

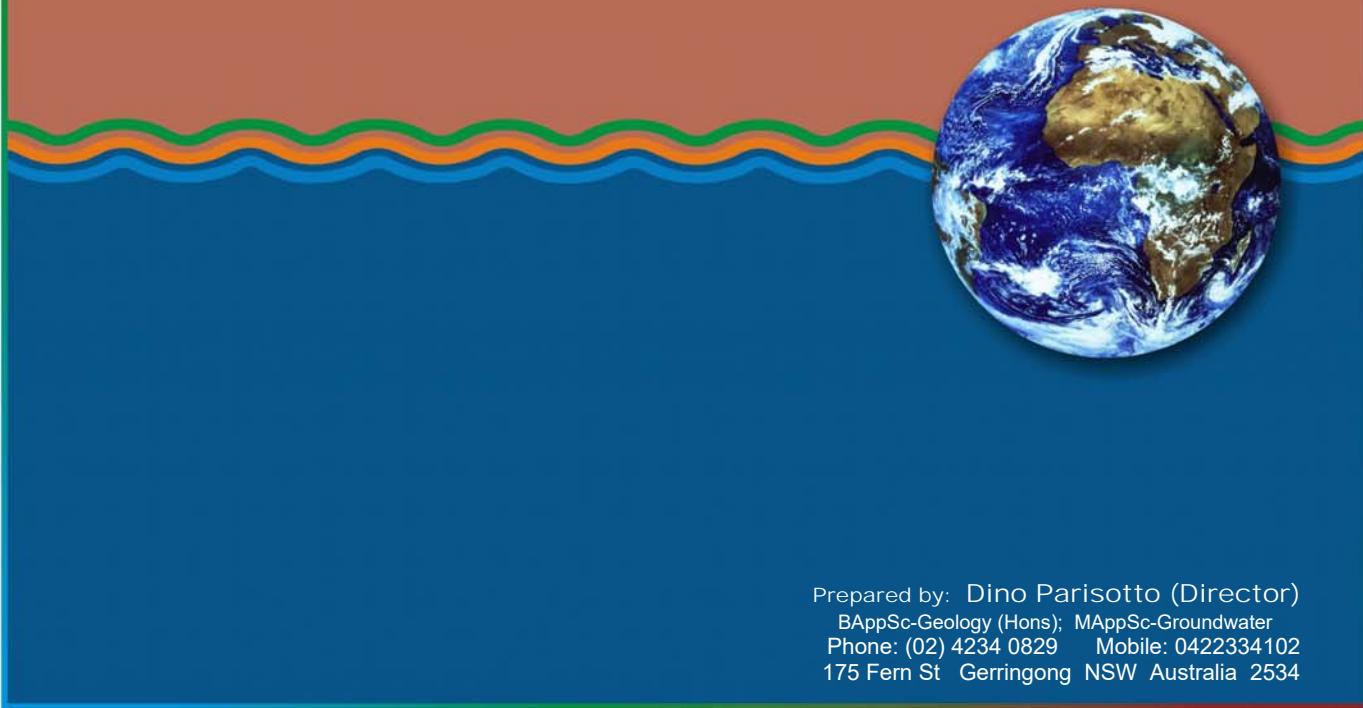


Kiama Municipal Council

# Minnamurra Waste Disposal Depot Annual Groundwater & Surface Water Monitoring Report (EPL 2018 to 2019)

Report E2W-059 (R001 v1)

31 October 2019



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**Client: Kiama Municipal Council**

**Project: Annual Surface and Groundwater Monitoring Report  
Minnamurra Waste Disposal Depot  
(EPL; 2018 to 2019)**

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## TABLE OF CONTENTS

<b>1. INTRODUCTION.....</b>	<b>4</b>
1.1 Background .....	4
1.2 Objectives .....	4
<b>2. SCOPE OF WORK.....</b>	<b>4</b>
<b>3. ENVIRONMENTAL SETTING .....</b>	<b>6</b>
3.1 Climate.....	6
3.2 Topography .....	6
3.3 Geology.....	7
3.4 Hydrogeology and Groundwater Flow Regime.....	7
3.5 Hydrology .....	8
<b>4. LICENCE CRITERIA AND RELEVANT GUIDELINES .....</b>	<b>9</b>
4.1 EPL Requirements .....	9
4.2 Previous Monitoring Results.....	10
<b>5. ENVIRONMENTAL MONITORING.....</b>	<b>10</b>
5.1 Landfill Gas Monitoring .....	11
5.2 Surface and Groundwater Monitoring Locations .....	12
<b>6. MONITORING RESULTS.....</b>	<b>13</b>
6.1 Groundwater Data.....	14
6.1.1 Groundwater Depth.....	14
6.1.2 Field Parameters.....	14
6.1.3 Nutrients (groundwater).....	15
6.1.4 Ammonia Trends .....	17
6.1.5 Hydrochemical Indicators.....	18
6.1.6 Inorganic Contaminants (Iron, Manganese and Fluoride) .....	19
6.1.7 Organic Contaminants (DOC, TOC and Phenols- Groundwater) .....	19
6.2 Surface Water.....	19
6.2.1 Physical Parameters .....	20
6.2.2 Nutrients (surface water).....	20
6.2.3 Organic Contaminants (TOC/DOC, Phenols & Fluoride).....	21
<b>7. CHEMICALS OF CONCERN AND CONTAMINANT PLUMES.....</b>	<b>22</b>
7.1 Ecological Issues.....	22
<b>8. CONCLUSIONS .....</b>	<b>23</b>
8.1 Recommendations.....	25
<b>9. LIMITATIONS .....</b>	<b>26</b>

## TABLES

- Table GW-1: Summary Analytical Report - Groundwater Wells (2018/19)  
Table SW-1: Summary Analytical Report – Surface Water (2018/19)  
Table SW-2: Rocklow Creek - Historical Ammonia Concentrations (mg/L, 1999 to 2019)

## GRAPHS

- Graph-1: Groundwater Ammonia Concentrations (mg/L) All Wells (1999 to 2019)  
Graph-2: Deep Groundwater Ammonia Trends (1999 to 2019)  
Graph-3: Shallow Groundwater Ammonia Trends (1999 to 2019)  
Graph-4: Net Increments of Ammonia; Up & Mid Stream Samples (1999 to 2019)

## FIGURES

- Figure 1: Site Location  
Figure 2: Monitoring Well Locations & Ammonia Concentrations (2018-2019)

## APPENDICES

- Appendix A: ALS Environmental Pty Ltd Laboratory Certificates  
Appendix B: Figure 7 from E2W Landfill Closure Plan  
Appendix C: Landfill Gas Monitoring (KMC 2019) & Figure 1

## 1. INTRODUCTION

Earth2Water Pty Ltd (E2W) was engaged by Kiama Municipal Council (KMC) to provide the 2018/2019 annual assessment report of landfill gas, surface and groundwater monitoring for the Minnamurra Waste Disposal Depot (MWDD).

This report is based on information provided in field and laboratory reports provided by ALS Environmental Pty Ltd, KMC (landfill gas) and previous monitoring reports by E2W (2004 to 2018), Eco-Engineers Pty Ltd and Forbes Rigby Pty Ltd (pre 2004).

This monitoring report for the MWDD is based on quarterly monitoring results (15 November 2018, 5 February 2019, 29 May 2019, and 28 August 2019) and NSW EPA Environmental Protection Licence (EPL) conditions (R1.10). E2W completed the landfill closure plan (LCP in October 2005) and construction quality assurance (April 2008) for the landfill rehabilitation works completed by KMC in January 2008.

### 1.1 Background

KMC has owned and operated the MWDD from the 1960's until its closure in October 2006. The MWDD operated as a Solid Waste Class 1 Landfill under the EPL No. 5958. The MWDD formerly comprised a night soil depot for liquid pump out sullage, which ceased in 1998. The existing licence and amendments required the submission of a Landfill Closure Plan (LCP), which was completed by E2W in October 2005.

Since November 2012, Minnamurra Landfill has accepted mixed food and garden organics, together with small loads of recyclable materials. All general waste materials are diverted to the waste facility at Shellharbour (Dunmore Waste Disposal Depot).

Since 2018, KMC has undertaken groundwater remedial works at the MD9B/9C well location to reduce the ammonia concentrations at the foreshore area. Groundwater extraction is occurring at low pump rates through three spear points with tank storage and irrigation of the grass/landfill mound (note: outlined in separate documentation).

### 1.2 Objectives

The objective of surface and groundwater monitoring in the 2018 to 2019 reporting period was to assess actual or potential impacts associated with the MWDD on the surrounding aquatic environment. Gas monitoring is undertaken by KMC to measure the performance of landfill rehabilitation works.

The objective of this annual report is to provide KMC and the NSW EPA with a summary of the monitoring results obtained in the 2018-2019 reporting period (i.e. EPL 5958 conditions).

## 2. SCOPE OF WORK

E2W was commissioned by KMC to collate and assess surface and groundwater monitoring data provided by ALS during 2018 and 2019. The annual reporting period covers four

quarterly monitoring events in November 2018, February 2019, May 2019 and August 2019 (Figures 1 & 2).

Each water monitoring event comprised the following:

- Sampling of onsite and offsite groundwater wells including; MD1B, MD1A, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, and MD10B<sup>1</sup>.
- Sampling of surface water at three locations along Rocklow Creek (Rocklow-Up, Rocklow-Middle and Rocklow-Down).

Landfill gas monitoring was conducted by KMC (Greg Hardy) at gas monitoring wells, biofilter pads and inside buildings. Monitoring was conducted using a calibrated landfill gas meter (GT402) on a quarterly basis.

E2W undertook the following scope of work to satisfy KMC's surface and groundwater monitoring program at MWDD:

- Provide advice to KMC (in relation to monitoring results- as required).
- Prepare this annual report for monitoring period (November 2018 to August 2019) and comply with Section R1.10 of the EPL (No. 5958). The annual report is to include the following:
  1. Tabulation of the monitoring data obtained for the period.
  2. Graphical representation of the current and previous monitoring data (minimum - last three years). Statistically significant variations or anomalies will be highlighted.
  3. Analyses and interpretation of monitoring data.
  4. Analyses and response to any complaints received.
  5. Identification of any deficiencies in the environmental performance of the MWDD, as highlighted by the monitoring data, trends and/or accidents.
  6. Recommendations to address the above identified deficiencies.
  7. Recommendations on improving the overall environmental performance of the facility.

Rehabilitation of the landfill commenced in August 2006 and was completed by KMC in January 2008. The work included reshaping, cut/fill of waste materials and capping with clays and soil/compost mix (i.e. evapotranspiration layer). The rehabilitation works may have temporarily degraded the runoff and shallow groundwater (2007) due to exposure and leaching of buried putrescible waste which was redistributed during the reshaping.

In early to mid 2016, E2W and Council commenced testing of new extraction bores near MD-9C to assess yields, water quality and the potential for reducing the leachate impact (i.e. ammonia >100 mg/L) by irrigation on the mound. Groundwater remedial works are progressing and include the installation of three extraction bores, and five monitoring wells in proximity to the MD-9C. Groundwater pumps and infrastructure has been installed and commissioned (i.e. extraction works planned for end of 2018).

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<sup>1</sup> The shallow well was consistently dry MD4A. The well (MD1A) was dry.

### 3. ENVIRONMENTAL SETTING

The Minnamurra Waste Disposal and Recycling Depot (MWDD) is located 1 km north of the Minnamurra town ship (Figures 1 and 2). The site is located within a swamp environment, bounded to the west by the rail line and Riverside Drive (formerly a part of the Princes Highway), and to the north and east by the confluence of Rocklow Creek and Minnamurra River. The site is approximately 1 km west of Mystics (Minnamurra) Beach (Figure 1).

The MWDD covers an area of approximately 50 acres (~20 ha), while the landfill mound occupies approximately 6 ha. At present, the MWDD comprises the following features:

- An elevated landfill mound (capped) ranging from 1 to 14 m AHD. The landfill mound was rehabilitated in 2006/2007 according to the LCP submitted by E2W in October 2005,
- A weighbridge and administration office/toilet block,
- KMC truck parking area,
- KMC storage sheds,
- Dog impounding facility,
- Green waste/composting,
- Waste/recycling receival & transfer station.

#### 3.1 Climate

The long-term mean and median rainfall values available for the Kiama Bowling Club (Latitude 344033 N and Longitude 1055103E) between 1897 and 2001 indicate that average yearly rainfall at the MWDD is 1261 mm/year. On average, the MWDD would receive approximately 1220 mm, based on rainfall records obtained from Shellharbour and Albion Park (Forbes Rigby, 1996).

The annual rainfall from August 2018 to July 2019 was 871 mm (drought), 2017 to 2018 was 663mm (drought), August 2016 to July 2017 was 923 mm which is also substantially less than previous years (August 2015 to July 2016 was 1260 mm, August 2014 to July 2015 was 1269<sup>2</sup> mm).

The annual rainfall in previous years are as follows; August 2013 to July 2014 = 873.0 mm<sup>3</sup>, 1201.8 mm =August 2012 to July 2013, 1282.8 mm =August 2011 to July 2012, 1308 mm =August 2010 to July 2011, 1054.4 mm =August 2009 to July 2010.

Periods of high monthly rainfall occurred in November 2017 (116.8 mm) and February 2018 (111.6 mm) are reflected in higher water levels in the following month.

#### 3.2 Topography

A plan of the existing site topography and surrounds is presented in Figure 1. The site is located within mangrove tidal flats, an estuarine environment associated with Rocklow Creek and Minnamurra River (Figure 7 of Appendix B).

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<sup>2</sup> Bombo Headland

<sup>3</sup> Climate data is from Kiama (Bombo Headland) (Station ID 068242), ~4.5 km SSE of MWDD.

Local relief is less than 3 m AHD around the footprint of the landfill (except southern wall), with slopes generally less than 5%. The landfill forms a mound, which reaches a maximum of 14 m AHD above the surrounding low-lying ground surface (approximately 1 m AHD).

The RL of the landfill footprint area ranges from approximately 0.6 m AHD (north-east corner) to 5.2 m AHD (southern wall). On the western side of Riverside Drive the land rises rapidly to a small east and north-east facing ridge where Dunmore House is situated (Figures 1 and 2).

### **3.3 Geology**

The site is located within Quaternary alluvial sediments comprising sands and silts. Based on drilling investigations undertaken by Forbes Rigby in 1996 and recent investigations at the site by KMC and E2W in 2005, the geology is dominated by fine to medium sandy sediments with minimal sandy silt and sandy clays. In most places, the sand is overlain by a 0.5 m thick organic silty loam.

Drill cores by the Geological Survey of NSW in the Rocklow Creek valley predominantly consist of poorly to well-sorted very fine to medium-grained quartz lithic sands. Sand deposits typically extend to a maximum depth of 14 m, with increasing clay content below about 7 m (Forbes Rigby, 1996).

### **3.4 Hydrogeology and Groundwater Flow Regime**

The hydrogeology at the site is dominated by a semi-confined sandy aquifer. Groundwater is encountered at depths of approx 1 m below natural ground level (~0.5 m AHD) along the west, north and east sides of the landfill mound. The depth to water along the southern wall is not well known.

The groundwater quality at the site varies from fresh to saline, with electrical conductivity ranging from 0.85 to 44.6 mS/cm (E2W, October 2005). Groundwater generally becomes more saline in the vicinity of mangroves and tidal saline water bodies (i.e. Rocklow Creek and Minnamurra River).

Recharge to the aquifer system beneath and surrounding the waste disposal facility occurs from rainfall infiltration mainly outside of the capped landfill mound. Infiltration of rainfall is moderate (~30%) around the footprint area, due to the low elevation and leakage through the organic silt layer.

Groundwater gradients in the area of the waste mound are controlled by topography, permeable sands and the nearby tidal water bodies (Rocklow Creek and Minnamurra River). The predominant groundwater flow direction at the site is considered to be north-east and towards the confluence of Rocklow Creek and Minnamurra River. The hydraulic gradient is likely to be variable, depending on the tidal regime and proximity to the river. It is interpreted that the groundwater gradient is at a maximum during low tide and potentially reverses at high tide or high rainfall.

Groundwater discharge at Rocklow Creek and Minnamurra River is influenced by the presence of a fresh groundwater/saltwater interface. The interface results from the density difference between groundwater and seawater. It is a dynamic and complex region with

upward hydraulic gradients, tidal fluctuations, diverse microbiological processes, surface and groundwater interaction and salinity variations. The groundwater/saltwater interface is generally associated with natural attenuation processes (biodegradation, dilution, sorption etc.), which tend to reduce levels of contaminants prior to discharge to marine ecosystems. The groundwater/saltwater interface is interpreted to exist at the boundary of the casuarinas and mangroves at the site.

The contamination of deep and shallow groundwater arises from nutrient enrichment at the MWDD and has been reported on in previous annual monitoring reports by Ecoengineers Pty Ltd (2004) and E2W (2005, 2006 and 2007).

The leachate plume originating from the MWDD is likely to persist for many years after landfill remediation due to the age (1960s) of the waste mound. Improvements in groundwater quality is expected over the short to medium term (up to ~10 years) reflecting the rate of natural attenuation and groundwater flushing effects from rainfall recharge.

### 3.5 Hydrology

The hydrology of the area is dominated by Rocklow Creek and Minnamurra River. Groundwater discharge, with possible leachate from both the Minnamurra and Shellharbour landfills, may be contributing to the nutrients detected in Rocklow Creek (Figure 1).

The Minnamurra River drains a catchment of approximately 142 km<sup>2</sup>. Seventy percent of the catchment is natural, mainly located on the steeper slopes of the Illawarra escarpment. The middle section of the catchment is characterised by a broad floodplain area called Terragong Swamp. This area, which comprises approximately 30% of the catchment, is used extensively for cattle grazing/dairying. The township of Jamberoo is located within this catchment. It can be expected that the Terragong Swamp farming area and Jamberoo itself are significant sources of nutrients and pollutants entering the river.

The entrance of Minnamurra River is permanently open, and the estuary is tidally influenced. The estuarine portion of the river extends approximately 7 km upstream from the mouth and has the suburb of Minnamurra on its western bank. The lower section of the river is an ecologically significant aquatic environment, comprising areas of seagrass, mangrove and salt marsh communities (Forbes Rigby, 1996).

Rocklow Creek catchment has an area of 23 km<sup>2</sup> and occupies the northern most portion of the Minnamurra River catchment. Rocklow Creek flows into the main arm of the Minnamurra River downstream of the MWDD, approximately 2 km upstream of the river entrance. Potential up-gradient sources of contamination may include the Shellharbour landfill, Princes Highway, Riverside Drive and nearby sand mining operations.

Water samples from Rocklow Creek and Minnamurra River have been collected by the DECCW/NSWEPA in 1991 and 2005 (Denis Pascall, August 2005), as part of a water quality and landfill impact assessment for the area (Forbes Rigby, 1996).

The following opinions were offered as a result of DECCW's sampling work:

- Concentrations of most indicators (except dissolved oxygen) are considerably higher in Rocklow Creek than in Minnamurra River; and

- Concentration of nutrients (ammonia) measured at several locations along Rocklow Creek indicate that Shellharbour and Minnamurra landfills may be contributing leachate into the aquatic ecosystem.

One upstream and one downstream Rocklow Creek location are sampled as part of the quarterly MWDD water quality monitoring program. Since 2009, a third location midstream of the creek has also been sampled. Access to the downstream location has been restricted due to mangrove growth along the track (no sample for past three years). Sampling is undertaken by ALS (formerly Ecowise- the sample location was re-established in 2014 once access was available through the mangroves).

#### **4. LICENCE CRITERIA AND RELEVANT GUIDELINES**

Under the NSW EPA requirements for Licence No. 5958, the criteria for surface and groundwater quality are based on the ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. E2W note that the ANZECC (2000) guidelines have been superseded by ANZECC (2018), however ANZEC (2000) are referenced for this EPL report.

The ANZECC guidelines include risk-based trigger levels and indicative interim working levels (IIWLs). The IIWLs are used when insufficient data is available to calculate a trigger level and are of low reliability. It should be noted that the ANZECC water quality guidelines are applicable to receiving water and not groundwater. However, they form an appropriate basis for undertaking a screening level assessment of groundwater quality. Selection of the applicable guideline values are based on an assessment of potential pathways by which human or environmental exposure might take place, as well as the beneficial end use of the groundwater.

The beneficial use classification for groundwater at the site depends on the quality of the water and its potential use in the long term. Although groundwater in the shallow aquifer surrounding (upgradient) the waste disposal facility is likely to be of relatively good quality (depending on the presence of saline intrusions), there are no known groundwater extraction bores (agricultural or domestic) within the immediate vicinity of the site. Therefore, the appropriate beneficial use category of the groundwater is for the protection of aquatic marine and freshwater ecosystems in discharge zones at Rocklow Creek and Minnamurra River, the closest aquatic environmental receptors for the site.

The adopted groundwater assessment guidelines are presented with the summary analytical results (i.e. Tables GW-1, SW-1, SW-2). Exceedances of the ANZECC (2000) trigger values for marine water ecosystems have been highlighted on the summary tables.

##### **4.1 EPL Requirements**

The Environmental Protection Licence (EPL No. 5958) details 20 monitoring points for the MWDD (two for landfill gas and fifteen for groundwater monitoring and three for surface water). The landfill gas monitoring points are required to be analysed for methane every 6 months (i.e. twice in the reporting period). Landfill gas monitoring was conducted on a quarterly basis by KMC (Appendix C) at gas wells, trenches and inside the five buildings.

The frequency of testing of the groundwater monitoring points (MD1B, MD2A, MD2B, MD2C, MD4A, MD4B, MD4C, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B) is also half yearly (EPL requirement, note: MD2A/MD6A are dry wells). However, KMC conducts the groundwater monitoring on a quarterly basis (November 2018, February 2019, May 2019 and August 2019) to establish water quality trends post landfill rehabilitation works.

Some of the groundwater monitoring locations (i.e. MD4A, MD2A) are not sampled as they do not have enough water for sampling). Other available wells onsite including MD3B, MD3C, MD7, MD5A/B/C and MD8 however are not part of the EPL (previously tested prior to landfill closure for characterising the local groundwater).

Table 4.1 (below) lists the analytes that are included in the groundwater testing suite.

**Table 4.1: Groundwater analytical suite (as per the EPL)**

Alkalinity (as CaCO <sub>3</sub> )	Dissolved Oxygen	Nitrate	Temperature
Ammonia	Fluoride	Potassium	Total Phenolics
Calcium	Iron	Sodium	Total Organic Carbon
Chloride	Magnesium	Standing Water Level	pH
Conductivity	Manganese	Sulphate	

Surface water monitoring is required to be undertaken twice a year to comply with the EPL, however they are also undertaken quarterly by KMC in conjunction with groundwater monitoring. Surface water samples are collected and analysed from an up-stream (Rocklow-Up) and mid-gradient (Rocklow-Middle) locations. An alternative sample location was established in May and August 2015 for the down-gradient location (Rocklow-Down, Figure 2).

The mid sample location was included to assess the performance of the landfill rehabilitation works and requirement for a bund wall around the landfill (i.e. access to the downstream location was impeded due to the thick vegetation and relocated in May 2015).

## 4.2 Previous Monitoring Results

The previous annual monitoring reports have been provided by E2W, Ecoengineers and Forbes Rigby. Groundwater ammonia results presented in these earlier reports are included in graphical form and attached in this report (Graphs 1, 2 & 3).

Ammonia is a key landfill leachate indicator based on the results obtained from monitoring wells placed around the MWDD. Landfill leachate has impacted the local groundwater system, with potential or actual impact to Rocklow Creek and Minnamurra River (Appendix B, Figure 7).

## 5. ENVIRONMENTAL MONITORING

Prior to May 2005, surface and groundwater monitoring was undertaken by KMC. Ecwise were (since August 2005) engaged to sample and analyse the surface and groundwater monitoring points as per the EPL and performed the November 2009 sampling round.

Ecowise were acquired by ALS in November 2009, who carried out the subsequent surface and groundwater sampling in the reporting period (2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2016-2017, 2017-2018, and 2018-2019). Quarterly sampling for the 2018/2019 reporting period was undertaken on the following dates:

- 15 November 2018,
- 5 February 2019,
- 29 May 2019; and
- 28 August 2019.

The procedure for sample collection, storage and handling employed by KMC and Ecowise/ALS are generally in accordance with NEPM (2013) and ANZECC (2000).

The following subsections outline the nature of the site's monitoring and analytical program, as well as conditions at the time of sample collection (from information provided by KMC).

### **5.1 Landfill Gas Monitoring**

The landfill gas testing locations include areas where final cover was placed and inside all buildings within 250 m of the deposited waste. Testing has been undertaken by KMC staff on a quarterly basis; 17 October 2018, 13 February 2019, 21 June 2019 and 2 October 2019.

The four rounds (October 2018, February 2019, June 2019, October 2019) of landfill gas testing undertaken by KMC are presented in Appendix C.

All buildings sampled (within 250 m of the deposited waste) recorded no detectable landfill gas readings in January 2017, June 2017, October 2017, February 2018, June 2018, and 17 October 2018, 13 February 2019, 21 June 2019, 2 October 2019

KMC (& E2W) are unaware of any reportable pollution incidences or complaints from the community related to the MWDD during the 2018/19 reporting period.

