CS ENERGY LTD

Kogan Creek Power Station and Mine
Triennial Groundwater Monitoring Review

November 2019

ENVIRONMENTAL MANAGEMENT STRATEGIES

A. B. N. 68 732 302 155

FINAL

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EXECUTIVE SUMMARY

Environmental Management Strategies (EMS) has been engaged by CS Energy Ltd to undertake a review of the groundwater monitoring program for Kogan Creek Power Station (PS) and Kogan Creek Mine near Brigalow, Queensland.

The aim of the review is to satisfy the requirement for an interpretive report under the Department of Environment Protection (DEHP) (now Department of Environment and Science) Permit BRID0033 Condition C7 (v) Groundwater and Condition (E2) (iv) Ash Disposal Management, which requires monitoring and assessment by a groundwater expert every three years. This report covers the three year period up to June 2019 and is the third such review with previous reviews covering three year periods to September 2013 and October 2016.

Whilst not specifically required for the power station and mine approval conditions, this report also assesses groundwater conditions from the groundwater elevation and quality data collected at these locations, to provide a sub-regional view of groundwater conditions in the mine/power station area. This additional assessment aids in the overall interpretation required for the permit.

The key groundwater management considerations at the mine/power station are:

- potential impacts of Out of Pit Ash Cell (OPAC)
- impact of mine pit on groundwater elevations;
- potential for groundwater seepage from the Initial Ash Disposal Area (IADA).

Key Findings

In the 3 year period under review, the Kogan area has had lower rainfalls than in the previous six year period following the 2010/2011 la Nina event.

Groundwater Flow at Mine and Power Station

Groundwater flow conditions in the vicinity of the site are thought to be complex, given the site's location relative to the course of the Condamine River and within the Surat Basin. The Springbok Sandstone and Walloon Coal Measures may discharge to the Condamine Alluvium in the vicinity of the mine. Regionally, to the south west, groundwater in the Springbok Sandstone and Walloon Coal Measures is likely to flow in a more south-westerly direction in the general direction of the dip of the strata.

Groundwater elevation data collection commenced in 2007 and the data set has been collated and interpreted as part of the review. The inferred groundwater flow directions in the vicinity of the power station/mine complex are:

- Condamine Creek alluvium: north and east towards the river depending on bore location. Potentially some influence of drainage towards the mine pit;
- Kogan and Eastern Branch Creek alluvium: to north (in direction of creek flow). Potentially some influence of drainage towards the mine pit; and
- Springbok Sandstone. Uncertain but possibly locally towards the mine and sub-regionally northwest to northeast. Connectivity with Walloon Coal Measures may exist in some areas
- Walloon Coal Measures. Locally towards the mine pit and sub-regionally towards the northeast with discharge to the Condamine River alluvium.

Bore water elevations can be influenced by a number of factors including:

- Extent to which groundwater adjacent to bore is under pressure;
- Extent and depth of monitoring horizon in a particular borehole. (Is the borehole measuring groundwater pressure at a particular point or providing an averaging effect over a thickness of geological strata that may contain groundwater at different elevations (eg coal seams);
- Geological formation being monitored and degree of aquifer “connectivity” ie horizontal and vertical hydraulic conductivity;
- Influence of recent recharge events; and
- Influence of mine depressurisation/dewatering or other groundwater extraction activities.

Highest heads are observed in most alluvial bores either to the north or east of the OPAC and upgradient Walloons bore MB27 located on elevated strata to the east of the mine. Lowest heads are observed in depressurized Walloon and inferred Springbok strata proximal to the mine.

Over the three year period the following general trends have been observed:

- Small declines in level (<0.25 m) in Condamine Alluvium bores such as MB1, MB2, KC1276, KC1277, KC1278 due to the lower than average rainfall conditions

- Either small declines in level from <0.5 m or slight increase (<0.15 m) in Springbok Sandstone bores such as MB9, MB10-R, MB16, MB17-R, MB18

- Groundwater levels have stabilised and in some cases increased in bores in the mine area that had previously declined which had been inferred to be as a result of mine depressurisation of the Walloon Coal Measures (MB25, MB29, MB30, KC1273-R). It is not clear at this time why groundwater pressures are increasing.

- Elsewhere pressures in Walloon Coal Measures bores are relatively stable with minor fluctuations (eg due to barometric pressure, earth tides) (MB24-R, MB26, MB27).

In the mine area, several bores have reported declining water elevations which are indicative of aquifer depressurisation/dewatering due to open pit development. Pressure declines have been observed in alluvial material in Kogan Ck at bore MB4, and in bores that intersect sedimentary strata (either Springbok or Walloons Coal Measures strata) on the northern, southern and western sides of the mine pit. This indicates that a depressurised zone has developed around the pit and may have extended as far as bore MB20 which is approximately 460 m to the west of the pit on the western side of Kogan Creek.

There is no evidence of shallow seepage emanating from the IADA. Bores that have intersected the regional water table approximately 20 to 25 m below ground surface show no influence of groundwater mounding from potential seepage through the floor of the IADA.

There is no evidence of OPAC ash disposal activities influencing water elevations in adjacent monitoring bores.

Groundwater Quality

Groundwater quality monitoring between 2016 and 2019 in the vicinity of IADA, mine and OPAC in general has shown similar concentrations to previous years.

Groundwater salinities and major salt concentrations in sandstones inferred to overlie Walloon Coal Measures rocks are highly saline and the inferred groundwater flow conditions may suggest that groundwater discharge zones may exist in the local area.

Groundwater quality data from the mine area in 1993 (pre-mining) indicates that water quality was moderately saline (2190–12800 mg/L) with neutral–alkaline pH (7 to 7.9) although a sample of “in-seam water” recorded a pH of 4.2.

IADA

Groundwater with elevated salinity (as electrical conductivity (EC) 5500–32000 µS/cm) is found in sandstones (inferred to be Springbok Sandstone) underlying the IADA and along the Paddy’s Gully drainage line.

The IADA is constructed on local alluvial sediments and the sandstone that is above the Walloon Coal Measures. The ground surface within the IADA footprint was compacted to meet EA requirements. The storage commenced operations with power generation in mid-2007 and ceased active ashing in early 2011.

Water quality monitoring of the pond in the IADA has shown that the water quality in the cell storage pond since December 2010 has been slightly alkaline, of low to moderate salinity and influenced by rainfall/evaporation. Salinity and major salt concentrations initially decreased since ashing ceased, however increased after May 2016 due to the transfer of OPAC water for enhanced evaporation. Salinity subsequently declined to pre-2016 levels in 2018..

There is no evidence that seepage from the IADA to monitoring bores has occurred to date. The presence of seepage would be likely indicated by:

- Continued presence of IADA water in shallow KG –series bores;
- Increase in potentiometric surface head in deep groundwater monitoring bores; and
- Initial groundwater salinity decrease in deep monitoring bores with reduced concentrations of key ions such as sodium and chloride.

OPAC

Over the review period, water quality in the OPAC. has been generally less saline than prior to 2016 whilst pH has been predominantly around 12

Detailed OPAC bubble investigations were completed in 2017 with a final report submitted to DES in January 2018. The investigations included the expansion of groundwater monitoring to include monitoring of groundwater pressure and water quality in deposited ash, within OPAC embankment and subgrade materials and in shallow groundwaters around the OPAC.

A detailed assessment of groundwater quality data in OPAC monitoring bores has been completed.

Based on the available groundwater monitoring data and field inspections, there is no evidence that seepage has left the OPAC facility ie has moved beyond the OPAC external footprint. Specifically, there is:

- No visible seepage around the outer toe of OPAC walls from the October 2018 dam surveillance monitoring.
- No evidence of ash water in environmental monitoring bores around the toe of the OPAC.

Groundwater Quality Exceedances – Ash Disposal EA

Groundwater contaminant trigger elevations were originally developed from groundwater quality data collected over the period 2007 to 2010. These data were used to amend the Ash Disposal Development Approval (SPDE 0494 7312) which was re-issued in December 2012 and more recently in September 2017 as BRID0033.. The background data indicated that mean concentrations of monitoring parameters can vary significantly (>10%) from bore to bore, depending on aquifer type and localised recharge/permeability conditions e.g. mean Cl concentrations of approximately 71 mg/L in bore MB2 compared with 24,540 mg/L in MB4. Based on the results of the analysis and the requirement for reporting to the regulator when trigger values are exceeded, it was proposed that trigger values be established from the existing range of results, with the exception of pH. pH trigger values were established as 6.5 – 8 for bores in Condamine Alluvium and Walloon Coal Measures as this is the pH range for most natural freshwater (ANZECC, 2000). A range of 6 - 8 pH units was used for Springbok Sandstone groundwaters.

For the review period, a number of out-of-range values have been measured for pH, EC, Na, Cl, SO4, Zn in various boreholes in various formations.

Trigger value exceedances generally fall into the following categories:

- Anomalous readings due to limited water availability in bores and possible influence of tree roots and foreign matter on water quality;
- Numerous measurements for zinc which were below the lower trigger value due to a reduction in the 'limit of reporting' by the laboratory;
- Zinc concentrations above trigger elevations in several bores;
- Differences in water quality in replacement boreholes compared to original bores;
- Values that fall outside the range of trigger values that were developed from the limited data sets that were available when the DA was amended in 2012.

There is no evidence that any exceedances have caused or could potentially cause environmental harm or are a consequence of the Power Station, Mine or Ash Disposal activities.

A recommended range of modified trigger values are shown below in Table E1 and capture the values that have been observed and which are not considered to represent environmental harm. The basis for the revised trigger values is that they more accurately reflect the "normal" range of these groundwater parameters for this area.

The observed elevated zinc values are considered anomalous and accordingly the upper ranges of zinc trigger values have not been modified.

Table E1 Revised Groundwater Trigger Values

	Contaminant Range Alluvium	**Contaminant Range Springbok**	**Contaminant Range Walloon Coal Measures**
pH_{lab}	6 – 8.2*	6 – 8.5*	6.5 – 8.5*
Electrical conductivity (EC)	280 - 1400	10000* – 31000*	1000* – 15000*
Sodium	50 - 300	2500 - 6000	300 – 2500*
Chloride	10* – 400	4000 - 10000	100 – 4000*
Sulphate	<1* – 80	50* – 1000*	<1 - 250
Zinc	<0.0005* - 0.3	<0.001* – 0.4	<0.001* - 0.4
Aluminium	<0.01 - 0.15	<0.01 - 0.3	<0.01 - 0.04

*modified values

1.0 INTRODUCTION

EMS has been engaged by CS Energy Ltd to review groundwater monitoring data on a triennial basis for Kogan Creek Power Station (PS) and Kogan Creek Coal Mine near Chinchilla, Queensland (Figure 1). This report covers the period of October 2016 to March 2019 (Report Period). Previous reports were prepared by EMS for the period September 2010 to September 2013 (EMS,2013) and subsequently September 2013 to September 2016 (2016 Report).

The aim of the review is to satisfy the requirement for the interpretive report required under the EHP Ash Disposal Permit BRID0033 (Condition C7 (v) Groundwater and Condition (E2) (iv) Ash Disposal Management), which requires monitoring and assessment by a groundwater expert every three years.

Whilst not specifically required for the power station and mine approval conditions, the report also assesses groundwater elevation and quality data collected at these locations to provide a sub-regional view of groundwater conditions in the mine/power station area. This additional assessment aids in the overall interpretation required for the permit.

1.1 Structure Of This Report And Key Terms

This report follows on from the 2016 Triennial Report. It covers in some details the analysis from the 2016 to 2019 period to compare with the findings from the 2016 Report. However, for further details the reader should refer to the 2016 Report and the OPAC Bubble Investigation Final Report (EMS, 2018).

The report is structured in the following way:

- Section 2 provides a summary of Environmental Authority groundwater requirements.
- Sections 3 – 6 outline geographic, climatic, geological and relevant hydrogeological information of the project.
- Sections 7 - 9 summarise the groundwater monitoring programs and provide an interpretation of data collected to date.
- Section 10 presents a summary of groundwater exceedance assessment. Further details are provided in Appendix A, which contains two reports that provide an assessment of groundwater quality data for the periods December 2016 to September 2017 and December 2017 to November 2018 from regulatory monitoring bores in the vicinity of the Kogan Creek Coal Mine and Ash Disposal Areas.

Throughout this 2019 Report, various abbreviations and acronyms are used. These are defined throughout the report, however, for ease of reference they are summarised below.

ABBREVIATION	MEANING
2016 Report	The second triennial interpretive report dated November 2016 issued by EMS for CS Energy as required by the EHP Permit
2019 Report	This report dated September 2019 issued by EMS covering the Report Period as required by the EHP Permit
DERM/EHP/DES	(former) Department of Resource Management and Department of Environment and Heritage Protection now Department of Environment and Science
EHP Permit	EHP Permit BRID0033 Condition C7 (v) Groundwater and Condition (E2) (iv) Ash Disposal Management
DNRM	Department of Natural Resources and Mining
DO	Dissolved oxygen
EMS	Environmental Management Strategies
IADA	Initial Ash Disposal Area
OPAC	Out of Pit Ash Cell
IPAC	In Pit Ash Cell
Report Period	October 2016 to June 2019

1.2 Background

The power station/coal mine complex site is located about 23 km south-east of Chinchilla on the southern margin of the Condamine River Valley in southeast Queensland (Figure 1). The Warrego Highway is approximately 8 km north of the site.

The mine is an open-cut coal mining operation in the Walloon Coal Measures that supplies around 2.8 million tonnes per annum of thermal coal to the adjacent Kogan Creek Power Station.

There are a number of solid waste disposal, wastewater, process water and stormwater storages at the mine and power station sites that need to be considered with respect to their potential to leak and generate leachates which could have the potential to cause environmental harm.

These include:

- Mine pit and related water management structures
- The Out of Pit Ash Cell (OPAC) constructed in mine spoil at the Kogan Creek Mine
- The In-Pit Ash Cell (IPAC) constructed in mine spoil in a back-filled area of the Kogan Creek Mine
- Power station ash disposal facilities and water management storages including:
  - Initial ash disposal area;
  - Drains reclaim dam;
  - Stormwater dams;
  - Short-term excess or boiler clean wastewater pond – potential for leakage via holes or tears in liner;
  - Fuel and chemical storage areas; and
  - Raw bore water storages.

Figure 1 Location Plan

The Kogan Creek site lies within the catchment of the Condamine River, which forms a part of the Queensland Murray Darling Basin, and consequently salinity management is an important issue. Town water supplies for Chinchilla are drawn from the Condamine River at the Chinchilla Weir downstream of the site.

Geologically, the site overlies sedimentary rock strata of the Surat Basin which is part of the Great Artesian Basin and an important water resource. The site lies within the Surat Basin Coal Seam Gas Cumulative Impact Zone established by the Office of Groundwater Impact Assessment (OGIA) for the Queensland Government. The OGIA has developed a regional groundwater model of the Surat Basin as a tool to manage and mitigate potential impacts on groundwater users of CSG industry groundwater abstractions from the Walloon Coal Measures.

2.0 OPERATING APPROVALS OVERVIEW

Initially three project approvals were in place for the power station/mine complex:

Applicant Aberdare Collieries Proprietary Limited		
DA IPDE00173405A11	27/07/05	Focus on ash cells at mine
EA MIM800345805	29/07/05	Covers other aspects of mine operations
Applicant Kogan Creek Power Station Proprietary Limited		
Amalgamated Permit ENCD00281405	05/03/07	Power Station site

Amendments to development approvals for the mine, ash disposal and power station operations took place in the review period. The current development approvals are:

Applicant Aberdare Collieries Proprietary Limited		
Amended approval BRID0033	18/09/17	Focus on ash cells at mine
EPML 0041 7213	10/08/18	Covers other aspects of mine operations. Minor Administrative amendments of Original EA MIN 100878709
Applicant Kogan Creek Power Station Proprietary Limited		
Amended approval EPPR00918113	19/11/18	Power Station site

A summary of the relevant groundwater monitoring approval conditions is provided below.

Summary of Specific Groundwater Approval Conditions

Document	Relevant Conditions	Comments
EPML 0041 7213 Mine	Groundwater Conditions C15-C21 *Specifies 10 monitoring points MB1 – MB10* *Maximum contamination elevations of ±10% background for Cl, SO4, EC, pH.* *Monitoring twice yearly.* *Standing water elevation quarterly.* *Exceedance reporting and investigation if contaminant limits exceeded.*	Covers other aspects of mine operations.
Amended approval BRID0033 Ash Disposal	Groundwater Conditions C6 to C9 *Specifies 10 monitoring points: MB1, MB2, MB7_R, MB9, MB10_R, MB29, KC1273_R, KC1276, KC1277, KC1278.* *Groundwater monitoring for SWL, pH, EC, Na, Cl, SO_4, Al, Zn.* *Monitoring twice yearly.* *Standing water elevation (SWL) quarterly.* *Triennial report to be prepared and made available to EHP upon request.* *Contaminant trigger ranges for Na, Cl, SO4, Al, Zn, EC, pH.* *Exceedance reporting and possibly investigations if contaminant limits exceeded.*	Covers IADA and OPAC
Amended approval BRID0033 Ash Disposal	Ash Disposal Management Plan Clause (E2) (iv)	Requires monitoring and assessment by expert every three years.
Amended approval EPR00918113	Groundwater Condition H8(ii), H(14). *Specifies7 monitoring points MB14, MB15, MB23S, MB23I, MB24S, MB24I, MB24D_R.* *Groundwater monitoring for SWL, pH, EC, Na, Cl, SO_4, Al, Zn.* *Monitoring twice yearly.*	Covers the Power Station site.

	Standing water elevation (SWL) quarterly. Annual summary of monitoring data to be made available to EHP upon request.	

The various Environmental Authorities are held by CS Energy Ltd or its subsidiary Aberdare Collieries Pty Ltd. CS Energy Ltd has contracted with Golding Contractors Pty Ltd (Golding) to manage and operate the Kogan Creek Coal Mine. Golding is responsible for compliance with mine Environmental Authority conditions. There is an overlap of authority for the day-to-day operations of the mine and power station infrastructure. For example whilst each Environmental Authority and/or Development Authority (EA) refers to land tenure lots, in practise, the workings of each water management facility are in accordance with the intent of a specific EA/DA issued. One example includes that the Southern Stormwater Dam is on the mining lease but is administered under the power station amended permit EPPR00918113.

2.1 Ash Storage Approval and Operations

Ash disposal is managed in accordance with Amended Approval BRID0033 dated 18 September 2017. This approval authorises the disposal of fly ash, economiser ash, boiler bottom ash and other power station waste products associated with the ash to a number of ash cells. Several facilities were approved as summarised below:

Ash Storage	Maximum Approved Surface Area of Cell (ha)	Maximum Capacity of Cell (m3 x 10^6)
Initial Ash Disposal Area (IADA)	80	5
Out of Pit Ash Cell (OPAC)	72	7
In-Pit West Ash Cell(s) each	40	5
In-Pit East Ash Cell(s) each	40	5

Currently Kogan Creek Power Station ash is stored in:

- the IADA located to the south of the site in the Paddy's Gully catchment; and
- the OPAC.

2.1.1 IADA

Ash deposition at the IADA commenced in May 2007. Ash was deposited as a high density slurry with minimal excess water. The IADA was designed for initial ash storage over approximately 4 years and subsequently ash disposal in the OPAC commenced in late 2010. The IADA is now used as a back-up ash storage facility and the site has been progressively rehabilitated with an engineered cover over the ash. Stored ash water has been periodically pumped to the OPAC. OPAC ash pore water is pumped to the IADA to evaporate.

2.1.2 OPAC

The OPAC was constructed over a period of about 4 years from 2006 to 2010 using mine overburden sourced from the open pit, with batters constructed at the angle of repose of the overburden. Dense phase ash is transported as a slurry via pipeline from the Kogan Creek PS. The pipeline is located adjacent to the coal conveyor and crosses Kogan Creek near the mine entrance. Ash is deposited in a cell that has been constructed from mine spoil. The cell has an internal plan area of 24 ha and consists of a basal layer of mine spoil (up to 10 m thick) surrounded by perimeter embankments of mine spoil which are up to 15 m high, side slopes of 6:1 external and 2:1 internal and crest widths of approximately 50 m. There is a 50 m offset between the southern cell wall and the mine pit low wall. The OPAC has been constructed with a liner system consisting of a basal Linear Low Density Polyethylene (LLDPE) liner overlying compacted clay spoil.

The internal batters of the cell are also lined to a height of 5 m. The partial lining of the OPAC to RL 325 m was to provide a low permeability barrier over the dispersive mine waste foundation material. This material would be subject to piping erosion under ponded water before being covered with the ash. An ash bund was constructed against the perimeter earth walls above RL 325 m to keep the decant pond away from the walls, to minimise seepage and prevent piping erosion through the walls (Golder,2009).

Supernatant and ash pore water is pumped from the decant pond to the waste water collection ponds at the power station for recycling or sent to the IADA for evaporation.

The OPAC facility is nearing the end of its operational life.

A number of monitoring bores have been constructed within the OPAC embankment and around the OPAC, including 21 additional bores constructed since 2016. Baseline electromagnetic (EM) surveys for groundwater presence have also been carried out. Electrical resistivity surveys were carried out in 2017 to detect the presence of any OPAC seepage and to provide geophysical information for the siting of additional monitoring bores.

Annual inspections of the OPAC are carried out each year, with the last inspection in October 2018 (Golder, 2018). The overall condition of the OPAC was good at the time of the inspection, with no noticeable changes since the previous inspection. No seepages or wet spots were observed on the external batters of the OPAC embankments.

2.1.3 IPAC

Construction of the first in - pit ash cell (IPAC) is nearing completion. The IPAC is located in an area of backfilled mine waste at the north western side of the general mine area (Figure 2).

The IPAC is located on mine fill. IPAC walls and base are constructed with compacted mine fill. The IPAC contains an HDPE liner.

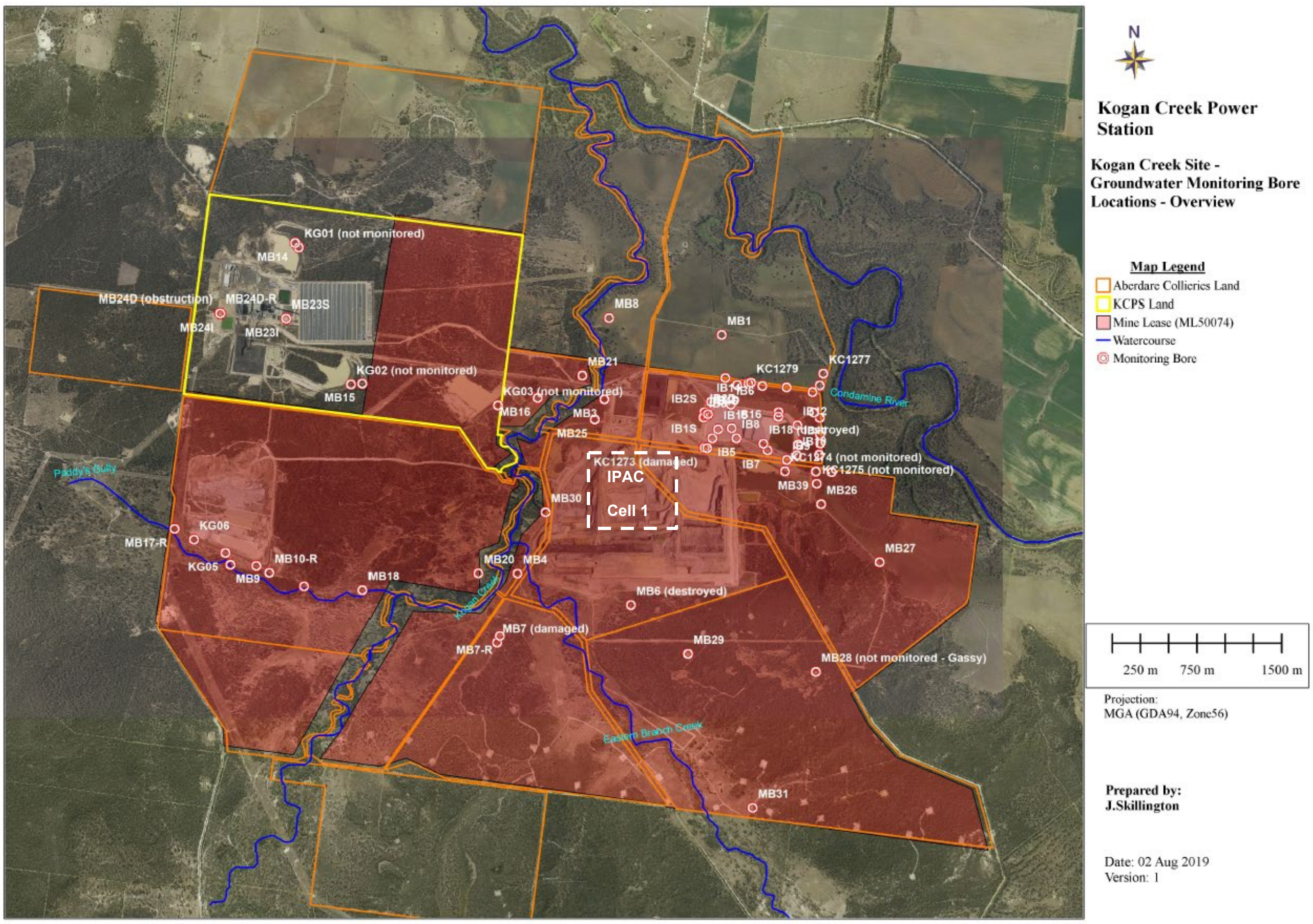


Figure 2 IPAC Cell 1

3.0 TOPOGRAPHY AND DRAINAGE

The mine is located on relatively low lying ground associated with valley floor alluvium and shallow weathered sedimentary strata which steadily rises to the south between Kogan and Eastern Creeks on its western side, and the Condamine River to the east. Floodwaters from both these waterways have the potential to flood the mine operational area, consequently flood diversion levees have been located on the western, northern and eastern sides of the mine area.

