/2016**	**22/04/2016**
EC (uS/cm)		3730	3810
TDS	2000 (poultry) 5000 (sheep)	2010	1890
pH		7.79	7.58
Total Alkalinity as CaCO3		685	683
Hydroxide Alkalinity as CaCO3		<1	<1
Bicarbonate Alkalinity as CaCO3		685	683
Carbonate Alkalinity as CaCO3		<1	<1
Chloride		767	815
Dissolved Sodium		476	482
Dissolved Calcium	1000	108	126
Dissolved Magnesium	2000	143	146
Dissolved Potassium		11	12
Sulfate as SO4 - Turbidimetric	1000	54	33
Total Aluminium	5	<0.01	0.02
Dissolved Aluminium	5	<0.01	<0.01
Dissolved Arsenic	0.5	<0.001	<0.001
Dissolved Bromine		2	1.9
Dissolved Copper	0.4 (sheep) 5 (poultry)	<0.001	<0.001
Dissolved Iodine		<0.1	<0.1
Total Iron		1.75	1.75
Dissolved Iron		1.29	0.07
Dissolved Lead	0.1	<0.001	<0.001
Total Manganese		1.12	1.4
Dissolved Manganese		1.05	1.22
Dissolved Nickel	1	0.003	0.003
Dissolved Selenium	0.02	<0.01	<0.01
Dissolved Zinc	20	<0.005	<0.005
Total Nitrogen as N		0.3	0.3
Ammonia as N		0.17	0.2
Nitrate as N	400	0.02	0.01
Nitrite as N	30	<0.01	<0.01
Nitrite + Nitrate as N		0.02	0.01
Total Kjeldahl Nitrogen as N		0.3	0.3
Total Phosphorus as P		0.02	<0.01
Reactive Phosphorus as P		0.01	<0.01
Dissolved Organic Carbon		2	26

	ANZECC 2000	GW104602
	Livestock	
Parameter	**Drinking Water (mg/L)**	**16/04/2018**
EC (uS/cm)		1700
TDS	2000 (poultry) 5000 (sheep)	954
pH		7.79
Total Alkalinity as CaCO3		461
Hydroxide Alkalinity as CaCO3		<1
Bicarbonate Alkalinity as CaCO3		461
Carbonate Alkalinity as CaCO3		<1
Chloride		327
Dissolved Sodium		206
Dissolved Calcium	1000	87
Dissolved Magnesium	2000	40
Dissolved Potassium		10
Dissolved Sulfate as SO4 2-	1000	8
Sulfate as SO4 - Turbidimetric	1000	-
Total Aluminium	5	<0.01
Dissolved Aluminium	5	<0.01
Dissolved Arsenic	0.5	<0.001
Dissolved Bromine		0.5
Dissolved Copper	0.4 (sheep) 5 (poultry)	<0.001
Dissolved Iodine		<0.1
Total Iron		0.14
Dissolved Iron		0.1
Dissolved Lead	0.1	<0.001
Total Manganese		0.048
Dissolved Manganese		0.05
Dissolved Nickel	1	<0.001
Dissolved Selenium	0.02	<0.01
Dissolved Zinc	20	<0.005
Ammonia as N		0.76
Nitrate as N	400	-
Nitrite as N	30	-
Nitrite + Nitrate as N		0.22
Total Kjeldahl Nitrogen as N		0.8
Total Phosphorus as P		<0.01
Reactive Phosphorus as P		<0.01
Dissolved Organic Carbon		3

	ANZECC 2000	GW105376	GW105376
	Livestock	Pre LW707	Post LW707
Parameter	**Drinking Water (mg/L)**		**25/07/2018**
EC (uS/cm)		2280	3070
TDS	2000 (poultry) 5000 (sheep)	1100	
pH		7.87	7.66
Total Alkalinity as CaCO3		486	646
Hydroxide Alkalinity as CaCO3		<1	<1
Bicarbonate Alkalinity as CaCO3		486	646
Carbonate Alkalinity as CaCO3		<1	<1
Chloride		485	716
Dissolved Sodium		275	393
Dissolved Calcium	1000	101	104
Dissolved Magnesium	2000	46	64
Dissolved Potassium		10	10
Dissolved Sulfate as SO4 2-	1000	13	17
Total Aluminium	5	<0.01	0.02
Dissolved Aluminium	5	<0.01	<0.01
Dissolved Arsenic	0.5	<0.001	<0.001
Dissolved Barium			1.06
Dissolved Bromine		0.7	
Dissolved Copper	0.4 (sheep) 5 (poultry)	0.005	<0.001
Dissolved Iodine		<0.1	
Total Iron		0.13	0.39
Dissolved Iron		0.07	0.37
Dissolved Lead	0.1	<0.001	<0.001
Dissolved Lithium			0.11
Total Manganese		0.03	0.023
Dissolved Manganese		0.031	0.02
Dissolved Nickel	1	<0.001	<0.001
Dissolved Selenium	0.02	<0.01	
Dissolved Silicon			4.11
Dissolved Strontium			1.98
Dissolved Zinc	20	0.008	<0.005
Total Nitrogen as N		-	-
Ammonia as N		0.94	1.35
Nitrate as N	400	-	-
Nitrite as N	30	-	-
Nitrite + Nitrate as N		0.15	0.03
Total Kjeldahl Nitrogen as N		0.9	1.4
Total Phosphorus as P		0.03	0.04
Reactive Phosphorus as P		<0.01	<0.01
Dissolved Organic Carbon		1	2

	ANZECC 2000	GW105534	GW105534
	Livestock	Pre LW707	Post LW707
Parameter	**Drinking Water (mg/L)**	**23/08/2017**	**25/07/2018**
EC (uS/cm)		3170	2530
TDS	2000 (poultry) 5000 (sheep)		
pH		7.47	7.84
Total Alkalinity as CaCO3		691	624
Hydroxide Alkalinity as CaCO3		<1	<1
Bicarbonate Alkalinity as CaCO3		691	624
Carbonate Alkalinity as CaCO3		<1	<1
Chloride		721	527
Dissolved Sodium		438	352
Dissolved Calcium	1000	131	111
Dissolved Magnesium	2000	69	53
Dissolved Potassium		13	12
Dissolved Sulfate as SO4 2-	1000	25	38
Total Aluminium	5	0.02	<0.01
Dissolved Aluminium	5		<0.01
Dissolved Arsenic	0.5		<0.001
Dissolved Barium			1.04
Dissolved Copper	0.4 (sheep) 5 (poultry)	<0.001	<0.001
Total Iron		1.15	1.52
Dissolved Iron			1.18
Dissolved Lead	0.1		<0.001
Dissolved Lithium			0.094
Total Manganese		0.012	0.015
Dissolved Manganese			0.014
Dissolved Nickel	1	<0.001	<0.001
Dissolved Silicon		4.17	4.71
Dissolved Strontium			1.72
Dissolved Zinc	20	<0.005	<0.005
Total Nitrogen as N		-	-
Ammonia as N		1.87	1.33
Nitrate as N	400	-	-
Nitrite as N	30	-	-
Nitrite + Nitrate as N		0.01	0.04
Total Kjeldahl Nitrogen as N		1.9	1.4
Total Phosphorus as P		0.01	<0.01
Reactive Phosphorus as P		<0.01	<0.01
Dissolved Organic Carbon		1	3