



## Appendix H Hydrogeological Reports



## Appendix H1 Conceptual Site Model



## Report

# Shoal Bay Waste Disposal Site Conceptual Site Model

AUSTRALIA



## Conceptual Site Model

26 February 2016  
42214019/R003/3




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Prepared by URS Australia Pty Ltd





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## ABBREVIATIONS

<b>Abbreviation</b>	<b>Description</b>
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
bgl	below ground level
BOD	biochemical oxygen demand
BoM	Bureau of Meteorology
BTEXN	benzene, toluene, xylene and naphthalene
COD	chemical oxygen demand
COPC	contaminant of potential concern
CSM	Conceptual Site Model
EPA	Environmental Protection Authority
EPL	Environmental Protection Licence
ERA	Ecological Risk Assessment
John Holland	John Holland Pty Ltd
km	kilometre
L/sec	litres per second
L/N	Leachate/natural
m	metres
mg/L	milligram per litre
mm	millimetre
NT	Northern Territory
°C	degrees Celsius
TDS	total dissolved solids
TOC	total organic carbon
TRH	total recoverable hydrocarbon
URS	URS Australia Pty Ltd
UXO	unexploded ordinance
VFA	volatile acids as acetic acid
WMP	Water Monitoring Plan



## INTRODUCTION

URS Australia Pty Ltd (URS) was commissioned by John Holland Pty Ltd (John Holland) to develop a conceptual site model (CSM) for the Shoal Bay Waste Disposal Site (the Site) as required by the NT EPA 2013 “Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory”. The Site is located on Vanderlin Drive, Holmes, Northern Territory (NT) (**Figure 1, Appendix A**) and is operated by John Holland (trading as Territoria Civil) under a contract with the City of Darwin (Council) pursuant to an environmental protection licence (EPL) No: EPL 12 – 08 (Licence) issued by the NT Environmental Protection Agency (EPA).

A hydrogeological investigation was undertaken by URS to inform development of this CSM, refer to “Shoal Bay Waste Disposal Site Hydrogeological Investigation, 26 November 2015 (42214019/R002/0) (URS, 2015). Works for the hydrogeological investigation included:

- Installation of 32 groundwater monitoring bores at 15 targeted locations across the Site, comprising 14 shallow (approximately 3 metres (m) below ground level [bgl]), 15 deep (approximately 12m bgl), and three karst identification bores (30m bgl).
- Groundwater level measurements, sampling and laboratory analysis in newly installed groundwater bores in September 2015.

This CSM will inform an Ecological Risk Assessment (ERA) and Water Monitoring Plan (WMP), also a requirement under the NT EPA 2013 Guidelines.

## 2 GEOGRAPHICAL SETTING

The Site is situated approximately 12 kilometres (km) north east of the Darwin Central Business District on Vanderlin Drive, Holmes, NT (**Figure 1, Appendix A**). The site layout, including bores installed at the site during the recent hydrogeological investigation (GW1 to GW15) are presented in **Figure 2, Appendix A**.

### 2.1 Topography

The topography in the vicinity of the Site undulates with elevations between 7 m Australian Height Datum (AHD) and 32.8 mAHD and broadly slopes east toward the floodplain at the south end of the Site and west at the northern end of the Site. Stages Two, Three and Four and to a lesser extent the green waste area form mounds at the Site with Stage Three reaching the highest elevation of 32.8 mAHD.

### 2.2 Surface Water, Drainage and Storage

Overland flow is east from the eastern portion of the site, toward the Meckit Creek floodplain and westward, toward the Buffalo Creek floodplain on the western portion of the site, following topography. Localised flows are expected on the landfill mounds due to surface grades. Surface water management includes a surface water drainage system where surface water is diverted away from the waste where possible. Structures include open drains and stormwater structures.

### 2.3 Land Use

According to former Department of Natural Resources, Environment, the Arts and Sport, the Site is located within an area of predominantly “intensive use”, which includes not only the Site itself, but the surrounding suburbs. Large areas to the southeast and east are described as “conservation and natural environments”.

### 2.4 Climate

The Darwin region experiences a monsoonal climate with distinct wet and dry seasons. Monthly Rainfall data for Darwin Airport (Station No. 014015) from 2013 to 2015 (Bureau of Meteorology [BoM], 2015a), and a summary of the long-term rainfall statistics is presented in Table 2-1. Based on the BoM Darwin Airport weather station, Darwin receives, on average 1,727 millimetre (mm) of rainfall annually, with nearly all of that falling during the months of December to April.

**Table 2-1 Darwin Airport – Monthly Rainfall Data (2013-2015) (BoM, 2015)**

Year	Monthly Rainfall (mm)												Annual Rainfall (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013	219.8	398.4	381.0	101.6	31.6	0.6	0.0	2.6	0.2	98.6	314.2	210.8	1,759.4
2014	608.6	369.0	92.4	177.2	8.6	0.0	0.0	0.0	0.0	14.8	165.8	111.0	1,547.4

Year	Monthly Rainfall (mm)												Annual Rainfall (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2015	484.6	353.2	230.8	21.2	13.8	0.4	0.0	0.2	3.4	42.6	84.2	509.4	1,547.4
Mean*	427.1	374.3	317.9	101.1	21.1	1.8	1.2	4.8	15.1	69.5	141.3	248.9	1,722.6

\* - 1941 to 2015

Mean maximum temperatures, as recorded during the period from 1941 to 2011, vary between 30.5 degrees Celsius (°C) in July and 33.3°C in November while mean minimum temperatures vary between 19.3°C in July and 25.3°C in November/December. Mean daily evaporation ranges from 5.7 mm in February to 8.0 mm in October (BoM, 2015b).

## 3 GEOLOGY AND HYDROLOGY

### 3.1 Regional Geology

The geology of the Darwin area has been described in detail by Verma (2002) and Nott (2003), indicating the region is underlain by a thin veneer of Cainozoic sediments overlying Cretaceous and Proterozoic-age rocks. The Cainozoic sediments consist predominantly of weathering product (regolith) and Quaternary-age sand, silt, clay, gravel and laterite and are generally less than 5 m in thickness. Underlying the Cainozoic sediments is the relatively flat-bedded, Cretaceous-age Darwin Member of the Bathurst Island Formation, which is composed primarily of claystone, siltstone, and sandstone with a basal conglomerate. This formation has an average thickness of approximately 40 m but can be significantly less in some areas. The Cretaceous strata lie unconformably over heavily folded rocks of the Middle and Lower Proterozoic age such as the Burrell Creek Formation, which consists of phyllite, mica-schist, siltstone, shale, and vein quartz. Strata of Jurassic and Archaean age are present in only a few small areas of the Darwin region.

Reference to the 1:100,000 scale geological water resources maps of Darwin (Sheet 5073) indicates presence of Quaternary unconsolidated sand, clayey sand, ferruginous clayey sand at the site, underlain by the Orosirian Burrell Creek formation.

### 3.2 Regional Hydrogeology

#### 3.2.1 Aquifer Types

Verma (2002) states that the Darwin area can be broken down into two main aquifer types described below:

- a) fractured and weathered non-carbonate rocks and
- b) fractured and weathered carbonate rocks.

The two aquifer types are described below.

#### *Fractured and Weathered Non-carbonate Aquifers*

Aquifers have been noted in the Proterozoic, non-carbonate rocks. Verma (2002) terms these as medium aquifers or, in the absence of faults or fractures, minor aquifers. Yields of up to 10 litres per second (L/sec) have been proven in medium aquifers while less than 0.5 L/sec can be expected in the minor aquifers.

Groundwater information within the area (1:100,000 Water Resources Map of Darwin [Sheet 5073]) indicates that groundwater may be encountered within unconfined Quaternary sediments (sand, silt and clay) and fractured, weathered bedrock. The groundwater resources in the area are classified as minor with generally low bore yields (less than 0.5 L/sec); however, higher yields with low aquifer storage may occur in sand lenses within the Quaternary sediments, gravel layers that may be present at the interface of the sediments, and fractures and quartz veins within the bedrock.

## *Fractured and Weathered Carbonate Aquifers*

Middle and lower Proterozoic-age carbonate rocks comprise the major aquifers in the Darwin region. Yields in excess of 5 L/s are not uncommon, especially if the dolomitic rocks are overlain by a reasonable thickness of the Burrell Creek Formation (Verma, 2002). In particular, the basal conglomerate at the contact of the Cretaceous-age Burrell Creek Formation and the underlying Proterozoic carbonates makes a reasonably good aquifer known as the McMinns Hydrostratigraphic Unit. The Dolomite or Carbonate Layer in the Middle Proterozoic-age rocks has also been identified as a major aquifer, as has the Coomalie/Koolpinyah dolomites. These aquifers have, historically, been heavily exploited in the Darwin region for both water supply and agriculture.

The 1:100,000 Water Resources Map of Darwin [Sheet 5073] identifies a karstic, high yielding aquifer, located in close proximity east of the Site and trending north-west.

### **3.2.2 Groundwater Quality**

According to Verma (2002), groundwater quality in the Darwin region varies depending on geographic location, distance from recharge area and coastline, and lithology. Three types of groundwater quality zones are described: a) fresh carbonate water, b) fresh non-carbonate water, and c) saline water. Fresh-carbonate water occurs in the dolomitic rocks, e.g. Coomalie and Koolpinyah aquifers. Typically, the water chemistry exhibits a Total Dissolved Solids (TDS) concentration of <1,000 milligram per litre (mg/L), a pH range of 7.0 to 9.0, and a hardness concentration of approximately 150 mg/L. Non-carbonate water occurs in non-carbonate rocks, e.g. Bathurst Island Formation, with a TDS concentration of 200 to 500 mg/L, and a pH range of 6.4 to 7.0. Saline waters have a TDS concentration in excess of 1,000 mg/L however can sometime range up to 60,000 mg/L along the coastlines and intertidal drainages.

Groundwater information within the area (1:100,000 Water Resources Map of Darwin [Sheet 5073]) indicates TDS concentrations less than 1000 mg/L are expected in groundwater within the vicinity of the site; groundwater is considered suitable for human and animal consumption.

### **3.3 Site Geology**

Lithology encountered during the recent hydrogeological investigation (URS, 2015), consisted of topsoil (silts and clays), generally underlain by weathered siltstone, with claystone encountered east of Stage One. Sandstone was encountered at approximately 9 mbgl to 20 mbgs across the site in bores drilled down to 30 mbgl. No identified karst or limestone strata was encountered in the hydrogeological investigation (URS, 2015).

The lithology encountered during the recent hydrogeological Investigation is presented (where possible) on conceptual cross-sections provided as **Figure 3** to **Figure 6 (Appendix A)**.

### **3.4 Site Hydrogeology**

#### **3.4.1 Aquifer Properties**

During the recent hydrogeological investigation (URS, 2015) groundwater was generally observed in transmissive fractures in partly to highly weathered bedrock conducted at the end of the dry season (September 2015).

Groundwater levels recorded on site in September 2015 are presented on conceptual cross-sections provided as **Figure 3 to Figure 6 (Appendix A)**. Variable water table gradients were observed during the recent hydrogeological investigation (URS, 2015), with groundwater depths indicative of upward hydraulic gradient north east of the Stage Two landfill, and downward hydraulic gradient in the centre of the Site (between Stage One and Stage Two).