Six onsite landfill gas wells (Gas 1 to Gas 6) were installed by E2W on 2 August 2006 and gas monitoring has been performed since then as part of the landfill rehabilitation work. Landfill gas monitoring is a requirement of the EPL, but only relates to onsite buildings/sheds and the waste mound (over the capped area).

Two gas monitoring wells (i.e. Gas 5 and Gas 6) have not been monitored since November 2009 as they are located at the same location as Trench 1 (i.e. alternative gas test location, Refer to Figure 1 in Appendix C). The gas well (Gas-2) was removed end of 2014 due to construction of the CRC shed.

Quarterly monitoring data (2018/2019) from the trenches (biofilter pads, Trench 1 to Trench 7) and gas monitoring wells (Gas 1, Gas 3 & Gas 4) showed similar concentrations to previous years (i.e. 2010/2011/2012/2013/2014/2015/2016/2017/2018). Methane gas readings were consistent at each sampling event through the monitoring period. The maximum methane (stable) gas reading was 420 ppm at Trench (4) on 13 February 2019 and 2 October 2019. The lowest readings were 120 ppm at Trench 2 in 21 June 2019. Gas well locations (Gas; 1, 2, 3) in 2018/2019 also reported low landfill gas concentration (i.e. less than 100 to 150 ppm).

Buildings were sampled for landfill gas in 2018/2019, with all locations recording no methane gas readings (non-detectable and compliant with EPL conditions).

E2W interpret that landfill gas is unlikely to be present in the buildings due to the previous results, landfill capping, and type of onsite buildings (i.e. well vented and/or air conditioned).

## 5.2 Surface and Groundwater Monitoring Locations

Groundwater monitoring was undertaken from up to 16 existing groundwater wells (shallow, intermediate and deep) located on the landfill mound perimeter and surface water monitoring at two locations along Rocklow Creek (up, middle and down-gradient of the landfill mound, whilst access was re-established at Rocklow-down in May 2015). Monitoring locations are shown on Figure 2.

The wells and surface water locations sampled in the 2018 and 2019 reporting period are outlined below:

- 15 November 2018. Groundwater wells: MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9B, MD9C, MD10A, MD10B, and Surface water; Rocklow-Up, Rocklow-Middle, Rocklow-Dn;
- 5 February 2019. Groundwater wells: MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, Rocklow-Down.
- 29 May 2019. Groundwater wells: MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9B, MD9C, MD10A, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, Rocklow-Down;
- 28 August 2019. Groundwater wells: MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9B, MD9C, MD10A, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, & Rocklow-Down.

The nature of saline water stratification within the local groundwater system and well network is presented in Table 5.2.1 (below) and Appendix B (Figure 7).

**Table 5.2.1: Summary of Groundwater Salinity Changes with Depth**

Well ID	Salinity (EC, $\mu\text{S}/\text{cm}$ )	Comment
MD1B	850	Fresh- water 10 m away is saline
MD2A	25,200	surface water from high tide
MD2B	29,100	saline groundwater
MD2C	44,600	saline groundwater
MD4A	NA	Damaged well (shallow/dry)
MD4B	15,300	saline groundwater
MD4C	33,100	saline groundwater
MD6A	11,100	surface water from high tide
MD6B	2,221	fresh - brackish groundwater
MD6C	27,400	saline groundwater
MD9A	3,375	fresh - brackish groundwater
MD9B	3,207	fresh - brackish groundwater
MD9C	3,600	fresh - brackish groundwater
MD10A	40,900	saline groundwater
MD10B	2,797	fresh - brackish groundwater

*Note: Electrical Conductivity data is from sampling by E2W on 29 June 2005.*

Well suffix 'A' and 'B' = shallow well screen (less than 3 m into water table).

Well suffix 'C' = well screen greater than 3 m below water table (refer to Figure 7 in Appendix B).

Several of the groundwater wells (MD-4A/B/C, MD-6A/B/C etc.) comprise nested wells, which target various depths within the coastal sand aquifer. The sampling frequency and depth of the groundwater samples are presented in Table 5.2.2 (below).

**Table 5.2.2: Monitoring Summary for the 2018 to 2019 Reporting Period**

Sample ID	Screen Interval (m AHD) - or Sample Location	Nov 2018	Feb 2019	May 2019	Aug 2019
(MD1A)	0.5 to -0.5	No Access/dry	No Access/dry	No Access/dry	No Access/dry
MD1B	-4.7 to -5.7	X	X	X	X
MD2A	0.525 to -0.475	X	X	X	X
MD2B	-2.93 to -3.93	X	X	X	X
MD2C	-5.2 to -6.2	X	X	X	X
(MD3B)	-3.22 to -4.22*				
(MD3C)	-5.55 to -6.55*				
MD4A	1.2 to 0.2	Dry	Dry	Dry	Dry
MD4B	-3.22 to -4.22	X	X	X	X
MD4C	-5.55 to -6.55	X	X	X	X
MD6A	0.71 to -0.30	X	X	X	X
MD6B	-1.05 to -2.05	X	X	X	X
MD6C	-8.8 to -9.8	X	X	X	X
(MD7)	0.5 to -0.5 *				
(MD8)	0.5 to -0.5*				
MD9A	0.58 to -0.42	X	X	X	X
MD9B	-2.3 to -3.3	X	X	X	X
MD9C	-4.75 to -5.75	X	X	X	X
MD10A	0.68 to -0.32	X	X	X	X
MD10B	-2.85 to -3.85	X	X	X	X
Rocklow-Up	Upstream of landfill	X	X	X	X
Rocklow-Middle	Midstream of landfill	X	X	X	X
Rocklow-Down	Downstream and opposite landfill	X (new location)	X (new location)	X (new location)	X (new location)

Note: \* = to be confirmed (logs not available). X = Sample collected.

(MD7), well in brackets = well is not an EPL requirement. Blank space = not sampled.

# = Not enough water for sampling

The groundwater monitoring wells and sampling depths for each event are summarised in Table 5.2.2 (above). The sampling labels for the nested wells ('A' to 'C') are attached to each of the depths associated with these wells (e.g. MD1A, MD1B, MD1C).

## 6. MONITORING RESULTS

All surface and groundwater analytical results for the 2018/19 reporting period are presented in Tables GW-1, and SW-1, SW-2, and SW-3. The ALS field record and laboratory reports are presented in Appendix A.

A summary of all groundwater monitoring data (1999 to 2019) for ammonia (mg/L) is presented in Graph-1, Graph-2 and Graph-3. The graphs highlight ammonia groundwater quality trends over the past ~ 20 years (January 1999 to August 2019). Ammonia concentrations are the key landfill leachate indicator for the site.

A summary of previous ammonia surface water results for Rocklow Creek is presented in Table SW-2. Ammonia is considered as the key landfill leachate indicator in surface water, however other sources of ammonia exist in the same catchment (i.e. fertiliser use in paddocks and Dunmore landfill on the opposite side of Rocklow Creek).

## 6.1 Groundwater Data

Groundwater for the 2018/19 reporting period was collected from a network of seventeen monitoring wells (mostly downgradient locations) at the MWDD (Figure 2). The results of the groundwater testing are summarised in Table GW-1, Graphs-1 to 3, Figure 2 and in the following subsections.

### 6.1.1 Groundwater Depth

The depth to groundwater was measured prior to each sampling event using a water level probe. Depth to the groundwater below top of casing and relative to a common reference (i.e. Australian Height Datum, mAHD) is presented in Table GW-1. The inferred radial groundwater flow direction for the site is presented in Figure 2. Given the proximity to Rocklow Creek, the groundwater flow direction and gradients would be influenced by tides.

The groundwater levels recorded during 2018/19 is similar to previous years and reflects the seasonal changes in rainfall and tide levels.

The reduced groundwater levels (m AHD) from the 16 wells sampled in 2018/19<sup>4</sup> indicate a relatively low water table elevation (<1 m AHD), which is characteristic of the swamp/estuarine environment. The annual rainfall from August 2018 to July 2019 was 871 mm reflecting a 3 year dry period (e.g. 2016-2017 & 2017-2018 was 923 mm, 663 mm, respectively at Bombo Headland).

Recharge to the aquifer system beneath and surrounding the waste disposal facility mainly occurs from rainfall infiltration and storm water runoff around the footprint. Minor recharge may occur through the landfill mound (e.g. <5% of annual rainfall). The infiltration of rainfall is interpreted to be moderate/high around the footprint area (uncapped areas) due to the sandy soils, low elevation and run-off.

### 6.1.2 Field Parameters

The field parameters measured during groundwater sampling are indicative only, due to the low purge volumes (ALS sampling) and dominant reduced/anaerobic condition of the groundwater (Table GW-1).

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<sup>4</sup> Note: MD2A, MD4A, MD10A, MD10B have no RL measurement.

Insitu measurements (within borehole) are likely to provide a more accurate rendition of the field chemistry, especially with respect to dissolved oxygen (parameters are not considered critical for the quarterly monitoring).

#### **6.1.2.1 Field pH**

The pH from the 15 wells (MD1A, MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B) ranged from pH 6.4 to 7.7 (average PH =7.07) in the 2018-2019 reporting period, indicating relatively neutral groundwater.

Fluctuation (minor) in pH is likely to relate to a combination of factors including leachate quality, acid sulphate soils, tidal influences (together with a rise in electrical conductivity) and surface water quality.

E2W considers that field pH measurements may be more reliable than laboratory, as the pH of waters can change once out of equilibrium with the natural environment and stored within containers (holding time for pH is less than 4 hrs).

#### **6.1.2.2 Electrical Conductivity (EC)**

The EC in groundwater collected from the site vary and range from approximately 592 to 49,400 uS/cm (average=20,100 uS/cm) in the 2018/19 reporting period. The salinity reflects the transgression/regression of fresh and marine groundwater and presence of saline groundwater at depth (Figure 2 & Appendix B).

The distribution of EC indicates fresh water is located under the landfill mound and close to the landfill footprint, with sharp salinity increases near Rocklow Creek and Minnamurra River (Figure 7, Appendix B). The saline water correlated with the fresh/saltwater interface and presence of mangroves/sedges (tidal area).

#### **6.1.2.3 Dissolved Oxygen (DO)**

The 15 wells recorded field dissolved oxygen (DO) concentrations ranging between 0.51 to 7.14 mg/L (average=1.6 mg/L) in the 2018/19 reporting period. The concentrations of dissolved oxygen were similar to those reported in previous annual monitoring reports.

It is likely the concentrations of DO would be lower if measured insitu, as opposed to during the purging and sampling process. Wells with low purge volumes (& sampling via a bailer) are unlikely to provide representative groundwater DO concentrations.

Landfill leachate and the organic rich sediments (estuary) are likely to deplete DO in the groundwater (e.g. MD9C). This phenomenon is seen on many landfill sites, where organic carbon and nutrients provide surplus electron acceptors, which react with and consume the available DO in groundwater.

#### **6.1.3 Nutrients (groundwater)**

##### **6.1.3.1 Nitrogen-based compounds**

Groundwater collected from the MWDD monitoring wells were analysed for ammonia and nitrate in the 2018/19 reporting period (note: Total nitrogen is not an EPL requirement).

Three (MD2A, MD6A, MD9A) out of the 15 wells reported one or more samples with nitrate concentrations above the ANZECC (2000) trigger value for freshwater ecosystems (0.7 mg/L, at 95% protection level). In 2018/2019, nitrate concentrations ranged from <0.01 (non-detected/below LOR) to 10.6 mg/L (average= 1.16 mg/L) which is similar to previous years. Elevated Nitrate has been detected in few shallow wells (MD2A, MD6A, MD9A) in the 2018/2019 monitoring round (i.e. 2016/2017 had nine wells above ANZECC 2000) in comparison to the 2012/2013 monitoring round (eight wells above ANZECC 2000). The nitrate concentrations in groundwater in 2018/2019 are generally low and below ANZECC (2000), except for the 3 shallow wells (MD2A, MD6A, MD9A). Nitrate is associated with the shallow wells due to oxidation of the ammonia concentrations.

Nitrogen species in the groundwater is predominantly ammonia, and indicative of a reducing groundwater environment. Thus, potential impact to the aquatic environment is interpreted to arise from ammonia, and to a lesser extent, the oxidised nitrogen form (nitrate).

The guidelines (ammonia) for the protection of freshwater and marine ecosystems vary according to pH and temperature. Given the range of pH and temperature measured across the site and in Rocklow Creek, the guideline values have been calculated as 1.88 and 2.84 mg/L for fresh and marine waters, respectively (at pH of 7.3).

Fourteen (14) out of 15 wells (excluding MD4A) reported ammonia concentrations in excess of the ANZECC (2000) trigger value for marine ecosystems (2.84 mg/L, based on a pH of 7.3) in the 4 rounds of sampling. Concentration of ammonia range from 0.04 to 147 mg/L, with an average of 34.17 mg/L (2018/2019).

Groundwater from the wells MD1B, MD2A, MD4B, MD4C, MD6A, MD6B, MD6C, MD9B, MD9C and MD10B, located on the north and eastern landfill perimeters (plume centreline path) reported the highest concentrations of ammonia (Figure 2).

The Well (**MD9C**) reported the maximum ammonia of 147 mg/L in November 2018. The results are similar to May 2016 (160 mg/L) and November 2014 (170 mg/L). The recent monitoring results are higher than the ammonia (maximum of 122 mg/L) in 2012/13. Ammonia trends are presented in the time series Graphs 1 to 3. Groundwater remedial works are underway at MD9C which is likely to reduce ammonia concentrations.

Highest ammonia concentrations correlate with the main downgradient area (plume centreline) of the waste mound and above average rainfall events. The ammonia concentrations from 2015 to 2019 are variable and elevated reflecting leachate spikes which are interpreted to reflect the variable dry climate with occasional and heavy rainfall events (e.g. March 2017 @ 309 mm).

It is noted that rehabilitation works were completed in early 2008, and the 2008/09 and 2009/10 ammonia concentrations have generally decreased since then at most well locations. Well locations MD2B, MD2C and MD9B have decreased in maximum ammonia concentrations in 2012/13 in comparison to the previous 2011/12 period.

The ammonia trends at the MB-9C, MD-10B area are currently variable, showing both rising and reducing trends at various depths due to the plume migration and KMC extraction works.

Groundwater extraction works are in progress for the rising ammonia trend (above 100 mg/L) at MD9C. A series of extraction and monitoring wells have been installed by E2W and KMC together to enable irrigation of the leachate on the batter slopes.

#### 6.1.4 Ammonia Trends

The groundwater ammonia trends from 1999 to 2019 are presented in Graphs-1, Graph-2 and Graph-3. The data indicates ammonia in most monitoring wells exceed the ANZECC (2000) marine water trigger value. A summary the ammonia trends are presented in Table 6.1.4.

**Table 6.1.4 Summary of Ammonia Trends in Groundwater (1999 to 2019)**

South-east of Landfill (Across-gradient)		North of Landfill (Down-gradient, plume centreline)	
Well ID	Trend	Well ID	Trend
MD1B	Overall Decreased, but recently increasing	MD4B	Variable to decreasing trend
MD2B	Overall Decreasing	MD4C	Overall Decreasing
MD2C	Overall Decreasing	<b>MD9B</b>	<b>Variable and increasing trend (currently &gt;120 mg/L)</b>
MD6B	Variable to decreasing trend	<b>MD9C</b>	<b>Variable trend (currently &lt;100 mg/l)</b>
MD6C	Variable to decreasing trend	MD10B	Variable trend (currently <80 mg/L)

Note: "B" and "C" denote shallow and deep wells, respectively.

The ammonia trends are generally variable over time; however most locations show a downward or stable trend. The ammonia from the quarterly monitoring events may reflect a combination of seasonal rainfall, plume movement, tidal fluctuations and landfill rehabilitation works.

Monitoring reports (e.g. E2W, 2008-09, 2009-10, 2010-11, 2011-12, 2012-13, 2013-2014, 2014-2015, 2016-2017, 2017-2018, 2018-2019) have identified spikes in ammonia concentrations that are interpreted to result from high rainfall and plume migration. For example, in February 2008, high rainfall (169.2 mm, 5 February) was followed by a rise in ammonia in early to mid 2008. In October 2009, 187.8 mm of rainfall, which was the highest monthly rainfall recorded for the 2009 calendar year (next highest December 2009, 106.2 mm). During the 2010-11 monitoring period, 22 March 2011 (163.8 mm rainfall) was followed by a rise in ammonia (May 2011, Graphs 1-3)<sup>5</sup>. Over the 2011/12 period, a combined 176.2mm rainfall from 20 to 23 July was followed by an increase in ammonia (November 2011, Graph 1-3). Rainfall of 289 mm in February and 213.2mm in March 2012 (502.2mm combined in 2 months) was followed by rises in ammonia (May 2012, Graph 1-3)<sup>7</sup>.

During the 2012/13 period, high rainfall was experienced in January 2013 (170.8 mm) and February 2013 (153.2 mm) resulting in elevated ammonia during the February monitoring. In addition, high rainfall in April 2013 (183.6 mm) was followed by a rise in ammonia in May 2013. This occurred again in the 2013/14 period with high rainfall in November 2013 followed by a rise in Ammonia in the November 2013 samples and high rainfall again in March and April 2014 followed by an increase in Ammonia in the May 2014 samples. The

<sup>5</sup> Rainfall data taken from the Kiama (Bombo Headland) Weather Station, (Station ID 068242)

ammonia peak in November 2014 (170 mg/L) and November 2015 are interpreted to be associated with high recharge rainfall events.

Heavy rain occurred in February (158.8 mm) and March (309 mm) 2017, however rainfall during the 2016 -2017 (923 mm), 2017-2018 (663mm), and 2018-2019 (871 mmm) monitoring period are below the annual average.

Rainfall events before or on the dates of sampling may contribute to rising ammonia concentrations in the groundwater due to flushing (e.g. leachate migration/generation and/or rising water table).

During 2014 to 2019 ammonia concentrations are generally variable at MD9C and MD9B (hotspot area). Ammonia exceeds 100 mg/L in 2015 at MD9C. The elevated ammonia concentrations are reported at the north east corner of the landfill as measured by wells at MD10B/MD9C/MD9B. This area has been further investigated and currently subjected to groundwater remedial works to minimise potential impacts to the aquatic ecosystems.

Review of aerial photographs taken of the landfill in late 2007 shows that the NE corner (where most of the wells are situated) was the last to be reshaped, capped and vegetated (& increase the potential for leachate generation and migration, as would have disturbance of soil and waste in that area). Continued monitoring of ammonia concentrations and climate is required to establish seasonal trends.

The amount of landfill leachate declined following the closure of the landfill and completion of rehabilitation works. The groundwater quality is likely to take years (5 years+) to show improvements due to the age and scale of the landfill mound, and generally flat hydraulic gradients.

Results from 2012 to 2019 monitoring periods show cyclical seasonal trends related to climate. Future monitoring is required to assess ammonia trends during various climate and active remedial works (MD9C/MD9B, MD10B). The MD9C area is interpreted to represent the centreline and core of leachate plume and main discharge area to Rocklow creek.

#### **6.1.4.1 Total Phosphorus (TP, groundwater)**

The total phosphorus (TP) is not an EPL requirement and was not sampled during the 2016-2019 monitoring period. In the 2007/08 monitoring period, the majority of TP concentrations from twelve wells exceeded the ANZECC (2000) trigger values for the protection of marine ecosystems.

#### **6.1.5 Hydrochemical Indicators**

Concentrations of major ions (chloride, sulphate, calcium, magnesium, sodium and potassium) in the groundwater at the site are presented in Table GW-1. The concentrations of major ions in all monitoring wells are within previously reported ranges and generally dominated by one cation (sodium) and anion (chloride).

In wells with freshwater, (MD6B and MD10B) calcium concentrations are similar to and sometimes greater than sodium. The calcium may relate to the geology (shells) or leachate.

The landfill leachate may be contributing concentrations of ions including calcium, potassium and magnesium. Contribution of sodium and chloride is difficult to ascertain as these ions are common with marine environments (e.g. salt spray, tidal influence).

#### **6.1.6 Inorganic Contaminants (Iron, Manganese and Fluoride)**

Dissolved iron (filtered at the laboratory) ranges from the 0.12 mg/L to 20.6 mg/L (average=3.1 mg/L). With the exception of MD6B, all the groundwater wells reported ANZECC (2000) exceedances (freshwater ecosystems, 0.3 mg/L) in at least one in of the four sampling rounds.

It is noted that the ANZECC (2000) guideline for iron is an indicative interim working level (IIWL) and is of low reliability. No guideline is available for iron in marine water, which has a higher relevance to Rocklow Creek and receiving water bodies.

Concentrations of manganese ranged from 0.021 mg/L to 0.838 mg/L (average=0.14 mg/L). The ANZECC (2000) guideline for manganese in fresh water is 1.9 mg/L. All results were reported below the ANZECC freshwater guidelines.

The levels of filterable iron and manganese are similar to the previous reporting periods.

Concentrations of fluoride ranged from 0.1 mg/L to 1.2 mg/L (average=0.627 mg/L). No recommended reliable ANZECC (2000) guidelines exist for fluoride in fresh or marine waters. The data ranges between the minimum and maximum values are similar to previous levels. The results indicate that fluoride levels are generally associated with landfill leachate.

#### **6.1.7 Organic Contaminants (DOC, TOC and Phenols- Groundwater)**

Concentrations of total and dissolved organic carbon (TOC/DOC) ranged from 5/5 mg/L to 91/91 mg/L in the 2018/19 reporting period. ANZECC (2000) guidelines do not exist for TOC. The TOC may relate to landfill leachate and/or naturally occurring organic matter/content associated with lowland/estuary.

Concentrations of phenols were all reported below the LOR (0.05 mg/L), except for MD-2C (0.76 mg/l on 28 August 2019). Further investigation is required at MD2C as Phenol concentrations exceeded the ANZECC (2000) guidelines of 0.4 mg/L (Marine water).

Phenols have been previously detected at MD9A in February 2016 (0.6 mg/L) and August 2016 (0.33 mg/L).

The November 2016 (0.35 mg/L) results from MD9A indicate phenol concentrations are likely to relate to the landfill leachate.

### **6.2 Surface Water**

Surface water sampling was undertaken quarterly during the 2018/19 reporting period (EPL requirement is only six-monthly sampling).

The three surface water locations provide a general indication of water quality impacts from the MWDD (Figure 2). Impacts to the water quality in Rocklow Creek may also occur from the neighbouring Shellharbour Waste Disposal Depot situated on the northern side of Rocklow Creek.

The three surface water locations are not sampled according to consistent tide (a low tide with outflow). Rocklow Creek represents a mix of tidal water and groundwater baseflow discharges. Therefore, variations in water quality can occur due to tidal dilution associated with incoming and outgoing flows.

The surface water monitoring data is variable and possibly reflecting a combination of tide sampling regimes and influence from the broader catchment area. Timing of the samples should be coordinated with the tide so that creek samples are collected during a run-out tide when the maximum amount of groundwater discharges into the creek.

## 6.2.1 Physical Parameters

### 6.2.1.1 pH

The pH in Rocklow Creek at the middle and upstream location is generally neutral (6.9 to 7.7) in 2018/19, and has not changed significantly from previous reporting periods.

### 6.2.1.2 TDS - EC

The conductivity (EC, mS/cm) of waters at the upstream location are generally lower than those recorded downstream (Rocklow-Middle), reflecting the tidal range and groundwater discharge from the catchment area.

Water collected from Rocklow Creek is brackish to saline (31.4 to 54.5 mS/cm). Sampling at low tide would result in decreased salinity due to an increased baseflow (fresh groundwater) contribution.

### 6.2.1.3 Dissolved Oxygen (DO)

The DO of waters ranged from 1.61 to 8.39 mg/L (average 5.13 mg/L). Higher Do values are associated with the up-stream section of Rocklow Creek.

## 6.2.2 Nutrients (surface water)

### 6.2.2.1 Nitrogen

Rocklow Creek surface water samples collected in the 2018/19 reporting period reported ammonia below the ANZECC (2000) guidelines for marine and freshwater ecosystems (2.84 and 1.88 mg/L, respectively, Tables SW-1 and SW-2).

Nitrate concentrations for the 2018-2019 ranged from 0.02 to 0.03 mg/L (average 0.0225 mg/L) and were below the ANZECC (2000) guidelines. Ammonia concentrations for the 2018-2019 ranged from 0.02 to 1.81 mg/L (average 0.587 mg/L) and were below the ANZECC (2000) guidelines. The elevated concentrations in the upstream sample indicates elevated and variable background/nutrient concentrations form the agricultural catchment area.

Water samples collected from Rocklow Creek during 2018/19 reporting period generally show variable concentrations of ammonia an upstream to downstream locations. The greatest increase in ammonia from upstream to midstream location occurs on 15 November 2018 (0.09 mg/L to 1.56 mg/L, Tables: SW-1 & SW-2). The midstream location corresponds to the area of MD-9C, where active remedial works are occurring to reduce ammonia concentrations in the groundwater.

Other increases in ammonia from upstream to downstream location occurs on 17 August 2017 (0.05 mg/L to 1.59 mg/L). The ammonia increments between the upper, mid and downstream samples are presented in Table SW-2 and Graph-4 (note: mid-stream location is downgradient to MD-9C, MD-4B and MD-10B which have elevated and irregular ammonia trends).