The power station complex is located on elevated ground of weathered to fresh sedimentary rocks to the west of Kogan Creek and approximately 30 m higher than the Kogan Creek floodplain. A conveyor and pipeline transport coal and ash respectively across Kogan Creek. There are no natural water bodies permanently on the sites but there are numerous stormwater/wastewater storage dams. To the south and west, the topography steadily rises and reaches a maximum altitude of around RL 400 m.

3.1 Catchment Characteristics

The mine and power station are located within the Condamine River catchment (Figure 3) which is located west of the Great Dividing Range in southern Queensland. The Condamine Catchment is at the headwater of the Murray-Darling Basin. Most creeks on the eastern side of the catchment flow away from the Great Dividing Range through undulating basaltic landscapes and valley systems that widen as they approach the Condamine River.

3.2 Soils

Topsoil depth is very shallow and the area has been subject to long periods of weathering and leaching. The soil at the site is of low fertility, lacking major nutrients, alkaline and highly sodic in nature with no evidence of potential acid generation (Sinclair Knight Merz, 1999). The subsoils (overburden) are considered unlikely to be acid forming as they are characterized by a low sulphur content and high inherent acid neutralizing capacity (Golding, 2008). Soils are also prone to erosion.

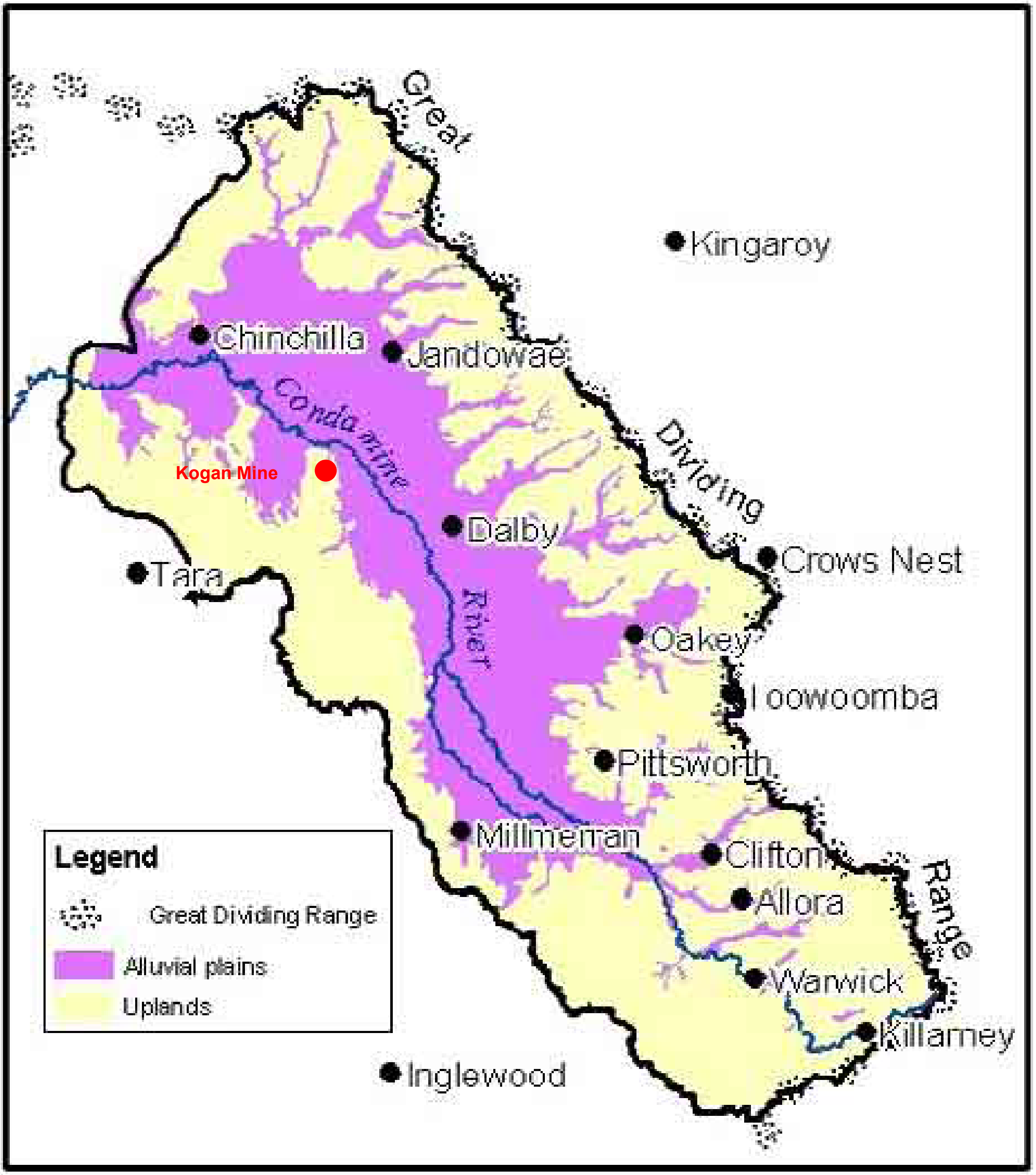


Figure 3 Condamine River Catchment

4.0 CLIMATIC CONDITIONS

4.1 Rainfall and Streamflow

Typically, the area surrounding the Kogan Mine and Power Station has a highly variable subtropical climate with summer dominant rainfall and a distinct dry season during the winter months, with an annual average rainfall in the order of 603 mm (data obtained from Bureau of Meteorology, Dalby Airport). Average temperatures in the region range between 6.4°C and 33.7°C and prevailing winds are from the southeast although northwest winds occur in spring and early summer (Golding, 2008).

The period 2012 to 2015 was characterised by below average annual rainfalls following the extreme rainfall of 2010/early 2011. Rainfall in 2016 was below average whilst 2017 (664.8 mm) was above average, principally due to the heavy rainfall in March (241.2 mm).

Rainfall in 2018 was below average and to June 2019 has been well below average.

No major runoff events (ie similar to 2010/11 and 2013 flows) have been observed in the Condamine River system since the January/March 2013 runoff events. Small to medium flows in the Condamine River were recorded in March/April 2014, May 2015, September 2016, April 2017 and December 2018.

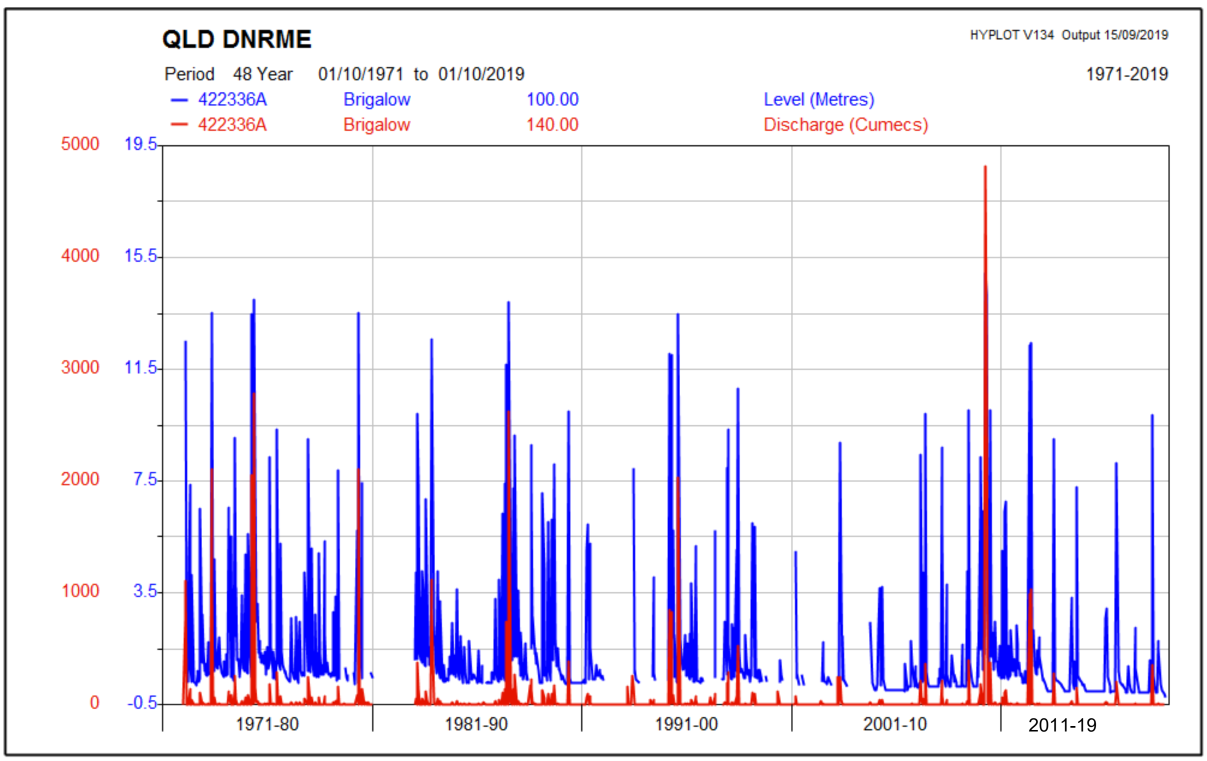


Figure 4 Stream Discharges Condamine River

Table 1 Rainfall Data Kogan Creek Mine

Month	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Dalby Airport Mean (1992 -2019)
Jan	-	29	58	68	71.5	51.5	15.2	137.9	117	195	23.8	107.4	87.4	78.0	27.4	3	73.4
Feb	-	12.5	19	45	200	52.5	213.4	11.3	44.5	73	4.8	49.4	51.8	26.6	144.8	8	77.3
Mar	-	27.5	5.5	78	14	65	129.4	103.2	47	81	171.8	12.8	14.4	241.2	9.2	188.4	58.7
Apr	-	11	39	11.5	46	61	9.1	30	39	23	16.4	10.8	0.6	0.6	29	0	18.4
May	-	30.5	4.5	5	9	59	16.4	2.5	14.5	41	28.8	86	7.0	6.2	10.0	12.6	35.7
June	-	148	0	143	30	62.5	12	0	82	5	24.4	9.8	45.8	13.6	0.2	33	31.2
July	-	0	28.5	0	61.5	1	38	18	16	22	5.2	18	46.0	54.8	2.2		22.7
Aug	-	6.5	0	74	30	3.6	111.7	50.5	4	9	27.8	24.4	40.8	9.8	14.0		22.8
Sep	-	19.5	15.5	23.5	77	26.6	131.9	26	7	3	24.4	15.4	146.8	0.4	7.2		29.4
Oct	50.2	121	7	85	50	25	119.2	97	31	27.4	22.4	47.2	19.2	102.4	106.6		63.1
Nov	76	77	43.5	56	167	77	57	84.5	67	57.6	40.6	9.4	41.2	71.2	13.6		68.9
Dec	67.5	63	90.5	213.5	88	18	333	112	61	8.2	54.6	63.8	67.2	60.0	189.8		95.7
Total (mm)		545.5	311.0	802.5	844.0	502.7	1184.3	672.9	530	571.2	445	454.4	568.2	664.8	554.0		603.1

5.0 GEOLOGY

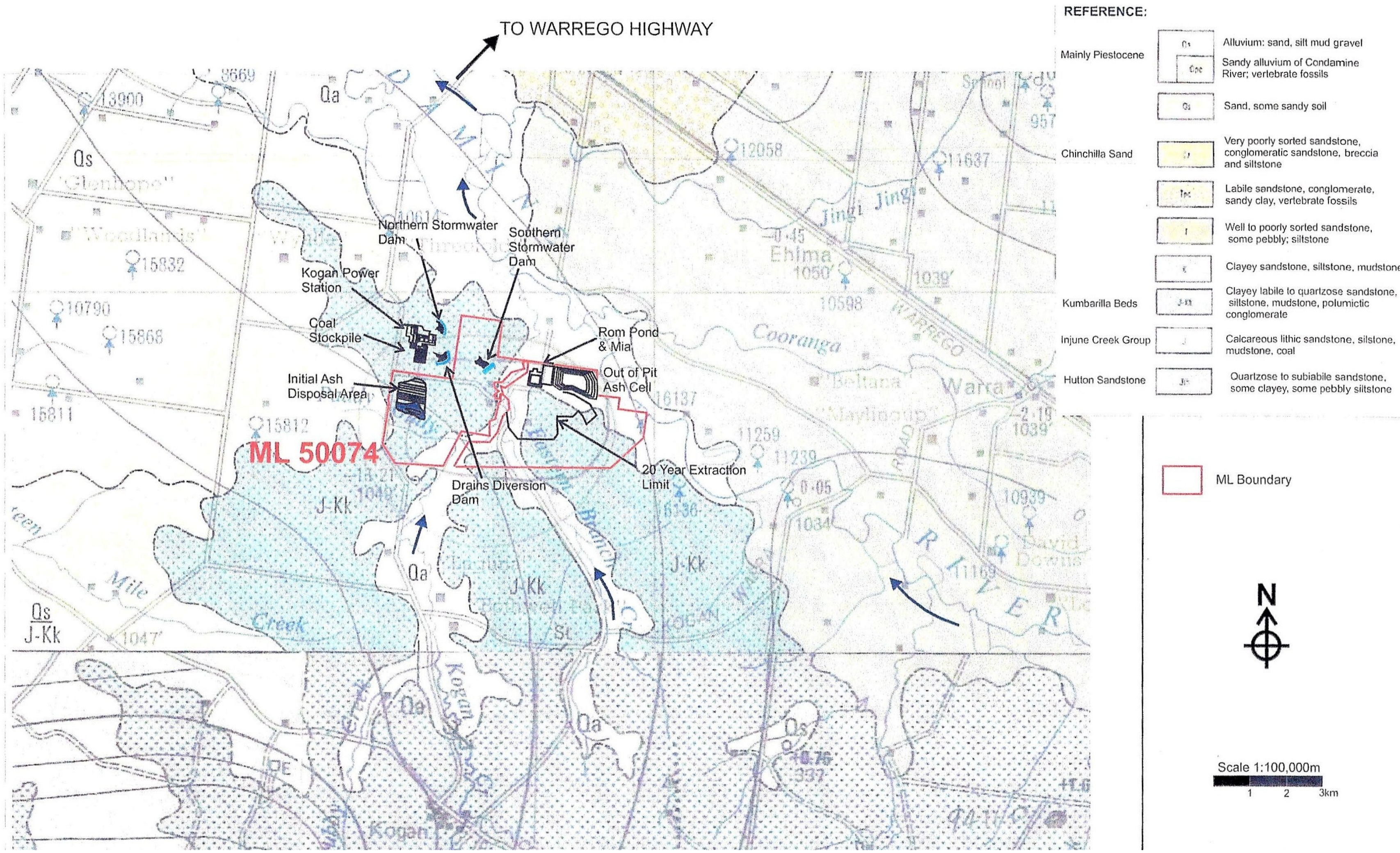
The general geology of the power station/mine sites as drawn from Queensland Geological Survey mapping is shown in Figure 5. The main geological units in the area are:

Alluvium	Associated with Condamine River, Kogan and Eastern Branch Creeks
Kumbarilla Beds	Sandstone, siltstone, mudstone, conglomerate
Springbok Sandstone	Cross bedded clayey lithic to very lithic sandstone, some porous; siltstone, mudstone
Walloon Coal Measures	Carbonaceous mudstone and siltstone; some sandstone and coal

The power station site and the Initial Ash Disposal Area (IADA) appear to be underlain by sandstones at shallow depth which are inferred to be the Late Jurassic Springbok Sandstone. These sandstones directly overlay the Walloon Coal Measures sediments.

The Walloon Coal Measures outcrop in the mine area and may directly subcrop beneath the Condamine River alluvium to the east of the site. The geology of the mine area is well understood from geological drilling, logging and subsequent mine development.

Figure 5 Regional Geology



6.0 HYDROGEOLOGY

Groundwater at the power station and coal mine areas is present in:

- Unconsolidated alluvial sediments of the Condamine River and Kogan Creek,
- Sediments associated with bedrock weathering;
- Possible higher permeability zones within underlying sandstone bedrock (referred to as Springbok Formation) between depths of 15 and 75 m; and
- Coal seams of the Walloon Coal Measures.

Groundwater usage for agricultural purposes from aquifers within the Condamine Alluvium and the underlying Walloon Coal Measures is widespread in the Condamine River valley. Groundwater from the Walloon Coal Measures is also extracted as part of coal seam methane gas production to the west and south of Kogan Creek PS/Mine.

A conceptual hydrogeological model of the power station/mine area is shown in Figure 6. Groundwater elevations in bores are a function of topography, depth of bore and geology intersected. Bores drilled into alluvium may have higher or similar standing water elevations to bores that monitor groundwater elevations in underlying sedimentary rock aquifers. Standing groundwater elevations in rock aquifers beneath the power station site are estimated to be 15-45 m below ground elevation, depending on bore location and land elevation. Condamine River alluvium has low salinity indicating recharge from the river. The power station and most of the mine site is underlain by sandstone, inferred to be Springbok Sandstone. The OPAC is probably underlain by alluvium on the eastern side, as well as a former channel/ billabong of the Condamine River beneath the middle of the site.

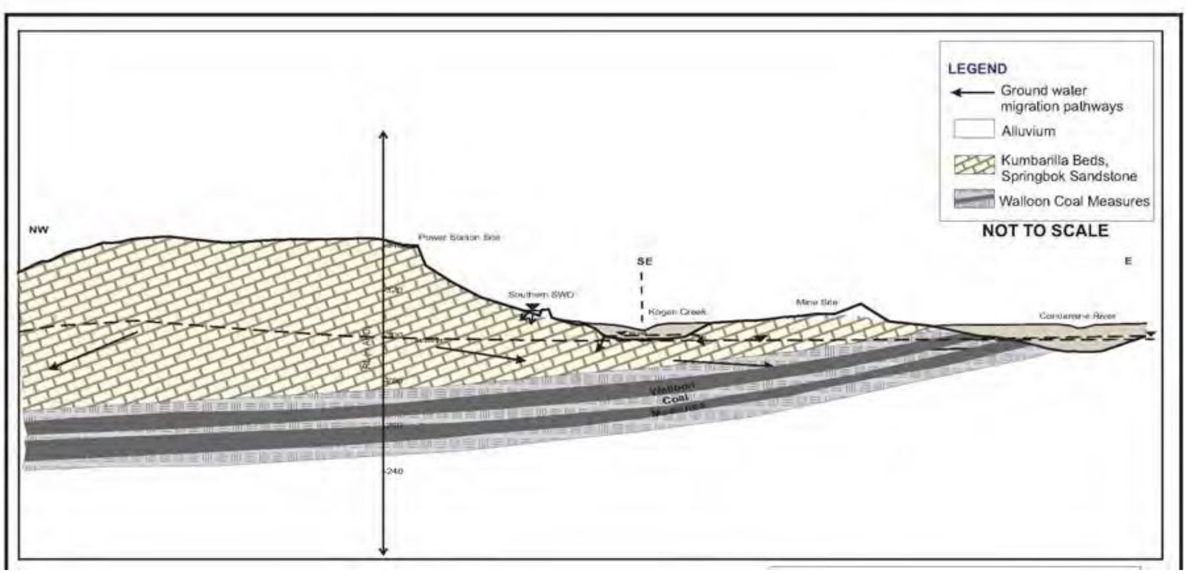


Figure 6 Conceptual Hydrogeological Model Pre–Mining

The Springbok Sandstone is essentially dry/unsaturated in the area. Groundwater was encountered in a low permeability sandstone inferred to be part of the Walloon Coal Measures 65–80 m below ground elevation (RL 340 m) at the power station site. The standing water elevation (48.66 m below top of casing or approximately RL 292.1 m AHD as measured on 10/05/2019) is generally consistent with regional standing water elevations from aquifers in the Walloon Subgroup which in the mine area are in the range RL 275 m to RL 298 m. Groundwater elevations in overlying alluvium have been generally between RL 295 m and RL 300 m.

Groundwater flow conditions in the vicinity of the site are thought to be complex, given the site's location relative to the course of the Condamine River and within the Surat Basin. Inferred groundwater flow directions in the vicinity of the power station/mine complex are:

- Condamine Creek alluvium: north and east towards the river depending on bore location. Potentially some influence of drainage towards the mine pit;
- Kogan and Eastern Creeks alluvium: to north (in direction of creek flow). Potentially some influence of drainage towards the mine pit; and
- Springbok Sandstone. Uncertain but possibly locally northwest to northeast
- Walloon Coal Measures. Locally towards the mine pit and sub-regionally towards the northwest to northeast.

The Springbok Sandstone (where water is present) and Walloon Coal Measures may discharge to the Condamine Alluvium. Regionally to the west of the site, groundwater in the Springbok Sandstone and Walloon Coal Measures is likely to flow in a more south-westerly direction in the general direction of the dip of the strata and the Condamine Balonne catchment drainage. Geologically the site overlies sedimentary rock strata of the Surat Basin at the eastern end of the Great Artesian Basin. The Springbok Sandstone is not considered to be a major aquifer of the Great Artesian Basin. The most significant aquifer units of the eastern Darling Downs are the Gubberamunda Sandstone (not present beneath the site) and the deeper Hutton and Precipice Sandstones.

Groundwater usage in the vicinity of the site is expected to be limited to domestic and stock watering from Condamine River alluvium and stock watering only from underlying Springbok Sandstone/Walloon Coal Measures bores due to quality constraints. The nearest registered non-CS Energy groundwater bore to the power station site is RN 30931 located approximately 1.5 km north of the power station boundary. This bore was drilled to 67 m and completed in a coal seam in 1969. There are no registered bores in alluvium downstream and to the north of the power station/mine on Kogan Creek or the western side of the Condamine River for at least 6 km.

Make-up water for the power station is supplied from deep bores drilled into the Hutton/Evergreen and Precipice Sandstones. CS Energy has a license to withdraw up to 300 ML/year from Bore RN 87436 (water licence 87436R) located approximately 1 km north of the mine site. The bore is approximately 640 m deep and draws water from the Walloon Coal Measures and Hutton Sandstone. Lagoon Gully No 1 and No 2 Bores are located 23 km south west of the site and are licensed to supply 1500 ML/annum (water licence 100812) and 200 ML/annum (water licence 100811) respectively. The bores were drilled to 1282 m into Precipice Sandstone and 1001.5 m into Hutton Sandstone respectively.

6.1 Background Groundwater Quality

Groundwater quality type can be categorised on the basis of available salinity data as follows:

Strata	Salinity
Condamine River alluvial sediments	Low salinity (<2000 mg/L TDS)
Kogan Creek alluvials	No data
Shallow bedrock (<20 m) Kumbarilla Beds/Springbok Sandstone	High salinity (> 8000 mg/L TDS) Note very high salinity (> 30000 mg/L TDS) in surficial clays overlying sandstone in bore MB4 to east of Kogan Creek
Deep bedrock (>40 m) Walloon Coal Measures mine area	Moderate salinity (1000 – 5000 mg/L TDS)
Deep bedrock (>50 m) Walloon Coal Measures power station area	High salinity (9000 – 15000 mg/L TDS)

Salinity in Condamine River and Kogan Creek alluvials is likely to be highly variable and will depend on bore location and depth of the water-bearing horizon from which groundwater is drawn (i.e. depth of screen/slotted casing).

Groundwater quality in sedimentary rock strata will also be influenced by local geology and hydrogeochemical interactions in the weathered zone, particularly where coal seams are shallow and have been oxidised. Such conditions can cause the oxidation of sulphides associated with the coal and potentially influence the concentrations of sulphate. The mobility of coal-related trace elements such as boron, molybdenum, fluoride, selenium and vanadium will be influenced by groundwater pH conditions. Data from leachate analysis on coal samples from Kogan Creek Mine M, N and O Seams recorded sulphate, boron and molybdenum concentrations of 70-110 mg/L, 1.5–3 mg/L and 0.11–0.15 mg/L respectively (AGEE, 1999).

Groundwater from RN 30931, located approximately 1.5 km north of the power station boundary, was analysed on three occasions between 1969 and 1970 with pH of 8 and a Total Dissolved Solids concentration of 4000–5000 mg/L. Sodium, chloride and bicarbonate were dominant ions. Fluoride was measured at 1 mg/L.

Pre-mining data indicates that generally, groundwater salinities in the area ranged between 2190 and 11550 mg/L, whilst pH was alkaline (7.0–8.5). This suggests that most bores (east of the Condamine River) were drawing water from Walloon Coal Measures or overlying strata (Springbok Sandstone/Kumbarilla Beds). "In-seam water" was the most saline (12,800 mg/L) and was also acidic (pH 4.2).

Groundwater with elevated salinity (EC 5500–25,000 µS/cm) is found in sandstones (inferred to be Springbok Sandstone) underlying the IADA and along the Paddy's Gully drainage line. In the power station area, no groundwater was encountered in the Springbok Sandstone.

7.0 GROUNDWATER MONITORING PROGRAM OVERVIEW

The aim of a groundwater monitoring program is to provide an early warning mechanism for changes in groundwater conditions attributable to the Mine, Ash Disposal and Power Station activities that have the potential to cause environmental harm under the Environmental Protection Act (EP Act, 1994). Groundwater monitoring is required for compliance with the Mine, Ash Disposal and Power Station EA/DAs.

An initial groundwater monitoring network was established in 2007. A number of bore construction programs have been undertaken since 2007 which has resulted in an expansion of the original network to:

- Replace bores that have been damaged or are unable to be sampled or where a groundwater elevation cannot be measured;
- Provide more detailed information in specific areas eg in vicinity of OPAC, IADA, IPAC and power station site.

The monitoring network includes bores that are specified in the various EA's as well as non-EA bores.

During the Review Period, the following changes to the groundwater monitoring programs occurred:

- Loss of EA bore MB6 due to expansion of pit to the south, This has been replaced by bore MB29
- Construction of bores IB1S/1D to IB14 either at the OPAC either in the perimeter, embankment, underlying basal fill (IB4D) or ash deposit (IB4S, IB15 and IB16)
- Expansion of the monitoring bore network on the northern and eastern sides of the OPAC with the construction of bores MB32 to MB39.

Bore locations are shown in Figure 6.