Groundwater flows along the path of least resistance down a hydraulic gradient. Preferential flow paths tend to develop along zones of higher permeability than the surrounding matrix, including fractures, faults, and weathered zones. They are, together, considered to be potential bedrock aquifers. The available groundwater level data indicates that groundwater may be preferentially flowing through one or more of the lateritic materials and the weathered bedrock.

### **3.4.2 Groundwater Quality**

Groundwater sampling and analytical results were provided in the recent hydrogeological investigation (URS, 2015). Groundwater field parameters for the groundwater sampling event are presented in **Table B-1 (Appendix B)**, and analytical results presented in **Table B-2 (Appendix B)**, with comparison to the Australian and New Zealand Environment Conservation Council (ANZECC) (2000) Australian and New Zealand Guidelines for Marine and Freshwater quality trigger values for protection of 95% of marine ecosystems, as per the Facilities EPL 12. Recent groundwater quality data from WW series bores is presented in **Table B-3 (Appendix B)**. It is noted that the WW series bores do not provide targeted screened intervals, and with large screened intervals, lose detection sensitivity to vertically variable water quality and provide only a gross measure of contamination (NT EPA, 2013). A summary of groundwater monitoring results is presented in **Table B-4, Appendix B**.

The results of historic and recent hydrogeological investigations indicate highly variable terrestrial groundwater quality exists at the site, with:

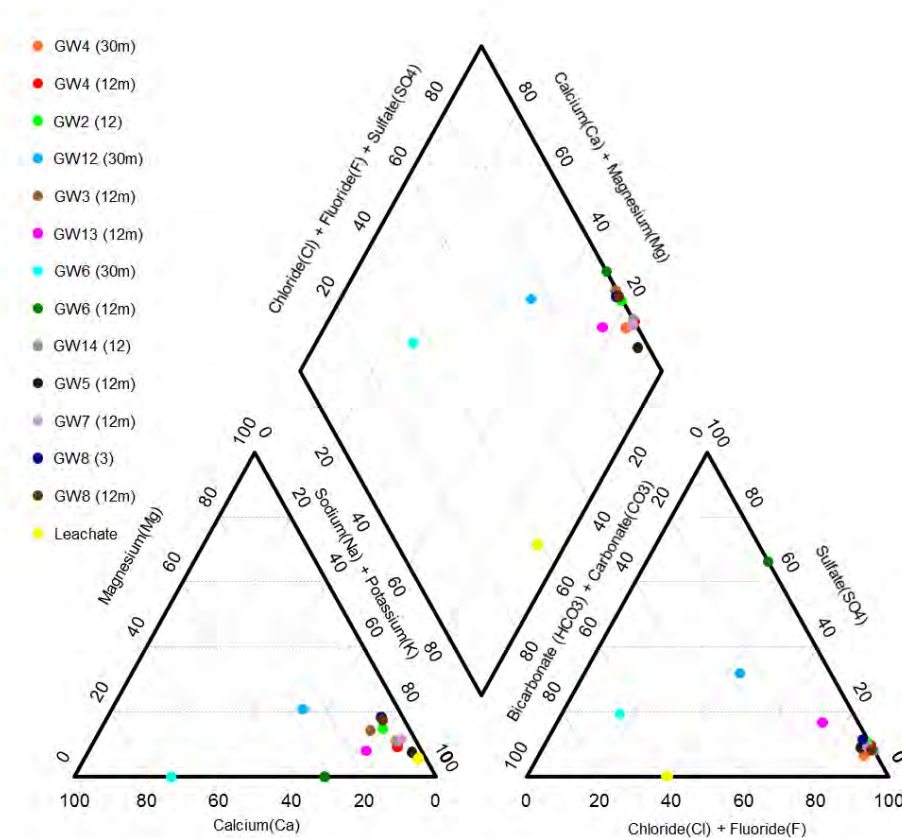
- salinities that range from fresh to hypersaline
- near-neutral to slightly acidic pH
- traces of dissolved metals that sometimes exceed applicable screening levels for marine water ecosystems. In the recent hydrogeological investigation (URS, 2015), notably greater concentrations of iron and/or zinc were observed in new bores west of Stage Three.
- generally low nutrient concentrations, with the following exceptions:
  - one new bore located east of the Stage One landfill reported occurrences of ammonium and nitrate notably higher than other bores (no screening levels were adopted for these analytes) in the recent hydrogeological investigation (URS, 2015)

Historic monitoring bores have historically reported elevated total nitrogen (not analysed in the most recent hydrogeological investigation), in particular total nitrogen has been reported significantly elevated in one bore west of Stage Three (Territoria Civil, 2013a).

- generally elevated concentrations of leachate indicators chemical oxygen demand (COD), volatile acids as acetic acid (VFA) and/or total organic carbon (TOC). In the recent hydrogeological investigation (URS, 2015), notably higher concentrations were

reported in shallow and/or deep bores east of Stage One and Stage Two landfills and north west of the Stage Three landfill.

Ionic proportions for major ions for groundwater for September 2015 are presented as a Piper Plot in **Chart 3-1**. **Chart 3-1** normalises concentrations to compare the relative proportions of each ion. This allows groundwater types, based on the proportions to be compared where influences such as evaporation and mixing are present. Ionic proportions for major ions for leachate samples collected in February 2016 (**Table D-1, Appendix D**) are present in **Chart 3-1** for comparison purposes.



**Chart 3-1 Groundwater Monitoring Bore and Leachate Piper Plot, September 2015**

The groundwater at all sites is predominantly of the sodium chloride type, with some carbonate/bicarbonate and/or calcium types present at one 12 m and two 30 m karst identification bores located in the centre of the Site (between Stage One and Stage Two) and west of the Greenwaste area.

Carbonate-bearing host materials (e.g. limestone) tend to yield a water chemistry with high proportions of carbonate/bicarbonate and calcium.

Bicarbonate ions are also a characteristic component of leachate, deriving from organic waste decomposition.

### 3.4.3 Assessment of Leachate Impact

The hydraulic gradient of the groundwater system reduces from the edge of the landfill eastwards towards the coast, as shown in Section C-C' (Figure 5). The hydrogeological investigation indicated that the hydraulic conductivities are variable. The greatest k values are around 0.5 m/day and the hydraulic gradient beyond the edge of the landfill is around 0.001. Therefore the Darcy velocity is 0.005 m/day and the particle velocity is 0.002 m/day, assuming a porosity of 25%. This means effectively that the leachate plume is migrating at a rate of 0.7 m/year. With the influence of attenuation through cation exchange (adsorption) and dilution, the effect at the nearest receptor in the coastal fringe is greatly diminished.

The impact of leachate on groundwater can be assessed through comparison of the ratios between leachate (L) ions, such as  $K^+$ ,  $NH_4^+$  and  $NO_3^-$  and ions that are more prevalent in natural (N) groundwaters ( $Ca^+$ ,  $Na^+$  and  $Mg^{2+}$ ). The ratio is determined as follows:

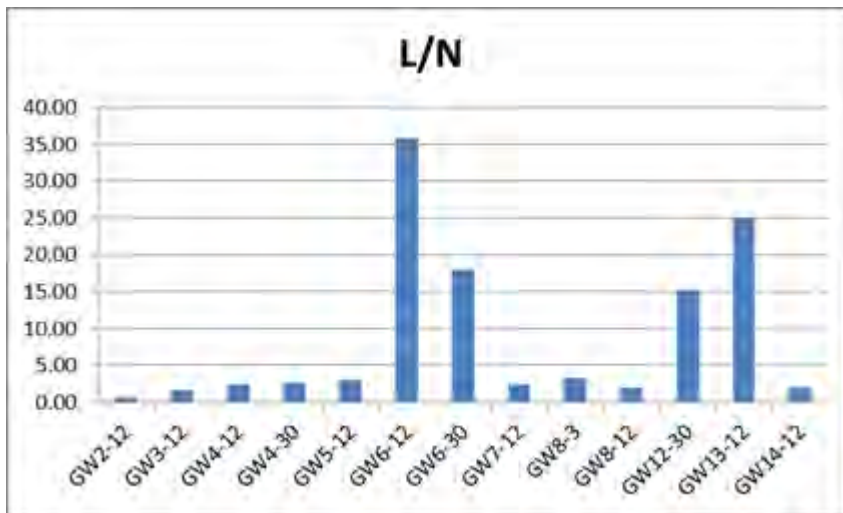
$$L/N = (K^+ + NH_4^+ + NO_3^-) / (Ca^+ + Na^+ + Mg^{2+}) * 100$$

The L/N ratio is generally less than 10 for natural groundwaters whereas leachate or leachate impacted groundwaters exhibit a ratio greater than 10.

The L/N ratios are plotted in **Figure 3-1**.

The plot shows that most bores exhibit natural groundwater quality, but GW6-12, GW6-30, GW12-30 and GW13-12 all exhibit chemistry indicative of leachate impacts.

**Figure 3-1 L/N Ratios - Shoal Bay Monitoring Bores**



### 3.5 Surface Water Quality

Recent surface water quality is presented in **Table C-1 (Appendix C)**.

The surface water sample quality (February 2016) for sites contained within the EPL boundary is characterised as:

- fresh,
- contains traces of metals,
- generally low nutrient levels,
- detectable phenolic compounds (phenol and 3 & 4 methylphenol, SW12),
- detectable TPH (all fractions, SW12 only), and
- detectable TRH (all fractions apart from C10-C16 & C34-C40, SW12 only).

Surface water quality (February 2016) for SW2 located outside of the EPL is characterised as:

- saline,
- contains traces of metals with elevated iron,
- elevated nutrients,
- detectable phenolic compounds (2 methylphenol)
- detectable TPH (all fractions apart from C29-C36)
- detectable TRH (all fractions apart from C34-C40), and
- detectable BTEXN.

### 3.6 Leachate Composition

Recent leachate quality analysis (February 2016) is presented in **Table D-1 (Appendix D)**.

Leachate is characterised as:

- saline,
- slightly alkaline with elevated nutrients,
- non-detectable PAH apart from naphthalene,
- detectable phenolic compounds (Phenol and 2-3 & 4 Methylphenol),
- detectable TPH (all fractions),
- detectable TRH (all fractions accept for C34-C40) and
- detectable BTEXN.

## 4 POTENTIAL CONTAMINANT SOURCES, CONTAMINANTS OF CONCERN, FATE AND TRANSPORT

### 4.1 Potential Sources of Contamination

Potential contamination sources are identified (where possible) on the conceptual cross-sections provided as **Figure 3 to Figure 6 (Appendix A)**. The potential sources are summarised below.

#### 4.1.1 *Known On-Site Sources of Potential Contamination*

Known on-site sources with the potential to impact the surrounding environment include:

- **Landfill leachate** - derived on-site through the degradation of the waste mass. Leachate is contained within the former and current landfilled waste mass. In addition, landfill leachate is stored within the lined leachate storage pond, although some degree of dilution from incident rainfall and runoff can be expected from this source.
- **Green waste leachate** - derived on-site from composting activities in the southern and western portion of the Site. This leachate is present within green waste mounds. The green waste area is enclosed by bunds and drains and a silt trap is maintained. The silt trap is designed to retain the volume of water expected from a one year event, but overflow occurs when this volume is exceeded.