Ammonia concentrations in Rocklow Creek (2018/19) are generally comparable to previous results (2017-2018, 2016-2017, 2014/2015, 2013/2014, 2012/13 and 2011/12, Table SW-2). However, the ammonia increments, and seasonal variability in the Rocklow-Mid and Rocklow-Low is evident from 2011 to 2019 (spiking of ammonia), which is interpreted to reflect tidal influences, variable background concentrations, climate and potentially the groundwater (MD9C) discharges.

Increases in ammonia from upstream to downstream of the landfill have been observed during previous monitoring periods (Graph-4). While these increases could be attributable to the discharge of groundwater impacted by ammonia from the MWDD, other sources of nitrogen input such as polluted runoff from the catchment (Shellharbour Landfill, agricultural areas) and nutrients bound in sediments is not discounted.

Graph-4 shows the ammonia increments in all monitoring periods since 1999 to 2019 and illustrates a decreasing difference between upstream and downstream ammonia concentrations. Ammonia concentrations at Rocklow-Up have remained relatively stable over time while ammonia concentrations at Rocklow-Middle and Rocklow-Down show a variable trend.

The ammonia contribution from the MWDD into Rocklow Creek is complicated by the sampling regime (i.e. sampling at various tides level with dilution from tidal water) and other potential sources of nitrogen in the area (Dunmore Landfill and nutrients from upstream agricultural areas). Surface water results should be interpreted as indicative only due to the dynamic nature of the catchment and multiple nutrient sources.

#### **6.2.2.2 Total Phosphorous (surface water)**

Total phosphorus (TP) is not an EPL requirement and were not analysed during the 2018/19 monitoring period.

Monitoring from previous years indicate that TP concentrations decrease from up to downstream of the landfill (except in August 2008), implying there is nutrient contribution from other (agricultural) sources in the catchment area.

#### **6.2.3 Organic Contaminants (TOC/DOC, Phenols & Fluoride)**

Concentrations of total organic carbon (TOC) ranged from 4 to 11 mg/L in the 2018/19 reporting period. No recommended ANZECC (2000) guidelines exist for DOC (concentrations could be related to natural waters or leachate).

Concentrations of phenols were reported all below LOR (0.05 mg/L) in all surface water samples, except for the upstream sample (i.e. Rocklow Up = 0.77 mg/L, 28 Aug 2019). The phenol is above the ANZECC (2000) guidelines of 0.4 mg/L and requires further assessment for the next sampling round (e.g. speciated phenol analyses).

Concentrations of fluoride ranged from 0.9 mg/L to 1.3 mg/L, with concentrations showing a general increase in the Rocklow-Mid & Rocklow-Low sampling locations relative to the upstream sample.

## 7. CHEMICALS OF CONCERN AND CONTAMINANT PLUME

The results of 2018/19 monitoring have been assessed to determine the surface and groundwater conditions with respect to the relevant guidelines which serve to protect aquatic ecosystems (both fresh and marine). Aquatic ecosystem protection is considered as the key beneficiary (environmental) of the local groundwater.

The primary landfill leachate indicator at the site is ammonia. Ammonia represents the analyte which exceeds ANZECC (2000) guidelines in majority of monitoring wells. The landfill is also a source of dissolved salts, metals (i.e. iron, which was generally above interim guidelines) and potentially organics. The dissolved salts, metals and organics are associated with the dissolution of ions from various types of buried waste material.

Results of the sampling (1999 to 2019) confirm that ammonia concentrations are elevated above background levels. Improvement in the groundwater quality (i.e. a decreasing ammonia trend) is evident in several wells (MD2B, MD2C, MD4C, MD6C) since landfill rehabilitation works (2007).

Groundwater remedial works are occurring to reduced elevated ammonia ( $>100 \text{ mg/L}$ ) at the plume centreline area, which including the well location (MD9B/9C and MD10B) on the north east corner of the site.

High rainfall periods since landfill rehabilitation completion are interpreted to have resulted in periodic ammonia increases (e.g. February 2008, March 2011, July 2011, February/March 2012, January/February 2013, April 2013, November 2013, March-April & late 2014, August 2015, June 2016, March 2017). The past three years indicate a dry weather pattern and potentially less dilution of the ammonia plume around the landfill perimeter.

It is likely the leachate plume arising from the landfill mound would migrate radially (local system) and with the regional flow regime towards the north-east and east (MD9 centreline). Landfill leachate infiltrates into the sandy aquifer and migrates towards Rocklow Creek and Minnamurra River.

The extent of natural attenuation and degradation of the nutrient plume prior to discharge is not well known, however the groundwater/saltwater interface and mangrove environment are likely to enhance attenuation of the ammonia plume (Appendix B, Figure 7).

### 7.1 Ecological Issues

Groundwater migrating from under the landfill mound to Rocklow Creek and Minnamurra River would be diluted by the dynamic and tidal nature of the environment. Contaminants contained within this discharge will be diluted and dispersed via biological, chemical and physical processes which occur at the groundwater/saltwater interface. Uptake of the nutrients by plants (mangroves, sedges) dependent on groundwater will also occur at the creek and river.

The adverse effects arising from landfill leachate on the Rocklow Creek and Minnamurra River aquatic environments is unclear and difficult to ascertain, given the multiple sources of nutrients present and disturbance in the catchment area. No obvious evidence of degradation is evident in the water bodies or surrounding vegetation (Note; some trees were damaged/removed during landfill rehabilitation works in 2007/2008).

Discharges of landfill leachate to Rocklow Creek would be at a maximum when the tide is low (& with fresh water) and groundwater gradients are steeper.

The net increment of ammonia in the midstream sample (Rocklow-Middle) averaged ~0.05 mg/L in the 2014/15, ~0.96 mg/L the 2015/16, ~0.146 mg/L in the 2016/2017, 0.605 mg/L in the 2017-2018, 0.285 mg/L in the 2018-2019 reporting period (Table SW-2). This net increment in 2018-2019 is also dependant on tidal regime during sampling.

The reduced net increment of ammonia may also reflect the below average climate (871 mm) during the 2018-2019 monitoring period.

The ammonia in groundwater plume (MD-4B, MD-9C, MD-10B) during 2018/19 is interpreted to contribute to the nutrient concentrations in the surface water (i.e. Rocklow-Middle & Down). However, other potential sources (Dunmore landfill) and variables are noted (e.g. climate, tide, degraded catchment runoff). Downstream ammonia concentrations have generally declined, but shows significant variability since monitoring commenced in 1999 (Graph-4).

While it is likely that some nitrogen-impacted groundwater may discharge into Rocklow Creek and Minnamurra River, it is unclear as to the extent of attenuation of the nitrogen plume prior to discharge. Attenuation is likely to occur through a combination of dilution, through mixing of groundwater from north of the creek, by flows and tidal movements within the creek and estuary itself, oxidation of the ammonia to nitrate, and finally as conversion to nitrogen gas. Rocklow creek has extensive mangroves and casuarinas.

Since early 2016, Council and E2W have investigated groundwater near MD9C and installed test bores (3) and pumping infrastructure to progress remedial works to reduce the elevated ammonia concentrations. Leachate management include extraction of groundwater at MD9C through three spear points (2018) and irrigation of the landfill mound.

Ammonia and nitrate concentrations in all surface water samples collected in the 2018/19 reporting period were below ANZECC (2000) trigger values for fresh and marine water ecosystems.

## 8. CONCLUSIONS

Surface and groundwater monitoring were undertaken at the Minnamurra Waste Disposal Facility by ALS on a quarterly basis from November 2018 to August 2019 (EPL reporting period). Monitoring data collected during the 2018/2019 period was assessed by E2W (Dino Parisotto) to determine the impact of the landfill facility on local groundwater and aquatic ecosystems.

Based on the environmental data reviewed and assessed, E2W offer the following conclusions:

- Elevated concentrations of nutrients, particularly ammonia continues to be detected in groundwater at the landfill site. Ammonia concentrations exceed the ANZECC (2000) guidelines for the protection of fresh and marine water ecosystems in 14 out of 15 monitoring wells sampled (i.e. MD-1A/MD-4A dry wells, whilst at MD-10A ammonia is below guidelines).

- The impacted wells are located on the footprint (downgradient) of the landfill mound, indicating contaminant migration towards Rocklow Creek and Minnamurra River (north-east and east).
- Elevated ammonia concentrations (above ANZECC 2000) were reported at majority of wells (Figure 2), with highest concentrations exceeding 100 mg/L reported at MD-9 (i.e. MD9B= 137 mg/L, and MD9C =147 mg/L). This area is currently being remediated via three spear points at MD-9/MD-10 area to reduce the ammonia concentrations.
- The nitrate concentrations in groundwater in 2018/2019 are generally low and below ANZECC (2000), except for the 3 wells (MD2A, MD6A, MD9A), which were above the ANZECC (2000) trigger value for freshwater ecosystems (0.7 mg/L, at 95% protection level). Nitrate concentrations in 2018/2019 are comparable to previous years.
- Ammonia concentrations in the 2018/19 monitoring period continue to be elevated and variable, however show an overall decreasing trend in most wells. One exception includes (MD9B) which has a rising ammonia trend and is currently being remediated. Variations in ammonia are inferred to reflect seasonal trends (prevailing dry climate, heavy storm events) and plume migration.
- Low concentrations of ammonia (below ANZECC 2000) were reported from the upstream, mid and down stream locations of Rocklow Creek during 2018/19. Increases in ammonia concentrations is not consistent in the downstream or Rocklow-Mid surface water locations relative to the upstream samples. The net increment of ammonia between the upstream, midstream and downstream concentrations continue to be variable since 1999. E2W interpret that some nutrient impact from the Minnamurra site occurs during 2018/2019 given the proximity of the groundwater ammonia plume (MD-9B/9C, MB1-B) to Rocklow Creek (Graph 4).
- Net increments of ammonia in the midstream sample (Rocklow-Middle) averaged ~0.05 mg/L in 2014/15, ~0.96 mg/L the 2015/16, ~0.146 mg/L in the 2016/2017, 0.605 mg/L in 2017-2018, and 0.285 mg/L in the 2018-2019 reporting period (Table SW-2). This net increment in 2018-2019 is also dependant on tidal regime during sampling. The elevated ammonia in nearby groundwater (MD-9C/MD-9B) may be contributing ammonia concentrations in the surface water (Rocklow-Mid/downstream). Further monitoring is required to verify this interpretation, as tidal dilution and multiple nutrient sources are situated around the creek (e.g. Dunmore landfill, degraded agricultural and industrial runoff).
- Recent water quality indicators were consistent with the results of previous monitoring periods. However, concentrations of phenols detected at well MD-2C (0.76 mg/L, 28 Aug 2019) and Rocklow Up (0.77 mg/L @ 28 Aug 2019) exceed the ANZECC (2000) guidelines (0.4 mg/L) and require further assessment for the next sampling round. Should phenols be detected again, additional laboratory analyses is proposed to include speciated phenol analyses.
- The quarterly testing of the gas monitoring wells (Gas 1, Gas 3, Gas 4) and trenches (Trench 1 to Trench 7 – gas biofilter pads) indicated that landfill gas levels are comparable to previous years. All buildings sampled (within 250 m of the deposited waste) recorded no detectable landfill gas readings on 17 October 2018, 13 February 2019, 21 June 2019, and 2 October 2019. The five buildings assessed for landfill gas during 2018/2019 include the weighbridge, cleaning shed, MRF, lunch room, and ute shed.
- KMC (& E2W) are unaware of any reportable pollution incidences or complaints from the community related to the MWDD during the 2018/19 reporting period.

The nutrients in the local surface and groundwater are likely to decrease over time due to the landfill closure and rehabilitation works. Leachate generation has decreased due to the

landfill capping from August 2006 to January 2008. Monitoring data in 2018/19 supports this interpretation and improvement in the local water quality.

The elevated ammonia concentrations reported at MD-9C/MD-9B and MD-10B relates to the plume centreline migrating from under the landfill mound to the site boundary and foreshore area. Other areas are showing a decrease in leachate strength associated with landfill closure works and reduction of leachate generation due to site capping works.

Monitoring over the next few years will continue to provide the relevant environmental data to assess the effectiveness and performance of the landfill rehabilitation.

Groundwater remediation works and monitoring of elevated ammonia at monitoring wells and Rocklow Creek is required to assess ammonia trends and potential adverse water quality impacts. Current remedial works include groundwater extraction at three spear points (area of MD-9C/MB-10B) and irrigation of the landfill mound since 2018. The groundwater remediation and monitoring are planned to continue at low extraction rates for at least 5 years.

## 8.1 Recommendations

E2W offer the following recommendations regarding the monitoring at the Minnamurra Waste Disposal Depot:

- Continue to monitor the groundwater and surface water and assess potential landfill leachate impacts.
- Council to document the groundwater remedial works (start date, extraction rates, volume extracted, water quality results) and correlation to EPL monitoring results.

### *Water Sampling Procedures*

- Recording of groundwater purge volumes and any observations (odour, sheen, turbidity) during sampling of monitoring wells,
- Use of calibrated field instruments for measuring field chemistry (pH, EC, DO, Eh, T) prior to sampling (documentation required to verify equipment calibration),
- Sampling of surface water to be timed with a **low ‘run out’ tide**. Documenting the tidal and climatic conditions during sampling.
- Include the details regarding the well conditions (eg. damaged or dry wells). Any damaged wells should be replaced or substituted with nearby wells.

The recommended groundwater monitoring program for the prescribed well locations (i.e. EPL conditions) is summarised in Table 8.1. E2W acknowledge that the EPL recommends a half yearly sampling frequency, whilst KMC have continued with quarterly groundwater monitoring and include the surface water sampling of Rocklow Creek at three locations. Increased monitoring frequency facilitates earlier detection of rising trends and decisions regarding potential remedial works.

E2W recommend the current surface water monitoring program is continued on a quarterly basis for the 2019/20 reporting period. Quarterly review of results from the Rocklow-Mid/Down stream sampling locations is required to address ecosystem risks associated with

the elevated ammonia concentrations at well (MD-9C/MD-9B & MD-10B) and the remedial/extraction works.

Continued monitoring of landfill gas at the gas monitoring wells, trenches (biofilter pads) and buildings (6 monthly) is recommended to comply with the EPL.

## 9. LIMITATIONS

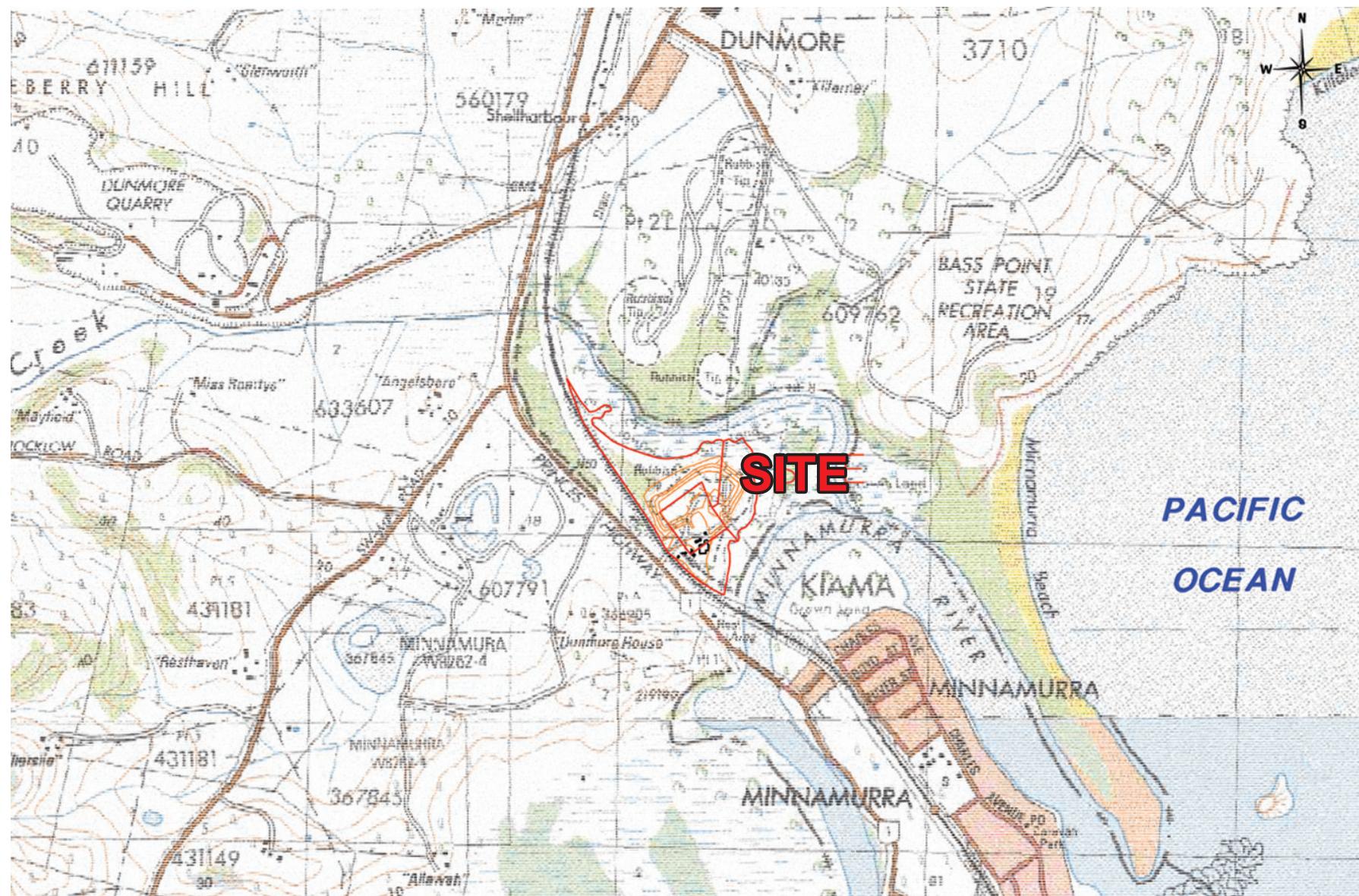
Earth2Water Pty Ltd has prepared this report for the use of Kiama Municipal Council in accordance with the standard terms and conditions of the consulting profession. This report is prepared in accordance with the agreed scope of work. The methodology adopted and sources of information used by E2W are outlined in this report.

This report was prepared during October 2019 and is based on the information reviewed at the time of preparation. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented by Ecowise and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, E2W should be notified of any such findings and be provided with an opportunity to review our content and recommendations.

## Figures



**SITE LOCATION**

Date: November 2019

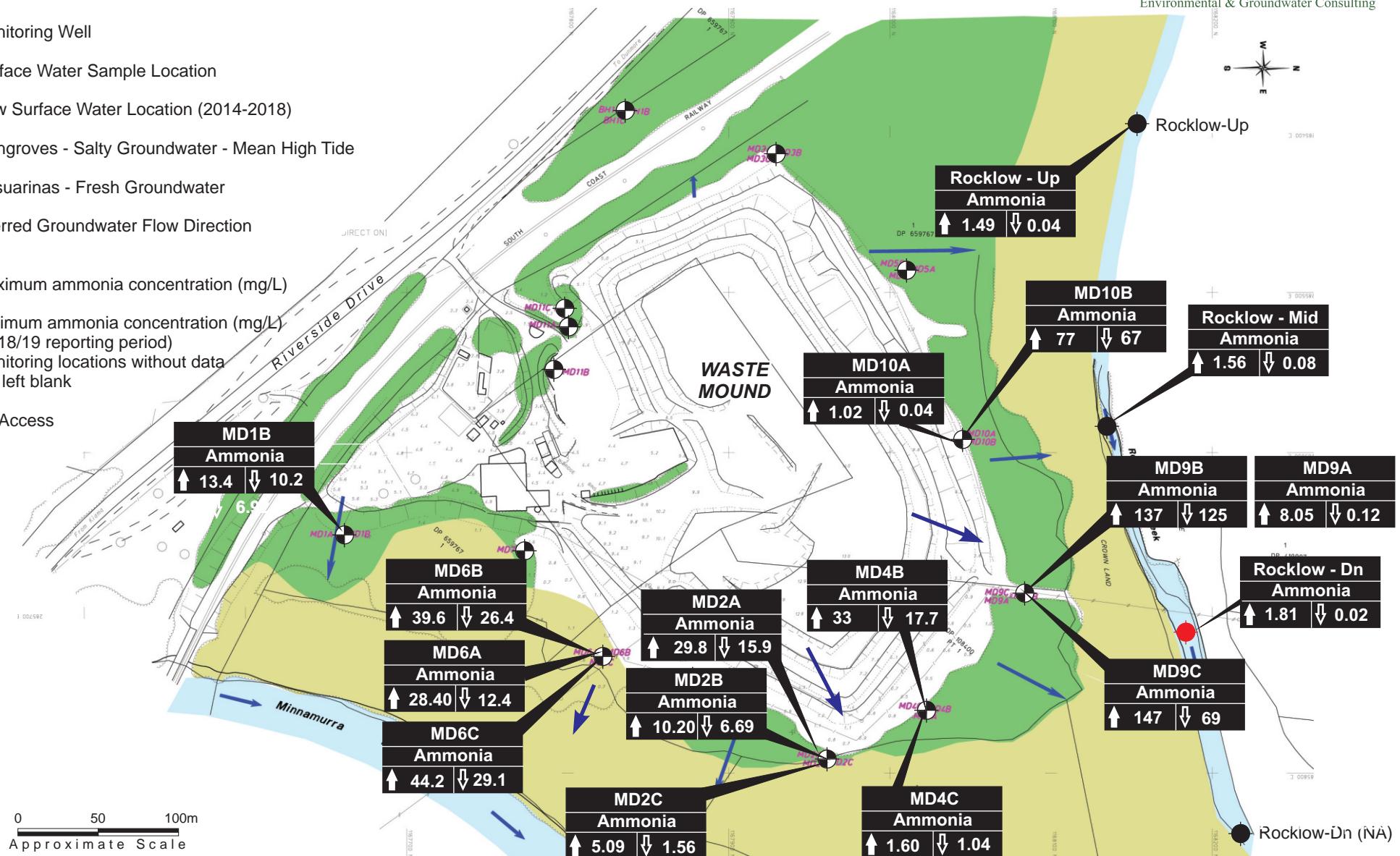
Reference: E2W\_059\_01.cdr

KIAMA COUNCIL - MINNAMURRA ANNUAL MONITORING REPORT (2018-2019)

**Figure 1**

**LEGEND**

- Monitoring Well
  - Surface Water Sample Location
  - New Surface Water Location (2014-2018)
  - Mangroves - Salty Groundwater - Mean High Tide
  - Casuarinas - Fresh Groundwater
  - ← Inferred Groundwater Flow Direction
- ↑ 3.2** Maximum ammonia concentration (mg/L)
- ↓ 0.4** Minimum ammonia concentration (mg/L)  
(2018/19 reporting period)  
Monitoring locations without data  
are left blank
- NA** No Access



Source: Neil Charters Pty Ltd

**MONITORING WELL LOCATIONS & MAXIMUM & MINIMUM AMMONIA CONCENTRATIONS (2018- 2019)**

Date: November 2019

Reference: E2W\_059\_04.cdr

KIAMA COUNCIL - MINNAMURRA ANNUAL MONITORING REPORT (2018-2019)

## Tables

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 1B	MD 1B	MD 1B	MD 1B	No. Sample	Min	Mean	Max
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19				
RL (mAHD at TOC)			NA							
Standing water level (mTOC)			1.55	1.51	1.52	1.60	4	1.51	1.55	1.60
Reduced SWL (mAHD)							4			
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.70	7.60	7.60	7.50	4	7.5	7.6	7.7
Temperature			20.40	23.10	21.00	21.00	4	20.4	21.4	23.1
Electrical Conduct (uS/cm)	0.125-2.2 (a)		606	592	601	604	4	592	601	606
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9-10 (a)	1.05	0.72	0.90	0.93	4	0.72	0.90	1.05
<b>Laboratory Analyses (mg/L)</b>										
Sodium (ICP)			33	38	33	32	4	32	34	38
Potassium (ICP)			12	13	13	13	4	12	13	13
Calcium (ICP)			42	46	46	47	4	42	45	47
Magnesium (ICP)			7	8	8	8	4	7	8	8
Chloride			40	50	40	42	4	40	43	50
Sulphate (SO4)			17	11	17	17	4	11	16	17
<b>Water Parameters (mg/L)</b>										
Alkalinity (as CaCO3)			194	222	196	189	4	189	200	222
Fluoride			<0.1	0.2	0.2	0.2	4	0.2	0.2	0.2
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND
<b>Metals (mg/L)</b>										
Iron (ICP)	0.3 (1)		<b>0.46</b>	<b>0.47</b>	<b>0.44</b>	<b>0.42</b>	4	0.42	0.45	0.47
Manganese (ICP)	1.90		0.042	0.046	0.044	0.044	4	0.042	0.044	0.046
<b>Nutrients (mg/L)</b>										
Nitrate (NO3 as N)	0.7 (7)		0.69	0.17	0.16	0.7	4	0.16	0.43	0.70
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>12.30</b>	<b>10.20</b>	<b>12.60</b>	<b>13.40</b>	4	10.20	12.13	13.40
Total Nitrogen	0.5 (3)	0.12 (4)								
Dissolved Organic Carbon (DOC)			6	5	8	6	4	5.00	6.25	8.00
Total Organic Carbon (TOC)			6	5	9	6	4	5.00	6.50	9.00