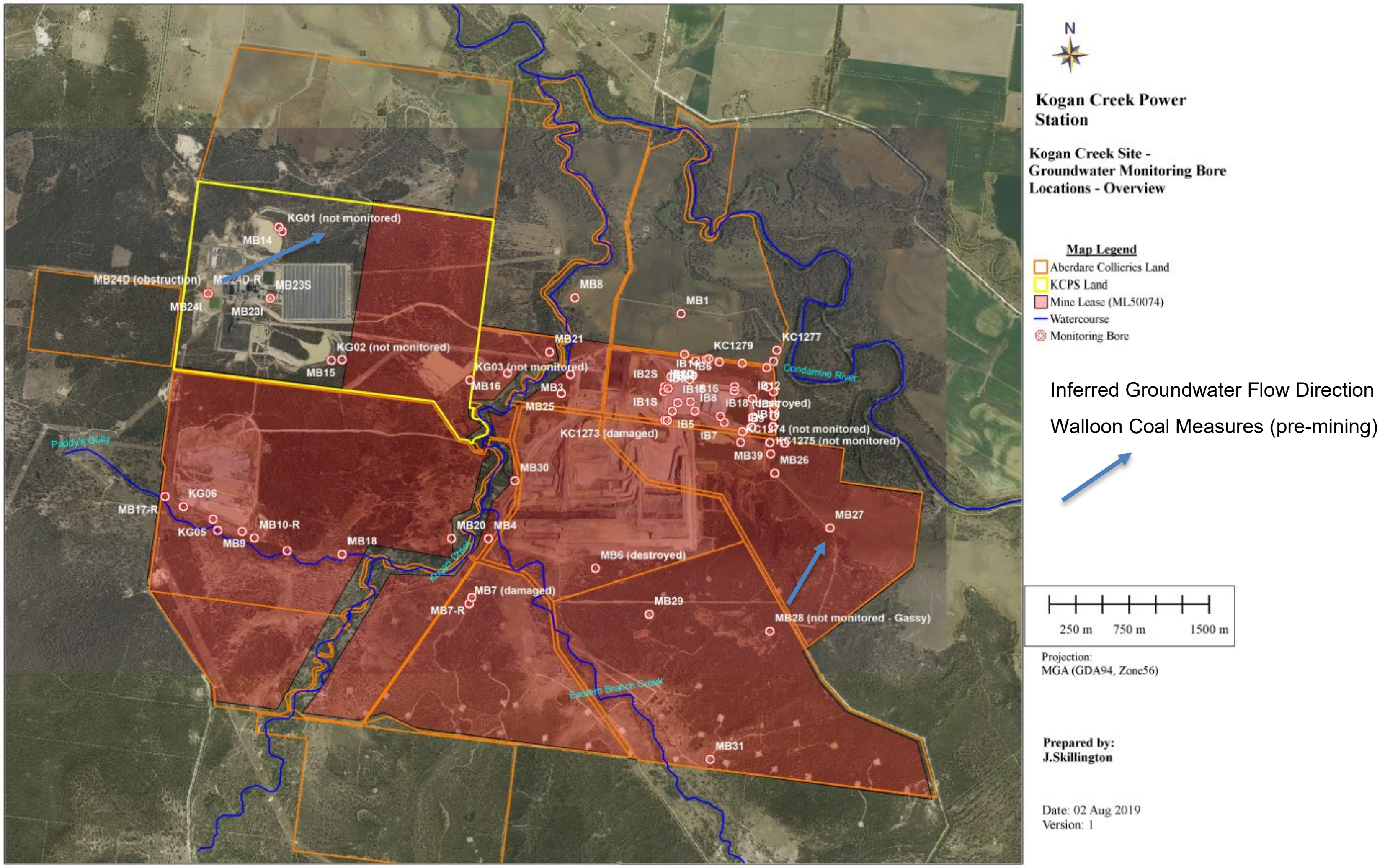


Figure 7 Groundwater Monitoring Bores Power Station and Mine

8.0 GROUNDWATER CONDITIONS

8.1 General

The generalised hydrogeological model for the region indicates that there are at least two groundwater flow regimes:

- A shallow semi-unconfined to semi-confined aquifer associated with alluvium; and
- Underlying confined aquifers associated with sedimentary strata of the Surat Basin, in which groundwater may be associated with several different structural units such as:
  - Fractures and joints within Kumbarilla Beds;
  - Fractures and joints and potentially permeable horizons within Springbok Sandstone where it may be present; and
  - Bedding partings, cleats and fault-controlled fractures associated with coal seams of the Walloon Coal Measures.

Deeper confined aquifers associated with the Hutton Sandstone and possibly Precipice Sandstone units of the Surat Basin will also underlie the site at depth.

Groundwater flow conditions in the vicinity of the site are thought to be complex, given the site's location relative to the course of the Condamine River and within the Surat Basin. Inferred groundwater flow directions in the vicinity of the power station/mine facilities are:

- Condamine Creek alluvium: north and east towards the river depending on bore location;
- Kogan and Eastern Creeks alluvium: north (in direction of creek flow); and
- Springbok Sandstone. Uncertain but possibly locally northwest to northeast
- Walloon Coal Measures. Locally towards the mine pit and sub-regionally towards the northwest to northeast.

The Springbok Sandstone and Walloon Coal Measures may discharge to the Condamine Alluvium. Regionally to the west of the site and within the Murray Darling Basin catchment, groundwater in the Springbok Sandstone and Walloon Coal Measures is likely to flow in a more south-westerly direction in the general direction of the dip of the strata and surface drainage direction.

Conceptually, groundwater flow may be modified by the following activities:

- Groundwater inflows into mine workings as a result of drainage from alluvium and exposed coal seams; and
- Leakage to depth initially via unsaturated flow from water management ponds such as the IADA, Lagoon Gully Pond and the various sediment control ponds at the power station.

- Potential leakage from lined ash storages such as the OPAC and (in future) IPAC cells.

8.2 Groundwater Elevation Data

Groundwater elevations in most bores have been generally recorded on either a quarterly or monthly basis as part of the groundwater sampling and analysis program. Continuous data loggers have been installed in several bores (MB6, MB7-R, MB24D/D-R, MB25 and MB31).

Numerous bores often record no groundwater presence which is a function of bore depth, historical water tables and possibly bore sampling procedures. No specific data manipulation is carried out by CS Energy or Golding (the mining contractor).

In order to assess the potential impacts of mining and power generation, the available groundwater data has been collated and assembled in a spreadsheet with the data provided as tables of standing water elevation and groundwater levels as measured to AHD elevation.

Data for bores in various formations for December 2016, December 2017 and November 2018 are summarised in Table 2. A series of groundwater level maps and plots of time series groundwater reduced elevations are presented in the following sections. Obvious spurious data points have been removed from the plots.

Table 2 Groundwater Level Data December 2016, 2017 and November 2018

		Groundwater Levels (RL m AHD			Location/Comment
Bore	Geological Formation Monitored	Dec-16	Dec-17	Nov-18	
MB1	Condamine Alluvium	297.83	297.74	297.74	Background
MB2	Condamine Alluvium	298.47	298.32	298.25	OPAC
MB3	Condamine Alluvium	dry	dry	dry	Kogan Ck
MB4	Condamine Alluvium	dry	dry	dry	Kogan Ck
MB5	Condamine Alluvium	297.16	297.01	296.05	OPAC
MB6	Walloon Coal Measures				destroyed
MB7	Walloon Coal Measures				destroyed
MB7-R	Walloon Coal Measures	276.54	277.05	277.30	Mine area
MB8	Condamine Alluvium	dry	dry	dry	Kogan Ck
MB9	Springbok Sandstone	295.02	295.20	295.17	IADA
MB10	Springbok Sandstone				u/s

MB10-R	Springbok Sandstone	294.70	294.59	294.64	IADA
MB12	Condamine Alluvium		294.21	294.23	OPAC
MB13	Condamine Alluvium		dry	dry	OPAC
MB14	Springbok Sandstone	dry	dry	dry	Power station ponds
MB15	Springbok Sandstone	dry	dry	dry	
MB16	Springbok Sandstone	294.14	293.99	293.63	
MB17	Springbok Sandstone				u/s
MB17-R	Springbok Sandstone	293.08	293.14	293.19	IADA
MB18	Springbok Sandstone	294.08	293.87	293.70	Between power station and mine
MB20	Springbok Sandstone	dry	dry	dry	
MB21	Springbok Sandstone	287.93	dry	287.95	
MB22					not drilled
KC1273	Walloon Coal Measures				destroyed
KC1273-R	Walloon Coal Measures	276.54	277.05	277.30	Mine
KC1274	Walloon Coal Measures				destroyed
KC1275	Walloon Coal Measures				u/s
KC1276	Condamine Alluvium	297.89	297.77	297.73	OPAC
KC1277	Condamine Alluvium	297.87	297.75	297.65	OPAC background
KC1278	Condamine Alluvium	297.89	297.77	297.69	OPAC
KC1279	Condamine Alluvium	dry	dry		u/s
MB24D	Walloon Coal Measures				u/s
MB24D-R	Walloon Coal Measures	291.43	291.56	291.68	Power station
MB25	Walloon Coal Measures	276.19	276.16	276.60	IPAC
MB26	Walloon Coal Measures	291.61	291.72	291.94	Mine
MB27	Walloon Coal Measures	297.83	297.79	297.79	Mine
MB28	Walloon Coal Measures	300.06[1]			u/s
MB29	Walloon Coal Measures	274.95	273.85	272.70	Mine
MB30	Walloon Coal Measures	273.67	274.60	274.10	IPAC
MB31	Walloon Coal Measures	287.09	286.23	286.76	Mine
MB32	Condamine Alluvium		dry	dry	OPAC
MB33	Condamine Alluvium		297.77	297.71	
MB34	Condamine Alluvium		297.75	297.69	
MB35	Condamine Alluvium		297.84	297.77	
MB36	Condamine Alluvium		297.83	297.48	
MB37	Condamine Alluvium		dry	dry	

MB38	Condamine Alluvium		297.66	297.64	
MB39	Condamine Alluvium		297.74	297.74	
MW23S	Springbok Sandstone	dry	dry	dry	Power station
MW23I	Springbok Sandstone	dry	dry	dry	
MW24S	Springbok Sandstone	dry	dry	dry	
MW24I	Springbok Sandstone	dry	dry	dry	
Kogan Bore	Walloon/Hutton Sandstone				Water supply bore
KG01	Springbok Sandstone				Power station ponds dry - not monitored
KG02	Springbok Sandstone				
KG03	Springbok Sandstone				
KG04	Springbok Sandstone	dry	dry	dry	IADA
KG05	Springbok Sandstone	dry	dry	dry	
KG06	Springbok Sandstone	dry	dry	dry	
		Pore Water Levels			
IB1S	OPAC Fill				OPAC Embankment or Ash
IB1D	OPAC Fill		dry	dry	
IB2S	OPAC Fill		dry	dry	
IB2D	OPAC Fill		dry	dry	
IB3	OPAC Fill		dry	dry	
IB4S	OPAC Ash		331.91	332.10	
IB4D	OPAC Fill		312.66	312.71	
IB5	OPAC Fill		dry	dry	
IB6	OPAC Fill		dry	dry	
IB7	OPAC Fill		dry	dry	
IB8	OPAC Fill		dry	dry	
IB9	OPAC Fill		dry	dry	
IB10	OPAC Fill		dry	dry	
IB11	OPAC Fill		dry	dry	
IB12	OPAC Fill		dry	dry	
IB13	OPAC Fill		313.57	313.36	
IB14	OPAC Fill		dry	dry	
IB15	OPAC Ash		331.81	332.08	
IB16	OPAC Ash		331.35	331.45	

Note: u/s = unserviceable [1] MW28 September 2015

What can influence bore water elevations?

Bore water elevations can be influenced by a number of factors including:

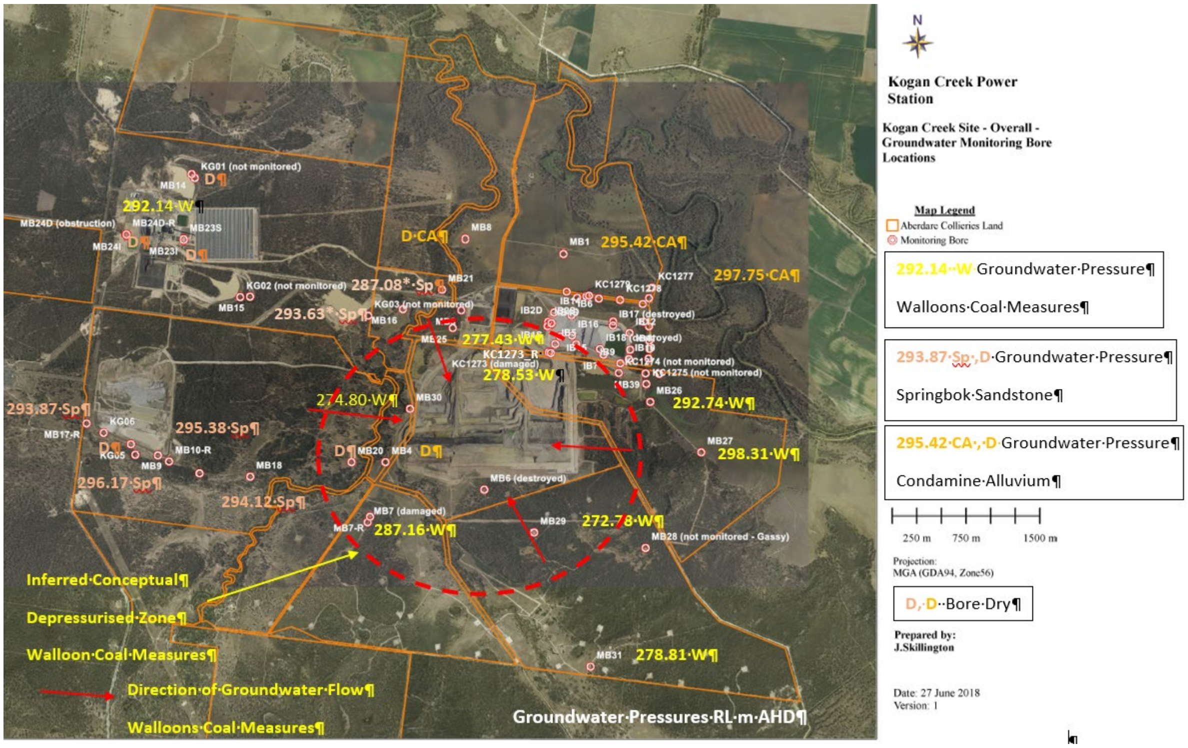
- Extent to which groundwater adjacent to bore is under pressure;
- Extent and depth of monitoring horizon in a particular borehole. Is the borehole measuring groundwater pressure at a particular point or providing an averaging effect over a thickness of geological strata that may contain groundwater at different elevations (eg coal seams) ?;
- Geological formation being monitored and degree of aquifer “connectivity” ie horizontal and vertical hydraulic conductivity;
- Influence of recent recharge events
- Influence of mine depressurisation/dewatering or other groundwater extraction activities.

8.3 Formation Groundwater Pressures

Groundwater pressures (heads) in selected bores (excluding OPAC monitoring bores) in various formations in May 2019 are shown at Figure 8. Maps showing groundwater heads in bores in the mine area and OPAC in October 2016, September 2017 and September 2018 are shown at Figures 9 to 11. Note the spatial distribution of data, the number of data points in each formation, the size of the area and the range and distribution of groundwater pressures across the mine and power station areas are such that it is not possible to generate groundwater contours that reasonably reflect the complex nature of groundwater distribution in the various formations in the investigation area. Figure 8 shows the inferred conceptual extent of the groundwater depressurisation zone around the mine pit. Bores MB4 alluvium and MB20 Springbok have dried up which is assumed to be due to leakage into the pit.

The following ranges of groundwater pressures between December 2016 and May 2019 were observed in the various formations.

Condamine Alluvium	RL 296.9 to RL 298.6	Most bores
Condamine Alluvium	RL 294.2 to RL 294.8	MB12
Springbok Sandstone	RL 286 to RL 295	Lowest head MB21 RL286.8 May 2019, Dry December 2017, June 2018
Walloon Coal Measures	RL 286 to RL 298	Regional background MB24D-R RL 291.68 at power station
Walloon Coal Measures	RL 272 to RL 287.2	Mine area and depressurization zone



Note: * Pressure at MB16, MB 21 September 2018

Figure 8 Groundwater Pressures May 2019

The highest heads in Walloon bores have been observed in upgradient bores MB28 RL 300-56 September 2015) and MB27 (RL 298.31 May 2019), both located on elevated strata to the east of the mine. Inferred pre-mining groundwater flow directions in the Walloon Coal Measures are shown at Figure 7. In the Springbok Sandstone the highest observed heads are measured at bore MB9 (RL 296.17 May 2019) south of the IADA.

Several alluvial bores north and east of the OPAC recorded groundwater levels in excess of RL 298 in May 2019, i.e. similar pressures to the highest recorded Walloons pressure at MB27. Lowest heads are observed in depressurized Walloon strata and inferred Springbok strata proximal to the mine.

Over the three year period the following general trends have been observed:

- Small declines in level (<0.25 m) in Condamine Alluvium bores such as MB1, MB2, KC1276, KC1277, KC1278 due to the lower than average rainfall conditions

- Either small declines in level from <0.5 m or slight increase (<0.15 m) in Springbok Sandstone bores such as MB9, MB10-R, MB16, MB17-R, MB18

- Groundwater levels have stabilised and in some cases increased in bores in the mine area that had previously declined which had been inferred to be as a result of mine depressurisation of the Walloon Coal Measures (MB25, MB29, MB30, KC1273-R).

- Elsewhere pressures in Walloon Coal Measures bores are relatively stable with minor fluctuations (eg due to barometric pressure, earth tides) (MB24-R, MB26, MB27).

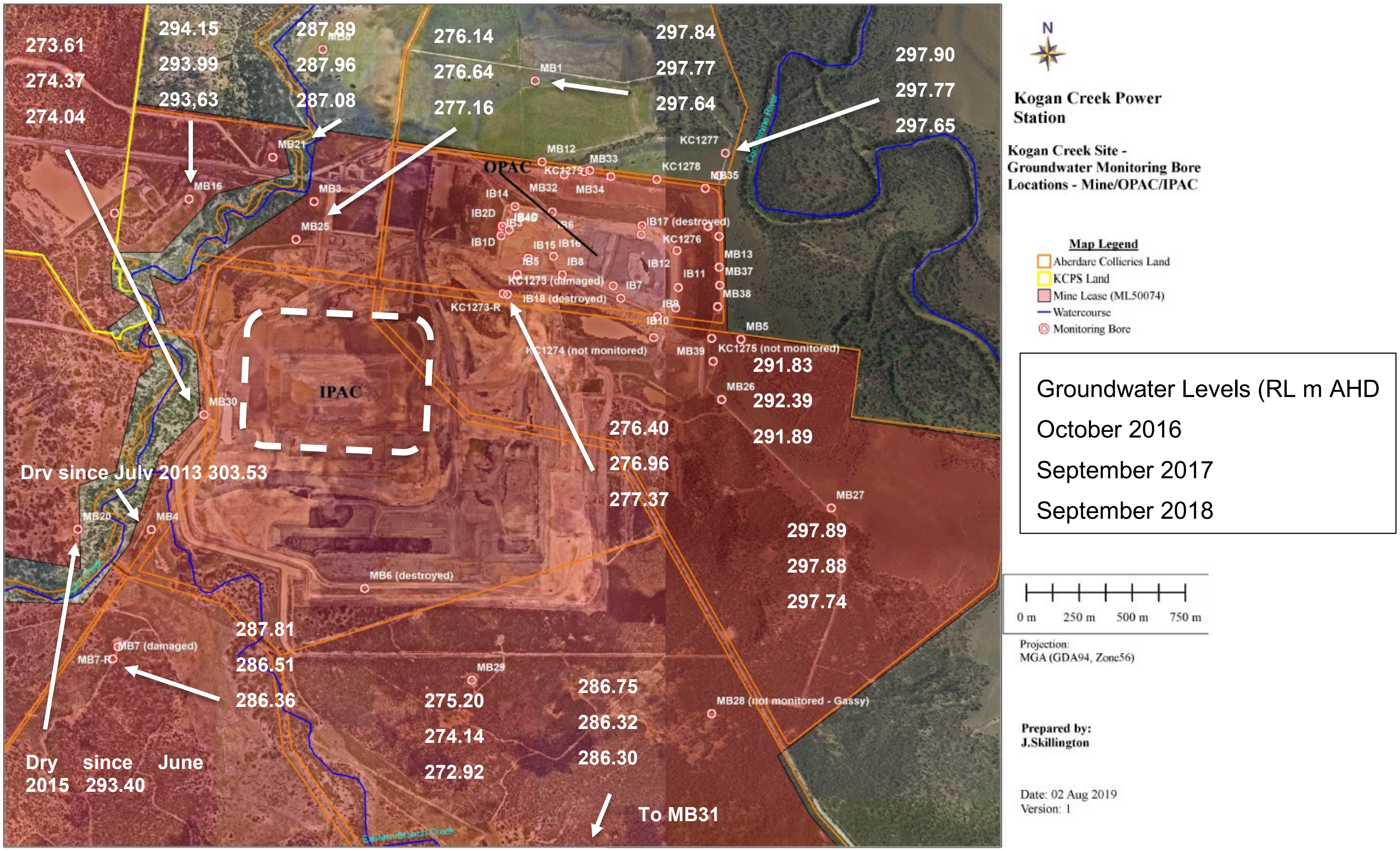
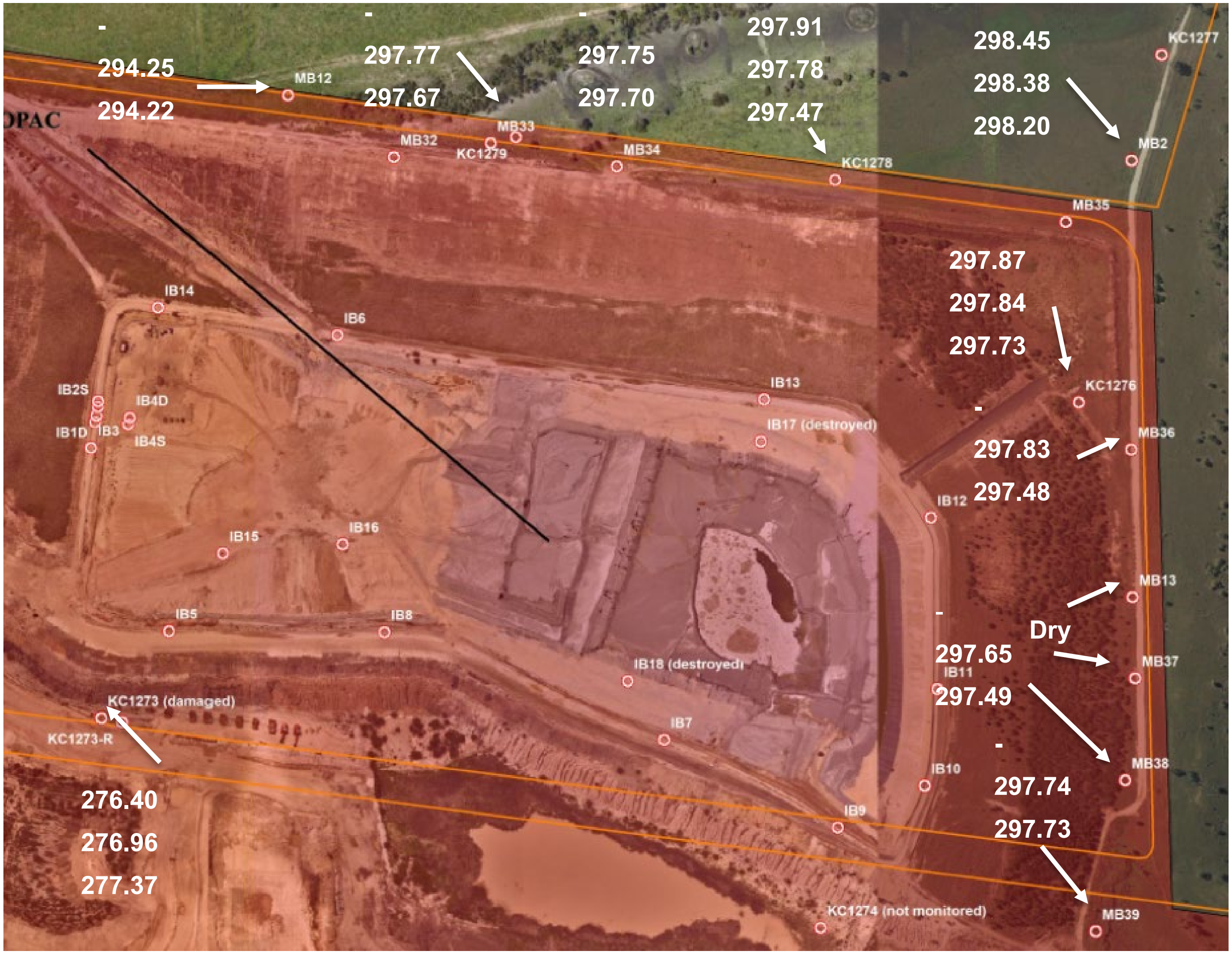


Figure 9 Groundwater Levels Mine Area

Groundwater Levels
(RL m AHD)
D = Dry

Figure 10 Groundwater Levels Monitoring Bores OPAC Ash , Embankment and Perimeter Bores September 2018



Groundwater Levels
(RL m AHD)
October 2016
December 2017
September 2018

Figure 11 Groundwater Levels Monitoring Bores OPAC Perimeter

8.3.1 Groundwater Elevations Alluvium

Groundwater elevations in alluvium/weathered rock are monitored in several bores (MB1, MB2, MB4, MB5 and MB12 – refer Figure 5 for locations). Since March 2012 groundwater elevations have been measured manually on a quarterly basis. Groundwater elevation data from April 2007 to May 2019 for the various bores are shown in Figure 12.

Bores MB1 and MB2 are located to the north and northeast of the OPAC respectively, and elevations have slowly declined since mid-2013 due to the mostly below average rainfall years since 2011. In May 2019 MB1 was reported as dry.

MB4 is a shallow bore (14 m depth) on the western side of the mine pit. It has been dry since the end of 2012 which is evidence of potential groundwater drainage to the mine pit in this area.