#### 4.1.2 *Other Possible On-site Sources of Potential Contamination*

The chemical storage facility, located at the southern end of the Transfer Station, provides a facility for the short-term storage of domestic chemicals received at the Shoal Bay Waste Disposal Facility. This facility is considered a possible on-site source of contamination due to the potential for spills and / or leaks of stored chemicals.

The recycling facility (outside the existing EPL) is also considered a possible on-site source of contamination due to the storage and dispose of batteries, gas bottles and un-gassed fridges for the potential for spills and / or leaks.

The compound area (outside the existing EPL) which stores lubricants to service the power generation equipment is also considered a potential for spills and / or leaks.

#### 4.1.3 *Potential Off-site Sources of Contamination*

The following off-site sources may potentially be responsible for contaminants of concern entering the hydrogeological environment, including (but not necessarily limited to):

- The adjacent unexploded ordinance (UXO) area and previous Royal Australian Air Force bombing activities;
- urban stormwater runoff;
- the former Leanyer landfill; and
- potential use of herbicides, pesticides or nitrogen based fertilisers at properties located up-hydraulic gradient of the Site.

## 4.2 Contaminants of Potential Concern

Identified contaminants of potential concern (COPCs) for leachate currently include nitrogen compounds (ammonia and nitrate), metals, phenolic compounds, benzene, toluene, xylene and naphthalene (BTEXN), TOC, VFAs, total recoverable hydrocarbon (TRH), chloride, sodium and salinity (as TDS).

## 4.3 Potential Migration Routes

Potential migration routes for contaminants to groundwater and surface water systems resulting from activities at the Site include (but are not necessarily limited to):

- Leachate migration through the landfill and lining systems (where present), landfill leachate storage pond and leachate generated by green waste storage;
- Potentially leachate impacted surface water runoff (from leachate seeps within the landfill, leachate contaminated runoff from green waste and failure and / or overflow of leachate storage ponds); and
- Surface water contaminated by wastes contained within the chemical storage facility, recycling facility, and compound area (via flow through surface water drainage features or infiltration of contaminated waters through the unsaturated zone).

Potential migration routes and exposure pathways for the groundwater and surface water systems resulting from off-site activities include (but are not necessarily limited to):

- Seepage of wastes through the unsaturated zone via leaking / damaged septic systems (former or current) if present.

This information is summarised, where possible, on conceptual cross-sections provided as **Figure 3 to Figure 6 (Appendix A)**.

## 4.4 Potential Receptors

Potential receptors for contaminants migrating off-site as a result of potential Site activities include (but are not necessarily limited to):

- Nearby groundwater users, particularly located down hydraulic gradient of the Site;
- The waters of the floodplain east and west of the Site (Mickett Creek and Buffalo Creek floodplains respectively) and their flora and fauna ecosystems; and
- On-site personnel and visitors.

This information is also summarised, where possible, on conceptual cross-sections provided as **Figure 3 to Figure 6 (Appendix A)**.

## 4.5 Potential Exposure Pathways

Potential exposure pathways to potential receptors as a result of Site activities include (but are not necessarily limited to):

- Infiltration of leachate, leachate impacted or otherwise impacted water to the groundwater system;

- Overland drainage of leachate, leachate impacted or otherwise impacted water to surface water bodies (i.e. via seepage through landfill or off the green waste area and / or tide water's entering flood plain);
- Potentially contaminated groundwater base flow / discharge to flood plain and associated ecosystem;
- Direct or indirect exposure to water users of groundwater / surface water usage for beneficial uses precluded by contaminants of potential concern, particularly down-gradient of the Site; and
- Direct exposure (dermal contact, accidental ingestion) of on-site personnel and visitors to leachate, leachate impacted waters or otherwise impacted waters.

This information is also summarised, where possible, on conceptual cross-sections provided as **Figure 3 to Figure 6 (Appendix A)**.

#### **4.6 Summary of Potential Contaminant Sources, COPCs, Fate and Transport**

The information presented in Section 4 is presented in conceptual cross-sections in **Figure 3 to Figure 6 (Appendix A)** and summarised in Table 4-2 below:

Table 4-1 Summary of Potential Contaminant Sources, COPCs, Fate and Transport

Source	COPC	Pathway	Receptor	Linkage Complete?	Explanation
Landfill Leachate (Waste mounds and Leachate Storage Pond)	Nitrogen compounds, metals, phenolic compounds, BTEXN, TRH, chloride, sodium and salinity, TOC, VFAs.	Seepage from landfill (from elevated leachate levels within the waste mass) and / or preferential pathways through the landfill i.e. via cracks.	On-site surface water ponds	Potentially complete	Depending on the volume of potential seeps and their location there is the potential for these to drain via overland flow to the surface water ponds located at the Site.
			On-site personnel / subcontractors (exposure)	Potentially complete	Exposure to landfill leachate of on-site personnel / subcontractors may potentially occur directly or indirectly. Direct exposure mechanisms include dermal contact and / or accidental ingestion as a result of clean-up activities. Indirect exposure mechanisms include dermal contact and / or accidental ingestion of leachate impacted water (i.e. say from storm water pits) during works to (or to manage) surface water management infrastructure.
		Environmental Monitoring	On-site personnel / subcontractors (exposure)	Potentially complete	Direct and indirect exposure to landfill leachate of on-site personnel/ subcontractors may potentially occur as a result of environmental monitoring activities. Direct exposure mechanisms include dermal contact and / or accidental ingestion as a result of removing leachate for the purposes of sampling or undertaking laboratory analysis from either the landfill cells or leachate storage pond. Indirect exposure mechanisms include dermal contact and / or accidental ingestion of leachate impacted water.
		Receiving waters from leachate storage pond (from overland flow and / or infiltration to and migration through groundwater).	Surface water environment	Potentially complete	There is potential, particularly during periods of high rainfall, for leachate impacted waters to overflow and migrate via overland flow or infiltration to and migration through groundwater to surface water features (on-site ponds, flood plain).
			On-site personnel / neighbouring land users (exposure)	Potentially complete	In the event of overflow at the leachate pond, exposure to landfill leachate of on-site personnel / subcontractors or neighbouring land users may potentially occur directly or indirectly. Direct exposure mechanisms include dermal contact and / or accidental ingestion as a result of clean-up activities (on or off-site). Indirect exposure mechanisms include dermal contact and / or accidental ingestion of leachate impacted water during works to (or to manage) surface water management infrastructure after overflow event or activities in and around leachate impacted surface water off-site.
		Infiltration of landfill leachate to the groundwater (from vertical and / or radial flow from the landfill and / or infiltration through base of leachate pond.	Perched groundwater	Potentially complete	Given the surficial geology comprises laterised siltstone, it is considered that (in the event of leachate overflowing from the leachate storage pond) leachate is likely to infiltrate the subsurface and migrate to groundwater.
			Shallow groundwater	Potentially complete	Based on the concentrations and trends of COPCs in the groundwater, it is considered that there are potential impacts to this aquifer on the basis of: <ul style="list-style-type: none"> <li>traces of dissolved metals exceeding applicable screening levels for marine water ecosystems, with notably greater concentrations of iron and/or zinc in bores west of Stage Three</li> <li>occurrences of ammonium and nitrate notably higher than other bores (no screening levels were adopted for these analytes) east of the Stage One landfill, and</li> <li>generally elevated concentrations of leachate indicators COD, VFA and/or TOC, with notably higher concentrations reported in shallow and/or deep bores east of Stage One and Stage Two landfills and north west of Stage Three landfill (no screening levels were adopted for these analytes).</li> </ul> COPCs present in landfill leachate in concentrations exceeding ANZECC 2000 95% marine species protection guidelines are copper, lead nickel, zinc, ammonia as N and phenols (for sample analysis conducted in January 2015). Of these, copper and zinc are present in perched groundwater exceeding ANZECC 2000 95% marine species protection guidelines.
			Down gradient shallow groundwater	Incomplete	It is considered that leachate has the potential to migrate down gradient to shallow groundwater systems. There are currently no down-gradient monitoring locations to indicate whether potential leachate impacts extend down-gradient of the Site.
			Migration to flood plain	Potentially complete	The flood plain is located down-hydraulic gradient of the Site and has the potential to be impacted from both surface water runoff and groundwater migration. King tides are reported to enter within 200 m of Stages 1 and 2 and therefore create a pathway for potentially contaminated surface water migration.
			Users of flood waters (exposure)	Potentially complete	Given potential impacts to the flood plain, there is the potential for indirect exposure (i.e. via leachate impacted surface water) to users of water in the flood plains. However, given the surrounding land uses, it is unclear whether there are any users if the flood plains down gradient of the Site and, if so, what uses the water is utilised for.

		Infiltration of landfill leachate to the regional groundwater (from vertical migration from the overlying shallow groundwater)	Regional groundwater	Incomplete	Based on the details known regarding the construction of the landfill, it appears likely that the waste mass is not in direct hydraulic connection with the regional groundwater, however head differences indicate that the potential for connection exists. Based on encountered geology as well as on differences in groundwater elevation, salinity and major ion chemistry between the shallow and regional groundwater, there is some evidence that the hydraulic connection between the shallow and the regional groundwater is limited, at least in the vicinity of the current monitoring locations. Given that there is evidence for potential leachate impacts to the shallow groundwater, this indicates a limited potential for migration from the shallow groundwater to the deeper regional groundwater.	
Landfill Leachate (Waste mounds and Leachate Storage Pond) (cont...)	Nitrogen compounds, metals, phenolic compounds, BTEXN, TRH, chloride, sodium and salinity, TOC, VFAs. (cont...)	Infiltration of landfill leachate to the regional groundwater (from vertical migration from the overlying shallow groundwater) (cont...)	Down gradient regional groundwater	Incomplete	There is evidence of limited hydraulic connection between the overlying shallow groundwater and the regional groundwater (discussed above), and thus limited potential for migration of leachate impacts to the regional groundwater, based on the current understanding of the Site. There is insufficient information to assess groundwater flow direction within the regional groundwater, although it is anticipated to be north east towards Meckit Creek and Shoal Bay.	
			Migration to Meckit Creek, Buffalo Creek and Shoal Bay	Incomplete	There is insufficient data to assess the potential for impacts to Meckit Creek, Buffalo Creek and Shoal Bay on the basis of leachate migration through the regional groundwater, although available information (as discussed above) suggests that this is hydraulic connection is limited or negligible based on the current understanding of the Site.	
Green Waste Leachate	Nitrogen compounds, metals, phenolic compounds, BTEXN, TRH, chloride, sodium and salinity, TOC, VFAs.	Environmental Monitoring	On-site Personnel/ Subcontractors (exposure)	Potentially Complete	Direct and indirect exposure to landfill leachate of on-site personnel / subcontractors may potentially occur as a result environmental monitoring activities. Direct exposure mechanisms include dermal contact and / or accidental ingestion as a result of removing leachate from the green waste ponds. Indirect exposure mechanisms include dermal contact and/or accidental ingestion of leachate impacted water.	
		Overflow from Green waste Ponds or Composting Pads	Surface Water Environment	Potentially Complete	There is the potential, particularly during periods of high rainfall, for leachate impacted waters from the green waste ponds or composting pads to overflow and migrate via overland flow to surface water features.	
			On-site Personnel & Neighbouring Land Users (exposure)	Potentially Complete	In the event of overflow at the green waste ponds or pads, exposure to green waste leachate of on-site personnel/subcontractors or neighbouring land users may potentially occur directly or indirectly. Direct exposure mechanisms include dermal contact and/or accidental ingestion as a result of clean-up activities (on or off-site). Indirect exposure mechanisms include dermal contact and/or accidental ingestion of leachate impacted water during works to (or to manage) surface water management infrastructure after overflow event or activities in and around leachate impacted surface water off-site.	
			Shallow Groundwater System	Potentially Complete	Given the surficial geology consisting of laterised siltstone, it is considered that (in the event of leachate overflowing from the green waste ponds or pads) leachate is likely to infiltrate the subsurface and migrate to the shallow groundwater.	
		Infiltration of green waste leachate to the shallow groundwater system (from vertical migration of green waste leachate through ponds and/or composting pads).	Refer to Discussion in Equivalent Section for Landfill Leachate.			
		Infiltration of green waste leachate to the deeper regional groundwater system (from vertical migration from the overlying shallow groundwater system)	Refer to Discussion in Equivalent Section for Landfill Leachate.			
Oil spills in hazardous chemical storage areas	Unknown but possibly TRH / BTEXN and other volatile / semi-volatile compounds	Migrations to stormwater drainage	Surface water environment	Potentially complete	Systematic monitoring for TRH/BTEXN and other volatile or semi volatile compounds that are likely to be associated with impacts resulting from waste oils is understood to have not been historically undertaken within the vicinity of hazardous chemical storage or down-gradient of the Site, and therefore it is currently not possible to assess if there are impacts to the groundwater or surface water environments on the basis of these compounds.	
			On-site personnel / subcontractors (exposure)			
		Infiltration of impacted waters to shallow groundwater	Shallow groundwater	Potentially complete		
			Down gradient shallow groundwater users (exposure)	Potentially complete		