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD2A	MD2A	MD2A	MD2A	No. Sample	Min	Mean	Max	MD 2B	MD 2B	MD 2B	MD 2B	No. Sample	Min
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19					15/11/18	13/2/19	29/5/19	28/8/19		
RL (mAHD at TOC)			1.17	1.17	1.17	1.17					1.17	1.17	1.17	1.17		
Standing water level (mTOC)			0.58	0.52	0.45	0.57	4	0.45	0.53	0.58	0.88	0.58	0.55	0.74	4	0.55
Reduced SWL (mAHD)			0.59	0.65	0.72	0.60	4	0.59	0.64	0.72	0.29	0.59	0.62	0.43	4	0.29
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.00	6.80	7.40	7.60	4	6.8	7.2	7.6	7.00	6.80	6.90	6.90	4	6.8
Temperature			17.60	20.30	16.70	16.70	4	16.7	17.8	20.3	17.50	17.80	17.60	17.20	4	17.2
Electrical Conduct (uS/cm)	0.125-2.2 (a)		17900	18400	19500	20700	4	17900	19125	20700	30300	34200	36400	36400	4	30300
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9-10 (a)	1.40	2.24	3.68	3.76	4	1.40	2.77	3.76	1.16	0.90	2.53	1.15	4	0.90
<b>Laboratory Analyses (mg/L)</b>																
Sodium (ICP)			2900	2930	3130	3330	4	2900	3073	3330	4690	5870	6290	6680	4	4690
Potassium (ICP)			174	172	183	175	4	172	176	183	191	242	254	262	4	191
Calcium (ICP)			254	283	261	280	4	254	270	283	344	419	438	423	4	344
Magnesium (ICP)			396	370	414	439	4	370	405	439	595	774	814	860	4	595
Chloride			5360	5900	5590	6710	4	5360	5890	6710	8950	11600	10600	11800	4	8950
Sulphate (SO4)			618	687	522	752	4	522	645	752	1480	1550	1440	1720	4	1440
<b>Water Parameters (mg/L)</b>																
Alkalinity (as CaCO3)			844	932	782	587	4	587	786	932	719	728	685	650	4	650
Fluoride			0.9	1.0	0.9	0.9	4	0.9	0.9	1.0	0.8	0.8	0.6	0.7	4	0.6
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND	<0.05	<0.05	<0.05	<0.05	4	ND
<b>Metals (mg/L)</b>																
Iron (ICP)	0.3 (1)		<b>0.41</b>	<b>8.93</b>	<b>1.13</b>	<b>0.24</b>	4	0.24	2.68	8.93	<b>1.03</b>	<b>1.28</b>	<b>1.4</b>	<b>1.42</b>	4	1.03
Manganese (ICP)	1.90		0.061	0.073	0.051	0.059	4	0.051	0.061	0.073	0.093	0.121	0.13	0.146	4	0.093
<b>Nutrients (mg/L)</b>																
Nitrate (NO3 as N)	0.7 (7)		0.46	0.46	<b>3.68</b>	<b>7.42</b>	4	0.46	3.01	7.42	0.04	0.01	0.08	0.02	4	0.01
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>29.80</b>	<b>28.30</b>	<b>21.70</b>	<b>15.90</b>	4	15.90	23.93	29.80	<b>6.69</b>	<b>7.21</b>	<b>10.20</b>	<b>9.64</b>	4	6.69
Total Nitrogen	0.5 (3)	0.12 (4)														
Dissolved Organic Carbon (DOC)			42	49	60	47	4	42.00	49.50	60.00	35	32	44	36	3	32.00
Total Organic Carbon (TOC)			42	49	65	48	4	42.00	51.00	65.00	33	32	44	36	4	32.00

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceeded IIWL values or fresh water not highlighted.

Prepared by: Earth2Water Pty Ltd

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 2C	MD 2C	MD 2C	No. Samples	Min	Mean	Max	MD4A	MD4A	MD4A	MD4A	No. of Samples
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19				15/11/18	13/2/19	29/5/19	28/8/19	
RL (mAHD at TOC)			1.165	1.165	1.165	1.165				Dry	Dry	Dry	Dry	0
Standing water level (mTOC)			0.89	0.61	0.58	0.77	4	0.58	0.71	0.89	-	-	-	0
Reduced SWL (mAHD)			0.28	0.56	0.59	0.40	4	0.28	0.45	0.59	-	-	-	0
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.00	6.90	6.80	7.00	4	6.8	6.9	7.0	-	-	-	0
Temperature			17.40	18.10	17.00	18.60	4	17.0	17.8	18.6	-	-	-	0
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		47400	47900	49400	47900	4	47400	48150	49400	-	-	-	0
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.97	0.86	1.65	1.44	4	0.86	1.23	1.65	-	-	-	0
<b>Laboratory Analyses (mg/L)</b>														
Sodium (ICP)			8560	8720	8730	8760	4	8560	8693	8760	-	-	-	0
Potassium (ICP)			327	326	322	327	4	322	326	327	-	-	-	0
Calcium (ICP)			477	502	482	471	4	471	483	502	-	-	-	0
Magnesium (ICP)			1040	1110	1100	1090	4	1040	1085	1110	-	-	-	0
Chloride			13300	16000	14000	15400	4	13300	14675	16000	-	-	-	0
Sulphate (SO4)			2440	2230	2210	2350	4	2210	2308	2440	-	-	-	0
<b>Water Parameters (mg/L)</b>														
Alkalinity (as CaCO3)			554	580	522	490	4	490	537	580	-	-	-	0
Fluoride			1	1	1	1	4	0.7	0.8	0.8	-	-	-	0
Phenols			0.40	<0.05	<0.05	<0.05	1	ND	ND	ND	-	-	-	0
<b>Metals (mg/L)</b>														
Iron (ICP)	0.3 (1)		<b>1.42</b>	<b>1.53</b>	<b>1.58</b>	<b>1.74</b>	4	1.42	1.57	1.74	-	-	-	0
Manganese (ICP)	1.90		0.156	0.149	0.15	0.158	4	<0.01	0.153	0.2	-	-	-	0
<b>Nutrients (mg/L)</b>														
Nitrate (NO3 as N)	0.7 (7)		<0.01	0.01	<0.01	<0.01	4	0.01		0.01	-	-	-	0
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	1.56	1.83	<b>4</b>	<b>5.09</b>	4	1.56	3.12	5.09	-	-	-	0
Total Nitrogen	0.5 (3)	0.12 (4)			21	21	28	21	4	21.00	22.75	28.00	-	0
Dissolved Organic Carbon (DOC)					24	20	28	21	4	20.00	23.25	28.00	-	0
Total Organic Carbon (TOC)														0

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
  2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
  3. Trigger value for total nitrogen for lowland rivers in SE Australia.
  4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
  5. Trigger value for total phosphorus in lowland rivers in NSW.
  6. Trigger value for total phosphorus in marine ecosystems in NSW.
  7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsampled well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 4B	MD 4B	MD 4B	No. Samples	Min	Mean	Max	MD 4C	MD 4C	MD 4C	MD 4C	No. Samples	Min	Mean	Max	
	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19				15/11/18	13/2/19	29/5/19	28/8/19					
<b>Field Measurements</b>																		
RL (mAHD at TOC)			1.63	1.63	1.63	1.63				1.59	1.59	1.59	1.59					
Standing water level (mTOC)			1.30	1.03	1.00	1.17	4	1.00	1.13	1.30	1.29	1.04	0.98	1.15	4	0.98	1.12	1.29
Reduced SWL (mAHD)			0.33	0.60	0.63	0.46	4	0.33	0.50	0.63	0.30	0.55	0.61	0.44	4	0.30	0.47	0.61
pH (field)	6.5-8.0 (a)	8-8.4 (a)	6.90	6.80	6.90	6.90	4	6.8	6.9	6.9	6.90	7.00	7.00	7.00	4	6.9	7.0	7.0
Temperature			17.40	18.30	18.50	18.20	4	17.4	18.1	18.5	17.60	18.40	17.10	17.50	4	17.1	17.7	18.4
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		17900	20000	22300	23000	4	17900	20800	23000	44500	44600	48700	48800	4	44500	46650	48800
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.94	0.73	0.80	3.27	4	0.73	1.44	3.27	0.58	1.78	2.47	0.73	4	0.58	1.39	2.47
<b>Laboratory Analyses (mg/L)</b>																		
Sodium (ICP)			2680	3160	3610	3740	4	2680	3298	3740	8010	8380	8790	9220	4	8010	8600	9220
Potassium (ICP)			148	159	178	176	4	148	165	178	288	308	324	338	4	288	315	338
Calcium (ICP)			407	389	386	402	4	386	396	407	410	429	449	472	4	410	440	472
Magnesium (ICP)			361	402	482	490	4	361	434	490	967	1040	1100	1130	4	967	1059	1130
Chloride			5290	6650	6760	7440	4	5290	6535	7440	12800	15700	13800	14900	4	12800	14300	15700
Sulphate (SO4)			695	907	991	927	4	695	880	991	2310	2090	2430	2320	4	2090	2288	2430
<b>Water Parameters (mg/L)</b>																		
Alkalinity (as CaCO3)			722	859	823	758	4	722	791	859	435	521	454	492	4	435	476	521
Fluoride			0	1	1	1	4	0.4	0.5	0.6	1	1	1	1	4	1.0	1.1	1.2
Phenols			0.40	<0.05	<0.05	<0.05	<0.05	ND	ND	ND	<0.05	<0.05	<0.05	1	4	ND	ND	ND
<b>Metals (mg/L)</b>																		
Iron (ICP)	0.3 (1)		<b>1.72</b>	<b>1.87</b>	<b>2.06</b>	<b>2.01</b>	4	1.72	1.92	2.06	<b>1.31</b>	<b>1.21</b>	<b>1.47</b>	<b>1.54</b>	4	1.21	1.38	1.54
Manganese (ICP)	1.90		0.113	0.112	0.11	0.124	4	0.110	0.11	0.12	0.169	0.154	0.159	0.17	4	0.154	0.163	0.170
<b>Nutrients (mg/L)</b>																		
Nitrate (NO3 as N)	0.7 (7)		0.2	0.02	0.06	0.03	4	0.02	0.08	0.20	<0.01	<0.01	<0.01	<0.01	4	0.00	NA	0.00
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>33</b>	<b>17.7</b>	<b>25.4</b>	<b>29.6</b>	4	17.70	26.43	33.00	<b>1.04</b>	<b>1.06</b>	<b>1.05</b>	<b>1.6</b>	4	1.04	1.19	1.60
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			39	40	52	38	4	38.00	42.25	52.00	16	17	24	17	4	16.00	18.50	24.00
Total Organic Carbon (TOC)			40	39	51	39	4	39.00	42.25	51.00	17	17	23	18	4	17.00	18.75	23.00

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD6A	MD6A	MD6A	MD6A	No. Samples	Min	Mean	Max	MD 6B	MD 6B	MD 6B	MD 6B	No. Samples	Min	Mean	Max		
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19					15/11/18	13/2/19	29/5/19	28/8/19						
RL (mAHD at TOC)			1.85	1.85	1.85	1.85					1.85	1.85	1.85	1.85						
Standing water level (mTOC)			1.28	1.20	1.14	1.28	4	1.14	1.23	1.28	1.36	1.22	1.17	1.28	4	1.17	1.26	1.36		
Reduced SWL (mAHD)			0.57	0.65	0.71	0.57	4	0.57	0.63	0.71	0.49	0.63	0.68	0.57	4	0.49	0.59	0.68		
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.20	7.20	7.20	7.60	4	7.2	7.3	7.6	7.10	7.00	7.00	7.10	4	7.0	7.1	7.1		
Temperature			18.9	23.2	18.1	18.5	4	18.1	19.7	23.2	18.9	20.6	19.8	19.0	4	18.9	19.6	20.6		
Electrical Conduct (uS/cm)	0.125-2.2(a)		1760	1700	1700	1650	4	1650	1703	1760	1620	1620	1600	1620	4	1600	1615	1620		
Dissolved Oxygen (mg/L)	8.5-11 (a)	9-10 (a)	1.29	2.37	1.35	3.86	4	1.29	2.22	3.86	0.88	0.81	2.06	0.88	4	0.81	1.16	2.06		
<b>Laboratory Analyses (mg/L)</b>																				
Sodium (ICP)			112	113	117	119	4	112	115	119	82	92	104	101	4	82	95	104		
Potassium (ICP)			42	44	44	41	4	41	43	44	44	46	48	45	4	44	46	48		
Calcium (ICP)			129	128	121	118	4	118	124	129	110	116	105	106	4	105	109	116		
Magnesium (ICP)			47	47	44	43	4	43	45	47	41	42	45	46	4	41	44	46		
Chloride			155	138	114	146	4	114	138	155	71	95	76	82	4	71	81	95		
Sulphate (SO4)			44	34	40	44	4	34	41	44	29	38	46	43	4	29	39	46		
<b>Water Parameters (mg/L)</b>																				
Alkalinity (as CaCO3)			576	712	595	477	4	477	590	712	614	699	636	575	4	575	631	699		
Fluoride			0.6	0.8	0.7	0.8	4	0.6	0.7	0.8	0.3	0.5	0.4	0.5	4	0.3	0.4	0.5		
Phenols			0.40	<0.05	<0.05	<0.05	4	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	4	0.05	0.05	0.05		
<b>Metals (mg/L)</b>																				
Iron (ICP)		0.3 (1)		0.14	1.23	0.21	0.12	4	0.12	0.43	1.23	0.20	0.20	0.18	0.18	4	0.18	0.19	0.20	
Manganese (ICP)		1.90		0.045	0.044	0.032	0.025	4	0.025	0.037	0.045	0.095	0.099	0.091	0.106	4	0.091	0.098	0.106	
<b>Nutrients (mg/L)</b>																				
Nitrate (NO3 as N)		0.7 (7)		4.0	1.2	3.5	10.6	4	1.19	4.82	10.60	<0.01	<0.01	0.08	0.06	4	0.06	0.07	0.08	
Ammonia (NH3 as N)		1.88 (2)		2.84 (2)	23.2	22.6	28.4	12.4	4	12.40	21.65	28.40	39.6	26.4	33.1	33.6	4	26.40	33.18	39.60
Total Nitrogen		0.5 (3)		0.12 (4)																
Dissolved Organic Carbon (DOC)					28	30	40	32	4	28.00	32.50	40.00	30	31	41	34	4	30.00	34.00	41.00
Total Organic Carbon (TOC)					29	34	40	32	4	29.00	33.75	40.00	30	32	40	35	4	30.00	34.25	40.00

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 6C	MD 6C	MD 6C	MD 6C	No. Samples	Min	Mean	Max	MD9A	MD9A	MD9A	MD9A	No. Samples	Min
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19					15/11/18	13/2/19	29/5/19	28/8/19		
RL (mAHD at TOC)			1.86	1.86	1.86	1.86					1.35	1.35	1.35	1.35		
Standing water level (mTOC)			1.54	1.4	1.32	1.51	4	1.32	1.44	1.54	0.56	0.62	0.6	0.63	4	0.56
Reduced SWL (mAHD)			0.32	0.46	0.54	0.35	4	0.32	0.41	0.54	0.79	0.73	0.75	0.72	4	0.72
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.30	7.20	7.20	7.30	4	7.2	7.3	7.3	6.40	6.50	7.20	7.50	4	6.4
Temperature			19.20	20.80	19.80	19.20	4	19.2	19.8	20.8	17.10	20.80	17.70	18.10	4	17.1
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		35800	36000	38000	38100	4	35800	36975	38100	19000	16900	8720	6580	4	6580
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.9	0.7	0.9	1.8	4	0.67	1.07	1.80	1.0	1.2	2.4	3.8	4	1.00
<b>Laboratory Analyses (mg/L)</b>																
Sodium (ICP)			5790	6610	7090	7120	4	5790	6653	7120	3080	2730	1330	982	4	982
Potassium (ICP)			187	228	240	238	4	187	223	240	125	114	77	69	4	69
Calcium (ICP)			335	385	377	372	4	335	367	385	147	138	94	81	4	81
Magnesium (ICP)			752	866	921	925	4	752	866	925	410	347	186	130	4	130
Chloride			10400	12500	11300	12400	4	10400	11650	12500	5860	5620	2520	1880	4	1880
Sulphate (SO4)			1830	1550	1940	1910	4	1550	1808	1940	664	693	314	267	4	267
<b>Water Parameters (mg/L)</b>																
Alkalinity (as CaCO3)			395	420	371	354	4	354	385	420	282	290	311	366	4	282
Fluoride			0.5	0.6	0.5	0.5	4	0.5	0.5	0.6	0.2	0.1	0.1	0.1	4	0.1
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	0.00	0.00	0.00	<0.05	<0.05	<0.05	<0.05	4	0.00
<b>Metals (mg/L)</b>																
Iron (ICP)	0.3 (1)		<b>18.70</b>	<b>19.80</b>	<b>20.60</b>	<b>19.70</b>	4	18.70	19.70	20.60	<b>0.34</b>	<b>0.45</b>	<b>&lt;0.05</b>	<b>&lt;0.05</b>	4	0.34
Manganese (ICP)	1.90		0.065	0.061	0.054	0.085	4	0.054	0.066	0.085	0.064	0.066	0.03	0.021	4	0.021
<b>Nutrients (mg/L)</b>																
Nitrate (NO3 as N)	0.7 (7)		<0.01	<0.01	<0.01	<0.01	4	0.00	#DIV/0!	0.00	0.01	0.01	<b>2.5</b>	<b>6.9</b>	4	0.01
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>44.2</b>	<b>29.1</b>	<b>41.1</b>	<b>44.0</b>	4	29.10	39.60	44.20	<b>8.1</b>	<b>5.7</b>	1	0.12	4	0.12
Total Nitrogen	0.5 (3)	0.12 (4)														
Dissolved Organic Carbon (DOC)			13	12	15	11	4	11.00	12.75	15.00	47	47	50	49	4	47.0
Total Organic Carbon (TOC)			12	12	15	10	4	10.00	12.25	15.00	50	58	51	50	4	50.0

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 9B	MD 9B	MD 9B	MD 9B	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19				
RL (mAHD at TOC)			1.35	1.35	1.35	1.35				
Standing water level (mTOC)			0.92	0.67	0.62	0.77	4	0.62	0.75	0.92
Reduced SWL (mAHD)			0.43	0.68	0.73	0.58	4	0.43	0.61	0.73
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.2	7.1	7.1	7.1	4	7.1	7.1	7.2
Temperature			16.8	18.7	19	18.7	4	16.8	18.3	19.0
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		3580	3680	3460	3460	4	3460	3545	3680
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.51	0.9	1.39	0.59	4	0.51	0.85	1.39
<b>Laboratory Analyses (mg/L)</b>										
Sodium (ICP)			256	286	289	292	4	256	281	292
Potassium (ICP)			119	134	137	131	4	119	130	137
Calcium (ICP)			108	106	108	107	4	106	107	108
Magnesium (ICP)			50	46	52	52	4	46	50	52
Chloride			447	514	365	390	4	365	429	514
Sulphate (SO4)			<10	<10	<10	<10	4			
<b>Water Parameters (mg/L)</b>										
Alkalinity (as CaCO3)			1110	1170	1090	1040	4	1040	1103	1170
Fluoride			0.6	0.8	0.7	0.7	4	0.6	0.7	0.8
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	0.00	0.00	0.00
<b>Metals (mg/L)</b>										
Iron (ICP)	0.3 (1)		<b>2.8</b>	<b>3.22</b>	<b>2.44</b>	<b>2.08</b>	4	2.08	2.64	3.22
Manganese (ICP)	1.90		0.151	0.148	0.133	0.15	4	0.133	0.146	0.151
<b>Nutrients (mg/L)</b>										
Nitrate (NO3 as N)	0.7 (7)		0.17	0.1	0.19	<0.01	4	0.10	0.15	0.19
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>137.0</b>	<b>125.0</b>	<b>134.0</b>	<b>127.0</b>	4	125.00	130.75	137.00
Total Nitrogen	0.5 (3)	0.12 (4)								
Dissolved Organic Carbon (DOC)			78	78	91	67	4	67	79	91
Total Organic Carbon (TOC)			77	72	91	65	4	65	76	91

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

**Minnamurra Waste Disposal Depot**

Sample ID	ANZECC, 2000		MD 9C	MD 9C	MD 9C	MD 9C	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19				
RL (mAHD at TOC)			1.40	1.40	1.40	1.40				
Standing water level (mTOC)			0.77	0.92	0.72	0.83	4	0.72	0.81	0.92
Reduced SWL (mAHD)			0.63	0.48	0.68	0.57	4	0.48	0.59	0.68
pH (field)	6.5-8.0 (a)	8-8.4 (a)	6.9	7	7.1	7	4	6.90	7.00	7.10
Temperature			18.7	17.6	19	18.8	4	17.60	18.53	19.00
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		7020	7290	8300	10100	4	7020.00	8177.50	10100.00
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.55	0.6	2.16	1.61	4	0.55	1.23	2.16
<b>Laboratory Analyses (mg/L)</b>										
Sodium (ICP)			888	781	1140	1380	4	781.00	1047.25	1380.00
Potassium (ICP)			103	144	124	132	4	103.00	125.75	144.00
Calcium (ICP)			190	171	186	193	4	171.00	185.00	193.00
Magnesium (ICP)			127	98	118	162	4	98.00	126.25	162.00
Chloride			1720	1420	1740	2920	4	1420.00	1950.00	2920.00
Sulphate (SO4)			132	132	77	158	4	77.00	124.75	158.00
<b>Water Parameters (mg/L)</b>										
Alkalinity (as CaCO3)			1060	927	919	812	4	812.00	929.50	1060.00
Fluoride			0.5	0.4	0.5	0.6	4	0.40	0.50	0.60
Phenols			0.40	<0.05	<0.05	<0.05	4	0.00		0.00
<b>Metals (mg/L)</b>										
Iron (ICP)	0.3 (1)		<b>5.98</b>	<b>5.25</b>	<b>5.25</b>	<b>4.15</b>	4	4.15	5.16	5.98
Manganese (ICP)	1.90		0.201	0.168	0.178	0.201	4	0.17	0.19	0.20
<b>Nutrients (mg/L)</b>										
Nitrate (NO3 as N)	0.7 (7)		<0.01	0.12	0.13	0.12	4	0.12	0.12	0.13
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	<b>69.9</b>	<b>147.0</b>	<b>91.0</b>	<b>94.4</b>	4	69.90	100.58	147.00
Total Nitrogen	0.5 (3)	0.12 (4)								
Dissolved Organic Carbon (DOC)			60	57	89	61	4	57.00	66.75	89.00
Total Organic Carbon (TOC)			59	58	88	66	4	58.00	67.75	88.00

**Notes:**

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsampled well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2018/19 Analytical Results - Minnamurra Waste Disposal Depot

## Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD10A	MD10A	MD10A	MD10A	No. Samples	Min	Mean	Max	MD 10B	MD 10B	MD 10B	MD 10B	No. Sample	Min	Mean	Max
	Freshwater	Marine	15/11/18	13/2/19	29/5/19	28/8/19					15/11/18	13/2/19	29/5/19	28/8/19				
<b>Field Measurements</b>																		
RL (mAHD at TOC)			NM	NM	NM	NM					NM	NM	NM	NM				
Standing water level (mTOC)			0.73	0.78	0.79	0.81	4	0.73	0.78	0.81	0.81	0.71	0.55	0.87	4	0.55	0.74	0.87
Reduced SWL (mAHD)							4								4			
pH (field)	6.5-8.0 (a)	8-8.4 (a)	6.6	6.4	7.1	7.4	4	6.4	6.9	7.4	7.2	7.2	7.2	7	4	7.0	7.2	7.2
Temperature			19	22.8	17.8	15.7	4	15.7	18.8	22.8	19.2	20.7	19.6	18.8	4	18.8	19.6	20.7
Electrical Conductivity (uS/cm)	0.125-2.2(a)		46700	44500	47800	41100	4	41100	45025	47800	1890	1920	2070	2010	4	1890	1973	2070
Dissolved Oxygen (mg/L)	8.5-11 (a)	9-10 (a)	1.92	1.8	6.26	7.14	4	1.80	4.28	7.14	0.71	1.01	2.02	1.2	4	0.71	1.24	2.02
<b>Laboratory Analyses (mg/L)</b>																		
Sodium (ICP)			7210	7010	7920	7370	4	7010	7378	7920	104	106	123	109	4	104	111	123
Potassium (ICP)			167	166	186	165	4	165	171	186	63	68	76	68	4	63	69	76
Calcium (ICP)			1040	1040	952	866	4	866	975	1040	73	82	96	97	4	73	87	97
Magnesium (ICP)			1000	1040	1080	997	4	997	1029	1080	34	33	37	38	4	33	36	38
Chloride			13200	14600	13500	13200	4	13200	13625	14600	204	210	189	179	4	179	196	210
Sulphate (SO4)			2590	1680	2470	2150	4	1680	2223	2590	<10	<10	<10	<10	4	0	0	0
<b>Water Parameters (mg/L)</b>																		
Alkalinity (as CaCO3)			179	296	237	285	4	179	249	296	598	638	683	666	4	598	646	683
Fluoride			0.4	0.6	0.5	0.6	4	0.4	0.5	0.6	0.8	1	0.9	0.8	4	0.8	0.9	1.0
Phenols			0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND	<0.05	<0.05	<0.05	4	ND	ND	ND
<b>Metals (mg/L)</b>																		
Iron (ICP)	0.3 (1)		<0.10	<b>5.38</b>	<0.10	<0.10	4	5.38	5.38	5.38	0.59	<b>0.64</b>	0.54	0.69	4	0.54	0.62	0.69
Manganese (ICP)	1.90		0.33	0.838	0.356	0.315	4	0.315	0.460	0.838	0.288	0.306	0.301	0.345	4	0.288	0.310	0.345
<b>Nutrients (mg/L)</b>																		
Nitrate (NO3 as N)	0.7 (7)		0.37	<0.01	0.15	0.33	4	0.15	0.28	0.37	0.08	0.19	0.32	<0.01	4	0.08	0.20	0.32
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.19	1.02	0.04	0.55	4	0.04	0.45	1.02	<b>73.40</b>	<b>75.60</b>	<b>67.00</b>	<b>77.00</b>	4	67.00	73.25	77.00
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			33	38	55	50	4	33.00	44.00	55.00	42	41	49	49	3	41.00	45.25	49.00
Total Organic Carbon (TOC)			28	38	57	51	4	28	44	57	43	44	48	47	4	43	46	48