The groundwater elevation in MB5 on the eastern side of the OPAC has been relatively stable at around RL 297 since 2015.

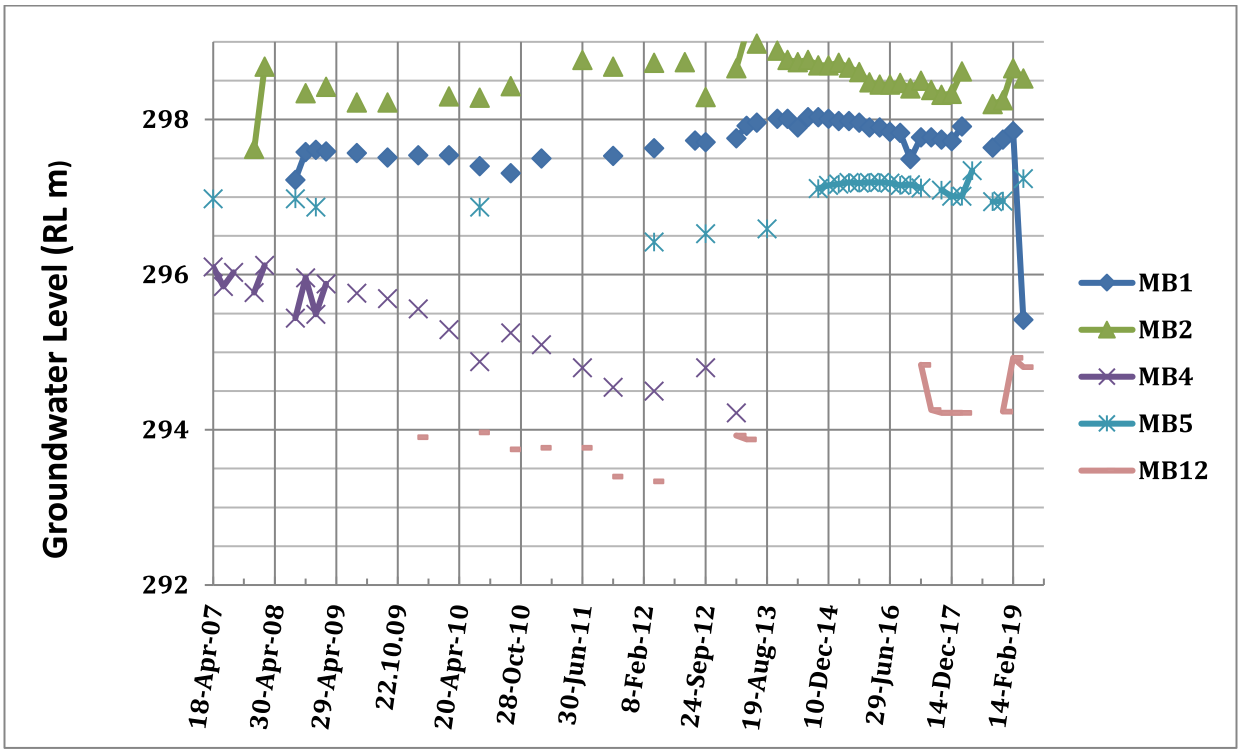


Figure 12 Groundwater Elevations Alluvial Bores

8.3.2 Groundwater Elevations Springbok Sandstone/ Walloon Coal Measures

Groundwater elevations in weathered to fresh sedimentary strata are monitored in several bores (MB7R, MB9, MB10-R, MB16, MB17-R, MB18, MB20, MB21, MB24D, MB29). Selected time series data are shown in Figure 13. Bores on the western side of Kogan Creek (MB10, MB16, MB17, MB20) indicate that groundwater elevations generally lie between RL 292 m and RL 296 m. There is no clear overall spatial trend with respect to groundwater flow directions.

Bore MB16 which is located adjacent to Kogan Creek has continued to decline to around RL 293. Water elevations in bore MB20 generally progressively declined from around RL 296 in July 2009 to below RL 293.8 in December 2014 when the bore became dry. No groundwater has been subsequently observed in MB20. MB20 is located approximately 500 m west of the mine pit on the western side of Kogan Creek. The data from MB20 and MB18 is possibly indicative of depressurization in the Springbok Sandstone/Walloon Coal Measures.

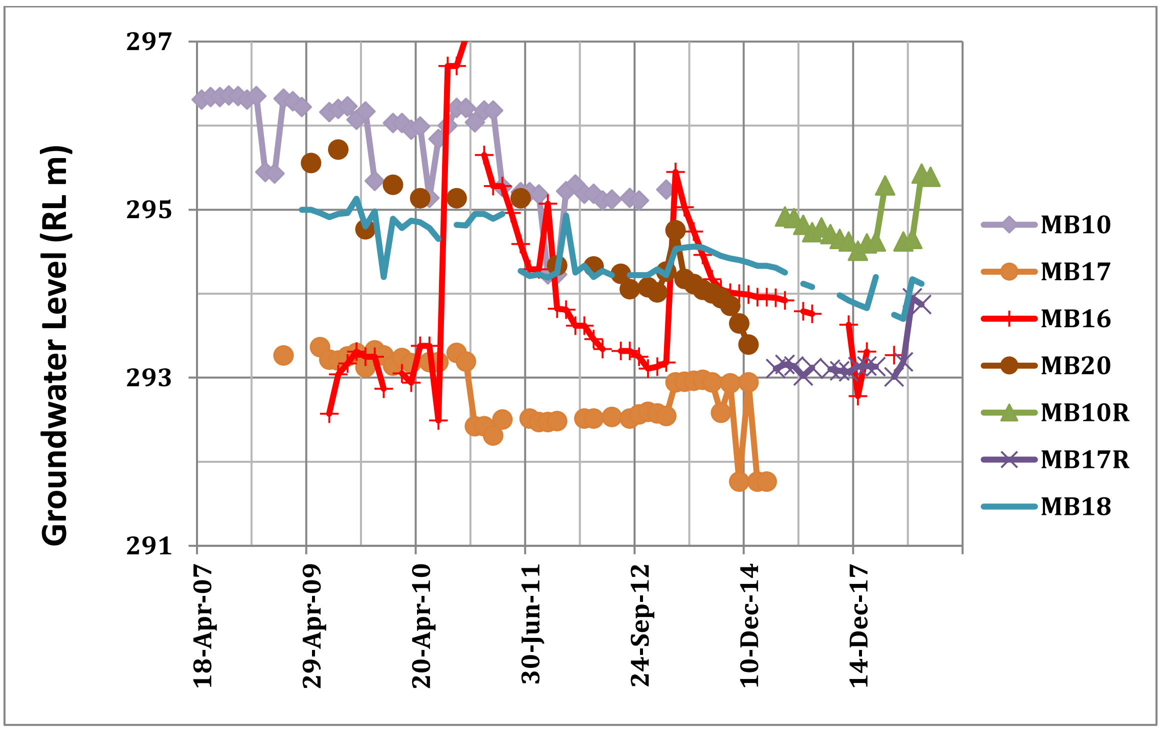


Figure 13 Groundwater Elevations in Springbok Sandstone/Walloon Coal Measures

8.4 Minesite/OPAC

Details of the groundwater monitoring network in the Mine area were provided in the 2016 Report. Monitoring of the bores continued throughout this Report Period on a quarterly basis and locations are set out in Figure .

Groundwater elevation data collection commenced in 2007. Pre-mining groundwater elevations in the Walloon Coal Measures in the current pit area would have been less than RL 300 m inclusive of any seasonal or other natural fluctuations or at least 10 m below ground elevation, assuming an average ground elevation of RL 310 m.

Groundwater levels for October 2016, November 2017 and November 2018 are shown in Figure 9. The levels indicate that the lowest levels are recorded in bores closest to the pit (KC1273-R, MB25, MB30, MB29, MB21). Background conditions are recorded at bores MB26 and MB27

A conceptual cross-section of groundwater elevations in the vicinity of the mine pit is shown at Figure 14, which shows;

- the inferred initial potentiometric surface falling from around RL 298 south of MB7R on the southern side of the pit to around RL 294 on the eastern side of the OPAC;
- the inferred potentiometric surface as at November 2015, with the pit floor at around RL 254.

Figure 15a shows long term water levels in bores MB4, MB6/MB29, MB7/MB7-R from 2007 to 2019. The data highlights the inferred dewatering that has occurred at MB4 and the ongoing declines in groundwater head at MB6 and its replacement bore MB29 and MB7/ MB7-R.

Figure 15b shows water elevation declines have occurred in bores KC1273-R, MB6, MB7-R, MB25, MB29 and MB30 since 2013. Baseline conditions appear to be present in MB26 and MB27 on the eastern side of the pit. .

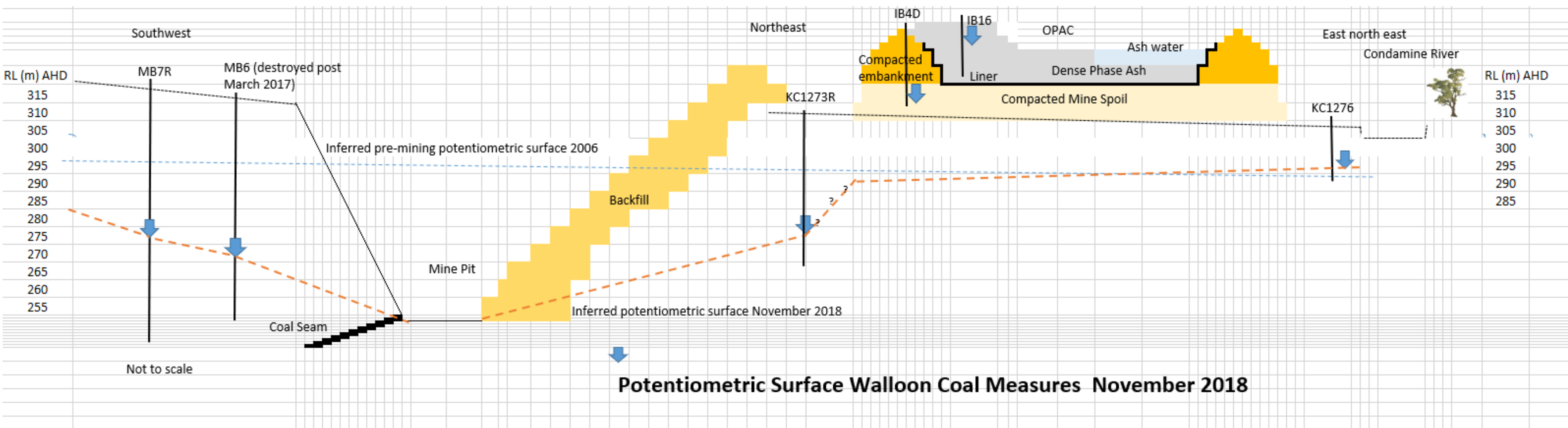


Figure 14 Groundwater Elevations Kogan Creek Mine and OPAC

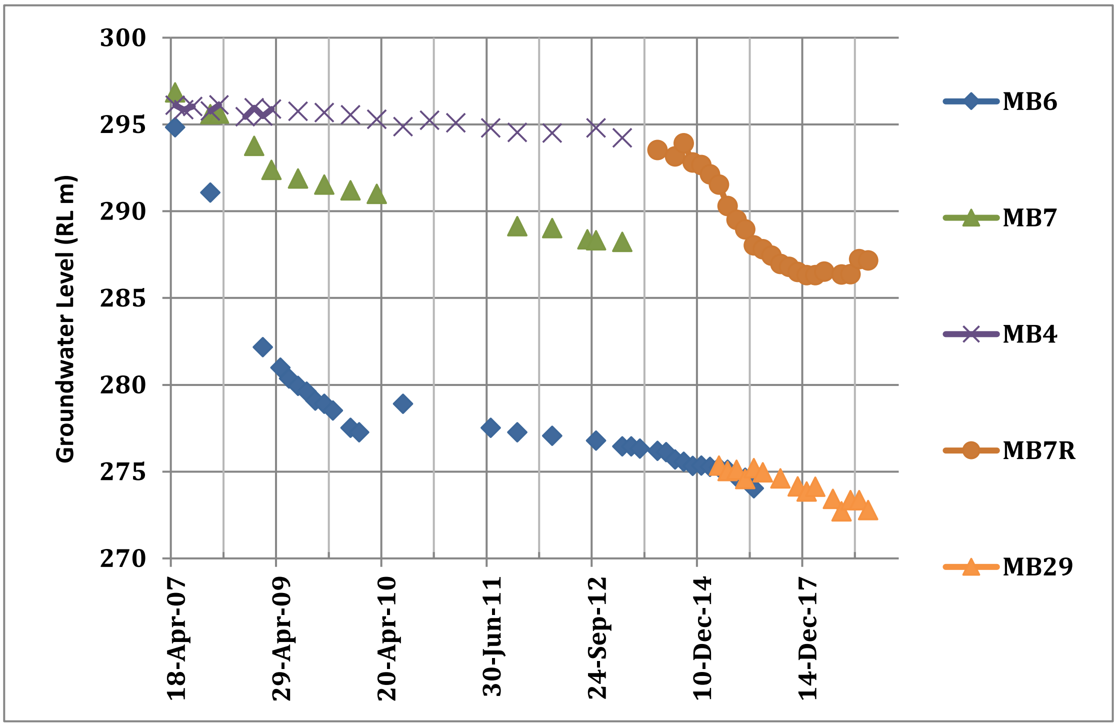


Figure 15a Groundwater Elevations Kogan Creek Mine 2007 – 2019

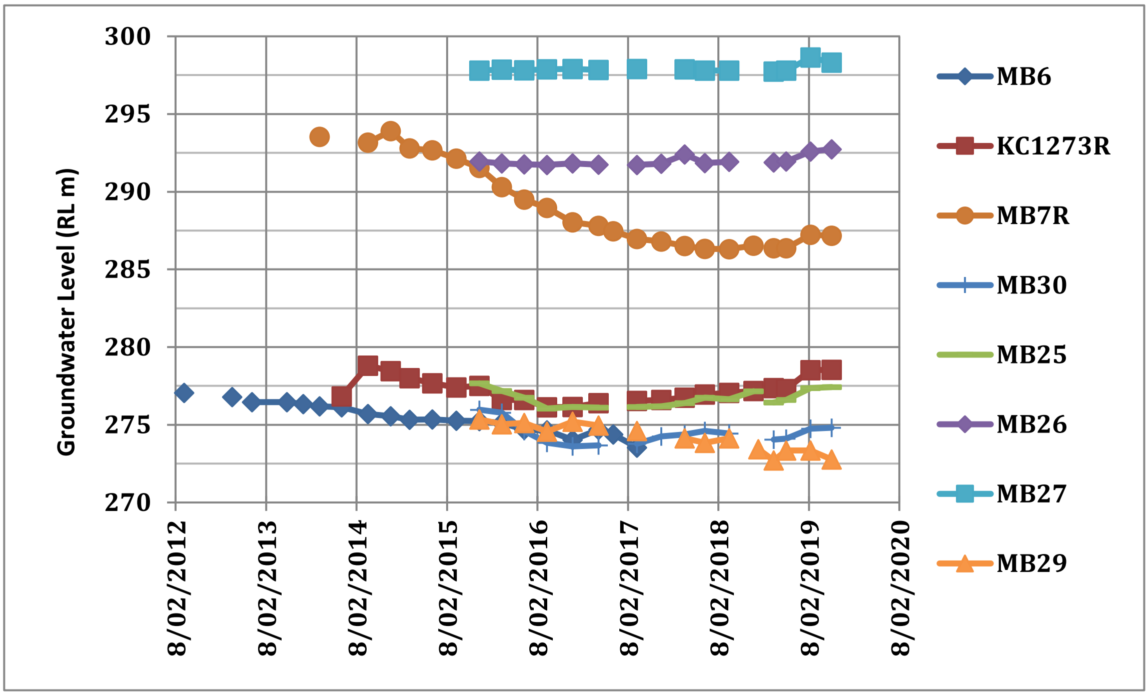


Figure 15b Groundwater Elevations Kogan Creek Mine 2013 – 2019

Hydrographs for bores MB6 and MB7-R are shown in Figures 15c and 15d. The logger in MB6 was working in March 2017 when the bore was last visited before it was destroyed. The continuous data matched very closely with the quarterly manual water levels. The logger in bore MB7-R was recording accurately till August 2015 but then appears to have malfunctioned.

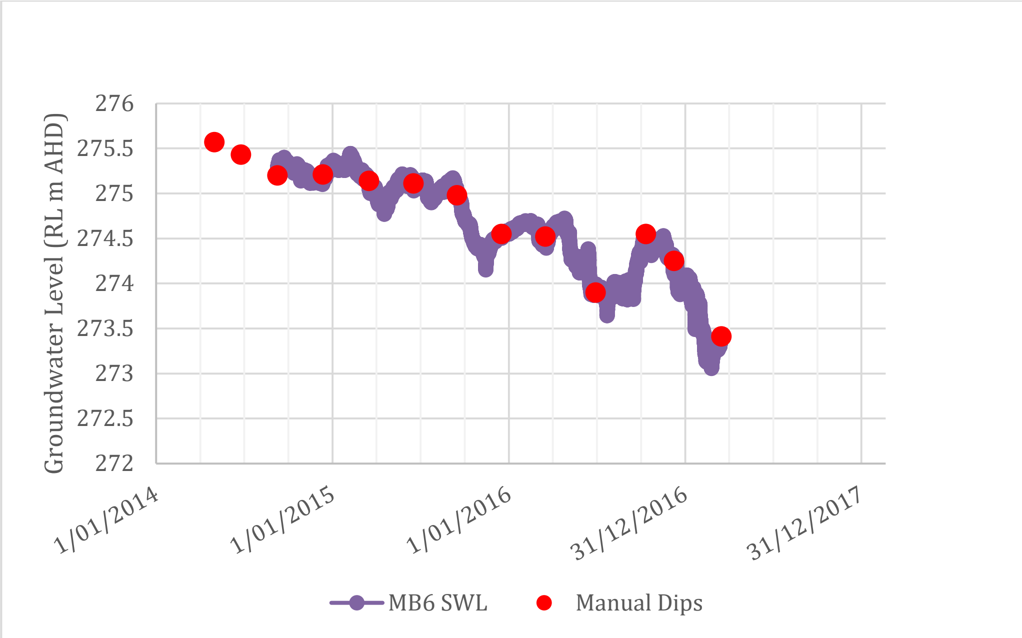


Figure 15c Groundwater Elevations Bore MB6

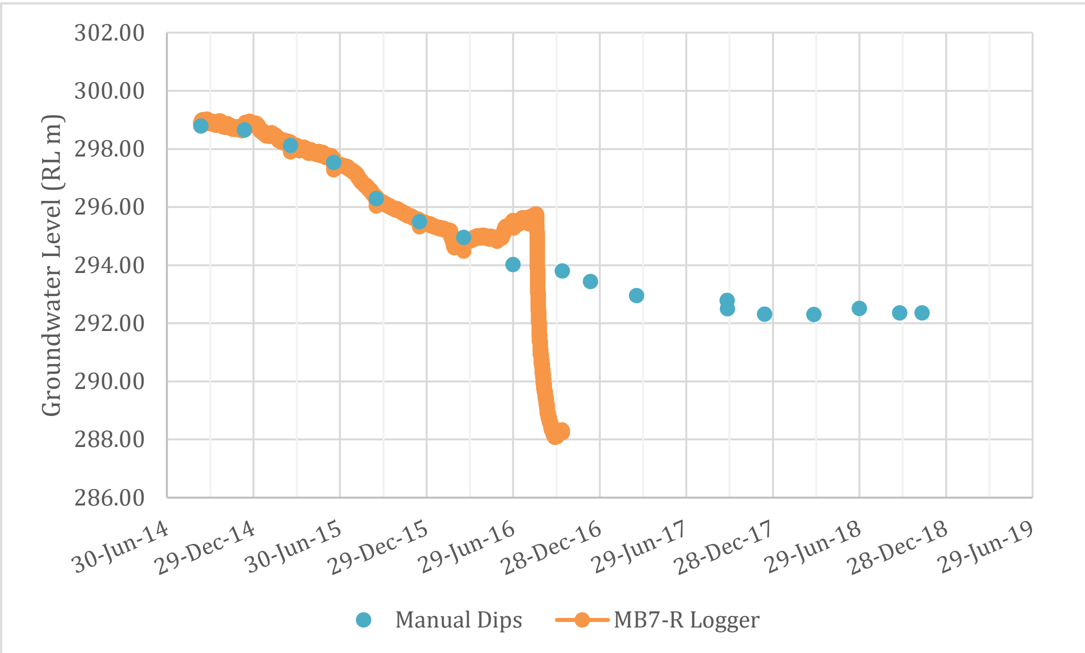


Figure15d Groundwater Elevations Bore MB7R

Estimated groundwater pressure declines from inferred background to November 2018 in bores MB7R, MB6, KC1273R and KC1276 are shown at Table 3.

Table 3 Estimated Background Groundwater Elevations in Mine Area Bores

Bore	Inferred Background Elevation (RL m AHD)	Potentiometric Elevation November 2018 (RL m AHD)	Groundwater Head Decline (m)
MB7-R	298	277.30	21.3
MB6*	296	273.54*	22.46
KC1273-R	293	277.30	15.70

*at March 2017. Subsequently destroyed

Whilst groundwater pressure declines have been observed, the low horizontal permeability of the exposed coal seams is of a magnitude that little free groundwater discharges to the pit floor. Consequently no pit dewatering is carried out.

8.4.1.1 Discussion

Groundwater elevation decline due to mine pit development has been occurring in monitoring bores in the vicinity of the pit since 2007.

Pressure declines have been observed in alluvial material in Kogan Ck at bore MB4, and in bores that intersect sedimentary strata (either Springbok or Walloons Coal Measures strata) on the northern, southern and western sides of the pit. This indicates that a depressurised zone has developed around the pit and may have extended as far as bore MB20 which is approximately 460 m to the west of the pit and on the western side of Kogan Ck.

Whilst pressure data in these new bores has been slightly different to the older bores, the recent pressure trends around the mine pit indicate pressures have stabilized and have increased slightly. It is not clear why pressure increases are occurring.

8.4.2 Groundwater Elevations OPAC

Ash deposition at the OPAC commenced in October 2010. Groundwater elevations were initially monitored in several bores located around the OPAC (MB2, MB5, MB12 and MB13) as well as a downgradient background bore MB1 – refer Figure 8. Bores KC1273 to KC1279 were drilled in late 2009 to augment the existing OPAC monitoring bores. Bore KC1273-R was drilled as a replacement bore for KC1273 in 2013. Monitoring is currently carried out on a quarterly basis in bores MB2, MB5, MB12, MB13, KC1273-R, KC1276, KC1277 and KC1278. Bores MB32 to MB39 were drilled in late 2017 to augment the existing monitoring network as part of OPAC bubble investigations.

In addition bores were constructed in the OPAC embankment and OPAC ash (bores IB1 to IB16) in 2017 as part of OPAC bubble investigations.

Figure 16 shows groundwater levels in all OPAC ash, embankment fill and perimeter monitoring bores in September 2018. Figure 11 shows groundwater levels in the perimeter monitoring bores on three occasions since October 2016. Figure 16 shows time series groundwater level data in long term perimeter OPAC bores.

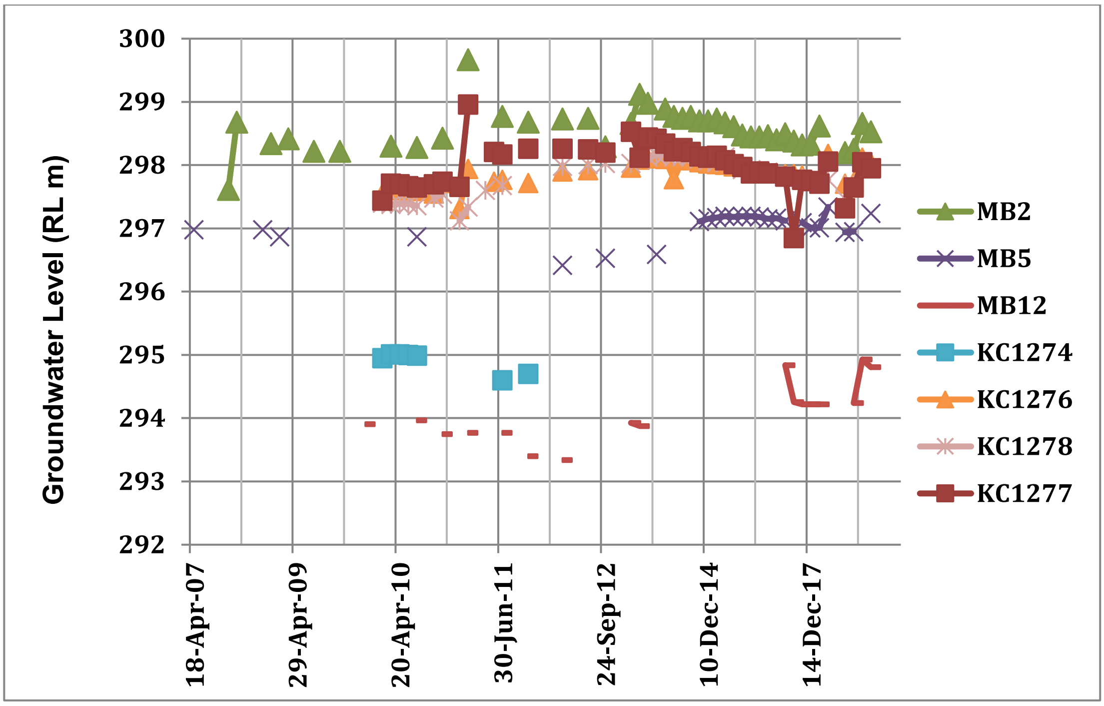


Figure 16 Groundwater Elevations OPAC

Key findings are discussed below.

Ash Pore Water

Ash pore water levels in bores IB4S, IB15 and IB16 have generally been relatively stable above RL 331 since May 2017 at the western end and in the centre of the OPAC storage (Figure 17). This indicates that ash is saturated at about 12 m below ash surface at the western end of the OPAC and is 23 to 24 m below ash surface where the ash pile is higher in the middle section of the OPAC. The data indicates that there has been little impact on ash dewatering from ash water extraction.