## 4.7 Gaps Identified

Gaps in the conceptual hydrogeological model include:

- the relative influence of seasonal recharge on groundwater quality
- tidal interactions between saline and fresh/brackish groundwater



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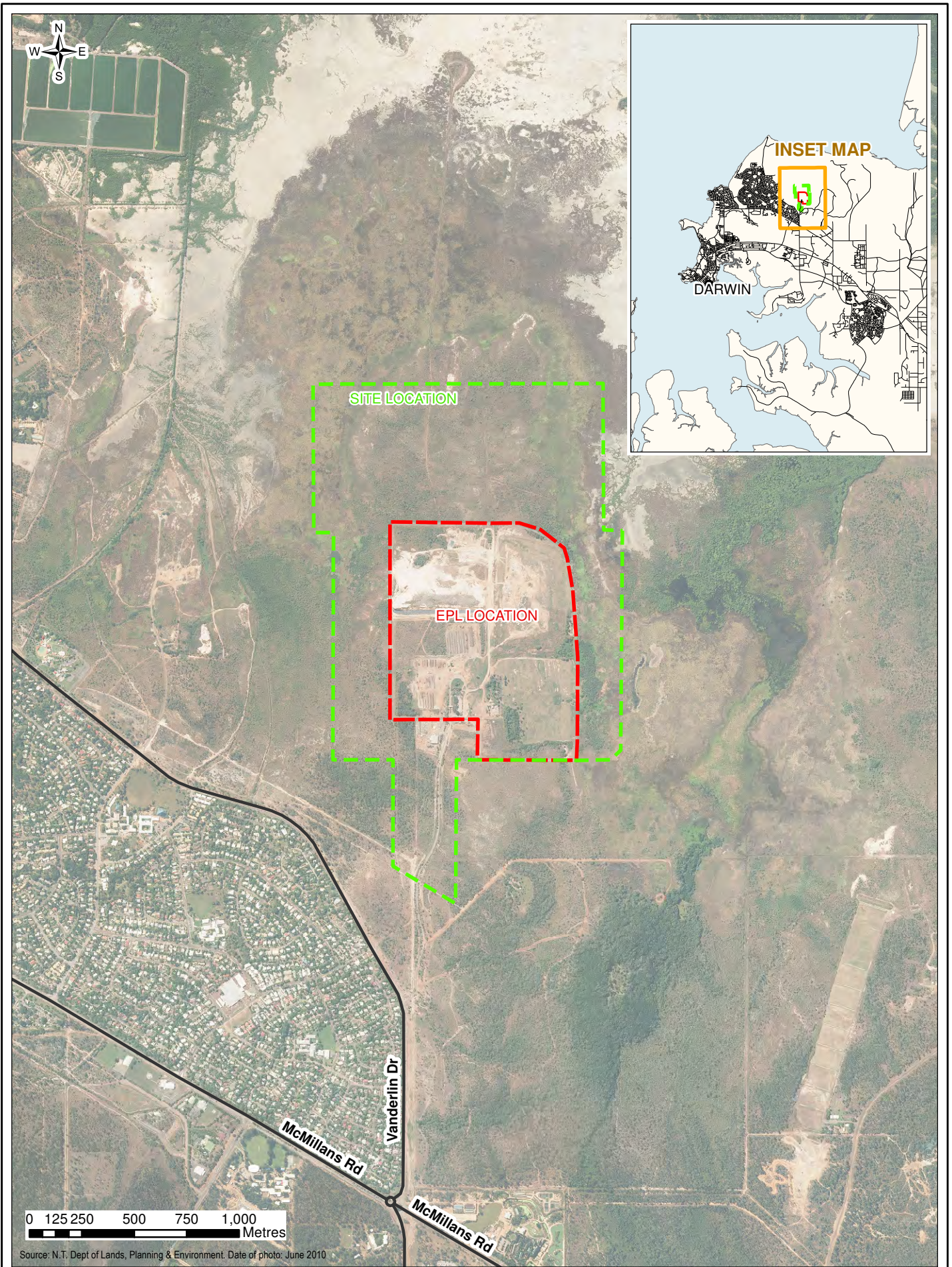
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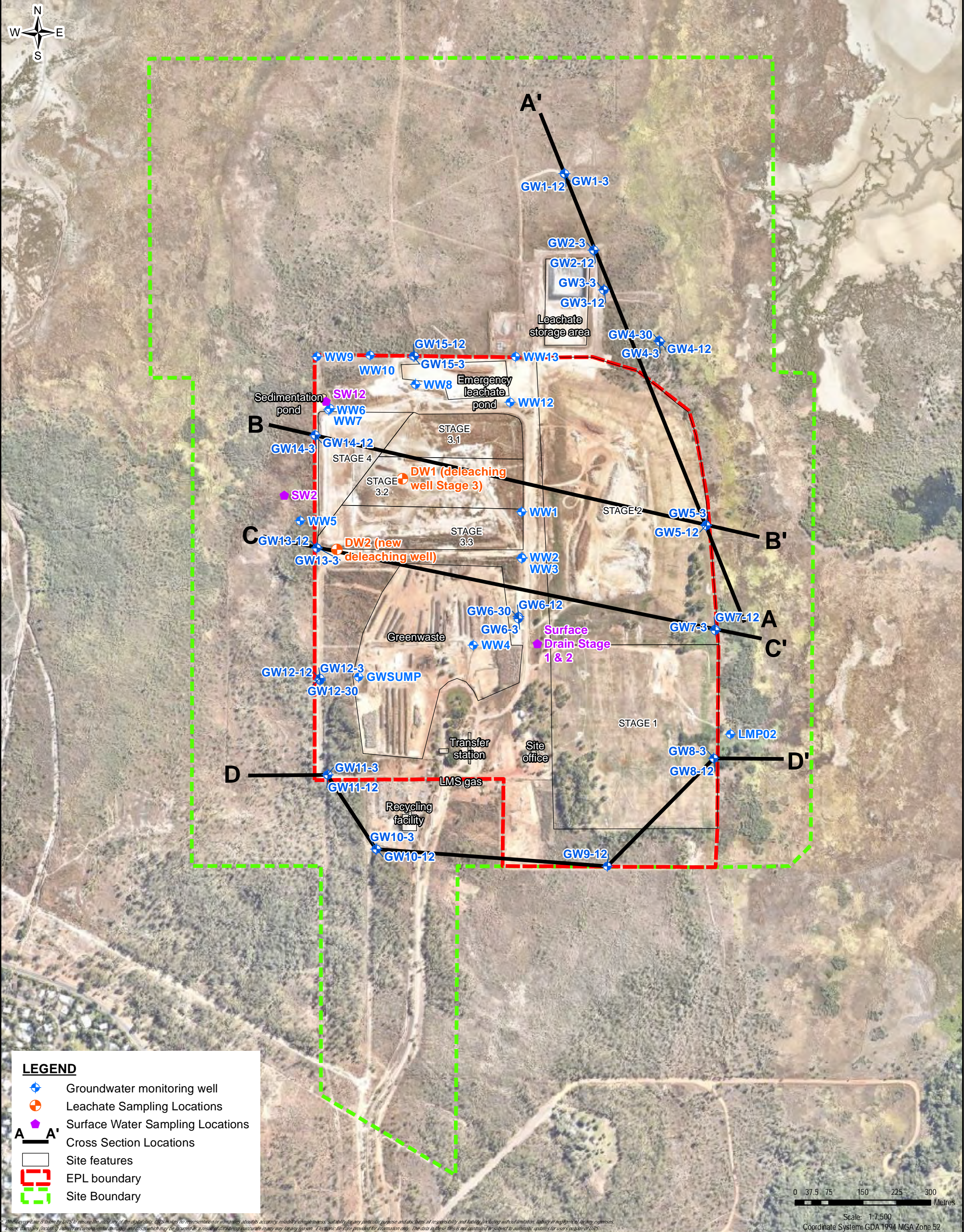