## Notes:

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

**Table SW-1: Minnamurra Waste Disposal Depot (Rocklow Creek)**

Sample ID	ANZECC, 2000		Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down
Field Measurements	Freshwater	Marine	15/11/18	15/11/18	15/11/18	13/2/19	13/2/19	13/2/19	29/5/19	29/5/19	29/5/19	28/8/19	28/8/19	28/8/19
pH (field)	6.5-8.0	8-8.4	7.3	6.9	7.1	7.4	7.2	7.3	7.4	7.5	7.7	7.3	7.1	7.6
Temperature			19.9	19.2	20	20.6	20.4	20.2	14	13.2	13	13.9	15	14.3
Electrical Conductivity (mS/cm)	0.125-2.2		31400	39700	45100	38200	51000	53000	33500	50000	54500	38900	40400	31500
Dissolved Oxygen (mg/L)	8.5-11.0	9.0-10.0	6.85	2.2	1.61	4.7	4.89	4.11	5.41	7.21	8.39	6.1	2.93	7.27
Turbidity (NTU)	6-50 (a)	0.5-10	NA			NA			NA			NA		
<b>Laboratory Analyses (mg/L)</b>														
Sodium (ICP)			6360	7790	7940	7580	11800	10700	6150	9240	10200	8530	8570	6040
Potassium (ICP)			217	269	274	288	435	400	228	344	376	312	312	210
Calcium (ICP)			292	358	354	337	495	438	295	404	434	409	414	263
Magnesium (ICP)			762	935	946	899	1410	1280	751	1140	1240	1070	1060	752
Chloride			9820	11700	12100	13400	19200	19800	10200	15100	15900	13300	13400	10700
Sulphate (SO4)			2100	2150	2180	1730	2380	2360	1220	2280	2670	2050	2050	1680
<b>Water Parameters (mg/L)</b>														
Fluoride			1	1.2	1.1	1	1.2	1.3	0.9	1.1	1.1	1	1	1
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.77	<0.05	<0.05
<b>Metals (mg/L)</b>														
Iron (ICP)	0.3 (1)		2.38	1.85	1.41	0.56	0.41	0.24	0.36	0.19	0.22	0.2	0.33	0.27
Manganese (ICP)	1.90		0.203	0.638	0.384	0.26	0.168	0.098	0.097	0.014	0.015	0.067	0.11	0.098
<b>Nutrients (mg/L)</b>														
Total Phosphorus (TP)	0.05 (5)	0.025 (6)	NA			NA			NA			NA		
Total Nitrogen	0.5 (3)	0.12 (4)												
Nitrate (NO3 as N)	0.7 (7)		<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.03	0.02	0.02	<0.01	<0.01
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.09	1.56	1.81	0.04	0.18	0.22	0.24	0.08	0.13	1.49	1.19	0.02
Ammonia Increment (Upper to Mid Rocklow)				1.47			0.13			-0.16			-0.30	
Ammonia Increment (Mid to lower Rocklow)					0.25			0.04			0.05			-1.17
Total Organic Carbon (TOC)			10	11	10	11	6	6	7	4	4	7	7	6

**Notes:**

1. Trigger value-indicative interim working level (IWL).
2. Ammonia trigger value; pH =8, 95% PL,adj to pH=7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.

**Table SW-2: Rocklow Creek - Historical Ammonia Concentrations (1999 - 2019)**

Sample ID	6/05/1999	17/08/1999	2/12/2000	28/02/2000	11/05/2000	10/08/2000	21/11/2000	15/02/2001	17/05/2001	16/08/2001	13/11/2001	22/02/2002	8/04/2002	19/08/2002	14/11/2002	11/02/2003	12/06/2003	22/08/2003	20/11/2003	17/02/2004	12/05/2004	11/08/2004	7/11/2004	2/02/2005	4/05/2005	16/08/2005	
<b>Upper Rocklow (mg/L)</b>	0.16	<0.02	0.10	0.16	0.03	0.06	0.04	0.10	0.22	0.35	0.18	0.10	0.07	0.13	0.06	0.01	0.11	0.14	0.03	0.17	0.28	0.03	0.22	<0.02	<0.02	0.06	
<b>Middle Rocklow (mg/L)</b>																											
<b>Lower Rocklow (mg/L)</b>	1.00	0.65	2.07	1.74	0.57	1.34	0.26	0.56	0.69	0.42	0.24	0.64	1.11	2.00	1.60	0.51	0.13	1.40	1.70	0.38	0.55	0.65	0.92	<0.02	0.31	1.40	
<b>Net Increment (mg/L)</b>	0.84	0.64	1.97	1.58	0.54	1.28	0.22	0.46	0.47	0.07	0.06	0.54	1.04	1.87	1.54	0.50	0.02	1.26	1.67	0.21	0.27	0.62	0.70	NA	0.30	1.34	

Sample ID	9/11/2005	28/02/2006	30/05/2006	30/08/2006	27/11/2006	26/02/2007	22/05/2007	21/08/2007	20/11/2007	21/02/2008	28/05/2008	26/08/2008	25/11/2008	16/02/2009	28/08/2009	27/11/2009	18/05/2009	26/02/2010	11/02/2003	12/06/2003	22/08/2003	20/11/2003	17/02/2004	12/05/2004	11/08/2004	7/11/2004	2/02/2005	4/05/2005	16/08/2005
<b>Upper Rocklow (mg/L)</b>	<0.02	<0.02	0.22	0.09	0.39	0.66	0.41	0.32	0.39	<0.1	0.27	0.12	<0.1	0.13	0.06	0.01	0.11	0.14	0.03	0.17	0.28	0.03	0.22	<0.02	<0.02	0.06			
<b>Middle Rocklow (mg/L)</b>																													
<b>Lower Rocklow (mg/L)</b>	<0.02	<0.02	0.64	0.90	1.20	0.32	0.62	0.48	1.60	NM	1.60	1.20	0.16	0.66	0.30	0.21	0.60	<0.1	<0.1	0.42	NM	NM	NM	NM	NM	NM	NM		
<b>Net Increment (mg/L)</b>	NA	NA	0.42	0.81	0.81	(0.34)	0.21	0.16	1.21	NA	1.33	1.08	NA	0.10	0.18	0.06	0.50	NA	NA	0.37	0.03	5.55	0.55	0.15	0.28	0.44			

Sample ID	30/05/2012	9/08/2012	20/11/2012	18/02/2013	30/05/2013	29/08/2013	26/11/2013	6/02/2014	6/05/2014	18/08/2014	17/11/2014	26/02/2015	27/05/2015	10/08/2015	3/11/2015	15/02/2016	30/05/2016	11/08/2016	9/11/2016	20/05/2010	17/08/2010	25/02/2011	23/05/2011	11/08/2011	20/02/2018	19/05/2018	17/08/2018	
<b>Upper Rocklow (mg/L)</b>	<0.01	0.04	0.10	0.10	0.12	0.16	0.09	0.16	0.39	0.14	0.14	0.14	0.06	0.09	0.12	0.19	0.17	0.06	0.07	0.99	0.52	0.05	0.20	<0.05	0.16	0.56		
<b>Middle Rocklow (mg/L)</b>	1.06	1.91	0.44	0.71	0.19	0.40	0.18	1.60	0.29	0.14	0.24	0.13	0.29	0.23	1.08	2.49	0.67	0.17	0.18	0.38	0.70	0.20	0.56	0.56	0.20	0.31	0.58	
<b>Lower Rocklow (mg/L)</b>	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.09	0.28	0.19	2.09	0.58	0.68	0.23		0.58	0.06	1.59	0.44	1.07	0.20	0.08	
<b>Net Increment (mg/L) Middle- Lower</b>	1.06	1.87	0.34	0.61	0.07	0.24	0.09	1.44	(0.10)	0.00	0.10	(0.05)	0.01	0.04	1.01	(1.91)	0.01	0.06	0.11	0.20	(0.64)	1.39	(0.12)	(0.32)	(0.15)	(1.01)		

Sample ID	15/11/2018	13/02/2019	29/05/2019	28/08/2019
<b>Upper Rocklow (mg/L)</b>	0.09	0.04	0.24	1.49
<b>Middle Rocklow (mg/L)</b>	1.56	0.18	0.08	1.19
<b>Lower Rocklow (mg/L)</b>	1.81	0.22	0.13	0.02
<b>Net Increment (mg/L) Middle- Lower</b>	0.25	0.04	0.05	(1.17)

**Legend**

NA = Not Analysed   NM= Not measured

Note: Rocklow Down was inaccessible during the 2010-2014 monitoring periods

**Table 8.1 - Recommended Groundwater Analytical Program for MWDD (2019/20)**

Analytes	Detection Limit	Sampling Frequency	Method Reference
Alkalinity	0.5 mg/L	6 monthly	APHA 2320B
pH/Eh	0.01 pH unit	3 monthly	pH meter and probe/APHA4500-HB
Electrical Conductivity	0.01 mS/cm	3 monthly	Conductivity meter and probe
Dissolved Oxygen	0.01 %	6 monthly	DO meter and probe
Temperature	1 deg	6 monthly	Temperature meter and probe
Ammonia	0.01 mg/L	3 monthly	FIA
Nitrate	10 µg/L	3 monthly	FIA
Calcium	1 mg/L	6 monthly	USEPA 6010 A
Chloride	0.5 mg/L	6 monthly	Titrated with mercuric nitrate using diphenol-carbazone/xylene cyanol FF indicator
Fluoride	0.1 mg/L	6 monthly	APHA4500-FC
Magnesium	0.02 mg/L	6 monthly	USEPA 6010 A
Sulphate	1 mg/L	6 monthly	ICID/MS
Sodium	0.05 mg/L	6 monthly	USEPA 6010 A
Total Alkalinity	0.5 mg/L	6 monthly	APHA 2340C
Potassium	0.05 mg/L	6 monthly	USEPA 6010 A
Dissolved Organic Carbon	0.50 mg/L	6 monthly	APHA 531 OC
Iron	1 µg/L	6 monthly	USEPA 6010 A
Manganese	1 µg/L	6 monthly	USEPA 6010
Phenols	1 µg/L	6 monthly	APHA 5530D
Standing Water Level	m AHD	6 monthly	Water level Probe

*Note:*

*The key landfill indicator (ammonia/nitrate) is proposed on a quarterly basis in groundwater/surface water locations*

*ICP - Inductively Coupled Plasma*

*FIA - Flow Injection Analyser*

*MS - Mass Spectrometry*

*FC - Client Filtered*

*µS/cm - micro Siemens per centimetre*

*µg/L - micrograms per litre*

*mg/L - milligrams per litre*

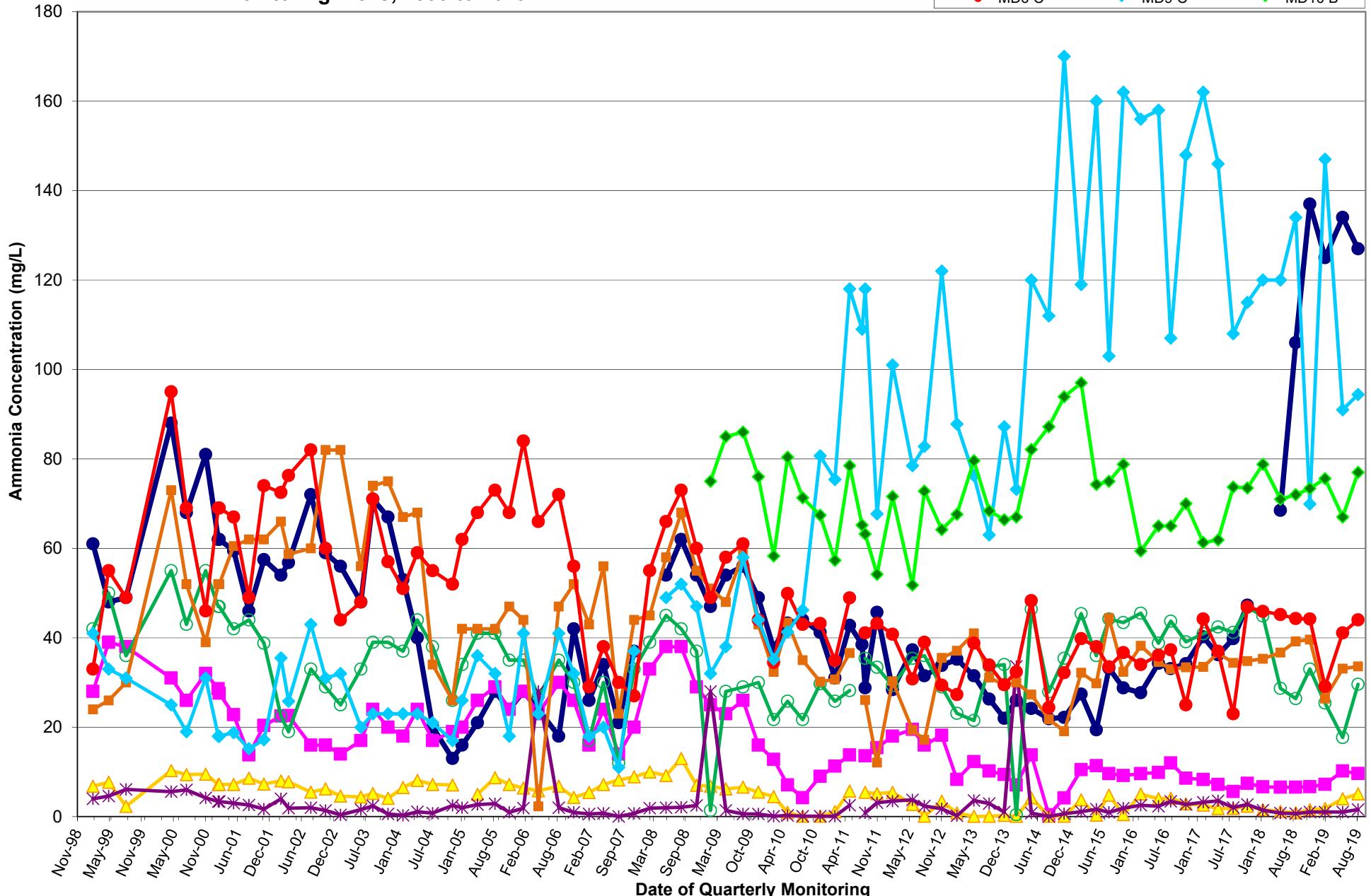
*APHA - American Public Health Association*

*USEPA - United States Environment Protection Agency*

## Graphs

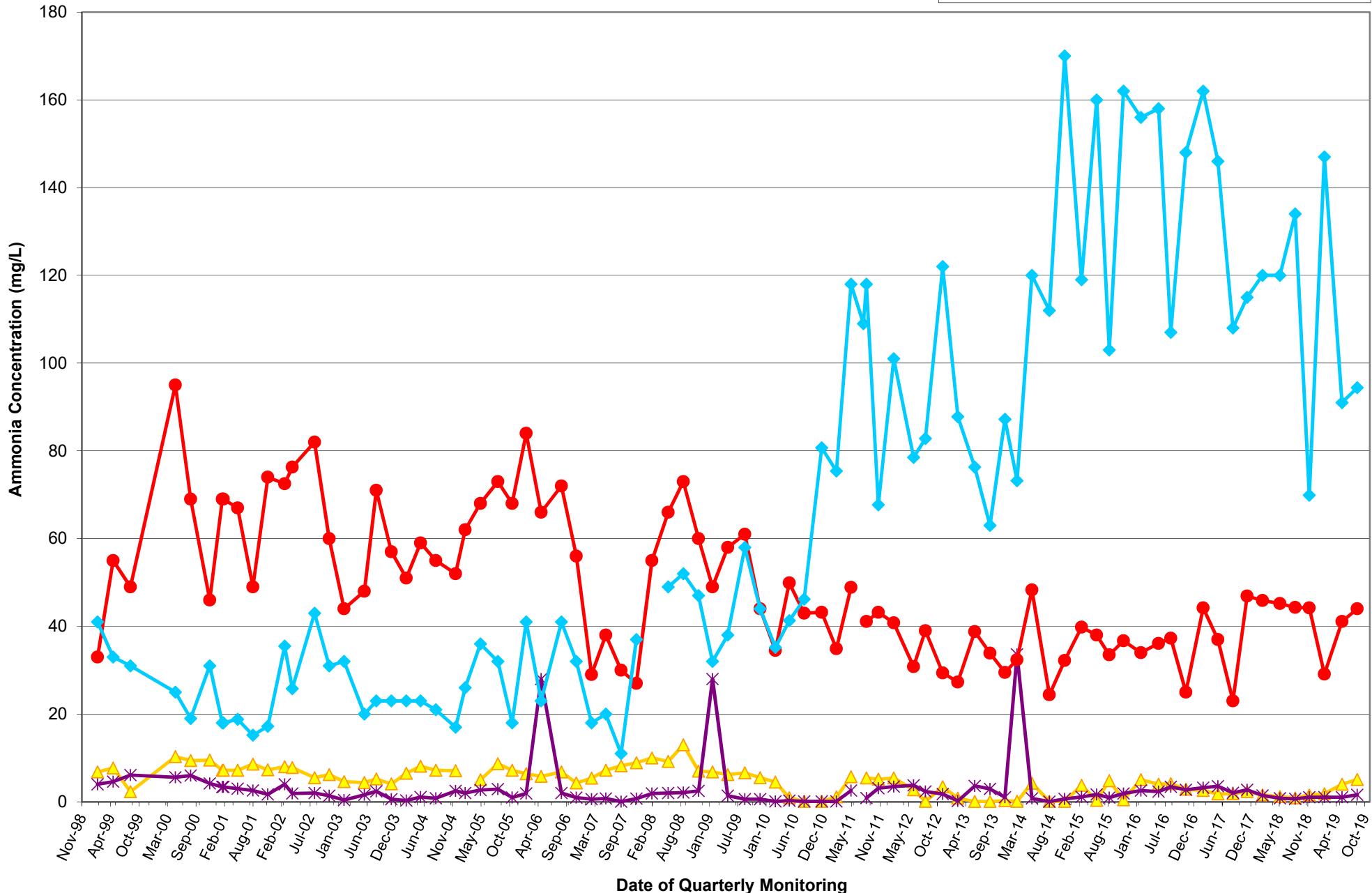
**Graph-1: Groundwater Ammonia Concentrations (mg/L)**  
**All Monitoring Wells; 1999 to 2019**

MD9B	MD2 B	MD2 C
MD4 B	MD4 C	MD6 B
MD6 C	MD9 C	MD10 B



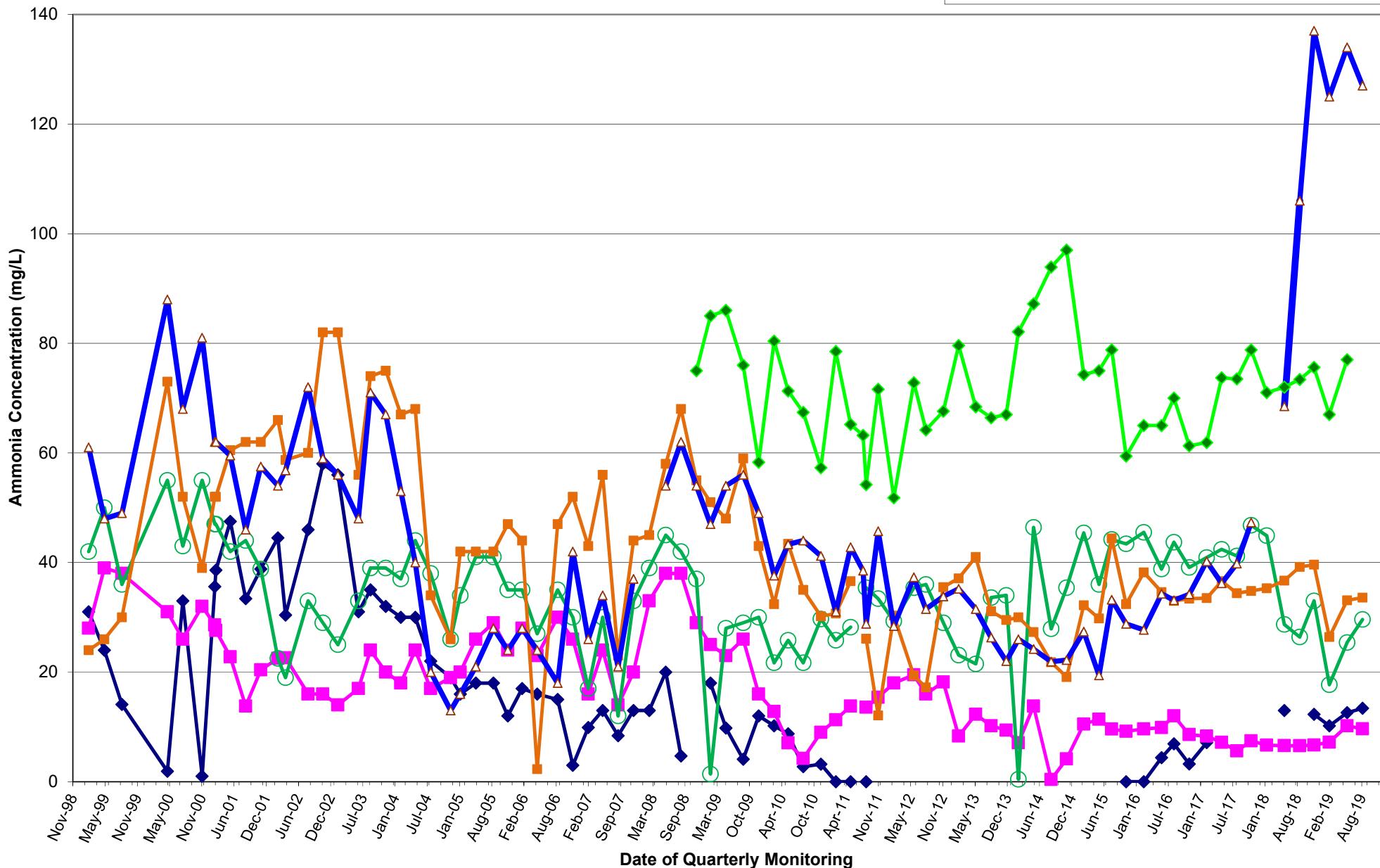
**Graph-2: Groundwater Ammonia Concentrations (mg/L)**  
**Deep Wells: 1999 to 2019**