OPAC Embankment

Most OPAC embankment bores (IB1D, 2S, 2D, 3 ,5, 6, 7, 8 ,9, 10. 11. 12) have been dry on all occasions sampled since May 2017.

By comparison groundwater levels in bores IB4D, which monitors groundwater head in OPAC subgrade below liner level, and IB13, which monitors free water presence in embankment fill, have recorded groundwater levels of around RL 313. These are respectively approximately 19.3 and 18.3 m lower than water levels in OPAC ash.

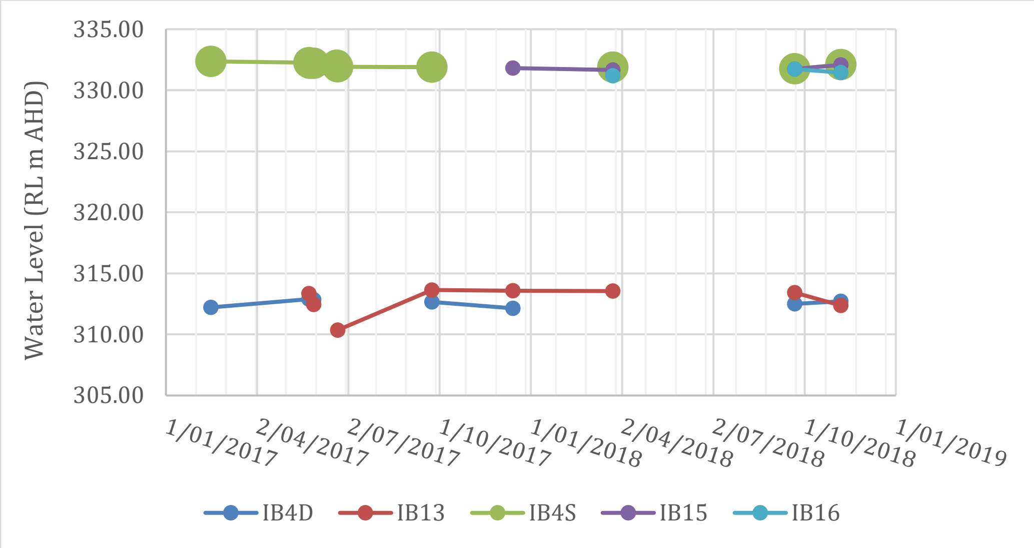


Figure 17 OPAC Ash Pore Water and Embankment/Subgrade Water Levels

Perimeter Monitoring Bores North and East of OPAC

Over the review period alluvium and shallow Walloons monitoring bores have generally shown slight declines in groundwater levels followed by rises between November 2018 and March 2019. The falls are consistent with the low observed annual rainfalls and indicates there is no hydraulic connection with the OPAC. (Figure 17). Groundwater levels in all bores were around RL 297.5 to 297.7 in September 2018 or approximately 16 m lower than groundwater heads in the OPAC subgrade. The elevated water levels in March 2019 are probably due to recharge from the high December (189.9 mm) and March rainfalls (188.4 mm).

Groundwater heads in the monitoring bores constructed in late 2017 (MB33 to MB39) are shown in Figure 18 along with data for the period from KC1276 and KC1278. Elevations in all bores shown were between RL 297 and RL 298.

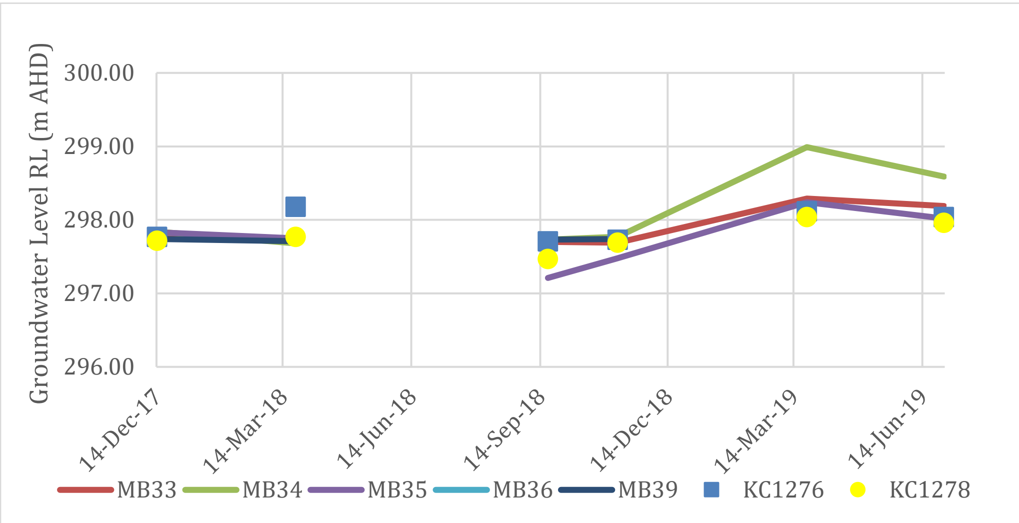


Figure 18 OPAC Perimeter Bores Condamine Alluvium

By comparison groundwater levels between the OPAC and the mine pit area have increased by over 1 m since June 2016 to around RL 278.5 in June 2019 as measured in bore KC1273-R (Figure 19). Historically, groundwater pressures have been declining in this area and were most likely influenced by coal seam depressurisation associated with the pit. It is not clear why groundwater pressures are slowly increasing in KC1273-R, but this trend has also been observed in IPAC bores MB25 and MB30.

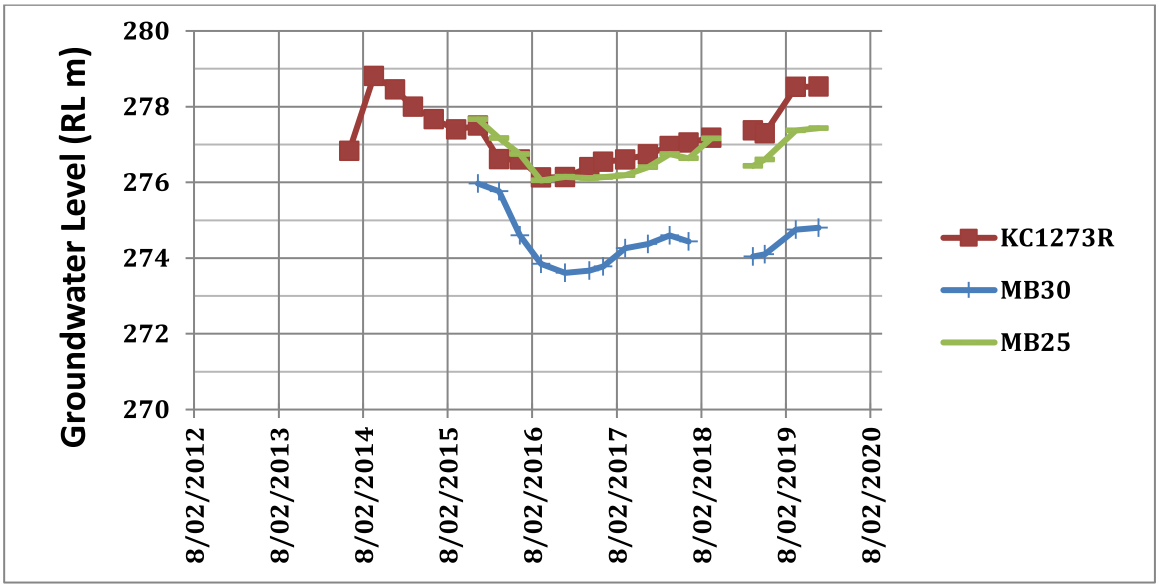


Figure 19 Groundwater Pressures Walloon Coal Measures Pit and IPAC Areas

8.5 IPAC

Groundwater monitoring in the vicinity of the IPAC is undertaken at bores MB25 and MB30 (Figure 9). MB25 is located approximately 280 m north of the IPAC, whilst MB30 is located approximately 140 m west of the IPAC. Both bores were drilled to around 45 m depth in natural ground to intersect water-bearing coal strata. Initial standing water levels in September 2015 were 31.86 m and 34.68 m in MB25 and MB30 respectively.

Groundwater levels have been monitored on a quarterly basis since June 2015 (Figure 19). Groundwater is semi-confined and the depths to water are measuring the elevation of the potentiometric surface (groundwater pressure) in the coals. Both bores have generally shown a similar response. A pressure decline was observed to March -June 2016 followed by a stabilisation period to December 2016 – March 2017 and a subsequent pressure increase.

The initial pressure decline may have been due to overall groundwater depressurisation associated with the mine pit, whilst the latter period of pressure increase post March 2017 may be due to pressure loading from IPAC construction.

8.6 IADA

Groundwater monitoring at the IADA initially consisted of two bores (MB9, MB10) and three shallow bores (KG04, KG05, KG06) which monitor for possible shallow seepage at the IADA. Monitoring of these bores commenced in April 2007 and apart from MB10 has continued through the period of this report. Subsequently MB17 and MB18 were established with monitoring commencing in July 2009, continuing throughout the period of this report. In 2015 MB10-R and MB17-R were drilled as replacements for MB10 and MB17 which had been found to be unsuitable for ongoing sampling. In both cases the opportunity was taken to construct the replacement bores closer to the IADA (Figure 20).

8.6.1 Groundwater Elevations IADA

Shallow bores KG04 - KG06 (approximately 10 m deep) constructed adjacent to and outside of the IADA were historically dry and have continued to be dry over the Review Period. No borehole data is available for the KG series bores at the IADA. It is understood that they were drilled/cased to the “first rock layer” i.e. they are shallow (less than 10 m deep).

Groundwater elevations are currently monitored at four deep bores (MB9, MB10-R, MB17-R, and MB18) in the vicinity of the IADA as shown in Figure 20.

Water intersections recorded in the drillers logs in the initial bores drilled in the area, MB9 and MB10, were at 19 m and 14 m depth respectively, associated with soaks in sandstone. The regional groundwater potentiometric surface in the vicinity of the IADA is around 20 to 25 m below ground surface in this area, based on groundwater elevation responses at bores MB9, MB10-R and MB17-R.

Groundwater elevations have remained relatively constant in MB9, MB10-R and MB17-R over the Review Period (Figure 21). Groundwater level has been at around 21 m depth at approximately RL 295 in bore MB9.

Bores MB9. MB10 and MB10-R have shown no influence of groundwater mounding from potential seepage through the floor of the IADA.

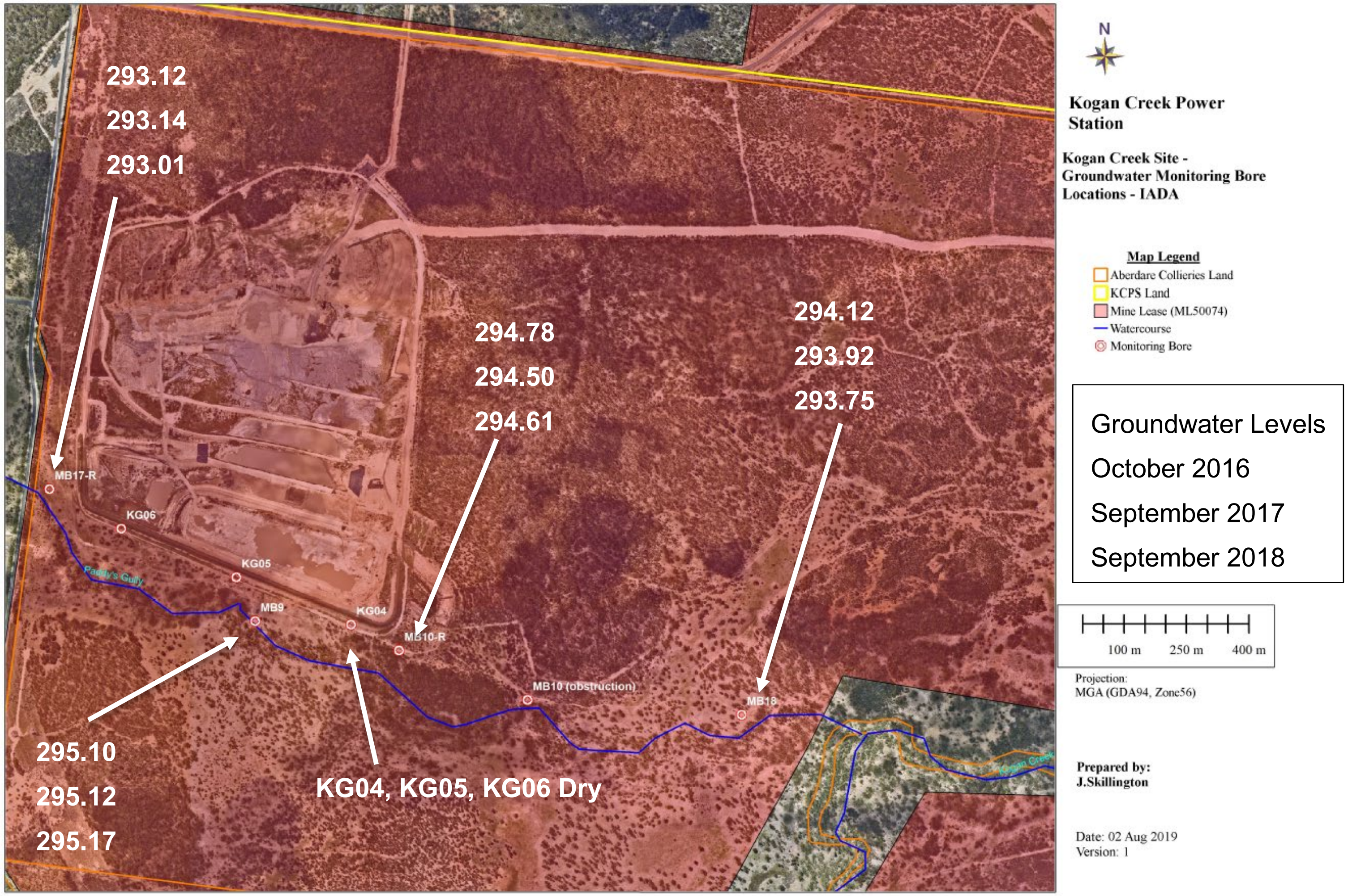


Figure 20 IADA Groundwater Levels 2016 to 2018

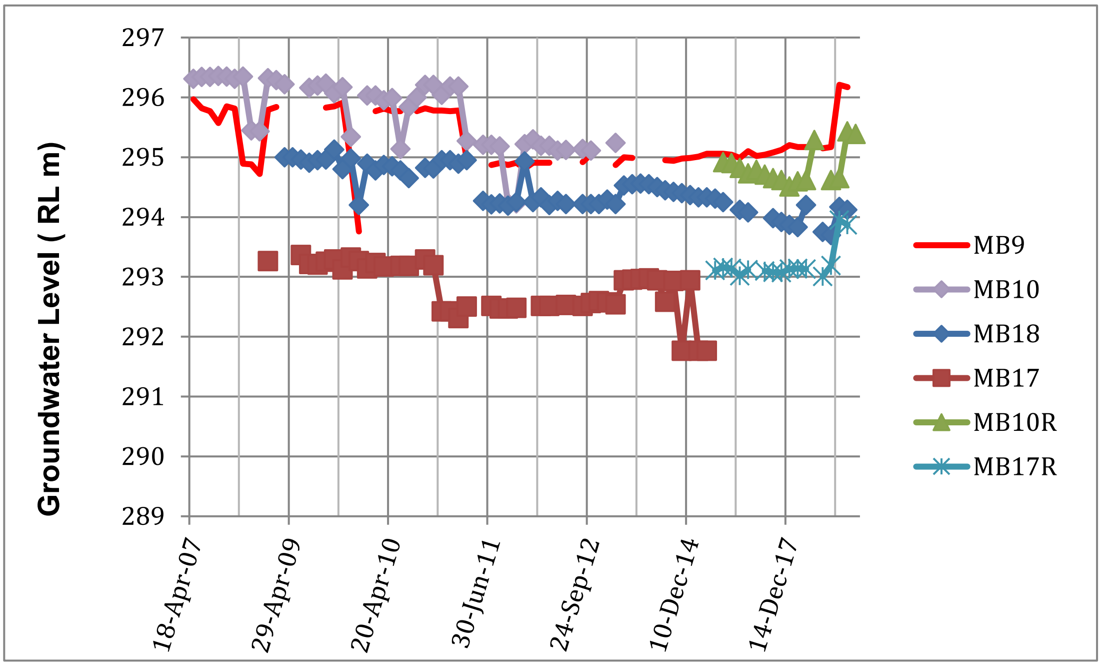


Figure 21 Groundwater Elevations IADA

8.6.2 Groundwater Elevations Power Station

A number of groundwater monitoring bores are monitored in the power station area (MB14, MB15, MB16, MB21, MB24S, MB24I and MB24D-R) – refer Figure 7 for locations. Due to the relative ground elevation between the power station site and Kogan Creek and the underlying consolidated sedimentary strata, groundwater data has only been regularly recorded at the deepest bore at the power station site (MB24D-R), and in bores MB16 and MB21 located adjacent to Kogan Creek. Bore MB24D-R was constructed in 2015 to replace MB24D as a groundwater sampling point. A continuous groundwater pressure recorder is installed in bore MB24D. Groundwater elevation data for bore MB16, 21 and 24D are shown at Figure 22.

At the power station site, the standing groundwater elevation is relatively stable at approximately 50 m below ground elevation at around RL 291 m, as recorded in bore MB24D in May 2013, and is inferred to be associated with the Walloon Coal Measures from 65 – 80 m depth.

No groundwater has been recorded in bores MB14 (28.3 m deep) and MB15 (17 m deep) that monitor groundwater elevations at the Northern Stormwater Dam (NSWD) and Drains Reclaim Dam (DRD) respectively.

Bores MB23S (7 m deep) and MB23I (33 m deep) and MB24S (7 m deep) and MB24I (36 m deep) monitor groundwater in Springbok Formation adjacent to the Submerged Chain Conveyor (SCC) Pond and Lagoon Gully Pond. There is no evidence of any basal seepage from unlined ponds at the power station (SCC Pond, Lagoon Gully

Pond), as underlying sandstone horizons in the monitoring bores are dry and unsaturated.

Bore MB16, located approximately 350 m east of the Southern Stormwater Dam, (SSWD) was drilled to 18 m depth and encountered clays with some gravel and coal to 17 m overlying shale. The bore responded to recharge events in 2010/11 and 2012/13, and has subsequently declined to around RL 294 m.

Bore MB21 is located approximately 400 m northeast of bore MB16. It was drilled to 23 m depth and encountered clays and sandy clay to 22 m overlying shale. Groundwater elevations in the bore have fluctuated between 19.6 and 21.2 m below ground elevation, between RL 288.2 m and RL 289.8 m. The bore also appears to have responded to the recharge events in 2010/11 and 2012/13, but has subsequently declined to pre-2011 elevations.

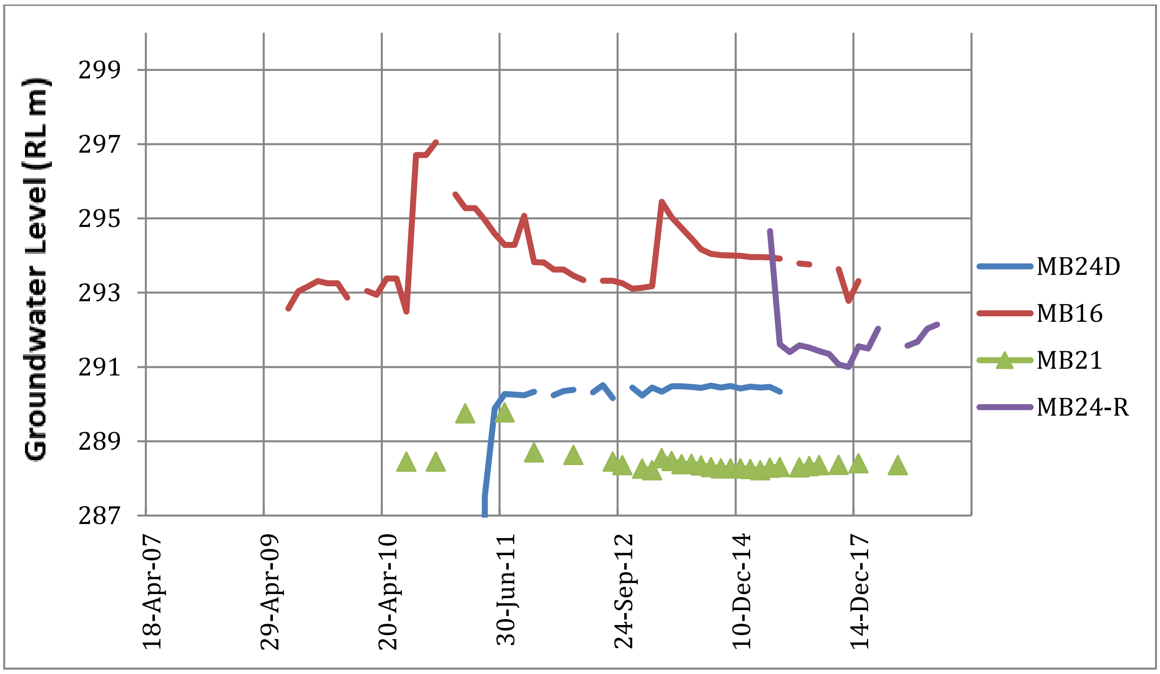


Figure 22 Groundwater Elevations Power Station

8.7 Key Findings – Groundwater Flow

Bore water elevations can be influenced by a number of factors including:

- Extent to which groundwater adjacent to bore is under pressure;
- Extent and depth of monitoring horizon in a particular borehole. (Is the borehole measuring groundwater pressure at a particular point or providing an averaging effect over a thickness of geological strata that may contain groundwater at different elevations (eg coal seams)?;
- Geological formation being monitored and degree of aquifer "connectivity" ie horizontal and vertical hydraulic conductivity;
- Influence of recent recharge events; and

- Influence of mine depressurisation/dewatering or other groundwater extraction activities.

Groundwater elevations in several bores close to Kogan Creek and the Condamine River (MB2, MB16, MB20, MB21 and KC1276, KC1277, KC1278) potentially showed the influence of recharge from the floods of 2010/11 and/or 2013 and elevations have generally declined a little since mid-2013 with the drier climatic conditions.

In the mine area, several bores have reported declining water elevations which are indicative of aquifer depressurisation/dewatering due to open pit development. Pressure declines have been observed in alluvial material in Kogan Ck at bore MB4, and in bores that intersect sedimentary strata (either Springbok or Walloons Coal Measures strata) on the northern, southern and western sides of the pit. This indicates that a depressurised zone has developed around the pit and may have extended as far as bore MB20 which is approximately 460 m to the west of the pit on the western side of Kogan Creek.

There is no evidence of “shallow” seepage emanating from the IADA. Bores that have intersected the regional water table approximately 20 - 25 m below ground surface show no influence of groundwater mounding from potential seepage through the floor of the IADA.

There is no evidence of OPAC ash disposal activities influencing water elevations in adjacent monitoring bores.

9.0 GROUNDWATER QUALITY

This section describes ash disposal area water quality and adjacent groundwater quality.

9.1 IADA

The IADA is constructed on local alluvial sediments and the sandstone that is above the Walloon Coal Measures. The ground surface within the IADA footprint was compacted to meet EA requirements. The storage commenced operations with power generation in mid 2007 and ceased active ashing in early 2011.

Water quality monitoring of the pond in the IADA (sampling point KS02) has shown that the water quality in the cell storage pond between September 2013 and March 2016 has been slightly alkaline (pH 7.37–9.05), variable salinity (EC 521–2980 µS/cm) and influenced by rainfall/evaporation. Salinity and major salt concentrations were generally low following the cessation of ashing until April 2016 when pumping of saline decant water from the OPAC to the IADA commenced. In May 2016 the pH had increased to 9.6 and the electrical conductivity to 10270 µS/cm due to inflow of OPAC water. Water quality at sampling point KS02 has returned to pre-2016 levels in 2018. OPAC water (ash water) is still pumped to the IADA when required for storage and/or evaporation using the evaporation fans. At times the water quality will be almost entirely stormwater or a combination of the two water sources.

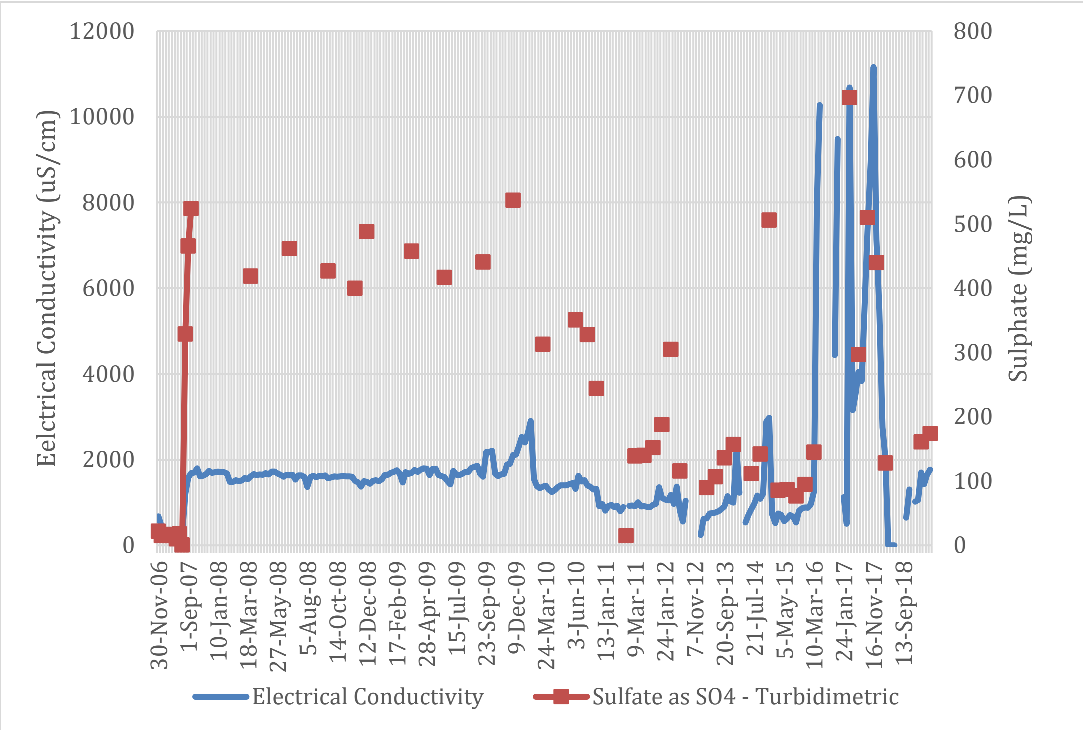


Figure 23 IADA Water Quality

Standing groundwater elevation beneath the site is approximately 20 to >25 m below ground surface. Regional groundwater flow direction in the Springbok Sandstone is uncertain, but is expected to be towards the northwest to northeast derived from higher elevations to the southwest.