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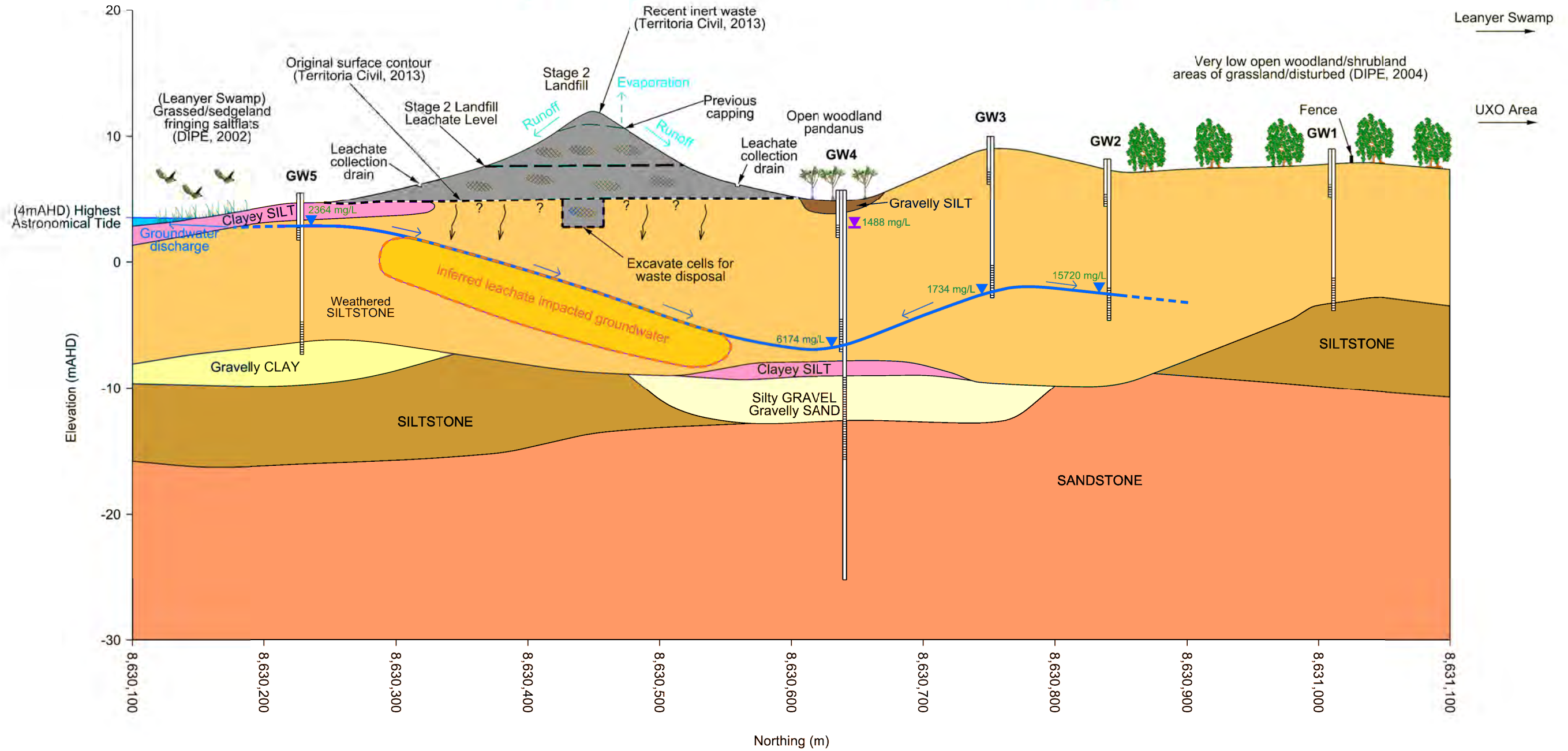
JOHN HOLLAND

**LOCATION MAP**



A  
SOUTH

A'  
NORTH



LEGEND

- Waste
- Inferred leachate impacted groundwater
- 3m Bore groundwater level (September 2015)
- 12m Bore groundwater level (September 2015)
- 30m Bore groundwater level (September 2015)
- Fugitive leachate emissions
- Groundwater seepage/flow direction
- Surface water flow direction
- 9816 mg/L Estimated field total dissolved solids (TDS)

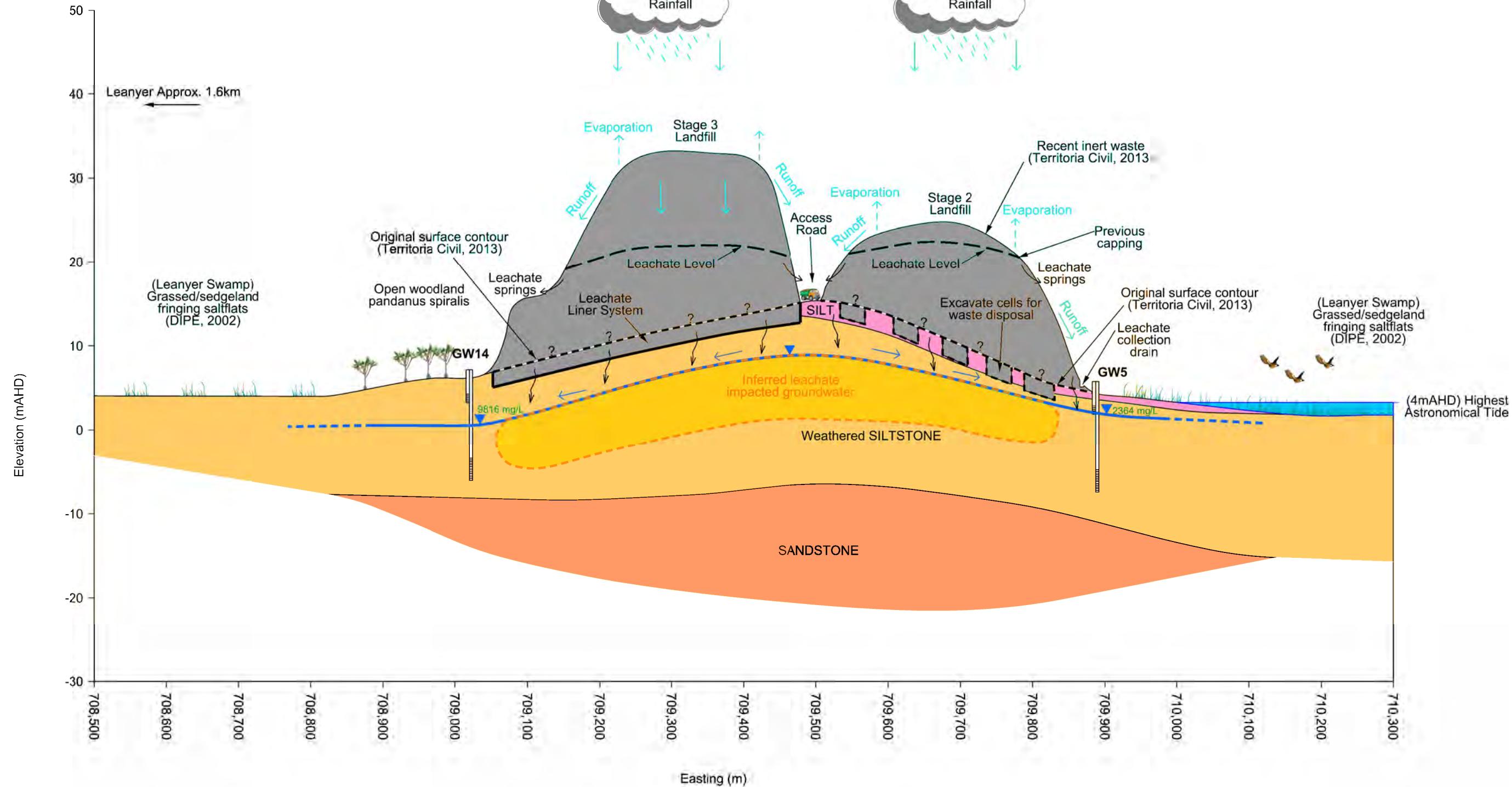
**Notes:**  
 - Schematic drawing only  
 - Leachate levels inferred only  
 Vertical Exaggeration, 1:10

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B WEST

B' EAST



LEGEND

- Waste
- Inferred leachate impacted groundwater
- 3m Bore groundwater level (September 2015)
- 12m Bore groundwater level (September 2015)
- 30m Bore groundwater level (September 2015)
- Fugitive leachate emissions
- Groundwater seepage/flow direction
- Surface water flow direction
- 9816 mg/L Estimated field total dissolved solids (TDS)

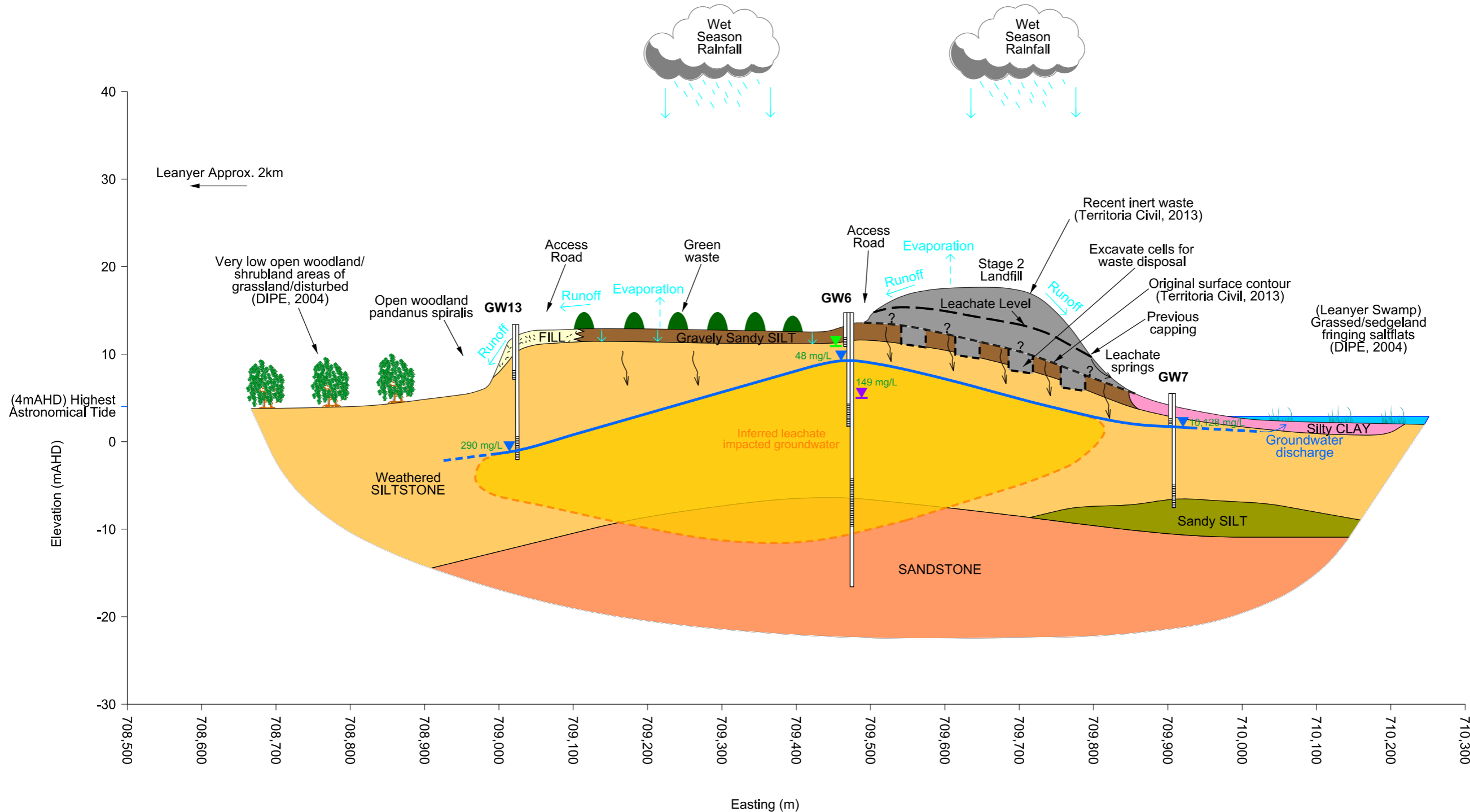
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C WEST