MD2 C MD4 C MD6 C MD9 C

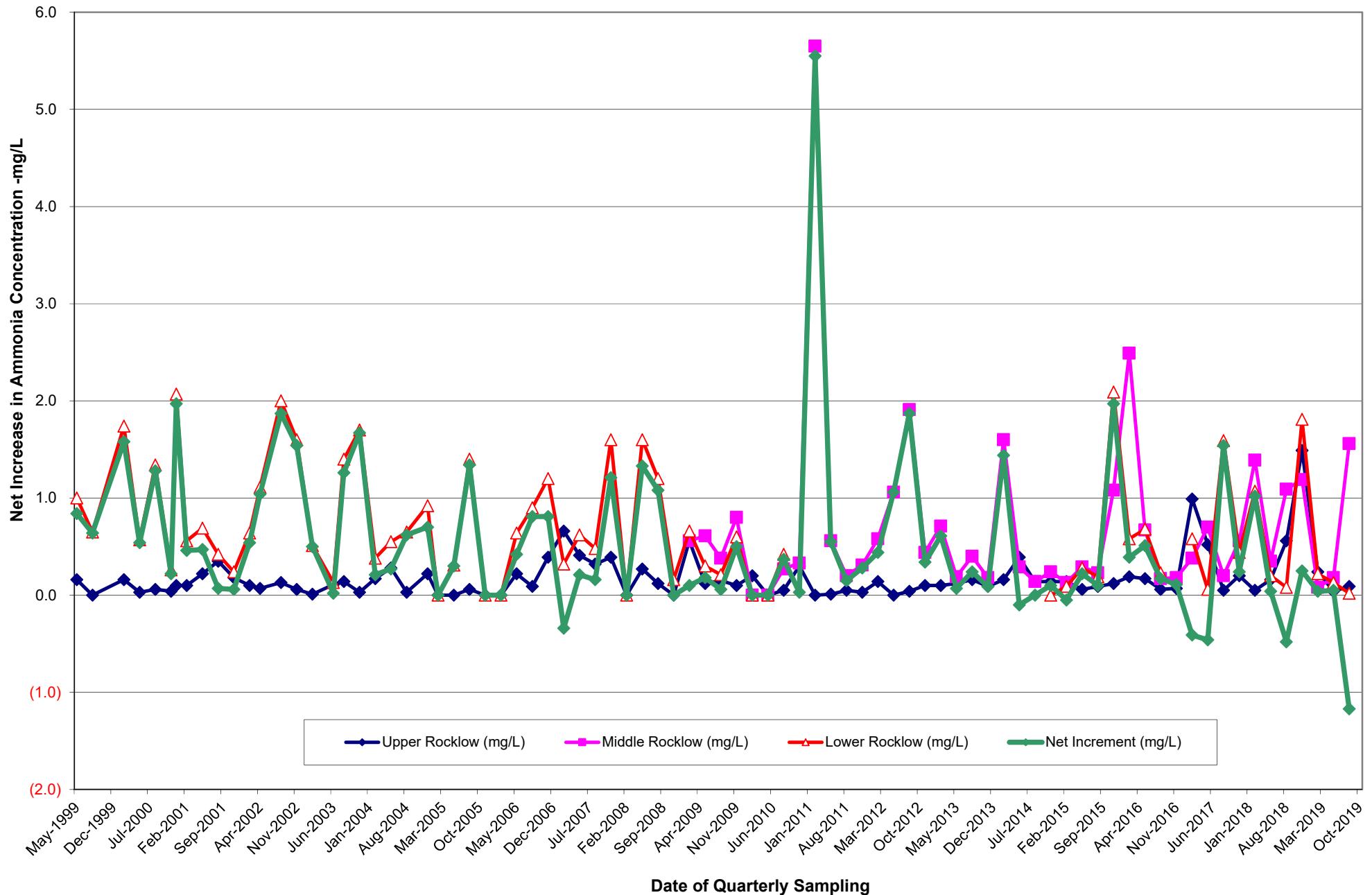


**Graph-3: Groundwater Ammonia Concentrations (mg/L)**  
**Shallow Wells : 1999 to 2019**

MD1 B	MD2 B	MD4 B
MD6 B	MD9 B	MD10 B



**Graph-04: Net Increments of Ammonia Between Up, Mid & Down Stream Samples (1999 to 2019)**



## Appendix A

# CHAIN OF CUSTODY



ALS Laboratory, please tick →

1) Sydney: 277 Wodonga Rd, Smithfield NSW 2116  
 Ph: 02 8784 3555 E: samples\_sydney@alsenviro.com  
 2) Newcastle: 1 Rosevear Rd, Waratah NSW 2304  
 Ph: 02 4963 9433 E: samples\_newcastle@alsenviro.com

Kiama Municipal Council

PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER: 126589

COC emailed to ALS? YES / NO)

EDD FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

## TURNAROUND REQUIREMENTS :

(Standard TAT may be longer for some tests  
e.g. Ultra Trace Organics)

ALS QUOTE NO.: SY-146-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMATTED (or default):

Email Reports to (will default to PM if no other addresses are listed): julien@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): julien@kiama.nsw.gov.au

ANALYSIS REQUIRED Including SUITES (NB. Suite Codes must be listed to attract additional charges)

LAB USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)	CONTAINER INFORMATION		TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	DOC (Filtered)	TOC	(Dissolved Filtered) Fe <sub>3+</sub>	Mn, (Dissolved Filtered) Fe <sub>3+</sub>	(Total) Fe, Mn, K, Mg, Ca, Na, K, Nitrate, Ammonium, NT-02A Alkalinity, Cl, SO <sub>4</sub> <sup>2-</sup> , Fluoride (Mg, Ca, Na, K, Nitrate, Ammonium, NT-01)	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.	
		SAMPLE ID	DATE / TIME									
1	MD 1A	15/11/10	12:30	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	Dry
2	MD 1B	12:35	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
3	MD 2A	11:00	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
4	MD 2B	11:10	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
5	MD 2C	11:25	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
6	MD 4A	10:25	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
7	MD 4B	10:27	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
8	MD 4C	10:40	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
9	MD 6A	11:40	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
10	MD 6B	11:50	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
11	MD 6C	12:05	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
12	MD 9A	9:50	W	500mL,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth

TOTAL

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved AP - Airfreight Unpreserved Plastic V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulfate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Vial Glass; H = HCl Preserved Plastic; HS = HCl Preserved Speciation bottle; SP = Sulfuric Preserved Plastic; ST = Sterile Bottle; ASS = Plastic Bag for Acid Substrate Solids; B = Unpreserved Reg Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; I = Iodoform Preserved

Environmental Division	
Wollongong	
Work Order Reference	
<b>EW1804736</b>	

**FORT LABOR**  
 Polythene seal  
 Plastic / frozen  
 Random sample  
 Comment

Telephone : 02 42253125

Melbourne: 24 Westall Rd, Springvale VIC 3171  
 Ph: 03 8545 9805 E: samples\_melbourne@alsenviro.com  
 Tasmania: 32 Shand St, Stafford QLD 4053  
 Ph: 07 3213 7222 E: samples\_brisbane@alsenviro.com  
 Townsville: 1 Burra Rd, Atherton QLD 4818  
 Ph: 07 4736 0600 E: samples\_townsville@alsenviro.com  
 Adelaide: 2-11 Dasma Ct, Belair QLD 4055  
 Ph: 08 8359 0690 E: addadl@alsenviro.com  
 Perth: 10 Hod Way, Malaga WA 6009  
 Ph: 08 9265 7655 E: samples\_perth@alsenviro.com  
 Launceston: 27 Wallington St, Launceston TAS 7250  
 Ph: 03 6331 2558 E: launlaun@alsenviro.com

## CERTIFICATE OF ANALYSIS

Work Order	<b>: EW1804736</b>	Page	<b>: 1 of 10</b>
Client	<b>: KIAMA COUNCIL</b>	Laboratory	<b>: Environmental Division NSW South Coast</b>
Contact	<b>: MR PAUL CZULOWSKI</b>	Contact	<b>: Glenn Davies</b>
Address	<b>: 11 MANNING STREET KIAMA NSW, AUSTRALIA 2533</b>	Address	<b>: 1/19 Ralph Black Dr, North Wollongong 2500 4/13 Geary Pl, North Nowra 2541 Australia NSW Australia</b>
Telephone	<b>: +61 02 4232 0444</b>	Telephone	<b>: 02 42253125</b>
Project	<b>: Minnamurra Landfill</b>	Date Samples Received	<b>: 15-Nov-2018 16:00</b>
Order number	<b>: 126589</b>	Date Analysis Commenced	<b>: 15-Nov-2018</b>
C-O-C number	<b>: ----</b>	Issue Date	<b>: 23-Nov-2018 12:11</b>
Sampler	<b>: Robert DaLio</b>		
Site	<b>: Minnamurra Landfill</b>		
Quote number	<b>: WO/017/18</b>		
No. of samples received	<b>: 20</b>		
No. of samples analysed	<b>: 20</b>		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

### Signatures

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Robert DaLio	Sampler	Laboratory - Wollongong, NSW



Accreditation No. 825  
Accredited for compliance with  
ISO/IEC 17025 - Testing

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED041G: LOR raised for Sulfate on sample 13 & 16 due to sample matrix.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- EP002: It has been noted that DOC is greater than TOC for various samples, however this difference is within the limits of experimental variation.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

## Analytical Results

Client sample ID				MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
Compound	CAS Number	LOR	Unit	15-Nov-2018 00:00				
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	7.7	7.0	7.0	7.0
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	606	17900	30300	47400
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	0.3	12.5	22.3	36.8
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	20.4	17.6	17.5	17.4
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	194	844	719	554
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	194	844	719	554
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	17	618	1480	2440
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	40	5360	8950	13300
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	42	254	344	477
Magnesium	7439-95-4	1	mg/L	---	7	396	595	1040
Sodium	7440-23-5	1	mg/L	---	33	2900	4690	8560
Potassium	7440-09-7	1	mg/L	---	12	174	191	327
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.042	0.061	0.093	0.156
Iron	7439-89-6	0.05	mg/L	---	0.46	0.41	1.03	1.42
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	<0.1	0.9	0.8	0.8
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	12.3	29.8	6.69	1.56
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	0.04	<0.01	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.69	0.46	0.04	<0.01

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
			Client sampling date / time	15-Nov-2018 00:00				
Compound	CAS Number	LOR	Unit	EW1804736-001	EW1804736-002	EW1804736-003	EW1804736-004	EW1804736-005
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.69	0.50	0.04	<0.01
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	---	5.36	181	298	437
Total Cations	---	0.01	meq/L	---	5.29	---	---	---
Total Cations	---	0.01	meq/L	---	---	176	275	490
Ionic Balance	---	0.01	%	---	0.65	---	---	---
Ionic Balance	---	0.01	%	---	---	1.42	3.95	5.72
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	DRY	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	6	42	35	21
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	6	42	33	24
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	1.05	1.40	1.16	0.97
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	11.6	14.5	12.0	10.0
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.55	0.58	0.88	0.89

## Analytical Results

Client sample ID				MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
Compound	CAS Number	LOR	Unit	15-Nov-2018 00:00				
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	6.9	6.9	7.2	7.1
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	17900	44500	1760	1620
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	12.6	34.2	1.0	0.9
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	17.4	17.6	18.9	18.9
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	722	435	576	614
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	722	435	576	614
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	695	2310	44	29
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	5290	12800	155	71
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	407	410	129	110
Magnesium	7439-95-4	1	mg/L	---	361	967	47	41
Sodium	7440-23-5	1	mg/L	---	2680	8010	112	82
Potassium	7440-09-7	1	mg/L	---	148	288	42	44
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.113	0.169	0.045	0.095
Iron	7439-89-6	0.05	mg/L	---	1.72	1.31	0.14	0.20
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.4	1.2	0.6	0.3
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	33.0	1.04	23.2	39.6
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	<0.01	0.09	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.20	<0.01	3.95	<0.01

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
		Client sampling date / time		15-Nov-2018 00:00				
Compound	CAS Number	LOR	Unit	EW1804736-006	EW1804736-007	EW1804736-008	EW1804736-009	EW1804736-010
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.20	<0.01	4.04	<0.01
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	---	178	418	16.8	14.9
Total Cations	---	0.01	meq/L	---	170	456	16.2	13.6
Ionic Balance	---	0.01	%	---	2.22	4.34	1.65	4.64
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	DRY	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	39	16	28	30
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	40	17	29	30
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	0.94	0.58	1.29	0.88
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	9.7	6.0	13.3	9.4
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.30	1.29	1.28	1.36

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
Compound	CAS Number	LOR	Unit	15-Nov-2018 00:00				
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.3	6.4	7.2	7.0	6.6
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	35800	19000	3580	7290	46700
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	25.8	13.5	2.3	4.8	34.8
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	19.2	17.1	16.8	17.6	19.0
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	395	282	1110	927	179
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	395	282	1110	927	179
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	1830	664	<10	132	2590
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	10400	5860	447	1420	13200
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	335	147	108	171	1040
Magnesium	7439-95-4	1	mg/L	752	410	50	98	1000
Sodium	7440-23-5	1	mg/L	5790	3080	256	781	7210
Potassium	7440-09-7	1	mg/L	187	125	119	144	167
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.065	0.064	0.151	0.168	0.330
Iron	7439-89-6	0.05	mg/L	18.7	0.34	2.80	5.25	<0.10
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.5	0.2	0.6	0.4	0.4
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	44.2	8.05	137	147	0.19
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.01	0.17	0.12	0.37

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
		Client sampling date / time		15-Nov-2018 00:00				
Compound	CAS Number	LOR	Unit	EW1804736-011	EW1804736-012	EW1804736-013	EW1804736-014	EW1804736-015
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	0.01	0.17	0.12	0.38
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	339	185	34.8	61.3	430
Total Cations	---	0.01	meq/L	335	178	23.7	54.2	452
Ionic Balance	---	0.01	%	---	---	1.96	---	---
Ionic Balance	---	0.01	%	0.61	1.79	---	6.12	2.52
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	13	47	78	57	33
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	12	50	77	58	28
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	0.94	1.00	0.51	0.60	1.92
Dissolved Oxygen - % Saturation	---	0.1	% saturation	10.1	10.3	5.3	6.2	20.5
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	1.54	0.56	0.92	0.92	0.73

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	15-Nov-2018 00:00				
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.2	7.1	6.9	7.3	---
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	1890	45100	39700	31400	---
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	1.1	32.7	28.9	22.2	---
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	19.2	20.0	19.2	19.9	---
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	---
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	---
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	598	193	212	150	---
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	598	193	212	150	---
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	<10	2180	2150	2100	---
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	204	12100	11700	9820	---
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	73	---	---	---	---
Magnesium	7439-95-4	1	mg/L	34	---	---	---	---
Sodium	7440-23-5	1	mg/L	104	---	---	---	---
Potassium	7440-09-7	1	mg/L	63	---	---	---	---
<b>ED093T: Total Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	354	358	292	---
Magnesium	7439-95-4	1	mg/L	---	946	935	762	---
Sodium	7440-23-5	1	mg/L	---	7940	7790	6360	---
Potassium	7440-09-7	1	mg/L	---	274	269	217	---
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.288	---	---	---	<0.001
Iron	7439-89-6	0.05	mg/L	0.59	---	---	---	<0.05
<b>EG020T: Total Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.384	0.638	0.203	---
Iron	7439-89-6	0.05	mg/L	---	1.41	1.85	2.38	---

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	15-Nov-2018 00:00				
				Result	Result	Result	Result	Result
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.8	1.1	1.2	1.0	---
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	73.4	1.81	1.56	0.09	---
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	---
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	0.08	<0.01	<0.01	<0.01	---
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	0.08	<0.01	<0.01	<0.01	---
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	17.7	---	---	---	---
Total Cations	---	0.01	meq/L	17.8	---	---	---	---
Ionic Balance	---	0.01	%	0.21	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	42	9	9	8	<1
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	43	10	11	10	---
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	0.71	1.61	2.20	6.85	---
Dissolved Oxygen - % Saturation	---	0.1	% saturation	7.7	17.6	23.7	74.6	---
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	---
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	0.81	---	---	---	---



## CHAIN OF CUSTODY

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CLIENT:  
Kiamo Municipal Council

OFFICE:  
PO Box 75 Kiamo NSW 2533

PROJECT:  
Minamurra Landfill

ORDER NUMBER:  
126589

PROJECT MANAGER:  
Craig Wilson

SAMPLER:  
Paul Czulowski

CONTACT PH: 4232 1418

SAMPLER MOBILE: 0408 251 560

RELINQUISHED BY:  
*Tag P-122*

EDD FORMAT (or default):  
DATE/TIME:  
13.2.19 14:15

RECEIVED BY:  
*Annetta*

DATE/TIME:  
13.2.19

RELINQUISHED BY:  
DATE/TIME:

Telephone: 02 42263125

Comments/Special Handling/Storage or Disposal:

Environmental Division  
Wollongong  
Work Order Reference  
**EW1900611**

AS USE ONE	SAMPLE DETAILS		CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price)		Additional Information												
	MATRIX: Solid(S) Water(W)	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	DOC (Filtered)	TOC	Dissolved Filtered) Fe, Mn, (Total) Fe, Mn, Mg, Ca, Na, K	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-02A (Alkalinity, Cl, SO4 & Fluoride) NT-01 (Mg, Ca, Na, K)	Nitrate, Ammonia, Total Phenolics												
	MD 1A	13.2.19 13:10	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 1B	13:15	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 2A	11:35	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 2B	11:50	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 2C	12:00	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 4A	10:50	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 4B	10:55	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 4C	11:15	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 6A	12:25	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 6B	12:40	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 6C	12:50	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	MD 9A	10:10	W	500ml,2X SP, 2 X VS, N	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		TOTAL																	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Edta Preserved; S = Sodium Hydroxide/Amber Glass Unpreserved; AG = Amber Glass Unpreserved; AP - Autoflame Unpreserved Plastic  
V = VOA, Vital HCl Preserved; VB = VOA, Vital Sodium Bisulphite Preserved; VS = VOA, Vital Sulphite Preserved; AV = Airfreight Unpreserved Vial; G = Sulphite Preserved; Z = Zinc Acetate Preserved Bottles; ST = Sterile Bottles; ASS = Plastic Bag for Acid Sulphate Solids; B = Unpreserved Bag.



## CHAIN OF CUSTODY

**CHAIN OF CUSTODY**

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Ph: 07 4796 0800 E:townsville.alesenviro.manel@alesenviro.com.au

<p><input type="checkbox"/> <b>Melbourne</b> 2-4 Westall Rd, Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@isagenix.com</p> <p><input type="checkbox"/> <b>Adelaide</b> 21 Burnside Rd, Pooata SA 5035 Ph: 08 8359 0860 E: samples.adelaide@isagenix.com</p>	<p><input type="checkbox"/> <b>Perth</b> 10 Hed Way, Malaga WA 6090 Ph: 08 9219 7655 E: samples.perth@isagenix.com</p> <p><input type="checkbox"/> <b>Launceston</b> 27 Wellington St, Launceston TAS 72700 Ph: 03 6231 2155 E: launceston@isagenix.com</p>
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**Water Container Codes:** P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VS = VOA Vial Sodium Bisulfite Preserved; SU = VOA Vial Sulfric Preserved; AV = Airfreight Unpreserved Vial; SG = Sulfite Preserved Plastic Bottles; ST = Sterile Bottles; AS = Acid Softop Sags; ASS = Acid Softop Sags; H = HCl preserved Speciation bottle; HS = HCl preserved Speciation bottle; SP = Sulfur Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles

## CERTIFICATE OF ANALYSIS

Work Order	<b>: EW1900611</b>	Page	<b>: 1 of 10</b>
Client	<b>: KIAMA COUNCIL</b>	Laboratory	<b>: Environmental Division NSW South Coast</b>
Contact	<b>: MR PAUL CZULOWSKI</b>	Contact	<b>: Glenn Davies</b>
Address	<b>: 11 MANNING STREET KIAMA NSW, AUSTRALIA 2533</b>	Address	<b>: 1/19 Ralph Black Dr, North Wollongong 2500 4/13 Geary Pl, North Nowra 2541 Australia NSW Australia</b>
Telephone	<b>: +61 02 4232 0444</b>	Telephone	<b>: 02 42253125</b>
Project	<b>: Minnamurra Landfill</b>	Date Samples Received	<b>: 12-Feb-2019 14:45</b>
Order number	<b>: 126589</b>	Date Analysis Commenced	<b>: 13-Feb-2019</b>
C-O-C number	<b>: ----</b>	Issue Date	<b>: 21-Feb-2019 16:57</b>
Sampler	<b>: ----</b>		
Site	<b>: Minnamurra Landfill</b>		
Quote number	<b>: WO/017/18</b>		
No. of samples received	<b>: 20</b>		
No. of samples analysed	<b>: 20</b>		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

### Signatures

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Dian Dao		Sydney Inorganics, Smithfield, NSW
Glenn Davies	Environmental Services Representative	Laboratory - Wollongong, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW



Accreditation No. 825  
Accredited for compliance with  
ISO/IEC 17025 - Testing

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED041G: Spike recovery failed for Sulfate due to matrix interferences.
- ED041G: LOR raised for Sulfate on sample 13 & 16 due to sample matrix.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- EP002: It has been noted that DOC is greater than TOC for various samples, however this difference is within the limits of experimental variation.
- EK057G/EK059G: It has been noted that Nitrite is greater than Nitrite + Nitrate as NOx on sample 14 & 15, however this difference is within the limits of experimental variation.
- It has been noted that Nitrite is greater than NOx for sample 14,15, however this difference is within the limits of experimental variation.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

## Analytical Results

Client sample ID				MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
Compound	CAS Number	LOR	Unit	13-Feb-2019 13:10	13-Feb-2019 13:15	13-Feb-2019 11:35	13-Feb-2019 11:50	13-Feb-2019 12:00
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	7.6	6.8	6.8	6.9
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	592	18400	34200	47900
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	0.3	12.1	25.4	36.6
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	23.1	20.3	17.8	18.1
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	222	932	728	580
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	222	932	728	580
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	11	687	1550	2230
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	50	5900	11600	16000
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	46	283	419	502
Magnesium	7439-95-4	1	mg/L	---	8	370	774	1110
Sodium	7440-23-5	1	mg/L	---	38	2930	5870	8720
Potassium	7440-09-7	1	mg/L	---	13	172	242	326
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.046	0.073	0.121	0.149
Iron	7439-89-6	0.05	mg/L	---	0.47	8.93	1.28	1.53
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.2	1.0	0.8	0.8
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	10.2	28.3	7.21	1.83
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	0.04	<0.01	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.17	0.46	0.01	0.01

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
		Client sampling date / time		13-Feb-2019 13:10	13-Feb-2019 13:15	13-Feb-2019 11:35	13-Feb-2019 11:50	13-Feb-2019 12:00
Compound	CAS Number	LOR	Unit	EW1900611-001	EW1900611-002	EW1900611-003	EW1900611-004	EW1900611-005
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.17	0.50	0.01	0.01
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	---	6.08	199	374	509
Total Cations	---	0.01	meq/L	---	5.67	---	---	---
Total Cations	---	0.01	meq/L	---	---	176	346	504
Ionic Balance	---	0.01	%	---	3.50	---	---	---
Ionic Balance	---	0.01	%	---	---	6.10	3.88	0.52
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	DESTROYED	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	5	49	32	21
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	5	49	32	20
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	0.72	2.24	0.90	0.86
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	8.8	24.9	9.5	9.0
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.51	0.52	0.58	0.61

## Analytical Results

Client sample ID				MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
Compound	CAS Number	LOR	Unit	13-Feb-2019 10:50	13-Feb-2019 10:55	13-Feb-2019 11:15	13-Feb-2019 12:25	13-Feb-2019 12:40
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	6.8	6.9	7.2	7.0
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	20000	44600	1700	1620
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	13.9	33.6	0.9	0.9
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	18.3	18.4	23.2	20.6
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	859	521	712	699
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	859	521	712	699
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	907	2090	34	38
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	6650	15700	138	95
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	389	429	128	116
Magnesium	7439-95-4	1	mg/L	---	402	1040	47	42
Sodium	7440-23-5	1	mg/L	---	3160	8380	113	92
Potassium	7440-09-7	1	mg/L	---	159	308	44	46
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.112	0.154	0.044	0.099
Iron	7439-89-6	0.05	mg/L	---	1.87	1.21	1.23	0.20
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.6	1.2	0.8	0.5
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	17.7	1.06	22.6	26.4
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	<0.01	0.12	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.02	<0.01	1.19	<0.01

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)	Client sample ID			MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
Client sampling date / time			13-Feb-2019 10:50	13-Feb-2019 10:55	13-Feb-2019 11:15	13-Feb-2019 12:25	13-Feb-2019 12:40	
Compound	CAS Number	LOR	Unit	EW1900611-006	EW1900611-007	EW1900611-008	EW1900611-009	EW1900611-010
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.02	<0.01	1.31	<0.01
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	---	224	497	18.8	17.4
Total Cations	---	0.01	meq/L	---	194	479	16.3	14.4
Ionic Balance	---	0.01	%	---	7.09	1.78	7.20	9.46
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	DRY	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	40	17	30	31
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	39	17	34	32
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	0.73	1.78	2.37	0.81
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	7.8	18.9	26.9	9.1
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.03	1.04	1.20	1.22

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
Compound	CAS Number	LOR	Unit	13-Feb-2019 12:50	13-Feb-2019 10:10	13-Feb-2019 10:20	13-Feb-2019 10:35	13-Feb-2019 09:50
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.2	6.5	7.1	6.9	6.4
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	36000	16900	3680	7020	44500
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	25.0	10.9	2.2	4.5	30.2
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	20.8	20.8	18.7	18.7	22.8
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	420	290	1170	1060	296
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	420	290	1170	1060	296
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	1550	693	<10	132	1680
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	12500	5620	514	1720	14600
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	385	138	106	190	1040
Magnesium	7439-95-4	1	mg/L	866	347	46	127	1040
Sodium	7440-23-5	1	mg/L	6610	2730	286	888	7010
Potassium	7440-09-7	1	mg/L	228	114	134	103	166
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.061	0.066	0.148	0.201	0.838
Iron	7439-89-6	0.05	mg/L	19.8	0.45	3.22	5.98	5.38
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.6	0.1	0.8	0.5	0.6
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	29.1	5.68	125	69.9	1.02
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.01	0.01	0.02
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.01	0.10	<0.01	<0.01