Bore MB17-R is located approximately 150 m west and topographically up slope from the IADA and has recorded electrical conductivity elevations (9060–10100 µS/cm) which are higher than those encountered in the IADA prior to April 2016. Local groundwater to the east is significantly more saline than IADA water. Bores MB9, MB10-R and MB18 have recorded respective salinities (as electrical conductivity) of 5550–14870 µS/cm, 16470-18298 µS/cm and 27000-31800 µS/cm.

Sulphate concentrations (MB9 – 681 – 981 mg/L, MB10-R - 112 – 1320 mg/L and MB18 – 948 - 1020 mg/L) tend to be much higher than background quality from bores in Walloon Coal Measures (MB6: 67-122 mg/L, MB7: <1-8 mg/L) on the mine site which may be a result of local sulphide oxidation. However, sulphate at MB17-R to the west of the IADA, is much lower and has ranged between 177 and 265 mg/L.

Chloride elevations in the 3 bores to the south and east of the IADA (MB9: 3170 - 5210 mg/L, MB10R: 5220 - 5580 mg/L and MB18: 8350 – 11400 mg/L) are also very elevated when compared with west of the IADA (MB17R: 2410 – 2750 mg/L).

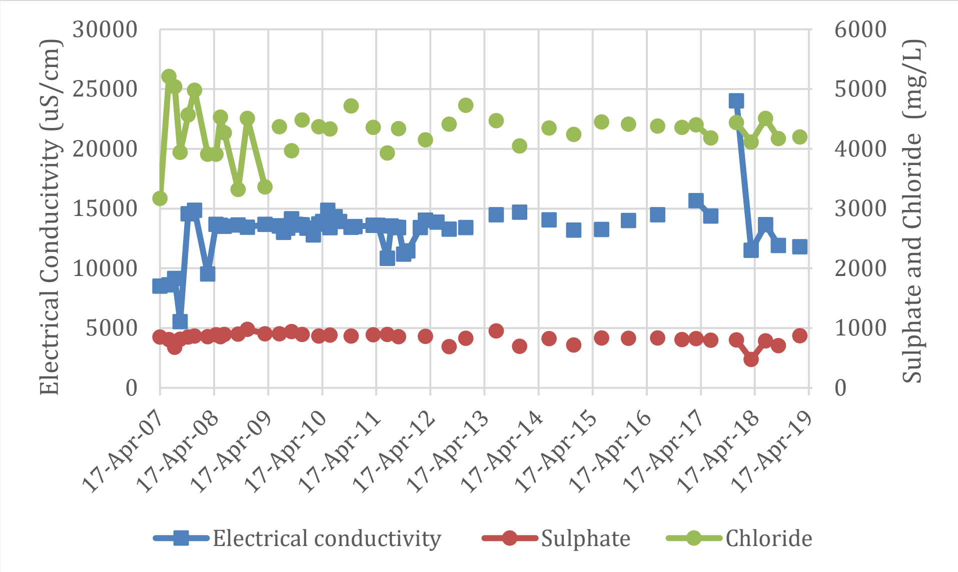


Figure 24 Groundwater Quality MB9

Given the age of the storage facility, vertical and horizontal rock permeability, depth to water intersections, potential solute migration rates in groundwater and the distance of the bores from the IADA (e.g. MB10-R is approximately 90 m from the storage), the observed groundwater quality is most likely to represent background quality related to local geological factors as previously described. There is no evidence from monitoring bores that seepage has occurred.

The presence of seepage could be expected to be indicated by:

- Continued presence and increasing depth of IADA water in shallow KG – series bores;
- Increase in potentiometric head in deep groundwater monitoring bores; and
- Initial groundwater salinity decrease in deep monitoring bores with reduced concentrations of key ions such as sodium and chloride.

9.2 Mine Site

Mine groundwater quality is generally slightly acidic to neutral in alluvium and weathered sediments, becoming more alkaline in coal seams. Regional groundwater in Walloon Coal Measures generally has a pH greater than 8. Groundwaters have variable salinity depending on bore location and aquifer zones intersected.

Bores MB6 and MB7 were screened from 43–58 m and 73–79 m respectively in sandstones within Walloon Coal Measures and recorded salinities of between 2380 and 6560 mg/L respectively and were considered background bores.

Bore MB4 drilled adjacent to Kogan Creek was screened in silty/sandy clay from 8-14 m depth and recorded very high salinity and sodium-chloride-sulphate rich groundwater (41400–52000 mg/L). MB20 which was drilled to replace MB4 (MB20 drilled to 18 m into Springbok? Sandstone) recorded a high salinity (but much lower than that encountered in MB4) sodium-chloride rich water (TDS 13100–14500 mg/L).

No groundwater has been recorded in bores MB3 and MB8 due to the bores being dry. Both are located on the eastern side of Kogan Ck north of the mine. MB3 was located to monitor potential seepage from the ROM Pond. Bores MB21 was drilled to replace MB3. MB21 has recorded a saline sodium-chloride rich water (TDS 2560 to 7480 mg/L)

9.3 OPAC

The key activities at the OPAC during the review period included:

- Expansion of ash placement to the eastern end of the storage;
- Raising of the decant pond level with consequent changes to the Mandatory Reporting Level;
- Expansion of ash pore water recovery bore locations and regular operation of the recovery bore system;
- Commencement of rehabilitation works on the final ash pile surface at the western end of the storage;
- The ongoing investigations into the bubble formation culminating in the submission of a final report to Department of Environment and Science (DES) in February 2018;
- Establishment of the OPAC embankment and ash storage area monitoring system
- Geophysical investigations on the northern and eastern sides of the OPAC resulting in expansion of the OPAC perimeter monitoring bore network;
- Regular annual inspections of the structural integrity of the OPAC embankment.

9.3.1 Bubble Investigation and Findings

Management actions since June 2016 resulted in partially draining the bubble such that it was estimated that about 100 m^3 of OPAC water remained below the bubble in February 2017.

CS Energy assessed a range of future bubble management options which included an assessment of risk against a number of criteria including health and safety, technical feasibility and risk of environmental impact. As at November 2017 and due to CS Energy's ash placement strategy, the bubble was still exposed (had not been covered with ash) but submerged beneath decant water.

With the advancement of the ash front, it was considered possible that the "source" area for the ash water in the bubble was by then covered with ash, which would possibly reduce the volume of ash water leakage from the "source" to a negligible amount.

It was further expected that residual ash water in the bubble, once it was covered with ash, would act as a perched lens of water beneath the liner with residual water slowly moving to areas of least resistance/lower pressure. This could either be into the overlying ash via the buried bubble puncture holes, horizontally at the contact zone between the liner and underlying fill or into the underlying compacted fill.

In summary, it was considered that the accumulation of ash water below the bubble is a localised phenomenon and of small volume compared to the substantial potential absorption volume and mass in mine spoil beneath the OPAC.

Based on the limited available data that was available at the sites monitored during the course of the bubble investigation, it was concluded that ash pore water was likely contained within the OPAC and had not migrated into the embankment of the OPAC or to depth into the 10 m thick mine spoil fill layer underlying the OPAC.

Ongoing monitoring of water levels and groundwater chemistry in 2018 and to May 2019 supports this view and is discussed in detail in the following section.

Given the findings of the groundwater investigation[1], it was concluded that direct action to remediate the bubble would be impractical and not necessary. Consequently ash deposition over the bubble area has continued.

9.4 OPAC Monitoring Network

The current OPAC monitoring network is shown at Figure 25.

The original network prior to the augmentation program in 2017 consisted of 12 groundwater monitoring bores on the northern, eastern and southern sides of the OPAC which included:

- MB1, MB2, MB5, MB12, MB13
- KC1273 (destroyed) and replaced by KC1273-R on the southern side of the OPAC between it and the mine pit.

[1] Refer *"Kogan Creek Power Station Ash Disposal OPAC Liner Bubble Investigation Final Report January 2018*" submitted to DES January 2018

- KC1274 (destroyed), KC1275 (destroyed), KC1276, KC1277, KC1278, KC1279

As a result of the bubble investigations, a total of twenty five monitoring bores were constructed in 2017, including:

- thirteen in the OPAC embankment - , IB1S/1D, IB2S/2D, IB3, IB5 to IB13
- four in the OPAC ash storage area - IB4S, IB4D, IB15, IB16 and
- eight shallow alluvial bores on the northern and eastern side of the OPAC – MB32, MB33, MB34, MB35, MB36, MB37, MB38 and MB39.

All OPAC embankment bores (except at IB13 and occasionally at IB1S) have been dry on all sampling occasions since July 2017.

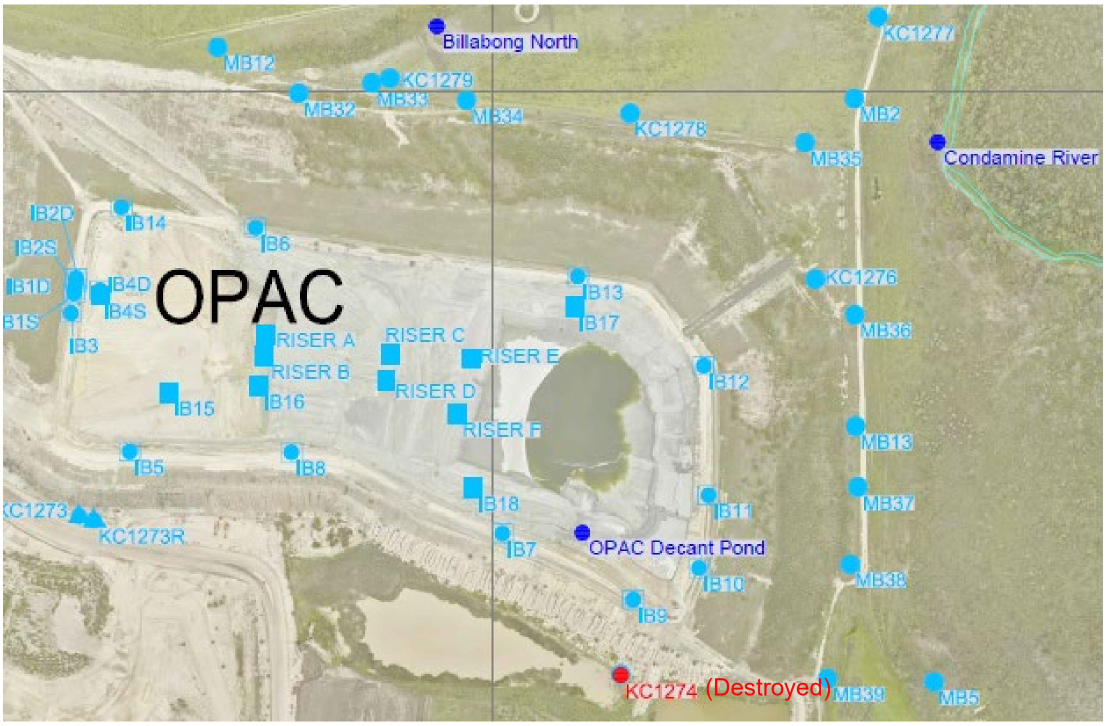


Figure 25 OPAC Area Groundwater and Surface Water Monitoring Network

9.4.1 OPAC Water Quality Trends

Ash is pumped to the OPAC as a slurry, with water sourced from the IADA and Submerged Chain Conveyor Pond (SCC) (located at the power station). Figure 26 indicates that salt concentrations in the OPAC (as measured by electrical conductivity (EC)) have generally risen since regular measurements began in late 2011. EC rose from approximately 2000–4000 µS/cm in 2012 and 2013, but subsequently doubled again over the next two years to around 8000 µS/cm by the end of 2015. Since December 2016 concentrations have fluctuated between 7000 and 10800 µS/cm. Since December 2016, ash slurry source water concentrations in the SCC pond have been mostly less than 8000 µS/cm. OPAC EC values were less than 7000 µS/cm in 2019.

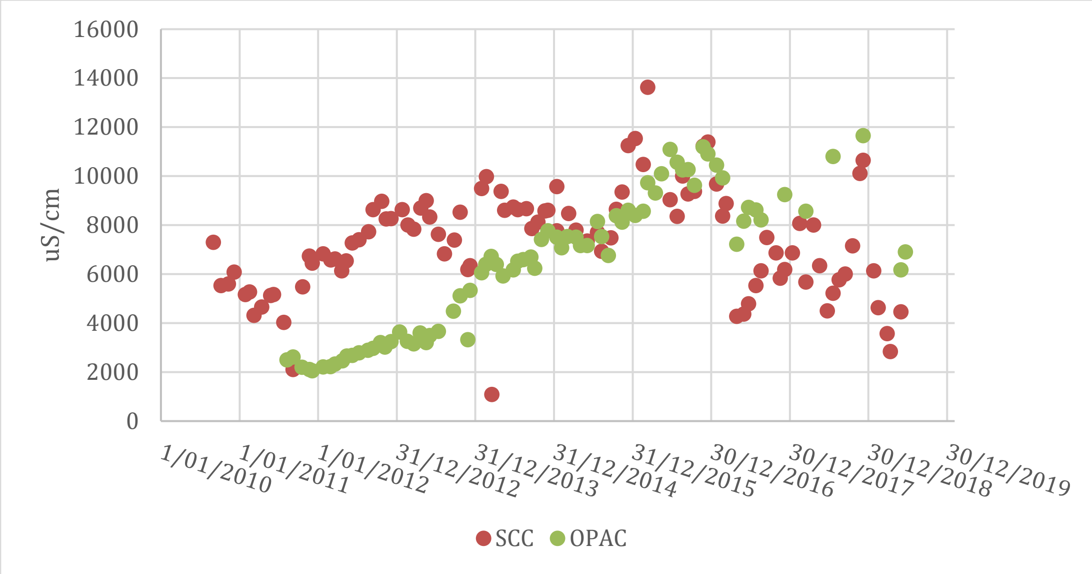


Figure 26 Electrical Conductivity in Pond Waters

Salts and trace elements have shown similar increases over time as is demonstrated in Figure 27 by the chloride and molybdenum concentrations over time. Overall parameter concentrations have increased in the order of 8 to 16 times for chloride and molybdenum respectively. This may be influenced by continual reuse/recycling of ash slurry water and enhanced evaporative processes, particularly since mid-2013, when there have been a series of drier years compared to the 2010/2011 wet period. Subsequent to the high rainfalls of early 2011, a significant quantity of relatively low salinity IADA water was stored in the OPAC. Figure 27 also indicates molybdenum concentrations generally ranged between 6 and 8 mg/L to March 2018 and were independent of pH, which generally fluctuated between 10 and 12 to that time. Only one detailed sampling event has taken place since March 2018.

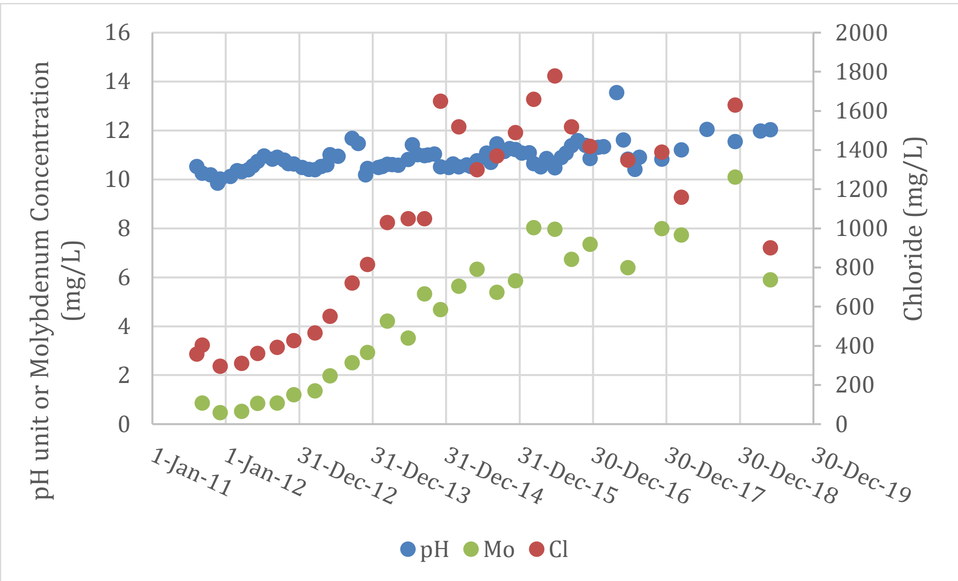


Figure 27 OPAC Decant Pond Water Quality

Major dissolved trace elements in decant water are aluminium (34.4 mg/L June 2019), boron (3.65 mg/L), molybdenum (5.9 mg/L) and fluoride (2.6 mg/L). Time series plots are shown in Figure 28. Note vanadium is also a major trace element (based on ash pore water chemistry data but is not part of the pond water analytical suite).

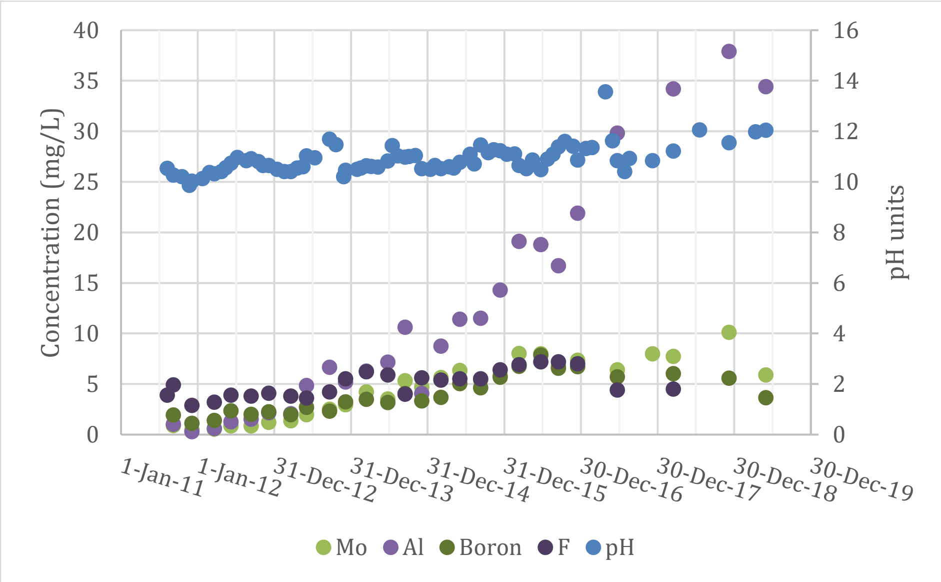


Figure 28 OPAC Decant Pond Major Trace Element Water Quality

Minor trace elements in decant water include arsenic and selenium which are present at concentrations up to 0.8 mg/L. Zinc which is an EA trigger monitoring parameter in groundwater is present at less than 200 ppb (0.2 mg/L).

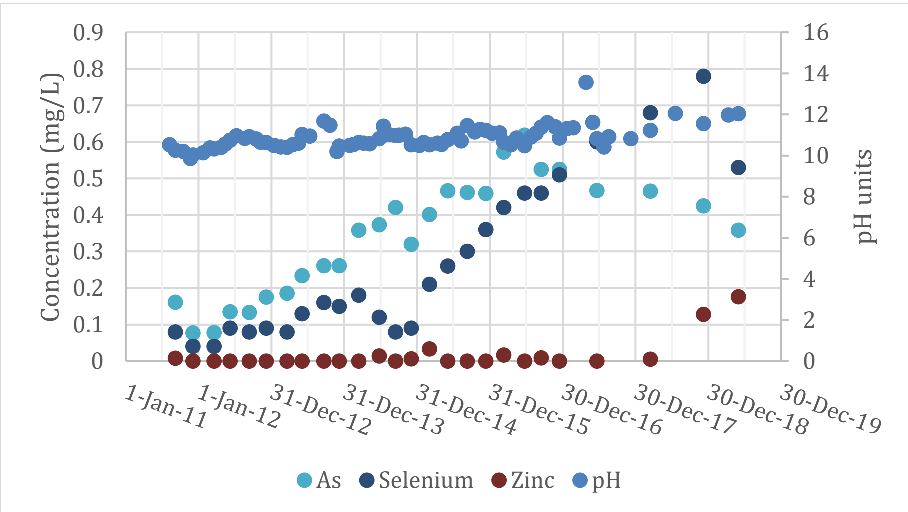


Figure 29 OPAC Decant Pond Minor Trace Element Water Quality

9.4.2 OPAC Groundwater Presence and Quality

Data from six sampling events to November 2018 has been evaluated to confirm the conceptual hydrogeochemical model and relationships between ash and embankment pore water qualities and underlying/adjacent groundwater. Figure 30 indicates:

- pH in ash pore water measured in bores IB4S, IB15 and IB16 is relatively constant at around 11.5 to 12;
- pH in embankment fill pore water (IB13)and the underlying basal mine fill (IB4D)) is generally between 6 to 8; and
- pH in alluvium (KC1278) and shallow Walloon Coal Measures (KC1273-R) is also generally between 6 to 8

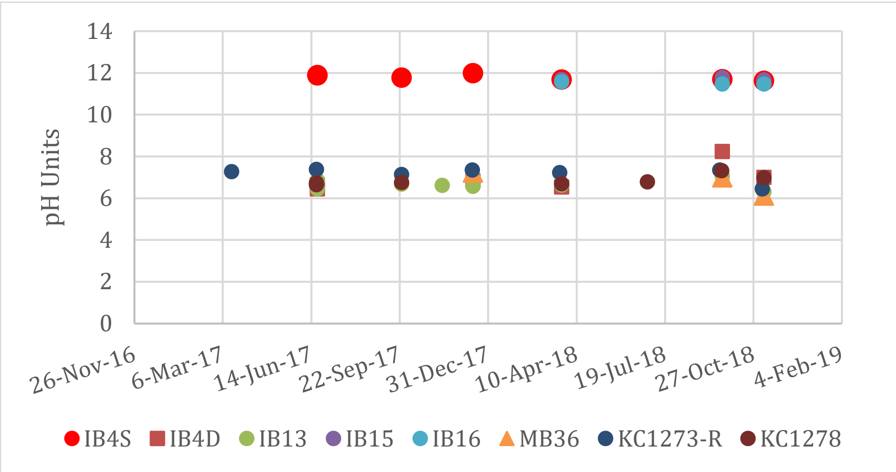


Figure 30 pH in OPAC Ash and Embankment Pore Water and Groundwater

However the presence of salts in the various waters (Figure 31) has a different hierarchy where:

- highest chloride levels are observed in embankment fill and underlying basal fill pore water in the range 2500 to 3300 mg/L;
- chloride levels in ash pore water are in the range 900 to 1600 mg/L
- chloride levels in the selected bores are between 70 and 200 mg/L.

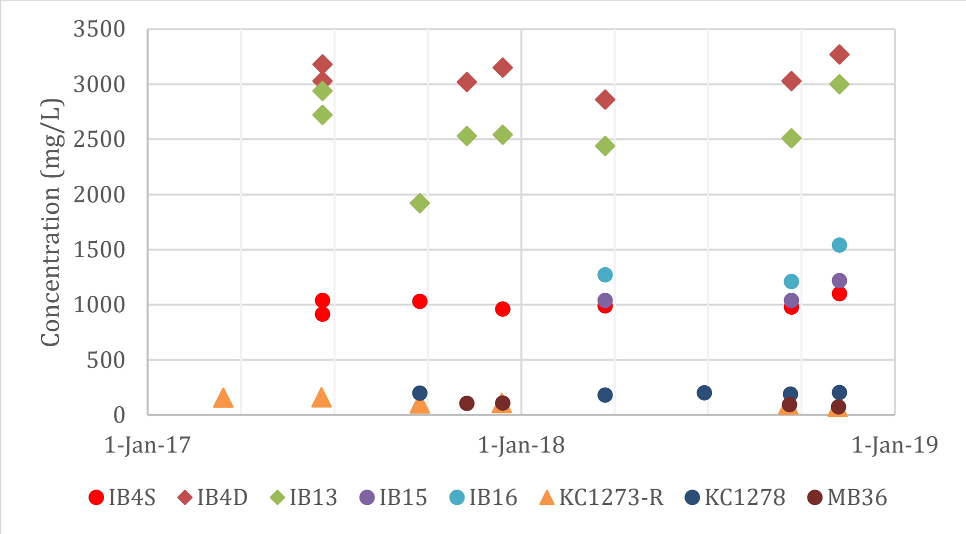


Figure 31 Chloride in OPAC Ash and Embankment Pore Water and Groundwater

A similar hierarchy as for pH exists for the key trace elements aluminium, boron, molybdenum, fluoride, vanadium, arsenic and selenium where the highest concentrations are found in pore water and /or decant water. Examples are provided for aluminium and boron. Aluminium has generally recorded concentrations above 10 mg/L in ash pore water since June 2016 , whereas embankment/subgrade pore water and groundwater concentrations are generally less than 0.1 mg/L (Figure 32).

Boron has generally recorded concentrations above 2 mg/L in ash pore water since June 2016 , whereas embankment/subgrade pore water and groundwater concentrations are generally less than 0.7 mg/L (Figure 33).