C' EAST



LEGEND

- Waste
- Inferred leachate impacted groundwater
- 3m Bore groundwater level (September 2015)
- 12m Bore groundwater level (September 2015)
- 30m Bore groundwater level (September 2015)
- Fugitive leachate emissions
- Groundwater seepage/flow direction
- Surface water flow direction
- 9816 mg/L Estimated field total dissolved solids (TDS)

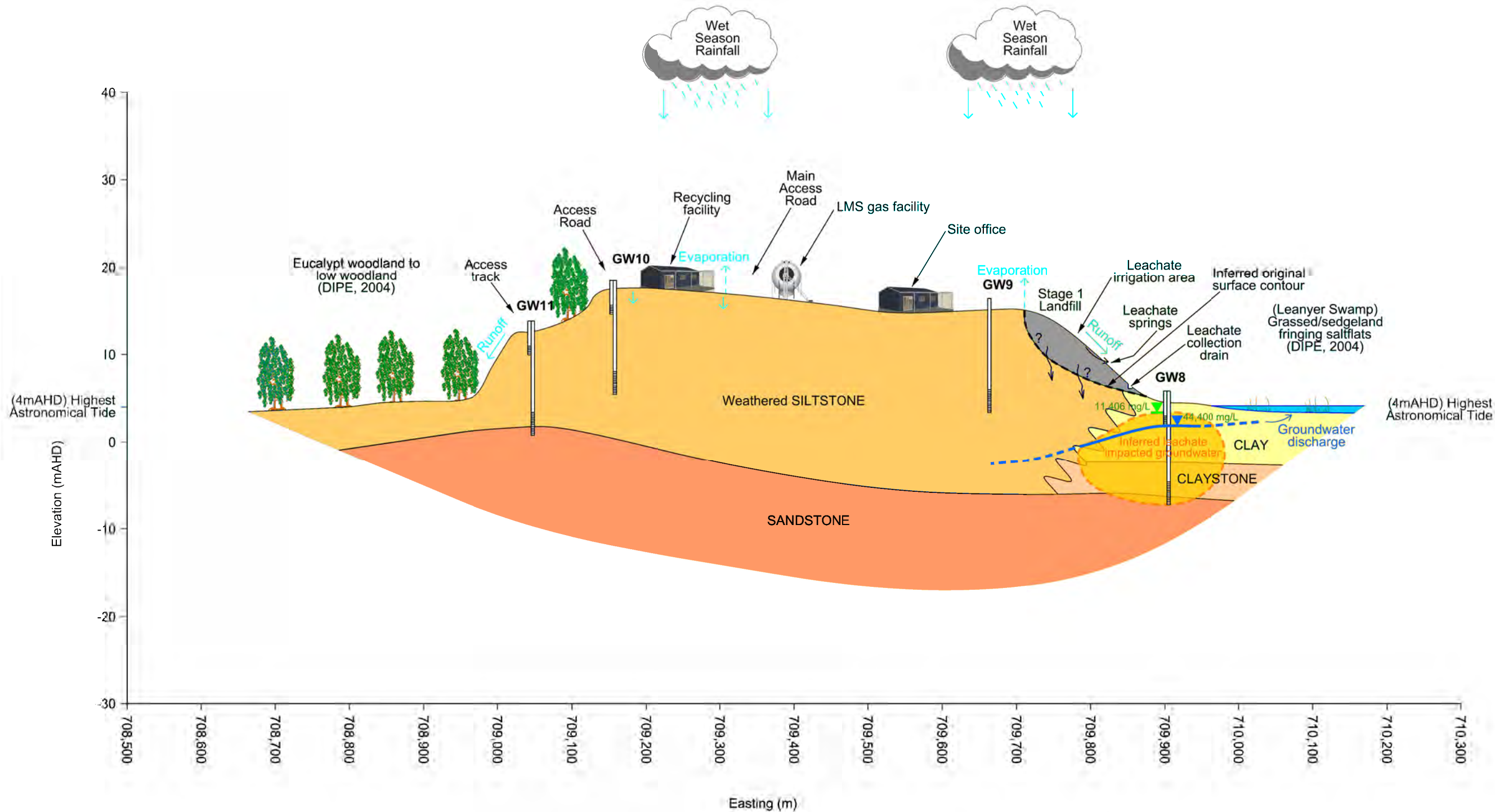
**Notes:**  
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 - Leachate levels inferred only  
 Vertical Exaggeration. 1:10

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D  
WEST

D'  
EAST



LEGEND

- Waste
- Inferred leachate impacted groundwater
- 3m Bore groundwater level (September 2015)
- 12m Bore groundwater level (September 2015)
- Fugitive leachate emissions
- Groundwater seepage/flow direction
- Surface water flow direction
- 9816 mg/L Estimated field total dissolved solids (TDS)

**Notes:**  
 - Schematic drawing only  
 - Leachate levels inferred only  
 - Cross section offset

Verticle Exaggeration, 1:10

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**APPENDIX B      GROUNDWATER ANALYSIS**

**Table-B-1 Recent Field Parameter Monitoring Results**

Borehole	Sampled Date	Oxygen (field)	Electrical Conductivity	pH (field)	Redox Potential*	Temperature	Observations
		ppm	mS/cm	pH unit	mV	°C	
GW2-12	16/9/2015	1.56	26.200	5.5	173	33.5	No odour, clear.
GW3-12	17/9/2015	1.50	2.890	5.3	123	30.2	No odour, brown, med turb.
GW4-12	16/9/2015	3.51	10.290	5.75	126	28.7	No odour, clear.
GW4-30	15/9/2015	3.01	2.480	5.94	23	31.5	No odour, clear.
GW5-12	21/9/2015	2.26	3.940	6.13	137	29.8	No odour, clear-brown, low-med turb.
GW6-12	17/9/2015	3.77	0.0796	4.85	118	33.1	No odour, brown, low turb.
GW6-30	17/9/2015	5.81	0.2480	7.28	51	31.3	No odour, brown, low turb.
GW7-12	21/9/2015	3.72	16.880	6.21	180	31.0	No odour, brown, low-med turb.
GW8-3	21/9/2015	0.20	19.010	5.59	126	31.4	No odour, clear.
GW8-12	21/9/2015	6.17	74.000	6.22	205	33.4	No odour, red-brown, med-low turb.
GW12-30	16/9/2015	3.92	0.0515	4.86	161	31.3	No odour, clear-brown, low turb.
GW13-12	17/9/2015	3.08	0.483	5.77	75	27.7	No odour, brown, high turb.
GW14-12	17/9/2015	5.26	16.360	4.47	201	29.3	No odour, brown, turb.

Legend:

ppm = parts per million

mS/cm = milliSiemens per centimetre

mV = millivolts

°C = degrees celcius

\* Redox values (Er) are expressed relative to an Ag/AgCl electrode in a saturated KCL solution, such that  $E_h = E_r + 199$

Table-B-2 Recent Groundwater Analytical Results – GW Series Bores

Borehole
Sample ID
Date Sampled
Laboratory Report Number
Sample Type

GW2-12	GW3-12	GW4-12	GW4-30	GW4-30	GW4-30	GW5-12	GW6-12	GW6-30	GW7-12
GW2_12_160915	GW3_12_170915	GW4_12_160915	GW4_30_150915	QAQC01_150915	QAQC02_150915	GW5_12_210915	GW6_12_170915	GW6_30_170915	GW_7_12_210915
9/16/2015	17/09/15	16/09/15	15/09/15	15/09/15	15/09/15	15/09/15	17/09/15	17/09/15	21/09/15
ES1531356	ES1531462	ES1531356	ES1531223	ES1531223	472621	ES1531727	ES1531462	ES1531462	ES1531727
Primary	Primary	Primary	Primary	Duplicate	Triplicate	Primary	Primary	Primary	Primary

Chem Group	Chem Name	Unit	LOR	ANZECC 2000 - Maintenance of Ecosystems Marine water 95%	GW2-12	GW3-12	GW4-12	GW4-30	GW4-30	GW4-30	GW5-12	GW6-12	GW6-30	GW7-12
Major Ions	Chloride	mg/L	1		7680	854	3260	690	696	660	1050	12	11	5340
	Calcium	mg/L	1		414	62	117	24	24	23	20	4	35	118
	Magnesium	mg/L	1		529	51	116	30	28	26	33	<1	<1	246
	Potassium	mg/L	1		42	9	49	12	11	11	22	4	8	84
	Sodium	mg/L	1		5020	481	1880	404	400	370	701	8	10	3180
	Sulphate (as SO4-)	mg/L	1		1250	103	467	70	66	25	147	32	18	736
	Total Anions	meq/L	0.01		244	26.4	102	21.8	21.9	-	34	1	2.2	168
	Total Cations	meq/L	0.01		284	28.4	98.4	21.5	21.2	-	34.8	0.74	2.39	167
	Ionic Balance	%	0.01		7.49	3.77	1.66	0.6	1.6	-	1.13	-	-	0.48
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1		68	7	1	44	43	42	65	<1	76	110
	Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<10	<1	<1	<1	<1
	Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	-	<1	<1	<1	<1
	Total Alkalinity as CaCO3	mg/L	1		68	7	1	44	43	42	65	<1	76	110
Nutrients	Ammonium (as N)	mg/L	0.01		0.04	0.03	0.04	0.07	0.05	<0.01	0.04	0.05	0.06	0.34
	Nitrate (as N)	mg/L	0.01		0.03	0.06	0.12	<0.01	<0.01	<0.02	0.08	0.25	0.05	0.16
	Nitrite (as N)	mg/L	0.01		0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01
	Nitrate & Nitrite (as N)	mg/L	0.01		0.04	0.06	0.12	<0.01	<0.01	-	0.08	0.25	0.05	0.16
	Reactive Phosphorus (as P)	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	0.02	<0.01	<0.01	0.02
Metals	Copper (Dissolved)	mg/L	0.001	0.0013	0.08	<0.001	0.039	0.002	0.002	0.002	0.003	0.011	<0.001	0.025
	Iron (Total)	mg/L	0.05		0.52	11	0.64	3.56	3.62	3.6	2.21	1.69	<0.05	10.4
	Manganese (Dissolved)	mg/L	0.001		0.055	0.313	0.489	1.51	1.49	1.6	0.011	0.021	0.258	0.428
	Zinc (Dissolved)	mg/L	0.005	0.015	0.778	0.278	0.389	0.081	0.079	0.067	0.071	0.376	0.093	0.162
Other Leachate Indicators	Total Organic Carbon	mg/L	1		2	6	17	<1	2	<5	<1	1	2	<1
	Biological Oxygen Demand	mg/L	2		<2	<2	4	4	3	<5	<2	<2	<2	<2
	Chemical Oxygen Demand	mg/L	10		50	25	110	16	15	340	50	<10	<10	168
	Volatile Acids as Acetic Acid	mg/L	5		44	16	18	14	14	<10	24	16	16	36