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
		Client sampling date / time		13-Feb-2019 12:50	13-Feb-2019 10:10	13-Feb-2019 10:20	13-Feb-2019 10:35	13-Feb-2019 09:50
Compound	CAS Number	LOR	Unit	EW1900611-011	EW1900611-012	EW1900611-013	EW1900611-014	EW1900611-015
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	0.01	0.11	<0.01	<0.01
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	393	179	37.9	72.4	453
Total Cations	---	0.01	meq/L	---	---	33.0	---	---
Total Cations	---	0.01	meq/L	384	157	---	61.2	447
Ionic Balance	---	0.01	%	---	---	6.91	---	---
Ionic Balance	---	0.01	%	1.21	6.44	---	8.42	0.68
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	12	47	78	60	38
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	12	58	72	59	38
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	0.67	1.20	0.90	0.55	1.80
Dissolved Oxygen - % Saturation	---	0.1	% saturation	7.6	13.5	9.7	5.9	21.0
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	1.40	0.62	0.67	0.77	0.78

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	13-Feb-2019 09:45	13-Feb-2019 08:25	13-Feb-2019 09:20	13-Feb-2019 09:00	13-Feb-2019 08:10
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.2	7.3	7.2	7.4	---
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	1920	53000	51000	38200	---
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	1.1	39.0	37.2	26.8	---
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	20.7	20.2	20.4	20.6	---
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	---
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	---
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	638	163	180	189	---
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	638	163	180	189	---
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	<10	2360	2380	1730	---
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	210	19800	19200	13400	---
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	82	---	---	---	---
Magnesium	7439-95-4	1	mg/L	33	---	---	---	---
Sodium	7440-23-5	1	mg/L	106	---	---	---	---
Potassium	7440-09-7	1	mg/L	68	---	---	---	---
<b>ED093T: Total Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	438	495	337	---
Magnesium	7439-95-4	1	mg/L	---	1280	1410	899	---
Sodium	7440-23-5	1	mg/L	---	10700	11800	7580	---
Potassium	7440-09-7	1	mg/L	---	400	435	288	---
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.306	---	---	---	<0.001
Iron	7439-89-6	0.05	mg/L	0.64	---	---	---	<0.05
<b>EG020T: Total Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.098	0.168	0.260	---
Iron	7439-89-6	0.05	mg/L	---	0.24	0.41	0.56	---

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	13-Feb-2019 09:45	13-Feb-2019 08:25	13-Feb-2019 09:20	13-Feb-2019 09:00	13-Feb-2019 08:10
				Result	Result	Result	Result	Result
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	1.0	1.3	1.2	1.0	---
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	75.6	0.22	0.18	0.04	---
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	---
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	0.19	<0.01	<0.01	0.02	---
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	0.19	<0.01	<0.01	0.02	---
<b>EN055: Ionic Balance</b>								
Total Anions	---	0.01	meq/L	18.7	---	---	---	---
Total Cations	---	0.01	meq/L	18.6	---	---	---	---
Ionic Balance	---	0.01	%	0.45	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	41	6	6	10	<1
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	44	6	6	11	---
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	1.01	4.11	4.89	4.70	---
Dissolved Oxygen - % Saturation	---	0.1	% saturation	11.4	45.6	54.3	52.3	---
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	---
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	0.71	---	---	---	---



## CHAIN OF CUSTODY

ALS Laboratory: please tick →

Standard TAT (List due date):

Non Standard or urgent TAT (List due date):

Standard TAT (List due date):

Non Standard or urgent TAT (List due date):

Standard TAT (List due date):

Non Standard or urgent TAT (List due date):

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Standard TAT (List due date):

Non Standard or urgent TAT (List due date):

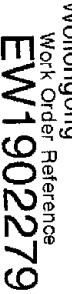
TOTAL:

CLIENT: OFFICE: PROJECT: ORDER NUMBER: PROJECT MANAGER: SAMPLER: COC emailed to ALS? ( YES / NO )	Turnaround Requirements: Contact PH: 4232 0418 EDD FORMAT (or default): DATE/TIME:	ALS QUOTE NO.: 126589 COC SEQUENCE NUMBER (Circle): coc: 1 2 3 4 5 6 7 or: 1 2 3 4 5 6 7 RELINQUISHED BY: Robert. RECEIVED BY: Helen DATETIME: 29.5.19. 14:55 29/5/19 DATETIME: RELINQUISHED BY:
---	---	--

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

SAMPLE DETAILS		CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price)		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.	
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	DOC (Filtered)	TOC
1	MD 1A	24.5.19 13:10	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	Destroyed
2	MD 1B	13:15	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
3	MD 2A	11:30	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	pH, Temp, EC, Sal, DO, Depth
4	MD 2B	11:45	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
5	MD 2C	12:00	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
6	MD 4A	10:55	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
7	MD 4B	11:00	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	Dry
8	MD 4C	11:15	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
9	MD6A	12:20	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
10	MD 6B	12:30	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
11	MD 6C	12:45	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
12	MD 9A	13:15	W	500mL,2X SP, 2 X VS, N	6	✓ ✓ ✓ ✓ ✓ ✓	YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth

Telephone : 02 42265125



Environmental Division  
Wollongong  
Work Order Reference  
**EW1902279**

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic; V = VOA Vial HCl Preserved; VB = VOA Vial Sulphuric Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved; Z = Zinc Acetate Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.



## CHAIN OF CUSTODY

ALS Laboratory, please tick →

Sydney: 277 Wodonga Rd, Smithfield NSW 2176  
Ph: 02 8734 8856 E: samples.sydney@alsenviro.com  
 Newcastle: 52 Shand St, Stafford QLD 4653  
Ph: 07 3243 7222 E: samples.brisbane@alsenviro.com  
 Townsville: 14-15 Dunes Cl, Bohle QLD 4818  
Ph: 07 4796 0600 E: townsville.enquiry@alsenviro.com  
 Melbourne: 24 Westall Rd, Springvale VIC 3171  
Ph: 03 8519 9600 E: samples.melbourne@alsenviro.com  
 Perth: 10 Hord Way, Matilda WA 6050  
Ph: 08 9213 7055 E: samples.perth@alsenviro.com  
 Adelaide: 2-1 Burne Rd, Port Pirie SA 5055  
Ph: 08 8559 0590 E: adelaide@alsenviro.com  
 Cairns: 125/126 Esplanade, Cairns QLD 4870  
Ph: 07 4033 2153 E: cairns@alsenviro.com

Brisbane: 42 Shand St, Stafford QLD 4653  
Ph: 07 3243 7222 E: samples.brisbane@alsenviro.com  
 Melbourne: 24 Westall Rd, Springvale VIC 3171  
Ph: 03 8519 9600 E: samples.melbourne@alsenviro.com  
 Perth: 10 Hord Way, Matilda WA 6050  
Ph: 08 9213 7055 E: samples.perth@alsenviro.com  
 Adelaide: 2-1 Burne Rd, Port Pirie SA 5055  
Ph: 08 8559 0590 E: adelaide@alsenviro.com  
 Cairns: 125/126 Esplanade, Cairns QLD 4870  
Ph: 07 4033 2153 E: cairns@alsenviro.com

Melbourne: 24 Westall Rd, Springvale VIC 3171  
Ph: 03 8519 9600 E: samples.melbourne@alsenviro.com  
 Perth: 10 Hord Way, Matilda WA 6050  
Ph: 08 9213 7055 E: samples.perth@alsenviro.com  
 Adelaide: 2-1 Burne Rd, Port Pirie SA 5055  
Ph: 08 8559 0590 E: adelaide@alsenviro.com  
 Cairns: 125/126 Esplanade, Cairns QLD 4870  
Ph: 07 4033 2153 E: cairns@alsenviro.com

CLIENT: Kiamia Municipal Council		PROJECT: Minnamurra Landfill		ORDER NUMBER:		TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)		Standard TAT (List due date): <input type="checkbox"/> Non Standard or urgent TAT (List due date):		LABORATORY USE ONLY		
OFFICE: PO Box 75 Kiamia NSW 2633		SAMPLE MANAGER: Paul Czulowski		CONTACT PH: 4232 0418		ALS QUOTE NO.:		COC SEQUENCE NUMBER (Circle) COC: 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> Other		RELINQUISHED BY: Craig		
SAMPLER: Craig Wilson		SAMPLER MOBILE: 0408 281 560		EDD FORMAT (or default): Email Reports to (will default to PM if no other addresses are listed): Email Invoice to (will default to PM if no other addressees are listed):		DATE/TIME:		RECEIVED BY: Craig		RELINQUISHED BY: RECEIVED BY: DATE/TIME:		
COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:												
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to affect suite price)		Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).	Additional Information			
						NT-02A (Alkalinity, Cl, SO4 & Fluoride) NT-01 (Mg, Ca, Na, K)	Nitrate, Ammonia, Total Phenolics		DOC (Filtered)	TOC	Dissolved Filtered) Fe, Mn,	(Total) Fe, Mn, Mg, Ca, Na, K
3	MD 9B	29-5-19 12:30	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
4	MD 9C	15:45	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
5	MD 10A	9:50	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
6	MD 10B	9:55	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
7	Rocklow Down	8:45	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
8	Rocklow Middle	9:40	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
9	Rocklow Up	9:15	W	500mL,2X SP, 2X VS, N	6	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sel, DO, Depth	
10	Blank	8:45	W	VS, N	2							
						TOTAL:						

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Autoglypt Unpreserved Plastic  
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulfite Preserved; VS = VOA Vial Sulfuric Preserved; AV = Autoglypt Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Acid Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

## CERTIFICATE OF ANALYSIS

Work Order	<b>: EW1902279</b>	Page	<b>: 1 of 10</b>
Client	<b>: KIAMA COUNCIL</b>	Laboratory	<b>: Environmental Division NSW South Coast</b>
Contact	<b>: MR PAUL CZULOWSKI</b>	Contact	<b>: Glenn Davies</b>
Address	<b>: 11 MANNING STREET KIAMA NSW, AUSTRALIA 2533</b>	Address	<b>: 1/19 Ralph Black Dr, North Wollongong 2500 4/13 Geary Pl, North Nowra 2541 Australia NSW Australia</b>
Telephone	<b>: +61 02 4232 0444</b>	Telephone	<b>: 02 42253125</b>
Project	<b>: Minnamurra Landfill</b>	Date Samples Received	<b>: 29-May-2019 15:45</b>
Order number	<b>: 126589</b>	Date Analysis Commenced	<b>: 29-May-2019</b>
C-O-C number	<b>: ----</b>	Issue Date	<b>: 05-Jun-2019 16:03</b>
Sampler	<b>: Robert DaLio</b>		
Site	<b>: Minnamurra Landfill</b>		
Quote number	<b>: WO/017/18</b>		
No. of samples received	<b>: 20</b>		
No. of samples analysed	<b>: 20</b>		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

### Signatures

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Glenn Davies	Environmental Services Representative	Laboratory - Wollongong, NSW



Accreditation No. 825  
Accredited for compliance with  
ISO/IEC 17025 - Testing

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED041G: LOR raised for Sulfate on sample 13 & 16 due to sample matrix.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- EP002: It has been noted that DOC is greater than TOC for various samples, however this difference is within the limits of experimental variation.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID		MD 1A	MD 1B	MD 2A	MD 2B	MD 2C			
Compound	CAS Number	LOR	Unit	Client sampling date / time	29-May-2019 13:10	29-May-2019 13:15	29-May-2019 11:30	29-May-2019 11:45	29-May-2019 12:00			
					EW1902279-001	EW1902279-002	EW1902279-003	EW1902279-004	EW1902279-005			
Result												
<b>EA005FD: Field pH</b>												
pH	---	0.1	pH Unit	---	7.6	7.4	6.9	6.8				
<b>EA010FD: Field Conductivity</b>												
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	601	19500	36400	49400				
<b>EA020FD: Field Salinity</b>												
Salinity	---	0.2	g/L	---	0.3	14.1	27.3	39.0				
<b>EA116: Temperature</b>												
Temperature	---	0.1	°C	---	21.0	16.7	17.6	17.0				
<b>ED037P: Alkalinity by PC Titrator</b>												
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1	<1			
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1	<1			
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	196	782	685	522				
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	196	782	685	522				
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>												
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	17	522	1440	2210				
<b>ED045G: Chloride by Discrete Analyser</b>												
Chloride	16887-00-6	1	mg/L	---	40	5590	10600	14000				
<b>ED093F: Dissolved Major Cations</b>												
Calcium	7440-70-2	1	mg/L	---	46	261	438	482				
Magnesium	7439-95-4	1	mg/L	---	8	414	814	1100				
Sodium	7440-23-5	1	mg/L	---	33	3130	6290	8730				
Potassium	7440-09-7	1	mg/L	---	13	183	254	322				
<b>EG020F: Dissolved Metals by ICP-MS</b>												
Manganese	7439-96-5	0.001	mg/L	---	0.044	0.051	0.130	0.150				
Iron	7439-89-6	0.05	mg/L	---	0.44	1.13	1.40	1.58				
<b>EK040P: Fluoride by PC Titrator</b>												
Fluoride	16984-48-8	0.1	mg/L	---	0.2	0.9	0.6	0.7				
<b>EK055G: Ammonia as N by Discrete Analyser</b>												
Ammonia as N	7664-41-7	0.01	mg/L	---	12.6	21.7	10.2	4.00				
<b>EK057G: Nitrite as N by Discrete Analyser</b>												
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	0.07	<0.01	<0.01				
<b>EK058G: Nitrate as N by Discrete Analyser</b>												
Nitrate as N	14797-55-8	0.01	mg/L	---	0.16	3.68	0.08	<0.01				

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 1A	MD 1B	MD 2A	MD 2B	MD 2C	
Compound	CAS Number	LOR	Unit	Client sampling date / time	29-May-2019 13:10	29-May-2019 13:15	29-May-2019 11:30	29-May-2019 11:45	29-May-2019 12:00
				Result	Result	Result	Result	Result	Result
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.16	3.75	0.08	<0.01	
<b>EN055: Ionic Balance</b>									
ø Total Anions	---	0.01	meq/L	---	5.40	184	343	451	
ø Total Cations	---	0.01	meq/L	---	4.72	188	369	502	
ø Ionic Balance	---	0.01	%	---	6.69	1.01	3.69	5.37	
<b>EN67 PK: Field Tests</b>									
Field Observations	---	0.01	--	DESTROYED	---	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>									
Dissolved Organic Carbon	---	1	mg/L	---	8	60	44	28	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	---	1	mg/L	---	9	65	44	28	
<b>EP025FD: Field Dissolved Oxygen</b>									
Dissolved Oxygen	---	0.01	mg/L	---	0.90	3.68	2.53	1.65	
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	10.2	38.1	26.5	17.3	
<b>EP035G: Total Phenol by Discrete Analyser</b>									
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>									
Depth	---	0.01	m	---	1.52	0.45	0.55	0.58	

## Analytical Results

Client sample ID				MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
Compound	CAS Number	LOR	Unit	29-May-2019 10:55	29-May-2019 11:00	29-May-2019 11:15	29-May-2019 12:20	29-May-2019 12:30
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	6.9	7.0	7.2	7.0
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	22300	48700	1700	1600
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	15.6	38.2	1.0	0.9
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	18.5	17.1	18.1	19.8
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	823	454	595	636
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	823	454	595	636
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	991	2430	40	46
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	6760	13800	114	76
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	386	449	121	105
Magnesium	7439-95-4	1	mg/L	---	482	1100	44	45
Sodium	7440-23-5	1	mg/L	---	3610	8790	117	104
Potassium	7440-09-7	1	mg/L	---	178	324	44	48
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.110	0.159	0.032	0.091
Iron	7439-89-6	0.05	mg/L	---	2.06	1.47	0.21	0.18
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.5	1.0	0.7	0.4
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	25.4	1.05	28.4	33.1
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	<0.01	0.09	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.06	<0.01	3.53	0.08

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
		Client sampling date / time		29-May-2019 10:55	29-May-2019 11:00	29-May-2019 11:15	29-May-2019 12:20	29-May-2019 12:30
Compound	CAS Number	LOR	Unit	EW1902279-006	EW1902279-007	EW1902279-008	EW1902279-009	EW1902279-010
			Result		Result	Result	Result	Result
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.06	<0.01	3.62	0.08
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	---	228	449	15.9	15.8
ø Total Cations	---	0.01	meq/L	---	220	504	15.9	14.7
ø Ionic Balance	---	0.01	%	---	1.62	5.73	0.20	3.65
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	DRY	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	52	24	40	41
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	51	23	40	40
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	0.80	2.47	1.35	2.06
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	8.5	25.7	14.6	22.5
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.00	0.98	1.14	1.17

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
Compound	CAS Number	LOR	Unit	29-May-2019 12:45	29-May-2019 10:15	29-May-2019 10:30	29-May-2019 10:45	29-May-2019 09:50
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.2	7.2	7.1	7.1	7.1
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	38000	8720	3460	8300	47800
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	27.2	5.7	2.1	5.3	36.8
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	19.8	17.7	19.0	19.0	17.8
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	371	311	1090	919	237
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	371	311	1090	919	237
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	1940	314	<10	77	2470
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	11300	2520	365	1740	13500
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	377	94	108	186	952
Magnesium	7439-95-4	1	mg/L	921	186	52	118	1080
Sodium	7440-23-5	1	mg/L	7090	1330	289	1140	7920
Potassium	7440-09-7	1	mg/L	240	77	137	124	186
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.054	0.030	0.133	0.178	0.356
Iron	7439-89-6	0.05	mg/L	20.6	<0.05	2.44	5.25	<0.10
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.5	0.1	0.7	0.5	0.5
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	41.1	1.00	134	91.0	0.04
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.02	<0.01	<0.01	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	2.51	0.19	0.13	0.15

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
		Client sampling date / time		29-May-2019 12:45	29-May-2019 10:15	29-May-2019 10:30	29-May-2019 10:45	29-May-2019 09:50
Compound	CAS Number	LOR	Unit	EW1902279-011	EW1902279-012	EW1902279-013	EW1902279-014	EW1902279-015
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	2.53	0.19	0.13	0.15
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	366	83.8	32.1	69.0	437
ø Total Cations	---	0.01	meq/L	---	---	35.3	---	---
ø Total Cations	---	0.01	meq/L	409	79.8	---	71.8	486
ø Ionic Balance	---	0.01	%	---	---	4.78	---	---
ø Ionic Balance	---	0.01	%	5.49	2.45	---	1.92	5.28
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	15	50	91	89	55
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	15	51	91	88	57
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	0.87	2.40	1.39	2.16	6.26
Dissolved Oxygen - % Saturation	---	0.1	% saturation	9.5	25.3	15.1	23.3	66.4
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	1.32	0.60	0.62	0.72	0.79

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	29-May-2019 09:55	29-May-2019 08:45	29-May-2019 09:40	29-May-2019 09:15	29-May-2019 08:45
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.2	7.7	7.5	7.4	---
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	2070	54500	50000	33500	---
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	1.2	48.3	43.6	27.3	---
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	19.6	13.0	13.2	14.0	---
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	---
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	---
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	683	125	131	139	---
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	683	125	131	139	---
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	<10	2670	2280	1220	---
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	189	15900	15100	10200	---
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	96	---	---	---	---
Magnesium	7439-95-4	1	mg/L	37	---	---	---	---
Sodium	7440-23-5	1	mg/L	123	---	---	---	---
Potassium	7440-09-7	1	mg/L	76	---	---	---	---
<b>ED093T: Total Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	434	404	295	---
Magnesium	7439-95-4	1	mg/L	---	1240	1140	751	---
Sodium	7440-23-5	1	mg/L	---	10200	9240	6150	---
Potassium	7440-09-7	1	mg/L	---	376	344	228	---
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.301	---	---	---	<0.001
Iron	7439-89-6	0.05	mg/L	0.54	---	---	---	<0.05
<b>EG020T: Total Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.015	0.014	0.097	---
Iron	7439-89-6	0.05	mg/L	---	0.22	0.19	0.36	---

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	29-May-2019 09:55	29-May-2019 08:45	29-May-2019 09:40	29-May-2019 09:15	29-May-2019 08:45
				Result	Result	Result	Result	Result
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.9	1.1	1.1	0.9	---
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	67.0	0.13	0.08	0.24	---
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	0.03	<0.01	<0.01	<0.01	---
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	0.32	0.02	0.03	<0.01	---
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	0.35	0.02	0.03	<0.01	---
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	19.0	---	---	---	---
ø Total Cations	---	0.01	meq/L	19.9	---	---	---	---
ø Ionic Balance	---	0.01	%	2.37	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	49	4	4	6	<1
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	48	4	4	7	---
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	2.02	8.39	7.21	5.41	---
Dissolved Oxygen - % Saturation	---	0.1	% saturation	22.2	80.0	69.6	52.8	---
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	---
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	0.55	---	---	---	---



## CERTIFICATE OF ANALYSIS

Work Order	<b>: EW1903709</b>	Page	<b>: 1 of 10</b>
Client	<b>: KIAMA COUNCIL</b>	Laboratory	<b>: Environmental Division NSW South Coast</b>
Contact	<b>: MS JULIE MILEVSKI</b>	Contact	<b>: Glenn Davies</b>
Address	<b>: 11 MANNING STREET KIAMA NSW, AUSTRALIA 2533</b>	Address	<b>: 1/19 Ralph Black Dr, North Wollongong 2500 4/13 Geary Pl, North Nowra 2541 Australia NSW Australia</b>
Telephone	<b>: +61 02 4232 0557</b>	Telephone	<b>: 02 42253125</b>
Project	<b>: Minnamurra Landfill</b>	Date Samples Received	<b>: 28-Aug-2019 14:44</b>
Order number	<b>: 126589</b>	Date Analysis Commenced	<b>: 28-Aug-2019</b>
C-O-C number	<b>: ----</b>	Issue Date	<b>: 05-Sep-2019 14:09</b>
Sampler	<b>: Robert DaLio</b>		
Site	<b>: Minnamurra Landfill</b>		
Quote number	<b>: WO/017/18</b>		
No. of samples received	<b>: 20</b>		
No. of samples analysed	<b>: 20</b>		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

### Signatures

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Robert DaLio	Sampler	Laboratory - Wollongong, NSW



Accreditation No. 825  
Accredited for compliance with  
ISO/IEC 17025 - Testing

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED041G: LOR raised for Sulfate on samples 13 and 16 due to sample matrix.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- EP002: It has been noted that DOC is greater than TOC for various samples, however this difference is within the limits of experimental variation.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per EN/67.11 Sampling of Groundwater
- Sampling completed as per EN/67.6 Sampling from Rivers and Streams
- Field tests completed on day of sampling/receipt.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

## Analytical Results

Client sample ID				MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
Compound	CAS Number	LOR	Unit	EW1903709-001	EW1903709-002	EW1903709-003	EW1903709-004	EW1903709-005
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	7.5	7.6	6.9	7.0
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	604	20700	36400	47900
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	0.3	15.0	27.6	36.2
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	21.0	16.7	17.2	18.6
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	189	587	650	490
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	189	587	650	490
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	17	752	1720	2350
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	42	6710	11800	15400
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	47	280	423	471
Magnesium	7439-95-4	1	mg/L	---	8	439	860	1090
Sodium	7440-23-5	1	mg/L	---	32	3330	6680	8760
Potassium	7440-09-7	1	mg/L	---	13	175	262	327
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.044	0.059	0.146	0.158
Iron	7439-89-6	0.05	mg/L	---	0.42	0.24	1.42	1.74
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.2	0.9	0.7	0.8
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	13.4	15.9	9.64	5.09
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	0.11	<0.01	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.70	7.42	0.02	<0.01

## **Analytical Results**

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 1A	MD 1B	MD 2A	MD 2B	MD 2C
		Client sampling date / time		28-Aug-2019 13:30	28-Aug-2019 13:35	28-Aug-2019 12:00	28-Aug-2019 12:10	28-Aug-2019 12:25
Compound	CAS Number	LOR	Unit	EW1903709-001	EW1903709-002	EW1903709-003	EW1903709-004	EW1903709-005
				Result	Result	Result	Result	Result
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.70	7.53	0.02	<0.01
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	---	5.31	217	382	493
ø Total Cations	---	0.01	meq/L	---	5.69	----	----	----
ø Total Cations	---	0.01	meq/L	---	----	199	389	503
ø Ionic Balance	---	0.01	%	---	3.33	----	----	----
ø Ionic Balance	---	0.01	%	---	----	4.14	0.97	0.95
<b>EN67 PK: Field Tests</b>								
Field Observations	---	0.01	--	destroyed	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	---	6	47	36	21
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	---	6	48	36	21
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	---	0.93	3.76	1.15	1.44
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	10.5	38.7	12.0	15.2
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	---	<0.05	<0.05	<0.05	0.76
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	---	1.60	0.57	0.74	0.77