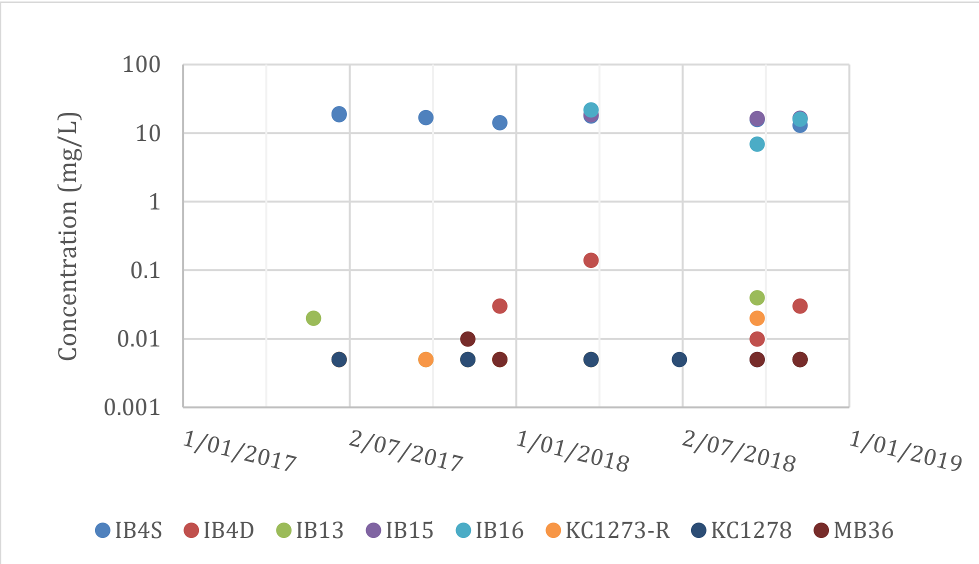


Figure 32 Aluminium in OPAC Ash and Embankment Pore Water and Groundwater

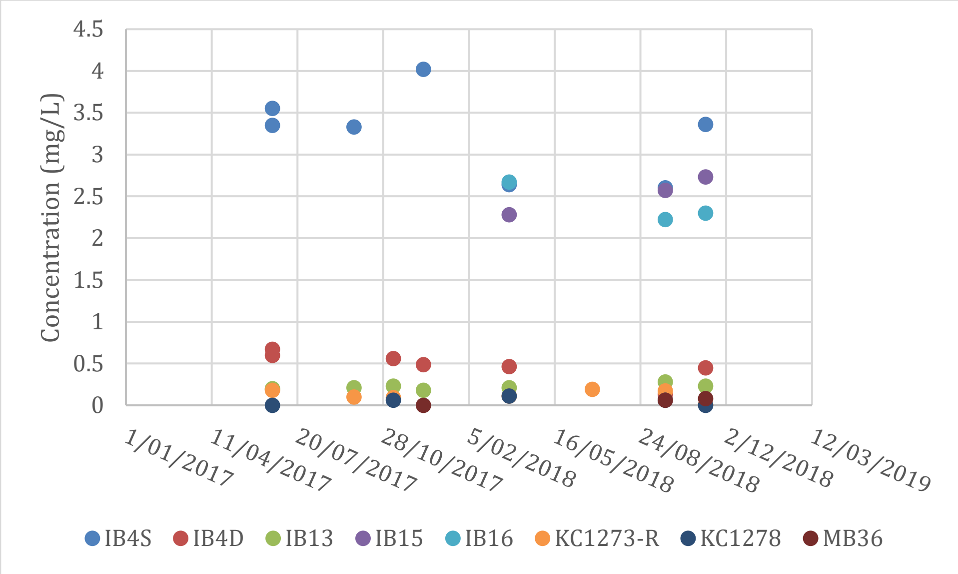


Figure 33 Boron in OPAC Ash and Embankment Pore Water and Groundwater

OPAC External Groundwater Monitoring

The groundwater monitoring network in the vicinity of the OPAC originally consisted of shallow bores: MB2 and MB5 (drilled 2006) as well as bore MB1 which is a background bore located in alluvium over coal on the Condamine River floodplain north of the OPAC,. The monitoring network for the OPAC had been augmented between 2009 and 2010 by an additional eight boreholes,MB12, MB13 and KC1273M to KC1278M prior to the 2016 installation of bores MB32 to MB39 as part of the OPAC bubble investigations.

Background bore MB1 measures a sodium-chloride-bicarbonate water of low salinity (550–1250 mg/L). Similar water quality was intersected at bores MB2, MB12, KC1273- R, KC1274, KC1276, KC1277 and KC1278. MB2, MB12, KC1277 and KC1278 are also located in alluvium. KC1273-R and KC1276 intersect the Walloon Coal Measures.

Chloride is a seepage early warning indicator species which is a required parameter for monitoring in the mine and ash disposal EAs. Chloride concentrations in OPAC monitoring bores for the period October 2016 to May 2019 are shown in Figure 34.

The data indicate stable Cl concentrations below around 200 mg/L in the long term monitoring bores MB2, KC1276 and KC1278. From the most recent sampling in May 2019, bores MB34, MB35, MB36, MB38 are reporting similar Cl concentrations to the long term monitoring bores. Bore MB39, located adjacent to the south eastern corner of the OPAC and in the former creek channel records higher Cl levels.

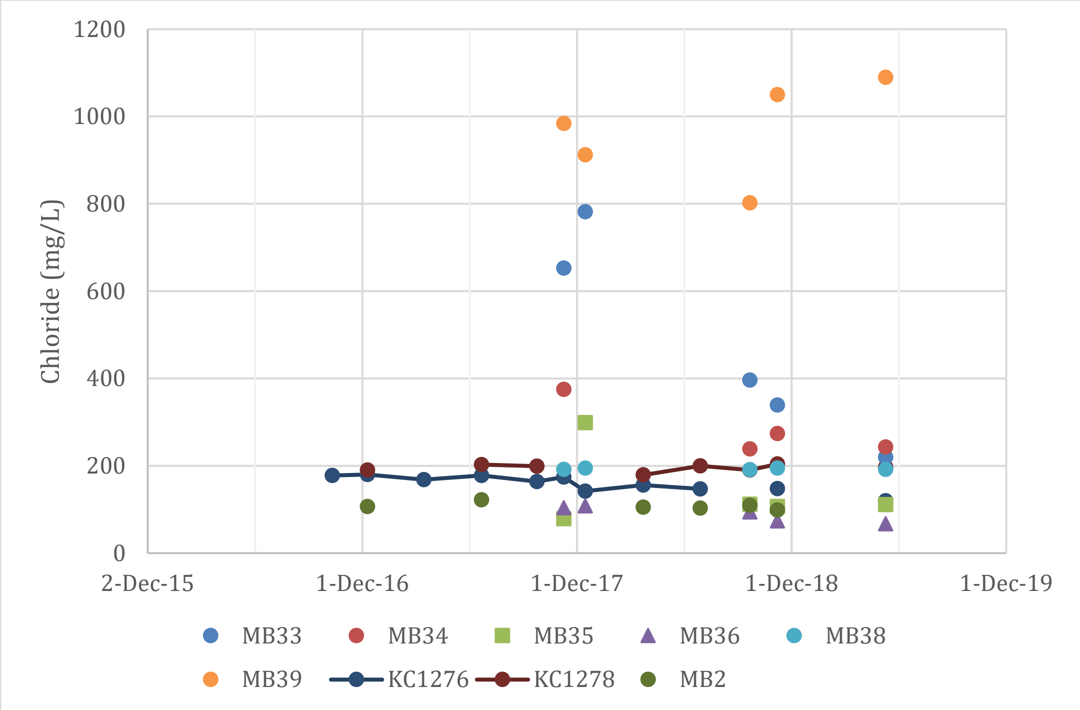


Figure 34 Chloride in Shallow Groundwater

9.5 Key Findings - Groundwater Quality

Groundwater quality monitoring between December 2016 to May 2019 in the vicinity of the IADA, mine and OPAC in general has shown similar concentrations to those reported in the 2016 Report.

Groundwater salinities and major salt concentrations in sandstones inferred to overly Walloon Coal Measures rocks are highly saline and the inferred groundwater flow conditions may suggest that groundwater discharge zones may exist in the local area.

Based on the available groundwater monitoring data and field inspections, there is no evidence that seepage has left the OPAC facility ie has moved beyond the OPAC external footprint. Specifically, there is:

- No visible seepage around the outer toe of OPAC walls from October 2018 dam surveillance monitoring.
- No evidence of ash water in environmental monitoring bores previously drilled around the toe of the OPAC.

There is no evidence of any IADA or OPAC seepage in local groundwaters.

10.0 GROUNDWATER COMPLIANCE REVIEW

10.1 Licence Compliance Monitoring Requirements

Groundwater monitoring is required for compliance with all three Environmental Approvals. CS Energy's current monitoring program for all bores, satisfies the Environmental Authority and Development Approval requirements. The current permit for ash disposal issued by the (then) Department of Environment and Heritage Protection (DEHP) is BRID 0033 which came into effect on 18 September 2017. Condition C6 details bores required to be monitored for the current ash disposal areas (IADA and OPAC). These are summarised in Table 4. Bores MB29, MB7-R, MB10-R and KC1273-R have replaced bores MB6, MB7, MB10 and KC1273 which have either been destroyed or become unusable.

Table 4 IADA/OPAC Monitoring Bores

Monitoring Bore	Latitude (degrees)	Longitude (degrees)	Formation	Ground RL (m)	Bore Depth (m)
MB1	-26.92063	150-79059	Condamine Alluvium	310.8	15.8
MB2	-26.92479	150.79926	Condamine Alluvium	310.7[1]	14.0
MB29	-26.94606	150.78708	Walloon Coal Measures	336.6	78.2
MB7-R	-26.94437	150.77032	Walloon Coal Measures	320.3[1]	74.7
MB9	-26.93832	150.74648	Springbok Sandstone	314.8	23.6
MB10-R	-26.93898	150.74993	Springbok Sandstone	315.1[1]	30.8
KC1273-R	-26.92966	150.78908	Walloon Coal Measures	315.6[1]	44.4
KC1276	-26.92692	150.79867	Walloon Coal Measures	312.1[1]	16.9
KC1277:	-26.92382	150.79958	Condamine Alluvium	309.6[1]	15.9
KC1278	-26.92492	150.79629	Condamine Alluvium	309.3	19.4

Reproduced from Permit BRID0033 Schedule C - Table 2: Groundwater monitoring locations

Note: Permit shows coordinates as latitudes and longitudes.

Coordinate Datum Horizontal AMG94 Zone 56 & Vertical AHD.

[1] Ground RL from October/November 2019 CS Energy surveys

Groundwater contaminant trigger elevations were developed from groundwater quality data collected over the period 2007-2010. These data were used to amend the Development Approval SPDE 0494 7312 re-issued in December 2012. The background data indicated that mean elevations of monitoring parameters can vary significantly (>10%) from bore to bore, depending on aquifer type and localised recharge/permeability conditions e.g. mean Cl concentrations of approximately 71 mg/L in MB2 compared with 24 540 mg/L in MB4. Based on the results of the analysis and the requirement for reporting to EHP when trigger values are exceeded, it was proposed that trigger values be established from the existing range of results, with the exception of pH. pH trigger values were established as 6.5–8 for all bores as this is the pH range for most natural freshwater (ANZECC, 2000).

Due to the significant range of elevations across the bores, different contaminant trigger values were established for the three main geological strata present at the site:

alluvium, Springbok Sandstone and Walloon Coal Measures strata. Groundwater contaminant trigger ranges are presented in Table 5.

Table 5 Groundwater Contaminant Trigger Ranges

	Contaminant Range Alluvium	Contaminant Range Springbok Sandstone	Contaminant Range Walloon Coal Measures
pH	6.5 - 8	6 - 8	6.5 – 8
Electrical conductivity (μS/cm)	280 - 1400	13000 – 27 000	1500 – 7 000
Sodium (mg/L)	50 - 300	2500 - 6000	300 – 1800
Sulphate (mg/L)	5 - 80	1 - 1000	<1 – 250
Chloride (mg/L)	50 - 400	4000 – 10 000	100 – 3 000
Aluminium (mg/L)	<0.01 – 0.15	<0.01 – 0.3	<0.01 – 0.04
Zinc (mg/L)	0.01 – 0.3	0.05 – 0.4	0.005 – 0.4

Note : Table reproduced from EHP Permit SPDE04947312 Schedule C – Table 3. Ranges are indicative background groundwater concentrations

10.2 Review of Monitoring Data

Monitoring data for groundwater quality characteristics and standing water levels were reviewed for the periods December 2016 to September 2017 and December 2016 to November 2018.

A number of out-of-range values were measured for pH, EC, Na, Cl, SO_4, Zn in various boreholes in various formations in each time period. The results and a discussion of their significance is included in Appendix A.

In summary, trigger value exceedances generally fall into the following categories:

- Anomalous readings due to limited water availability in bores and possible influence of tree roots and foreign matter on water quality;
- Numerous measurements for zinc which were below the lower trigger value due to a reduction in the 'limit of reporting' by the laboratory;
- Zinc concentrations above trigger elevations in several bores;
- Differences in water quality in replacement boreholes compared to original bores; and
- Values that fall outside the range of trigger values that were developed from the limited data sets that were available when the DA was amended in 2012.

There is no evidence that any exceedances have caused or could potentially cause environmental harm, or are attributable to the Mine, Power Station or Ash Disposal activities.

10.3 Revised Groundwater Trigger Values

Modified trigger values have been developed and are summarised in Table 6 below and capture the values that have been observed and which are not considered to represent environmental harm. The observed elevated zinc values are considered anomalous and accordingly the upper ranges of zinc trigger values have not been modified.

Table 6 Revised Groundwater Trigger Values

	Contaminant Range Alluvium	**Contaminant Range Springbok Sandstone**	**Contaminant Range Walloon Coal Measures**
pH_{lab}	6* – 8.2*	6 – 8.5*	6.5 – 8.5*
Electrical conductivity (EC)	280 - 1400	10000* – 31000*	1000* – 15000*
Sodium	50 - 300	2500 - 6000	300 – 2500*
Chloride	10* – 400	4000 – 10000	100 – 4000*
Sulphate	<1* – 80	50* – 1000	<1 - 250
Zinc	<0.001* - 0.3	<0.001* – 0.4	<0.001* - 0.4
Aluminium	<0.01 - 0.15	<0.01 - 0.3	<0.01 - 0.04

*modified values

11.0 CONCLUSIONS

The report covers the three year period from October 2016 to June 2019.

Climatically, the Kogan area has had lower rainfalls than in the previous three year period following the 2010/2011 la Nina event.

Groundwater Flow at Mine and Power Station

Bore water elevations can be influenced by a number of factors including:

- Extent to which groundwater adjacent to bore is under pressure;
- Extent and depth of monitoring horizon in a particular borehole. Is the borehole measuring groundwater pressure at a particular point or providing an averaging effect over a thickness of geological strata that may contain groundwater at different elevations (eg coal seams);
- Geological formation being monitored and degree of aquifer "connectivity" ie horizontal and vertical hydraulic conductivity;
- Influence of recent recharge events
- Influence of mine depressurisation/dewatering or other groundwater extraction activities.

Groundwater flow conditions in the vicinity of the site appear to be complex, given the site's location relative to the course of the Condamine River and within the Surat Basin. The Springbok Sandstone and Walloon Coal Measures may discharge to the Condamine Alluvium in the vicinity of the mine. Regionally, further to the west of the site, groundwater in the Springbok Sandstone and Walloon Coal Measures is likely to flow in a more south-westerly direction in the general direction of the dip of the strata.

Groundwater elevation data collection commenced in 2007 and the data set has been collated and interpreted as part of the review and was previously discussed in the 2016 Report. The inferred groundwater flow directions in the vicinity of the power station/mine complex are:

- Condamine Creek alluvium: north and east towards the river depending on bore location. Potentially some influence of drainage towards the mine pit;
- Kogan and Eastern Branch Creeks to north (in direction of creek flow). Potentially some influence of drainage towards the mine pit; and
- Springbok Sandstone. Uncertain but possibly locally towards the mine and sub-regionally northwest to northeast
- Walloon Coal Measures. Locally towards the mine pit and sub-regionally towards the northeast with discharge to the Condamine River alluvium.

Mine

The key groundwater management considerations at the mine are:

- impact of mine pit on groundwater elevations
- potential for groundwater seepage from IADA

- potential impacts of OPAC

IADA

Groundwater with elevated salinity (EC 5500–32000 µS/cm) is found in sandstones (inferred to be Springbok Sandstone) underlying the IADA and along the Paddy's Gully drainage line.

The IADA is constructed on local alluvial sediments and the sandstone that is above the Walloon Coal Measures. The ground surface within the IADA footprint was compacted to meet EA requirements. The storage commenced operations with power generation in mid 2007 and ceased active ashing in early 2011.

Water quality monitoring of the pond in the IADA has shown that the water quality in the cell storage pond from December 2010 to May 2016 has been slightly alkaline, with low to moderate salinity and influenced by rainfall/evaporation. Salinity and major salt concentrations initially decreased since ashing ceased, but increased since the storage of OPAC water in May 2016. Salt levels subsequently returned to 2016 levels in 2018.

There is no evidence of shallow seepage emanating from the IADA. Bores that have intersected the regional water table show no influence of groundwater mounding from potential seepage through the floor of the IADA.

There is no evidence that seepage from the IADA to monitoring bores has occurred to date. The presence of seepage would be indicated by:

- Continued presence of IADA water in shallow KG – series bores;
- Increase in potentiometric surface head in deep groundwater monitoring bores; and
- Initial groundwater salinity decrease in deep monitoring bores with reduced concentrations of key ions such as sodium and chloride.

OPAC

A detailed assessment of groundwater quality data in OPAC monitoring bores has been completed The overall findings are:

- interpretation of groundwater quality in environmental monitoring bores drilled around the toe of the OPAC indicates no evidence of ash water;
- dam surveillance monitoring in October 2016 reported no visible seepage around the outer toe of OPAC walls; and
- there is no evidence that seepage has left the OPAC facility ie has moved beyond the OPAC footprint.

12.0 REFERENCES

Out of Pit Ash Cell – Liner Concept Design and Selection Golder Associates, October 2009

Proposed Kogan Creek Power Station Impact Assessment of Ash Disposal on the Groundwater Regime prepared for Consolidated Electric Power Asia Limited. Australasian Groundwater & Environmental Consultants Pty Ltd, October 1999

Proposed Kogan Creek Power Station Impact Assessment of Ash Disposal on the Groundwater Regime Australian Groundwater and Environmental Engineers October 1999

Kogan Creek Power Station and Kogan Mine Groundwater and Surface Water Monitoring Review Environmental Management Strategies October 2011

Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review Environmental Management Strategies October 2013

Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review Environmental Management Strategies October 2016

Kogan Creek Power Station Ash Disposal OPAC Liner Bubble Investigation Final Report January2018 submitted to DES January 2018

Kogan Creek Coal Mine Baseline Surface Water and Groundwater Water Quality Monitoring Review Environmental Management Strategies October 2018

Kogan Creek Coal Mine – Out Of Pit Ash Cell –Annual Inspection Golder Associates November 2018

Proposed Kogan Creek Power Station Impact Assessment of Ash Disposal on the Groundwater Regime prepared for Consolidated Electric Power Asia Limited. Australasian Groundwater & Environmental Consultants Pty Ltd, October 1999

Water Management Plan CS Energy Ltd/Aberdare Collieries Pty Ltd Kogan Creek Mine. Golding Contractors Pty Ltd, 2008.

13.0 LIMITATIONS

EMS has prepared this report for the use of CS Energy Ltd in accordance with generally accepted consulting practises. No other warranty, expressed or implied, is made as to the professional advice included in this report.

This report does not encompass an audit of sampling or analytical procedures or protocols or verification of the efficacy of data provided by third parties. EMS have relied on the water quality data presented in reports and water quality and related data provided by CS Energy for interpretation purposes. In particular, it is an implicit assumption of this report that data presented in third party reports are an accurate collation of data from the original laboratory certificates. From time to time, potential data anomalies can be inferred from time series data sets. EMS has used its best endeavours to advise CS Energy of potentially significant anomalies in data sets when considered appropriate.

This report has not been prepared for use of parties other than the client, the owner and their respective consulting advisers. It may not contain sufficient information for the purposes of other parties or for other uses. It is recommended that any plans and specifications prepared by others and relating to the content of this report be viewed by EMS to verify that the intent of our recommendations is properly reflected in other's designs. To the best of our knowledge, information contained in this report is accurate at the date of issue. However, some conditions including contaminant concentrations can change, limiting use of the report after a protracted delay.

for ENVIRONMENTAL MANAGEMENT STRATEGIES

Report Prepared by:

John Grounds

Principal

APPENDIX A

KOGAN CREEK POWER STATION
ASH DISPOSAL MONITORING BORES
REVIEWS OF GROUNDWATER TRIGGER VALUE EXCEEDANCES

Note To: John Skillington

Cc Brendan Monckton, Roger Hartigan

Date: 30 January 2018

Kogan Creek Power Station and Mine Water Review December 2016 to September 2017

A review of the groundwater level and water quality data for the period December 2016 to September 2017 for bores that monitor ash disposal activities as detailed in Development Approval SPDE04947312 has been completed. There are a number of water quality measurements which fall either above or below the range of values with acceptable upper and lower values of a stratum presented in Schedule C - Table 3: Groundwater contaminant trigger levels. In addition, there are a number of standing water level measurements that exceed the 2m trigger level for non-pumping fluctuations.

In general, the exceedances observed are similar to those previously observed and in the same bores as was reported in the document *Review of Groundwater Quality Exceedances* by Environmental Management Strategies that was submitted to DEHP as Appendix A to the report *Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review November 2016.*

That report reviewed monitoring data for groundwater quality characteristics and standing water levels for the period September 2013 to September 2016.

A number of out-of-range values identified in that review had been measured for pH, EC, Na, Cl, SO_4, Zn in various boreholes in various formations.

In summary trigger value exceedances generally fell into the following categories:

- Anomalous readings due to limited water availability in bores and possible influence of tree roots and foreign matter on water quality;
- Numerous measurements for zinc which were below the lower trigger value due to a reduction in the 'limit of reporting' by the laboratory;
- Zinc concentrations above trigger elevations in several bores;
- Differences in water quality in replacement boreholes compared to original bores; and
- Values that fall outside the range of trigger values that were developed from the limited data sets that were available when the DA was amended in 2012.

The report concluded that there was no evidence that any exceedances were a result of ash disposal activities or had caused or could potentially cause environmental harm.

Water Level Changes 2016/2017

Over the review period water levels in most bores declined slightly due to groundwater depressurisation around the mine pit and generally dry conditions. The exceptions were alluvial bores MB1 and MB2 where measured levels were generally stable and Walloons bore KC1273-R where groundwater pressures increased slightly.

Analytical Results

The analytical results for December 2016 to September 2017 continue to show:

- Zinc values below current detection limit in a number of bores (MB1, MB2, MB9, MB10-R, KC1273-R, KC1276, KC1277, KC1278)
- SO4 below trigger limit (MB2)
- Cl below trigger limit (KC1276, KC1277)
- Na below trigger limit (KC1276)
- EC below trigger limit (KC1276)

Note bore KC1276 is referred to in the DA as a Walloon Coal Measures bore when it is monitoring the Condamine Alluvium. There would be no water quality exceedances for KC1276 if it is treated as a Condamine Alluvium bore.

Bores MB7-R, MB9 and MB10 are discussed below.

Bore MB7-R

This bore continues to report elevated concentrations of EC, sodium and chloride above trigger limits as was reported in Appendix A to the report *Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review November 2016.* The findings of that report are still relevant to the current data and are repeated below:

"MB7-R was drilled to replace MB7 which was damaged. The bore is approximately 25 m from MB7 and was drilled to 74 m and screened from 52 to 64 m across coal seams, with gravel pack from 49 – 74 m. The bore is gravel packed opposite coal seams and carbonaceous sandstones.

MB7 was drilled to 79 m, and screened from 73 to 79 m, presumably across a coal seam as no geology was recorded on the bore log.

MB7-R has recorded higher background levels of EC, Cl, Na than MB7.

The reported higher salt concentrations in the shallower borehole are consistent with previous observations (AGEE, 1999), which indicated that the upper coal seams can have a highly saline water of around 20000 µS/cm, whereas the lower coal seams (which are reportedly higher water yielding with thicker coal seams) can have a lower salinity of around 8000 µS/cm.

The difference in background values is considered to be representative of the natural variability in groundwater quality that can occur over small distances and depth intervals in Walloon Coal Measures strata."

In addition, the bore is on the southern side of the mine pit, and is not in an area that is or could be influenced by ash deposition from the IADA or OPAC.

Bore MB10-R

This bore has reported elevated concentrations of sulphate above the trigger limit for the Springbok Sandstone.

Bore MB10-R was drilled as a replacement bore for MB10 in July 2015 as sampling was not possible between December 2012 and June 2014. MB10 was reportedly blocked with sticks and grass. MB10 was one of the original bores drilled pre 2007. Bore MB10-R is located adjacent to the IADA spillway, approximately 330 m to the west of MB10 (Figure 1). MB10-R was drilled to 30.8 m and is screened from 24 to 30 m, whereas MB10 was shallower, reportedly screened from 15 m to its total depth of 21 m. The projected location of MB10-R on a conceptual hydrogeological cross-section is shown at Figure 2.