**Legend**  
Exceeds the Adopted Trigger Value  
 [blank] - No trigger value adopted  
 \* LOR exceeds the trigger value

Table B-2 Recent Groundwater Analytical Results –GW Series Bores (Continued)

Borehole
Sample ID
Date Sampled
Laboratory Report Number
Sample Type

GW8-3	GW8-12	GW8-12	GW8-12	GW12-30	GW12-30	GW12-30	GW13-12	GW14-12	GW14-12	GW14-12
GW8 3 210915	GW8 12 210915	QAQC07 210915	QAQC08 210915	GW12 30 160915	QAQC03 160915	QAQC04 160915	GW13 12 170915	GW14 12 2 170915	QAQC05 170915	QAQC06 170915
21/09/15	21/09/15	21/09/15	21/09/15	16/09/15	16/09/15	16/09/15	17/09/15	17/09/15	17/09/15	17/09/15
ES1531727	ES1531727	ES1531727	473201	ES1531356	ES1531356	472745	ES1531462	ES1531462	ES1531462	472991
Primary	Primary	Duplicate	Triplicate	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate

Chem Group	Chem Name	Unit	LOR	ANZECC 2000 - Maintenance of Ecosystems Marine water 95%	GW8-3	GW8-12	GW8-12	GW8-12	GW12-30	GW12-30	GW12-30	GW13-12	GW14-12	GW14-12	GW14-12
Major Ions	Chloride	mg/L	1		6470	28,700	31,500	31,000	6	6	6.9	26	5520	5640	5600
	Calcium	mg/L	1		238	1040	1030	910	2	2	2.3	3	165	177	220
	Magnesium	mg/L	1		462	1930	1930	1300	1	1	1.3	1	217	214	320
	Potassium	mg/L	1		99	346	339	360	1	1	1.3	4	62	68	83
	Sodium	mg/L	1		3410	15,200	15,300	14,000	4	4	4	15	3000	2900	3600
	Sulphate (as SO4-)	mg/L	1		1160	3560	3600	1300	6	12	<5	8	653	664	220
	Total Anions	meq/L	0.01		210	889	968	-	0.41	0.42	-	1.02	169	173	-
	Total Cations	meq/L	0.01		201	881	884	-	0.38	0.38	-	0.99	158	154	-
Ionic Balance	%	0.01		2.25	0.46	4.55	-	-	-	-	-	3.41	5.71	-	
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1		165	246	252	260	6	<1	<20	6	<1	2	<20
	Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<10	<1	<1	<10	<1	<1	<1	<10
	Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<10	<1	<1	<10	<1	<1	<1	<10
	Total Alkalinity as CaCO3	mg/L	1		165	246	252	260	6	<1	<20	6	<1	2	<20
Nutrients	Ammonium (as N)	mg/L	0.01		36.7	6.45	6.39	6.7	0.04	0.04	0.01	0.29	0.04	0.04	<0.01
	Nitrate (as N)	mg/L	0.01		1.61	<0.01	0.02	<1	0.03	0.03	<0.02	0.43	0.38	0.37	0.48
	Nitrite (as N)	mg/L	0.01		0.04	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	-
	Nitrate & Nitrite (as N)	mg/L	0.01		1.65	<0.01	0.02	-	0.03	0.03	-	0.43	0.38	0.37	-
	Reactive Phosphorus (as P)	mg/L	0.01		<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05
Metals	Copper (Dissolved)	mg/L	0.001	0.0013	0.005	0.263	0.275	0.27	0.006	0.006	0.006	<0.001	0.005	0.004	0.002
	Iron (Total)	mg/L	0.05		2.6	15.3	11.5	7.8	2.49	2.7	5.5	24.2	62.6	80.2	27
	Manganese (Dissolved)	mg/L	0.001		0.098	0.175	0.174	0.22	0.049	0.047	0.045	0.049	2.7	2.64	2.9
	Zinc (Dissolved)	mg/L	0.005	0.015	0.289	0.257	0.28	0.26	0.159	0.169	0.14	0.101	0.163	0.156	0.15
Other Leachate Indicators	Total Organic Carbon	mg/L	1		16	4	5	9.8	1	<1	<5	4	1	1	<5
	Biological Oxygen Demand	mg/L	2		<2	<2	<2	<5	<2	<2	<5	<2	<2	<2	<10
	Chemical Oxygen Demand	mg/L	10		160	<500	<500	1700	<10	<10	<20	51	118	<10	120
	Volatile Acids as Acetic Acid	mg/L	5		55	103	99	<20	12	14	<10	11	28	25	<10

**Legend**  
Exceeds the Adopted Trigger Value  
 [blank] - No trigger value adopted  
 \* LOR exceeds the trigger value

Table-B-3 Recent Groundwater Analysis - WW Series Bores

<b>Borehole</b>	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
<b>Sample Type:</b>	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
<b>Sample ID</b>	ES1602463001	ES1602463002	ES1602463003	ES1602463004	ES1602463005	ES1602463006	ES1602463007	ES1602463008	ES1602463013	ES1602463009
<b>Sample date:</b>	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
pH Value	pH Unit	0.01	5.56	5.61	6.22	5.69	6.58	6.52	6.01	6.28	7.12	7.23
Electrical Conductivity @ 25°C	µS/cm	1	175	90	61	241	7200	71100	2660	5310	2070	783
<b>Alkalinity by PC Titrator</b>												
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	4	4	6	<1	9	30	5	24	629	77
Total Alkalinity as CaCO <sub>3</sub>	mg/L	1	4	4	6	<1	9	30	5	24	629	77
<b>Sulfate (Turbidimetric) as SO<sub>4</sub><sup>2-</sup> by DA</b>												
Sulfate as SO <sub>4</sub> - Turbidimetric	mg/L	1	2	4	9	2	305	3390	113	156	5	4
<b>Chloride by Discrete Analyser</b>												
Chloride	mg/L	1	30	15	5	51	2290	27300	762	1580	213	168
<b>Dissolved Major Cations</b>												
Calcium	mg/L	1	3	2	2	2	96	1900	52	88	48	25
Magnesium	mg/L	1	2	1	<1	<1	130	2060	60	103	16	17
Sodium	mg/L	1	25	13	7	40	1240	14700	396	845	146	48
Potassium	mg/L	1	<1	<1	<1	<1	28	285	23	16	80	100
<b>Dissolved Metals by ICP-MS</b>												
Cadmium	mg/L	0.0001	<0.0001	0.0001	0.0001	0.0434	0.0002	0.0106	0.0003	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.010	<0.001	<0.001	0.003	0.004
Copper	mg/L	0.001	0.001	0.002	<0.001	0.025	0.001	<0.010	0.009	<0.001	0.005	0.007
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.018	<0.001	<0.001	<0.001	0.003
Manganese	mg/L	0.001	0.021	0.014	0.039	0.022	0.054	54	0.438	0.415	0.121	0.054
Nickel	mg/L	0.001	0.001	0.001	1.22	0.004	0.016	1.37	0.018	0.024	0.015	0.002
Zinc	mg/L	0.005	0.213	0.206	0.371	0.346	0.731	2.73	1.4	0.012	0.022	0.024
Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.05	2.3	0.97	2.83
<b>Dissolved Trivalent Chromium</b>												
Trivalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Dissolved Hexavalent Chromium</b>												
Hexavalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Ferrous Iron by Discrete Analyser</b>												
Ferrous Iron	mg/L	0.05	<0.05	<0.05	0.13	<0.05	<0.05	<0.05	<0.05	2.44	15.9	1.31
<b>Dissolved Ferric Iron by ICPMS and DA</b>												
Ferric Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	1.52

<b>Borehole</b>
<b>Sample Type:</b>
<b>Sample ID</b>
<b>Sample date:</b>

WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
ES1602463001	ES1602463002	ES1602463003	ES1602463004	ES1602463005	ES1602463006	ES1602463007	ES1602463008	ES1602463013	ES1602463009
2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
<b>Ammonia as N by Discrete Analyser</b>												
Ammonia as N	mg/L	0.01	0.07	0.06	0.08	0.09	0.05	1.54	0.04	1.3	102	0.19
<b>Organic Nitrogen as N (TKN-NH<sub>3</sub>) By Discrete Analyser</b>												
Organic Nitrogen as N	mg/L	0.1	0.6	<0.1	<0.1	0.3	<0.1	<0.5	1.6	0.2	<0.1	5.7
<b>Total Kjeldahl Nitrogen By Discrete Analyser</b>												
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.7	0.1	<0.1	0.4	0.1	1.5	1.6	1.5	101	5.9
<b>Ionic Balance</b>												
Total Anions	meq/L	0.01	0.97	0.59	0.45	1.48	71.1	841	23.9	48.3	18.7	6.36
Total Cations	meq/L	0.01	1.4	0.75	0.4	1.84	70.1	911	25.3	50	19.3	7.29
Ionic Balance	%	0.01	----	----	----	----	0.71	3.98	2.83	1.76	1.62	6.86
<b>Total Organic Carbon (TOC)</b>												
Total Organic Carbon	mg/L	1	1	<1	<1	<1	<1	<1	4	2	45	45
<b>Oxygen - Dissolved (DO)</b>												
Dissolved Oxygen	mg/L	0.1	7.4	8.2	8.9	8.5	9	8.5	8.4	6.2	6	4.1
<b>Chemical Oxygen Demand (Spectrophotometric)</b>												
Chemical Oxygen Demand	mg/L	10	<10	<10	<10	<10	<10	<200	<10	10	154	226
<b>Biochemical Oxygen Demand (BOD)</b>												
Biochemical Oxygen Demand	mg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	9	7
<b>Polychlorinated Biphenyls (PCB)</b>												
Total Polychlorinated biphenyls	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
<b>PCB Surrogate</b>												
Decachlorobiphenyl	%	0.1	114	119	126	72.7	116	121	71.8	115	100	110
<b>Phenolic Compounds</b>												
Phenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3- & 4-Methylphenol	µg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
2-Nitrophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dimethylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

<b>Borehole</b>
<b>Sample Type:</b>
<b>Sample ID</b>
<b>Sample date:</b>

WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
ES1602463001	ES1602463002	ES1602463003	ES1602463004	ES1602463005	ES1602463006	ES1602463007	ES1602463008	ES1602463013	ES1602463009
2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
Pentachlorophenol	µg/L	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
<b>Polynuclear Aromatic Hydrocarbons</b>												
Naphthalene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	<1.0
Acenaphthylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	µg/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.6	<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
<b>Phenolic Compound Surrogates</b>												
Phenol-d6	%	0.1	34.2	36.9	29.9	37.8	25.8	41.3	38	33.9	29.2	30.8
2-Chlorophenol-D4	%	0.1	66.9	70.9	58.6	70.6	52	67.1	67.8	62.4	54.8	58.4
2.4.6-Tribromophenol	%	0.1	80.8	85	71.4	92	70.6	77.9	82.1	80.2	82	70.7
<b>PAH Surrogates</b>												
2-Fluorobiphenyl	%	0.1	88.9	96.8	80.9	92.3	73.3	76.3	81	86.8	73	78.6
Anthracene-d10	%	0.1	98.4	104	98.2	111	93.5	102	100	91.6	89.1	85.7
4-Terphenyl-d14	%	0.1	70.1	76	73.7	74.9	65.5	72.1	83.4	68.5	64.5	69.8
<b>Total Petroleum Hydrocarbons</b>												
C6 - C9 Fraction	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	100	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	390	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	<50	<50	<50	<50	<50	<50	<50	<50	490	<50
<b>Total Recoverable Hydrocarbons - NEPM 2013 Fractions</b>												
C6 - C10 Fraction	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	180	<100
>C16 - C34 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	300	<100
>C34 - C40 Fraction	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