## Analytical Results

Client sample ID				MD 4A	MD 4B	MD 4C	MD 6A	MD 6B
Compound	CAS Number	LOR	Unit	28-Aug-2019 11:10	28-Aug-2019 11:15	28-Aug-2019 11:30	28-Aug-2019 12:30	28-Aug-2019 13:00
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	---	6.9	7.0	7.6	7.1
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	---	23000	48800	1650	1620
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	---	16.2	38.0	1.0	0.9
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	---	18.2	17.5	18.5	19.0
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	---	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	---	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	---	758	492	477	575
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	---	758	492	477	575
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	---	927	2320	44	43
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	---	7440	14900	146	82
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	402	472	118	106
Magnesium	7439-95-4	1	mg/L	---	490	1130	43	46
Sodium	7440-23-5	1	mg/L	---	3740	9220	119	101
Potassium	7440-09-7	1	mg/L	---	176	338	41	45
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.124	0.170	0.025	0.106
Iron	7439-89-6	0.05	mg/L	---	2.01	1.54	0.12	0.18
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	---	0.6	1.1	0.8	0.5
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	---	29.6	1.60	12.4	33.6
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	---	<0.01	<0.01	0.28	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	---	0.03	<0.01	10.6	0.06

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 4A	MD 4B	MD 4C	MD 6A	MD 6B	
Compound	CAS Number	LOR	Unit	Client sampling date / time	28-Aug-2019 11:10	28-Aug-2019 11:15	28-Aug-2019 11:30	28-Aug-2019 12:30	28-Aug-2019 13:00
				Result	Result	Result	Result	Result	Result
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	---	0.01	mg/L	---	0.03	<0.01	10.9	0.06	
<b>EN055: Ionic Balance</b>									
ø Total Anions	---	0.01	meq/L	---	244	478	14.6	14.7	
ø Total Cations	---	0.01	meq/L	---	228	526	15.6	14.6	
ø Ionic Balance	---	0.01	%	---	3.55	4.76	3.60	0.26	
<b>EN67 PK: Field Tests</b>									
Field Observations	---	0.01	--	destroyed	---	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>									
Dissolved Organic Carbon	---	1	mg/L	---	38	17	32	34	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	---	1	mg/L	---	39	18	32	35	
<b>EP025FD: Field Dissolved Oxygen</b>									
Dissolved Oxygen	---	0.01	mg/L	---	3.27	0.73	3.86	0.88	
Dissolved Oxygen - % Saturation	---	0.1	% saturation	---	34.2	7.6	40.5	9.4	
<b>EP035G: Total Phenol by Discrete Analyser</b>									
Phenols (Total)	---	0.05	mg/L	---	<0.05	0.97	<0.05	<0.05	
<b>FWI-EN/001: Groundwater Sampling - Depth</b>									
Depth	---	0.01	m	---	1.17	1.15	1.28	1.28	

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
Compound	CAS Number	LOR	Unit	28-Aug-2019 13:10	28-Aug-2019 10:30	28-Aug-2019 10:45	28-Aug-2019 10:55	28-Aug-2019 09:50
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.3	7.5	7.1	7.0	7.4
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	38100	6580	3460	10100	41100
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	27.6	4.2	2.1	6.5	32.8
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	19.2	18.1	18.7	18.8	15.7
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	354	366	1040	812	285
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	354	366	1040	812	285
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	1910	267	<10	158	2150
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	12400	1880	390	2920	13200
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	372	81	107	193	866
Magnesium	7439-95-4	1	mg/L	925	130	52	162	997
Sodium	7440-23-5	1	mg/L	7120	982	292	1380	7370
Potassium	7440-09-7	1	mg/L	238	69	131	132	165
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.085	0.021	0.150	0.201	0.315
Iron	7439-89-6	0.05	mg/L	19.7	<0.05	2.08	4.15	<0.10
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.5	0.1	0.7	0.6	0.6
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	44.0	0.12	127	94.4	0.55
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	6.90	<0.01	0.12	0.33

## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		MD 6C	MD 9A	MD 9B	MD 9C	MD 10A
		Client sampling date / time		28-Aug-2019 13:10	28-Aug-2019 10:30	28-Aug-2019 10:45	28-Aug-2019 10:55	28-Aug-2019 09:50
Compound	CAS Number	LOR	Unit	EW1903709-011	EW1903709-012	EW1903709-013	EW1903709-014	EW1903709-015
Result								
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	6.90	<0.01	0.13	0.33
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	397	65.9	31.8	102	423
ø Total Cations	---	0.01	meq/L	---	---	34.7	---	---
ø Total Cations	---	0.01	meq/L	410	59.2	---	86.4	450
ø Ionic Balance	---	0.01	%	---	---	4.42	---	---
ø Ionic Balance	---	0.01	%	1.72	5.34	---	8.24	3.12
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	11	49	67	61	50
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	10	50	65	66	51
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	1.80	3.83	0.59	1.61	7.14
Dissolved Oxygen - % Saturation	---	0.1	% saturation	19.4	39.3	6.3	17.2	71.4
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	1.51	0.63	0.77	0.83	0.81

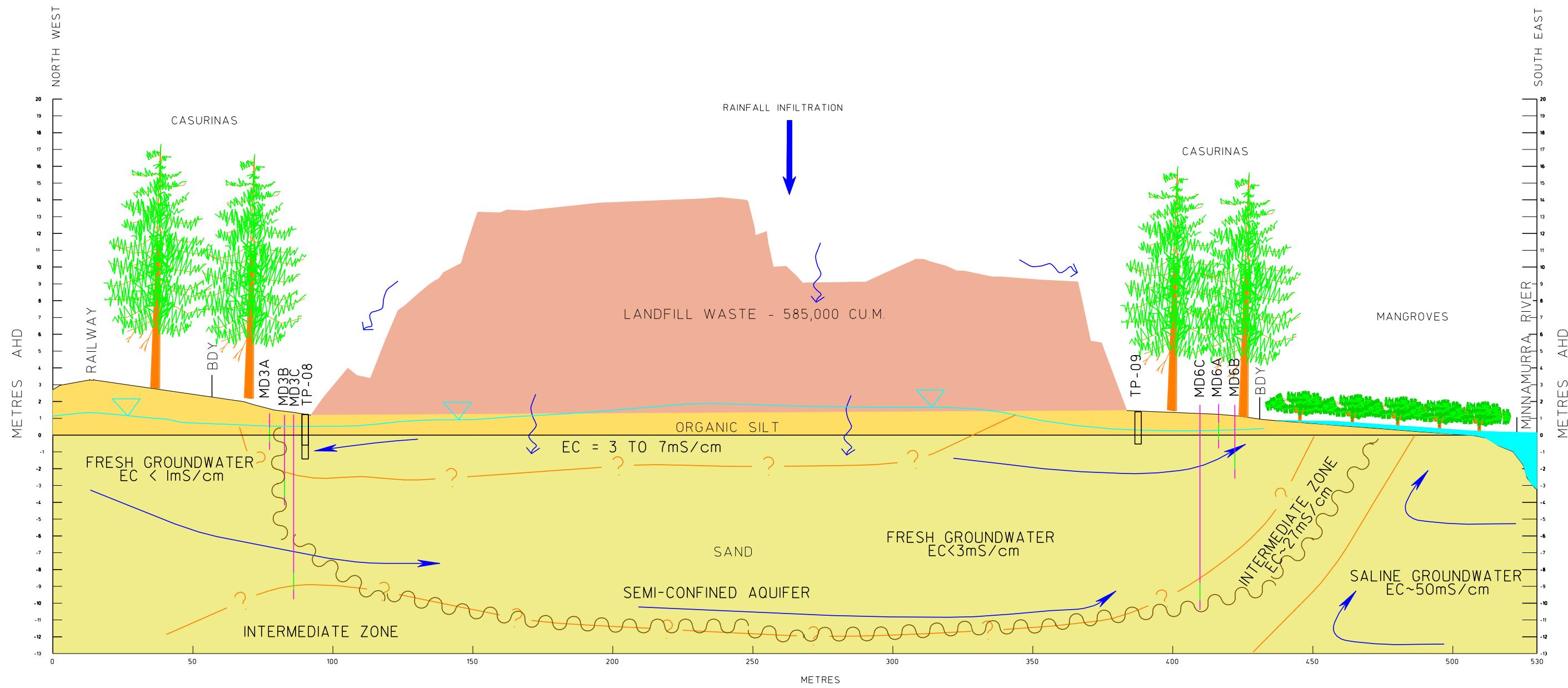
## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	28-Aug-2019 10:00	28-Aug-2019 08:20	28-Aug-2019 09:40	28-Aug-2019 08:40	28-Aug-2019 08:15
				Result	Result	Result	Result	Result
<b>EA005FD: Field pH</b>								
pH	---	0.1	pH Unit	7.0	7.3	7.1	7.6	---
<b>EA010FD: Field Conductivity</b>								
Electrical Conductivity (Non Compensated)	---	1	µS/cm	2010	38900	40400	31500	---
<b>EA020FD: Field Salinity</b>								
Salinity	---	0.2	g/L	1.2	32.3	32.7	25.3	---
<b>EA116: Temperature</b>								
Temperature	---	0.1	°C	18.8	13.9	15.0	14.3	---
<b>ED037P: Alkalinity by PC Titrator</b>								
Hydroxide Alkalinity as CaCO <sub>3</sub>	DMO-210-001	1	mg/L	<1	<1	<1	<1	---
Carbonate Alkalinity as CaCO <sub>3</sub>	3812-32-6	1	mg/L	<1	<1	<1	<1	---
Bicarbonate Alkalinity as CaCO <sub>3</sub>	71-52-3	1	mg/L	666	170	182	136	---
Total Alkalinity as CaCO <sub>3</sub>	---	1	mg/L	666	170	182	136	---
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub> 2- by DA</b>								
Sulfate as SO <sub>4</sub> - Turbidimetric	14808-79-8	1	mg/L	<10	2050	2050	1680	---
<b>ED045G: Chloride by Discrete Analyser</b>								
Chloride	16887-00-6	1	mg/L	179	13300	13400	10700	---
<b>ED093F: Dissolved Major Cations</b>								
Calcium	7440-70-2	1	mg/L	97	---	---	---	---
Magnesium	7439-95-4	1	mg/L	38	---	---	---	---
Sodium	7440-23-5	1	mg/L	109	---	---	---	---
Potassium	7440-09-7	1	mg/L	68	---	---	---	---
<b>ED093T: Total Major Cations</b>								
Calcium	7440-70-2	1	mg/L	---	409	414	263	---
Magnesium	7439-95-4	1	mg/L	---	1070	1060	752	---
Sodium	7440-23-5	1	mg/L	---	8530	8570	6040	---
Potassium	7440-09-7	1	mg/L	---	312	312	210	---
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	0.345	---	---	---	<0.001
Iron	7439-89-6	0.05	mg/L	0.69	---	---	---	<0.05
<b>EG020T: Total Metals by ICP-MS</b>								
Manganese	7439-96-5	0.001	mg/L	---	0.067	0.110	0.098	---
Iron	7439-89-6	0.05	mg/L	---	0.20	0.33	0.27	---

## Analytical Results

Client sample ID				MD 10B	Rocklow Down	Rocklow Middle	Rocklow Up	BLANK
Compound	CAS Number	LOR	Unit	EW1903709-016	EW1903709-017	EW1903709-018	EW1903709-019	EW1903709-020
				Result	Result	Result	Result	Result
<b>EK040P: Fluoride by PC Titrator</b>								
Fluoride	16984-48-8	0.1	mg/L	0.8	1.0	1.0	1.0	---
<b>EK055G: Ammonia as N by Discrete Analyser</b>								
Ammonia as N	7664-41-7	0.01	mg/L	77.0	1.49	1.19	0.02	---
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.02	0.01	<0.01	---
<b>EK058G: Nitrate as N by Discrete Analyser</b>								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.02	<0.01	<0.01	---
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Nitrite + Nitrate as N	---	0.01	mg/L	<0.01	0.04	0.01	<0.01	---
<b>EN055: Ionic Balance</b>								
ø Total Anions	---	0.01	meq/L	18.4	---	---	---	---
ø Total Cations	---	0.01	meq/L	20.0	---	---	---	---
ø Ionic Balance	---	0.01	%	4.12	---	---	---	---
<b>EP002: Dissolved Organic Carbon (DOC)</b>								
Dissolved Organic Carbon	---	1	mg/L	49	5	6	6	<1
<b>EP005: Total Organic Carbon (TOC)</b>								
Total Organic Carbon	---	1	mg/L	47	7	7	6	---
<b>EP025FD: Field Dissolved Oxygen</b>								
Dissolved Oxygen	---	0.01	mg/L	1.20	6.10	2.93	7.27	---
Dissolved Oxygen - % Saturation	---	0.1	% saturation	12.7	59.7	28.8	75.3	---
<b>EP035G: Total Phenol by Discrete Analyser</b>								
Phenols (Total)	---	0.05	mg/L	<0.05	0.77	<0.05	<0.05	---
<b>FWI-EN/001: Groundwater Sampling - Depth</b>								
Depth	---	0.01	m	0.87	---	---	---	---

## Appendix B



## SECTION B - B1

## LEGEND

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*earth2water*  
International & Groundwater



**COUNCIL OF THE  
MUNICIPALITY OF KIAM**

 NCPL  
Neil Charters Pty Ltd  
SURVEY AND DESIGN SERVICES

PARED BY

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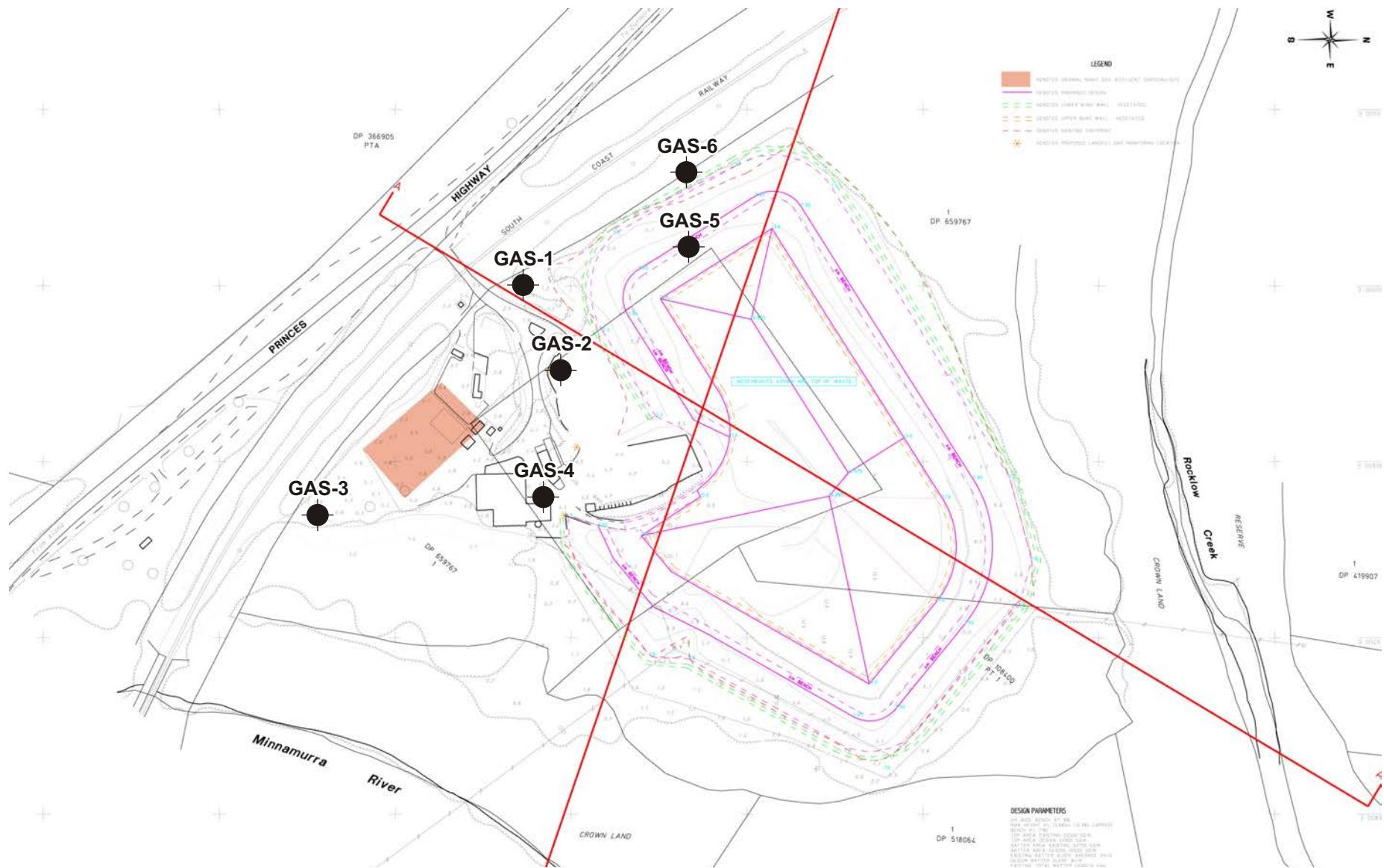
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NCPL

## Appendix C



Source: Neil Charters Pty Ltd

Date: 7 August 2006

Reference: E2W\_047\_10.cdr

KIAMA MUNICIPAL COUNCIL - MINNAMURRA LANDFILL

Figure 1

## LANDFILL GAS MONITORING

GAS 1	Site Entrance
GAS 2	40m South of Landfill (Removed)
GAS 3	Carpark South of Landfill
GAS 4	Next to Secondhand Shop
TRENCH 1	West Bank
TRENCH 2	North Bank West Side
TRENCH 3	North Bank Middle
TRENCH 4	South Bank Side
TRENCH 5	East Bank Side
TRENCH 6	North Bank East Side
TRENCH 7	Lower Level South Side

LEL % from inside trench pipe cap. This is normally not needed, but wanted to keep a record.

WELL ID	DATE	TIME	LEL PPM				COMMENTS	
			MAX		STABLE			
			LEL%	PPM	LEL%	PPM		
Trench 4	7-Feb-18	730		1,150		400	Good Readings	
Trench 1	7-Feb-18	735	95	700		220	*****	
Trench 2	7-Feb-18	740		500		150	*****	
Trench 3	7-Feb-18	750	100	1,050		230	*****	
Trench 6	7-Feb-18	755		680		150	*****	
Trench 5	7-Feb-18	800	100	900		140	*****	
Trench 7	7-Feb-18	805	90	1,100		200	*****	
Gas 1	7-Feb-18	810		250		120	*****	
Gas 2							Removed due to new CRC site	
Gas 3	7-Feb-18	815		330		120	Good Readings	
Gas 4	7-Feb-18	820		360		110	*****	
Weighbridge	7-Feb-18	830		0		0	All Building with clear readings	
Cleaning Shed	7-Feb-18	835		0		0	*****	
MRF	7-Feb-18	840		0		0	*****	
Lunchroom	7-Feb-18	845		0		0	*****	
Ute Shed	7-Feb-18	850		0		0	*****	
Trench 4	12-Jun-18	855		1,000		390	Good Readings Wet Ground	
Trench 1	12-Jun-18	900	98	750		200	*****	
Trench 2	12-Jun-18	905		450		120	*****	
Trench 3	12-Jun-18	910	100	1,050		160	*****	
Trench 6	12-Jun-18	915		590		190	*****	
Trench 5	12-Jun-18	920	100	650		170	*****	
Trench 7	12-Jun-18	925	100	1,200		200	*****	
Gas 1	12-Jun-18	930		300		120	*****	
Gas 2							Removed due to new CRC site	
Gas 3	12-Jun-18	935		310		140	Good Readings Wet Ground	
Gas 4	12-Jun-18	940		320		110	*****	
Weighbridge	12-Jun-18	945		0		0	All Building with clear readings	
Cleaning Shed	12-Jun-18	950		0		0	*****	
MRF	12-Jun-18	955		0		0	*****	
CRC Lunchroom	12-Jun-18	1000		0		0	*****	
Ute Shed	12-Jun-18	1005		0		0	*****	

**CALIBRATED WITH SPAN GAS:**

## LANDFILL GAS MONITORING

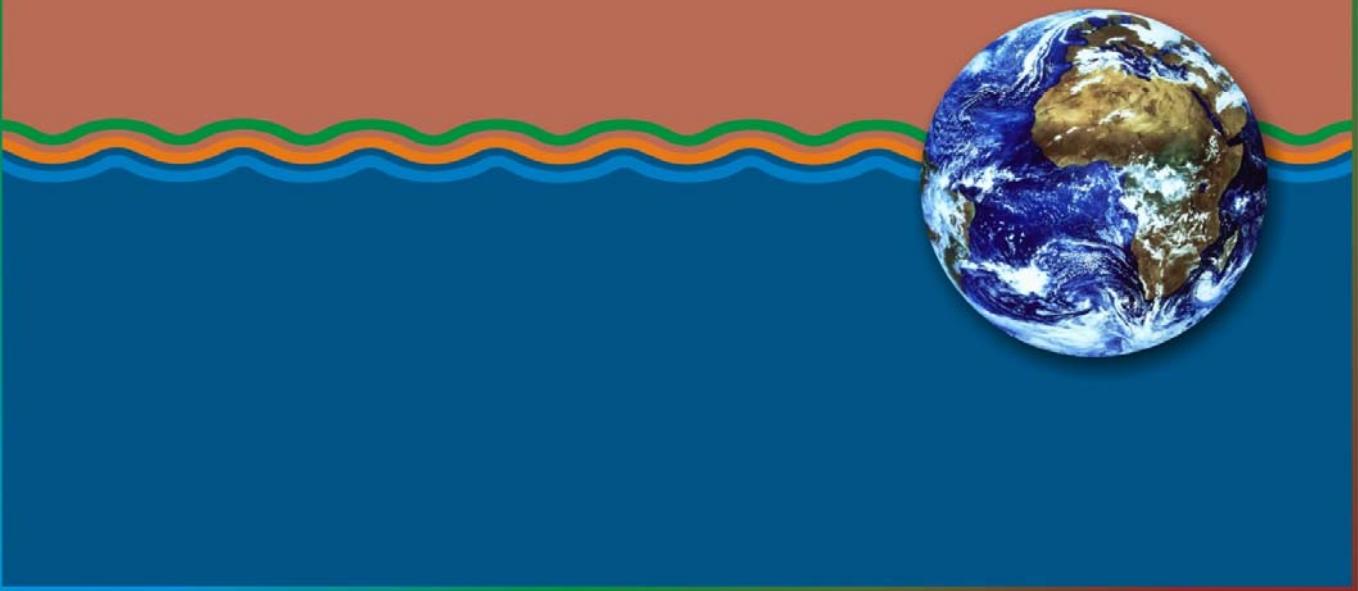
GAS 1	Site Entrance
GAS 2	40m South of Landfill (Removed)
GAS 3	Carpark South of Landfill
GAS 4	Next to Secondhand Shop
TRENCH 1	West Bank
TRENCH 2	North Bank West Side
TRENCH 3	North Bank Middle
TRENCH 4	South Bank Side
TRENCH 5	East Bank Side
TRENCH 6	North Bank East Side
TRENCH 7	Lower Level South Side

**LEL % from inside trench pipe cap. This is normally not needed, but wanted to keep a record.**

WELL ID	DATE	TIME	LEL PPM				COMMENTS	
			MAX		STABLE			
			LEL%	PPM	LEL%	PPM		
Trench 4	13-Feb-19	800		1,200		420	Good Readings	
Trench 1	13-Feb-19	805	98	700		250	*****	
Trench 2	13-Feb-19	810		510		160	*****	
Trench 3	13-Feb-19	815	100	1,000		250	*****	
Trench 6	13-Feb-19	820		690		240	*****	
Trench 5	13-Feb-19	825	100	980		140	*****	
Trench 7	13-Feb-19	830	90	1,200		210	*****	
Gas 1	13-Feb-19	835		260		110	*****	
Gas 2							Removed due to new CRC site	
Gas 3	13-Feb-19	840		340		130	Good Readings	
Gas 4	13-Feb-19	845		290		120	*****	
Weighbridge	13-Feb-19	850		0		0	All Building with clear readings	
Cleaning Shed	13-Feb-19	855		0		0	*****	
MRF	13-Feb-19	900		0		0	*****	
Lunchroom	13-Feb-19	905		0		0	*****	
Ute Shed	13-Feb-19	910		0		0	*****	
Trench 4	21-Jun-19	1020		1,100		290	Good Readings Windy Conditions	
Trench 1	21-Jun-19	1025	100	790		190	*****	
Trench 2	21-Jun-19	1030		400		120	*****	
Trench 3	21-Jun-19	1035	90	940		150	*****	
Trench 6	21-Jun-19	1040		550		180	*****	
Trench 5	21-Jun-19	1045	100	500		150	*****	
Trench 7	21-Jun-19	1050	100	900		210	*****	
Gas 1	21-Jun-19	1055		330		120	*****	
Gas 2							Removed due to new CRC site	
Gas 3	21-Jun-19	1100		330		150	Good Readings	
Gas 4	21-Jun-19	1105		300		100	*****	
Weighbridge	21-Jun-19	155		0		0	All Building with clear readings	
Cleaning Shed	21-Jun-19	200		0		0	*****	
MRF	21-Jun-19	210		0		0	*****	
CRC Lunchroom	21-Jun-19	215		0		0	*****	
Ute Shed	21-Jun-19	220		0		0	*****	



## LAST PAGE OF REPORT



***Thank you for the opportunity to work with  
Kiama Council.***

Your feedback is welcomed regarding  
Earth2Water Pty Ltd services.  
Dino Parisotto ([dino@earth2water.com.au](mailto:dino@earth2water.com.au))