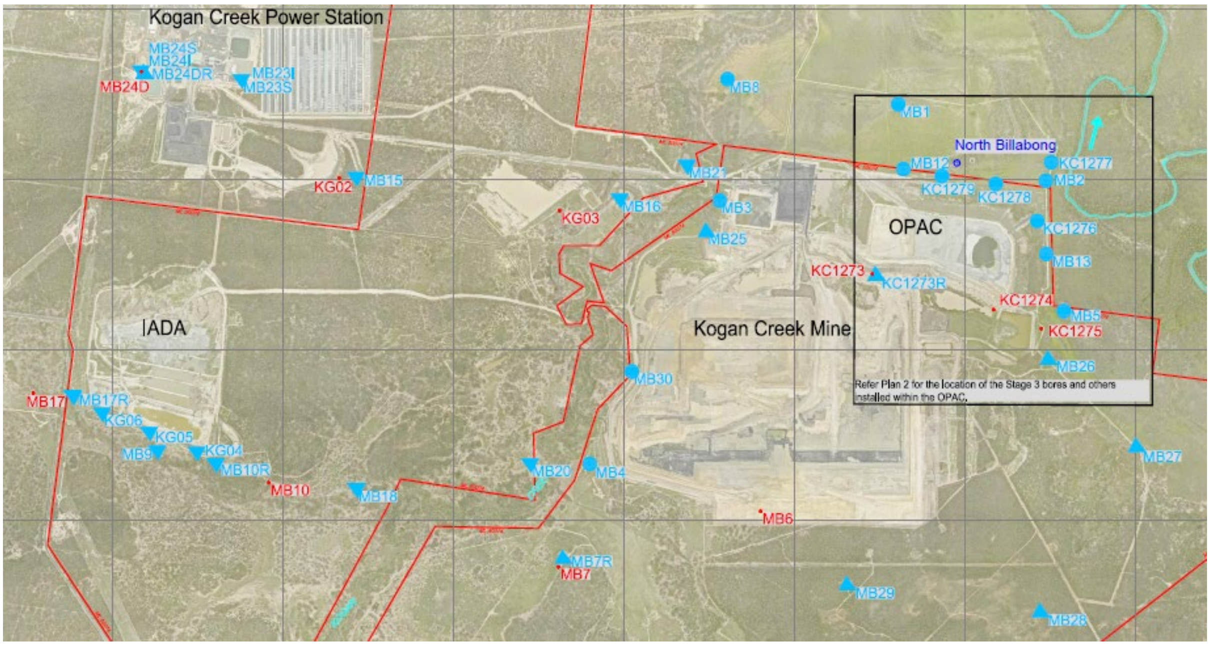


Figure 1 Bores in vicinity of IADA

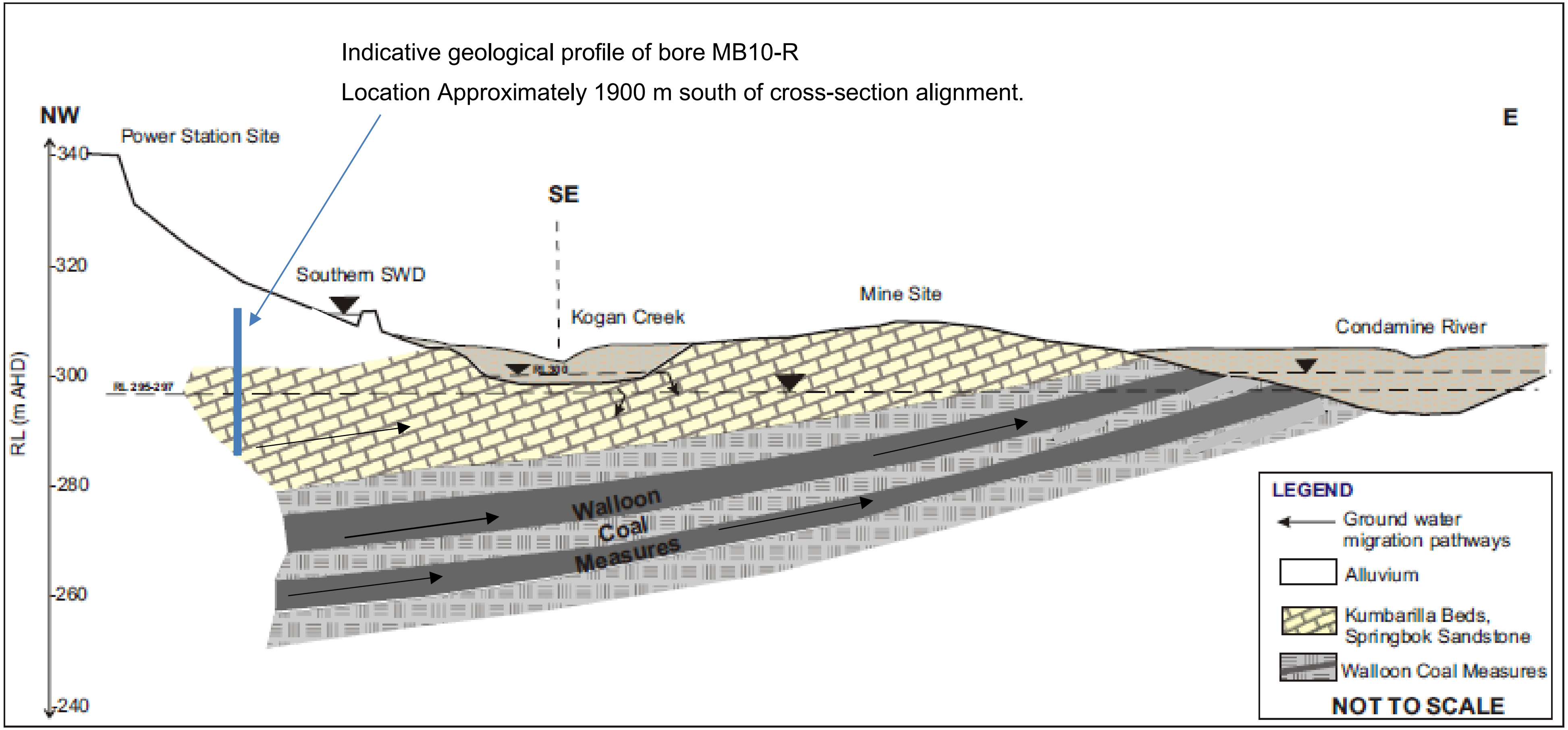


Figure 2 Indicative Location of MB10-R Relative to Conceptual Hydrogeological Cross - Section

Figure 3 shows a time series of sulphate concentrations in various Springbok Sandstone (inferred) bores east of the IADA and west of Kogan Creek. Sulphate concentrations of between 1120 and 1320 mg/L have been recorded in MB10-R since September 2015 (Figure 2). Bore MB9 has also recorded elevated sulphate concentrations of between 681 and 981 mg/L since April 2007, whilst MB18 several hundred meters further to the east recorded levels of around 1000 mg/L between 2009 and December 2012 when last sampled. MB9 is located 100+m down slope from the IADA embankment and has reported relatively constant sulphate levels (generally between 800 and 1000 mg/L) since initial IADA operations. As the Springbok Sandstone is believed to be a regional groundwater discharge zone in this area, the elevated sulphate concentrations are considered to be natural and possibly due to evaporite or sulphide oxidation processes. They are not considered to be due to IADA ash disposal activities.

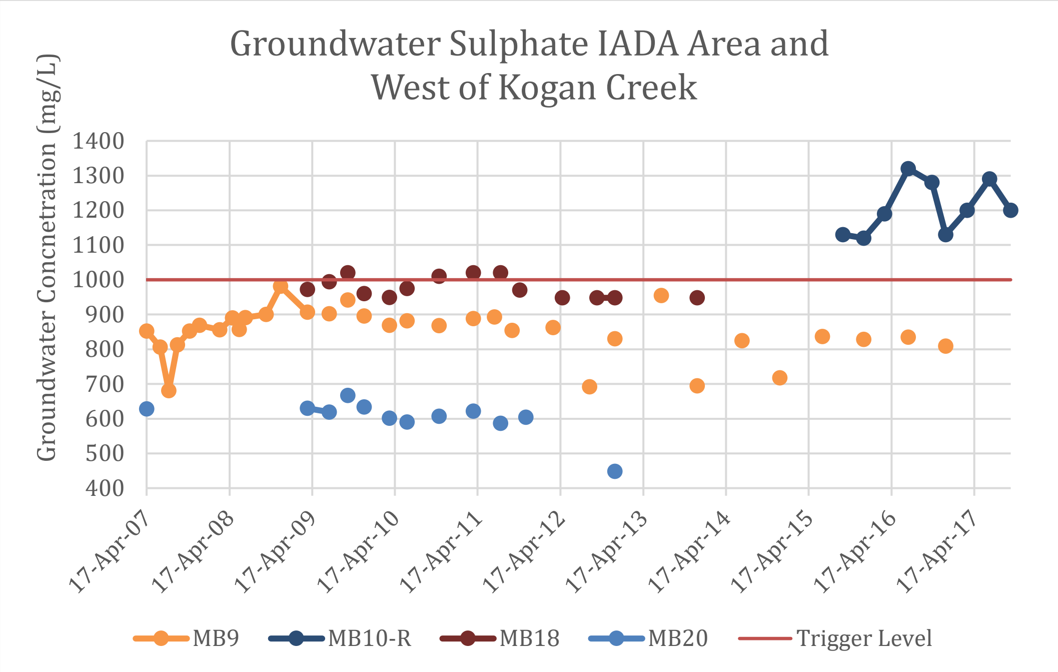


Figure 3 Sulphate in Groundwater Bores IADA Area

The attached Piper Diagram (Figure 4) indicates that the major cation/anion water chemistry types of Springbok Sandstone bores MB9, MB10-R, MB18, MB10 and Walloon bores MB7-R, MB30 at the mine are very similar but distinct to other inferred Springbok bores MB17 and MB17-R (west of the OPAC) and Walloons bores MB24 (power station site) and MB25 at the mine. The Durov plot (Figure 5) shows increasing groundwater salinity in a west to east direction from bore MB17 (west of IADA) to MB18 along the alignment of Paddy's Gully towards Kogan Creek. Sodium and chloride concentrations both show a similar concentration gradient.

Summary

In summary, a review of the groundwater level and water quality data for the period December 2016 to September 2017 for bores that monitor ash disposal activities as detailed in Development Approval SPDE04947312 has been completed. Key findings are:

Elevated concentrations of sulphate above the trigger limit for the Springbok Sandstone have been recorded in bore MB10-R. The bore shows similar water quality characteristics to other Springbok Sandstone and Walloon Coal Measures bores. As the Springbok Sandstone is believed to be a regional groundwater discharge zone in this area, the elevated sulphate concentrations in MB10-R are considered to be natural and possibly due to evaporite or sulphide oxidation processes. They are not considered to be due to IADA ash disposal activities.

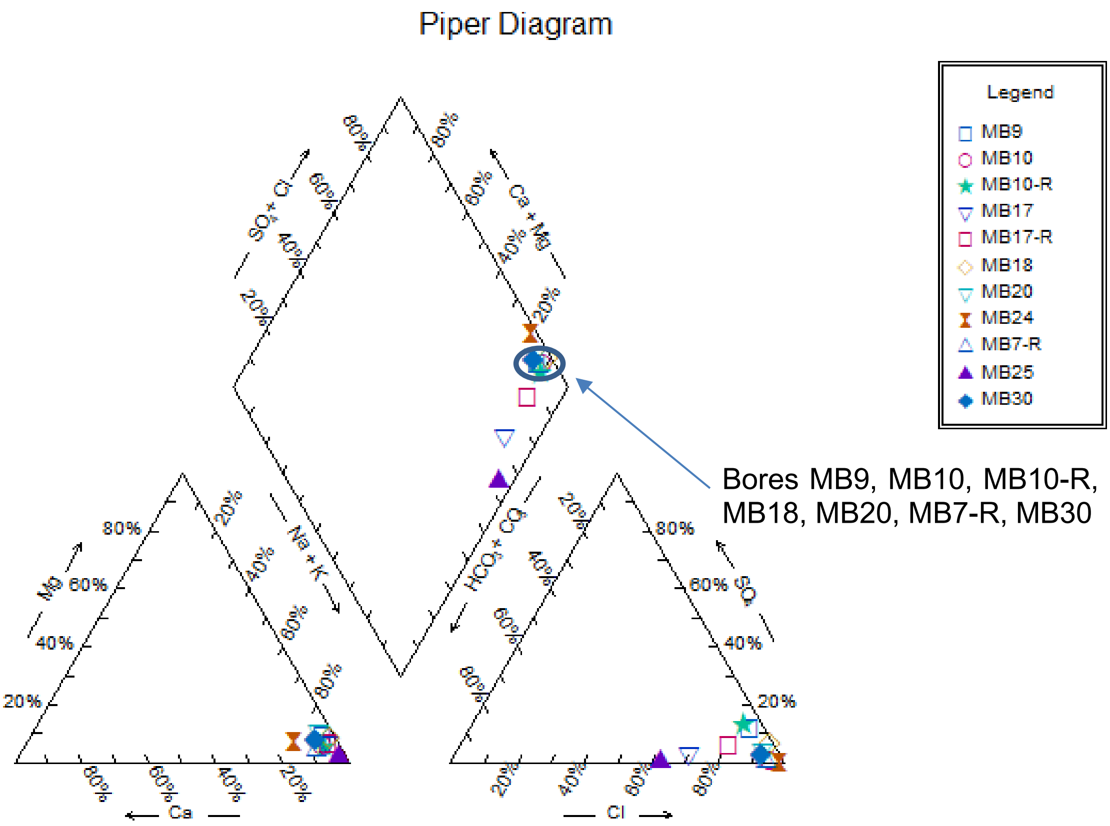


Figure 4 **Piper Diagram Springbok and Walloon Coal Measures Bores**

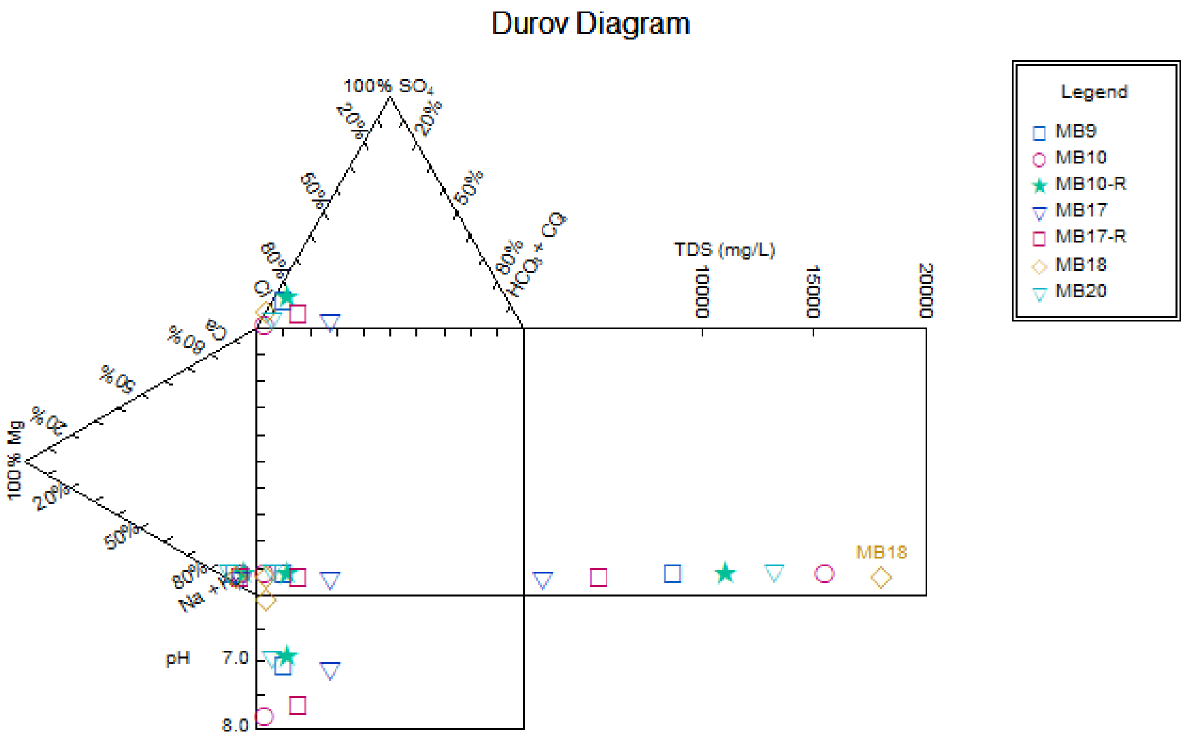


Figure 5 Durov Plot Groundwater Salinity Springbok Sandstone IADA to Kogan Creek

		MB9	MB10	MB10-R	MB17	MB17-R	MB18	MB20	MB24	MB7-R	MB25	MB30
Formation Monitored		Springbok Sandstone	Springbok Sandstone	Springbok Sandstone	Springbok Sandstone	Springbok Sandstone	Springbok Sandstone	Springbok Sandstone	Walloon Coal Measures	Walloon Coal Measures	Walloon Coal Measures	Walloon Coal Measures
Date	Date	16/12/2016	16/06/2015	16/12/2016	12/12/2012	16/12/2016	12/12/2012	12/12/2012	16/06/2015	9/12/2016	9/12/2016	8/12/2016
pH	pH	7.07	7.82	6.92	7.1	7.66	6.1	6.94	7.08	7.33	8.02	7.13
Electrical Conductivity	µmho/cm	14100	26700	17300	4580	8770	27600	20960	25490	9490	3106	12140
Calcium	mg/L	96	239	164	26	45	117	158	520	141	11	167
Magnesium	mg/L	151	173	104	37	68	299	288	174	38	6	122
Sodium	mg/L	2780	4890	3530	941	1760	6390	4160	3780	1770	666	2540
Potassium	mg/L	27	17	22	13	17	19	19	44	15	3	13
Bicarbonate	mg/L	478	579	769	800	760	255	686	218	314	661	522
Sulfate	mg/L	809	91	1130	58	226	948	448	3	2	< 1	140
Chloride	mg/L	4360	9410	5310	1050	2520	9850	7430	8080	3150	657	4480

Table 1 Major Chemistry Analyses Springbok Sandstone and Walloon Coal Measures Bores

GROUNDWATER EXCEEDANCE REVIEW – ASH DISPOSAL KOGAN CREEK MINE AND POWER STATION

A review of the groundwater level and water quality data for the period December 2017 to November 2018 for bores that monitor ash disposal activities as detailed in Environmental Authority (EA) BRID0033 was undertaken. There are a number of water quality measurements which fall either above or below the range of acceptable upper and lower values of a stratum presented in Schedule C - Table 3: Groundwater contaminant trigger levels.

In general, the exceedances observed are similar to those previously observed and in the same bores as was reported in previous assessments[2] to this review.

Earlier reviews examined monitoring data for groundwater quality characteristics and standing water levels for the period September 2013 to September 2016 and December 2016 to September 2017 respectively.

A number of out-of-range values identified in the previous reviews had been measured for pH, EC, Na, Cl, SO_4, Zn in various boreholes in various formations.

In summary trigger value exceedances generally fell into the following categories:

- Anomalous readings due to limited water availability in bores and possible influence of tree roots and foreign matter on water quality;
- Numerous measurements for zinc which were below the lower trigger value due to a reduction in the 'limit of reporting' by the laboratory;
- Zinc concentrations above trigger elevations in several bores;
- Differences in water quality in replacement boreholes compared to original bores; and
- Values that fall outside the range of trigger values that were developed from the limited data sets that were available when the Development Approval (DA) was amended in 2012.

The reports concluded that there was no evidence that any exceedances were a result of ash disposal activities or had caused or could potentially cause environmental harm.

Analytical Results December 2017 to November 2018

The analytical results for December 2017 to November 2018 show the following trigger value exceedances:

- Zinc values below current trigger levels and in some cases below the current Limit of Reporting (0.005 mg/L) in a number of bores (MB1, MB2, MB9, MB29, MB7-R, MB10-R, KC1273-R, KC1276, KC1277)
- Zinc value above the High EA trigger level (0.3 mg/L) at MB2
- SO4 below trigger level (5 mg/L) at MB2 and KC1277
- SO4 above the high EA trigger level (1000 mg/L) for MB10-R
- pH below trigger level (6.5) at KC1273-R
- Cl below trigger level (50 mg/L) at KC1277

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[2] *Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review November 2016 Appendix A*
Review of Groundwater Quality Exceedances Environmental Management Strategies 2016

- Na below trigger level (300 mg/L) at KC1276
- EC below trigger level (1500 µS/cm) at KC1276

Note bore KC1276 is referred to in the EA as a Walloon Coal Measures bore when it is actually monitoring the Condamine Alluvium. There would be no water quality exceedances for KC1276 if it is treated as a Condamine Alluvium bore.

None of these exceedances are considered to be indicative of ash disposal activities.

More detailed comments on results from several bores are provided below.

Bore KC1273-R

This bore is located on the northern side of the coal mine pit and to the south of the OPAC and monitors the Walloon Coal Measures at depths of 14 to 43 m below ground level.

A pH_{field} value of 6.45 was recorded in November 2018 which is below the lower pH trigger value of 6.5. This is the first time a pH_{field} reading has been less than 6.5. pH_{field} values have ranged between 7.04 and 7.63 since monitoring commenced in December 2013. The November 2018 result is possibly anomalous, however further monitoring will confirm if this is the case or not. The bore is monitored quarterly.

It should be noted that the pH trigger values selected for inclusion in the Development Approval conditions were based on a typical range of pH found in natural groundwaters and were not based on site specific data. Also the EA conditions for pH trigger values do not distinguish between field and laboratory measurements.

$pH_{laboratory}$ values at KC1273-R have fluctuated between 7.64 and 8.79 since monitoring commenced in December 2013. pH_{field} measurements are generally considered to be more reliable, assuming of course that the measuring instrument is properly calibrated.

Due to the time between field and laboratory measurements, various chemical reactions, such as precipitation, dissolution of colloids solution and degassing may change the actual pH. Alkaline pH is commonly associated with Walloon Coal Measures strata.

Bore MB7-R

This bore continues to report elevated concentrations of EC, sodium and chloride above trigger limits as was reported in Appendix A to the report *Kogan Creek Power Station and Mine Triennial Groundwater Monitoring Review November 2016.* The findings of that report are still relevant to the current data and are repeated below:

"MB7-R was drilled to replace MB7 which was damaged. The bore is approximately 25 m from MB7 and was drilled to 74 m and screened from 52 to 64 m across coal seams, with gravel pack from 49 – 74 m. The bore is gravel packed opposite coal seams and carbonaceous sandstones.

MB7 was drilled to 79 m, and screened from 73 to 79 m, presumably across a coal seam as no geology was recorded on the bore log.

MB7-R has recorded higher background levels of EC, Cl, Na than MB7.

The reported higher salt concentrations in the shallower borehole are consistent with previous observations (AGEE, 1999), which indicated that the upper coal seams can have a highly saline water of around 20000 µS/cm, whereas the lower coal seams (which are reportedly higher water yielding with thicker coal seams) can have a lower salinity of around 8000 µS/cm.

The difference in background values is considered to be representative of the natural variability in groundwater quality that can occur over small distances and depth intervals in Walloon Coal Measures strata."

In addition, the bore is on the southern side of the mine pit, and is not in an area that is or could be influenced by ash deposition from the IADA or OPAC.

Bore MB10-R

This bore has reported elevated concentrations of sulphate above the trigger limit for the Springbok Sandstone.

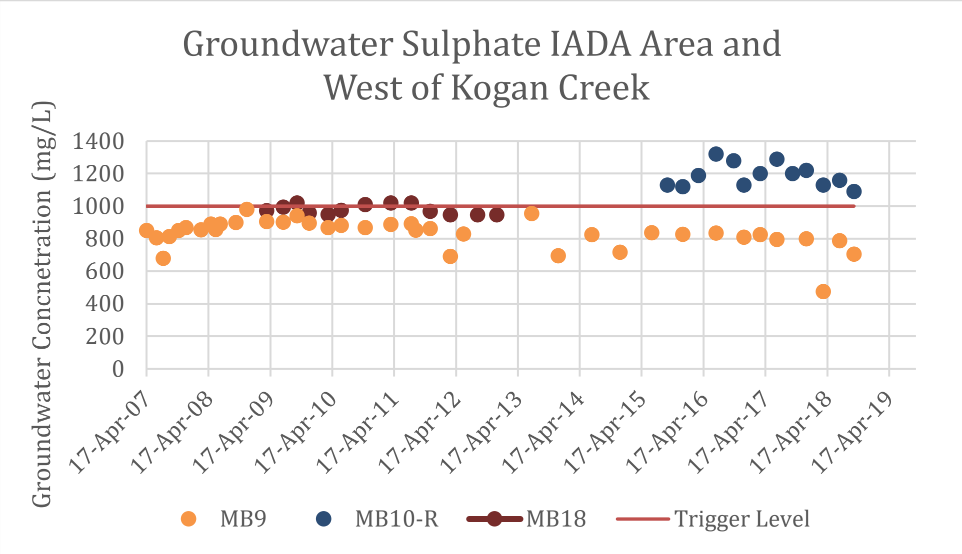
Bore MB10-R was drilled as a replacement bore for MB10 in July 2015 as sampling was not possible between December 2012 and June 2014. MB10 was reportedly blocked with sticks and grass. MB10 was one of the original bores drilled pre 2007. Bore MB10-R is located adjacent to the IADA spillway, approximately 330 m to the west of MB10 (Figure 1). MB10-R was drilled to 30.8 m and is screened from 24 to 30 m, whereas MB10 was shallower, reportedly screened from 15 m to its total depth of 21 m.

Figure 1 Bores in vicinity of IADA

Note: MB10-R position is approximate

Sulphate concentrations of between 1090 and 1320 mg/L have been recorded in MB10-R since September 2015 (Figure 2). Figure 2 indicates that sulphate concentrations in MB10-R have been relatively stable oscillating between mid-year peak values and low values in December or March.

Figure 2 Sulphate in Groundwater Bores IADA Area



Note bore MB9 has also recorded elevated sulphate concentrations of between 681 and 981 mg/L since April 2007, whilst MB18 several hundred meters further to the east recorded levels of around 1000 mg/L between 2009 and 2013. MB9 is located 100+m down slope from the IADA embankment and has reported relatively constant sulphate levels since initial IADA operations. The elevated sulphate concentrations at MB10-R are considered to be natural and possibly due to evaporative or sulphide oxidation processes. They are not considered to be due to IADA ash disposal activities.

Summary and Conclusions

A review of the groundwater level and water quality data for the period December 2017 to November 2018 for bores that monitor ash disposal activities as detailed in Environmental Authority (EA) BRID0033 has been completed. There are a number of water quality measurements which fall either above or below the range of acceptable upper and lower values of a stratum presented in Schedule C - Table 3: Groundwater contaminant trigger levels.

In general, the exceedances observed are similar to those previously observed and in the same bores as was reported in previous assessments to this review.

None of the exceedances are considered to be indicative of ash disposal activities.