<b>Borehole</b>
<b>Sample Type:</b>
<b>Sample ID</b>
<b>Sample date:</b>

WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
ES1602463001	ES1602463002	ES1602463003	ES1602463004	ES1602463005	ES1602463006	ES1602463007	ES1602463008	ES1602463013	ES1602463009
2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	LMP02	GWSUMP
>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	480	<100
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	<100	<100	<100	<100	<100	<100	<100	180	<100
<b>BTEXN</b>												
Benzene	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
<b>TPH(V)/BTEX Surrogates</b>												
1,2-Dichloroethane-D4	%	0.1	82	91	92.3	88.5	95.7	90.7	86.9	95.3	99.9	97.3
Toluene-D8	%	0.1	82.3	107	108	99.4	111	94.7	95.8	108	126	119
4-Bromofluorobenzene	%	0.1	94.8	106	109	105	114	97	102	112	122	119
<b>Explosives</b>												
HMX	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
RDX	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
1,3,5-Trinitrobenzene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
1,3-Dinitrobenzene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Tetryl	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,4,6-TNT	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
4-Amino-2,6-DNT	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2-Amino-4,6-DNT	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
4- & 2-AM-DNT(Isomeric Mixture)	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,4-Dinitrotoluene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,6-Dinitrotoluene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,4- & 2,6-DNT(Isomeric Mixture)	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Nitrobenzene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2-Nitrotoluene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
3-Nitrotoluene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
4-Nitrotoluene	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Nitroglycerine	µg/L	200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
PETN	µg/L	200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
<b>Explosives Surrogate</b>												
o-Dinitrobenzene	%	0.1	95.1	97.7	93.6	98.9	108	94.8	93.7	97.2	93	90.4

**Table-B-4 Summary of Historical Groundwater Analysis**

<b>Bore</b>	<b>Lab pH</b>	<b>Salinity</b>	<b>Metals</b>	<b>Nutrients</b>
WW1	Acidic	Fresh	Trace metals with copper and zinc generally above adopted ANZECC guidelines.	Generally low nutrient concentrations
WW2	Acidic	Fresh	Trace metals with copper and zinc generally above adopted ANZECC guidelines.	Generally low nutrient concentrations
WW3	Slightly Acidic to Acidic	Fresh	Trace metals with nickel, zinc and copper generally above adopted ANZECC guidelines.	Generally low nutrient concentrations
WW4	Acidic	Fresh	Trace metals with cadmium, copper, nickel and zinc above adopted ANZECC guidelines.	Generally low nutrient concentrations
WW5	Slightly Acidic to Acidic	Saline	Trace metals with copper, nickel and zinc generally above adopted ANZECC guidelines. Sulfate slightly above adopted ANZECC guidelines in 2014 and 2015.	Generally low nutrient concentrations
WW6	Slightly Acidic to Acidic	Hypersaline	Trace metals with cadmium, copper, lead, nickel and zinc generally above adopted ANZECC guidelines. Sulfate exceeds adopted ANZECC guidelines.	Elevated ammonia above adopted ANZECC guideline
WW7	Acidic	Saline	Trace metals with copper, nickel and zinc generally above adopted ANZECC guidelines.	Slightly elevated nutrient concentrations with some exceedance of adopted ANZECC guidelines in ammonia
WW8	Slightly Acidic to Acidic	Saline	Trace metals with copper, nickel and zinc generally above adopted ANZECC guidelines.	Slightly elevated nutrient concentrations with some exceedance of adopted ANZECC guidelines in ammonia
LMP02	Slightly Acidic to Slightly Alkaline	Brackish	Trace metals with copper, nickel and zinc generally above adopted ANZECC guidelines.	Elevated nutrient concentrations. Ammonia generally exceeds adopted ANZECC guideline.



**APPENDIX C SURFACE WATER ANALYSIS**

**Table-C-1 Recent Surface Water Analysis**

<b>Surface Water Site</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

SW12	STG 1&2	SW2
REG	REG	REG
ES1602463010	ES1602463011	ES1602463012
2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR			
pH Value	pH Unit	0.01	7.58	7.78	7.62
Electrical Conductivity @ 25°C	µS/cm	1	778	1140	4190
<b>Alkalinity by PC Titrator</b>					
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	156	147	1040
Total Alkalinity as CaCO <sub>3</sub>	mg/L	1	156	147	1040
<b>Sulfate (Turbidimetric) as SO<sub>4</sub><sup>2-</sup> by DA</b>					
Sulfate as SO <sub>4</sub> - Turbidimetric	mg/L	1	47	114	<1
<b>Chloride by Discrete Analyser</b>					
Chloride	mg/L	1	100	190	610
<b>Dissolved Major Cations</b>					
Calcium	mg/L	1	55	79	2
Magnesium	mg/L	1	17	20	4
Sodium	mg/L	1	55	74	394
Potassium	mg/L	1	34	70	146
<b>Dissolved Metals by ICP-MS</b>					
Cadmium	mg/L	0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	0.004	0.002	0.029
Copper	mg/L	0.001	0.002	0.003	0.007
Lead	mg/L	0.001	<0.001	<0.001	0.004
Manganese	mg/L	0.001	0.193	0.12	0.011
Nickel	mg/L	0.001	0.006	0.002	0.049
Zinc	mg/L	0.005	0.012	0.011	0.073
Iron	mg/L	0.05	0.99	1.89	4.55
<b>Dissolved Trivalent Chromium</b>					
Trivalent Chromium	mg/L	0.01	<0.01	<0.01	0.03
<b>Dissolved Hexavalent Chromium</b>					
Hexavalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01
<b>Ferrous Iron by Discrete Analyser</b>					
Ferrous Iron	mg/L	0.05	1.02	0.89	4.92

<b>Surface Water Site</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

SW12	STG 1&2	SW2
REG	REG	REG
ES1602463010	ES1602463011	ES1602463012
2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR			
<b>Dissolved Ferric Iron by ICPMS and DA</b>					
Ferric Iron	mg/L	0.05	<0.05	1	<0.05
<b>Ammonia as N by Discrete Analyser</b>					
Ammonia as N	mg/L	0.01	3.17	5.41	248
<b>Organic Nitrogen as N (TKN-NH<sub>3</sub>) By Discrete Analyser</b>					
Organic Nitrogen as N	mg/L	0.1	8.2	4.6	<5.0
<b>Total Kjeldahl Nitrogen By Discrete Analyser</b>					
Total Kjeldahl Nitrogen as N	mg/L	0.1	11.4	10	236
<b>Ionic Balance</b>					
Total Anions	meq/L	0.01	6.92	10.7	38
Total Cations	meq/L	0.01	7.4	10.6	39
Ionic Balance	%	0.01	3.43	0.31	1.32
<b>Total Organic Carbon (TOC)</b>					
Total Organic Carbon	mg/L	1	78	51	152
<b>Oxygen - Dissolved (DO)</b>					
Dissolved Oxygen	mg/L	0.1	0.8	7.4	5
<b>Chemical Oxygen Demand (Spectrophotometric)</b>					
Chemical Oxygen Demand	mg/L	10	326	162	546
<b>Biochemical Oxygen Demand (BOD)</b>					
Biochemical Oxygen Demand	mg/L	2	95	<2	38
<b>Polychlorinated Biphenyls (PCB)</b>					
Total Polychlorinated biphenyls	µg/L	1	<1	<1	<1
<b>PCB Surrogate</b>					
Decachlorobiphenyl	%	0.1	125	108	104
<b>Phenolic Compounds</b>					
Phenol	µg/L	1	1.6	<1.0	<1.0
2-Chlorophenol	µg/L	1	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1	<1.0	<1.0	3.2
3- & 4-Methylphenol	µg/L	2	5.8	<2.0	<2.0
2-Nitrophenol	µg/L	1	<1.0	<1.0	<1.0
2,4-Dimethylphenol	µg/L	1	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0

<b>Surface Water Site</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

SW12	STG 1&2	SW2
REG	REG	REG
ES1602463010	ES1602463011	ES1602463012
2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR			
2,6-Dichlorophenol	µg/L	1	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	2	<2.0	<2.0	<2.0
<b>Polynuclear Aromatic Hydrocarbons</b>					
Naphthalene	µg/L	1	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1	<1.0	<1.0	<1.0
Acenaphthene	µg/L	1	<1.0	<1.0	<1.0
Fluorene	µg/L	1	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1	<1.0	<1.0	<1.0
Anthracene	µg/L	1	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1	<1.0	<1.0	<1.0
Pyrene	µg/L	1	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1	<1.0	<1.0	<1.0
Chrysene	µg/L	1	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	µg/L	1	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	µg/L	1	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	µg/L	1	<1.0	<1.0	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5	<0.5	<0.5
<b>Phenolic Compound Surrogates</b>					
Phenol-d6	%	0.1	38.6	30.8	32.6
2-Chlorophenol-D4	%	0.1	63.2	58.4	63.8
2,4,6-Tribromophenol	%	0.1	90.8	73.3	86.1
<b>PAH Surrogates</b>					
2-Fluorobiphenyl	%	0.1	92	78.4	88.7
Anthracene-d10	%	0.1	97.2	89	98.1
4-Terphenyl-d14	%	0.1	86.6	59.9	61.7
<b>Total Petroleum Hydrocarbons</b>					
C6 - C9 Fraction	µg/L	20	70	<20	40
C10 - C14 Fraction	µg/L	50	70	<50	420
C15 - C28 Fraction	µg/L	100	220	<100	1410
C29 - C36 Fraction	µg/L	50	200	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	490	<50	1830
<b>Total Recoverable Hydrocarbons - NEPM 2013 Fractions</b>					
C6 - C10 Fraction	µg/L	20	70	<20	40

<b>Surface Water Site</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

SW12	STG 1&2	SW2
REG	REG	REG
ES1602463010	ES1602463011	ES1602463012
2/02/2016	2/02/2016	2/02/2016

Analyte grouping/Analyte	Units	LOR			
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	70	<20	30
>C10 - C16 Fraction	µg/L	100	<100	<100	600
>C16 - C34 Fraction	µg/L	100	360	<100	1190
>C34 - C40 Fraction	µg/L	100	<100	<100	<100
>C10 - C40 Fraction (sum)	µg/L	100	360	<100	1790
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	<100	600
<b>BTEXN</b>					
Benzene	µg/L	1	<1	<1	1
Toluene	µg/L	2	<2	<2	3
Ethylbenzene	µg/L	2	<2	<2	3
meta- & para-Xylene	µg/L	2	<2	<2	3
ortho-Xylene	µg/L	2	<2	<2	3
Total Xylenes	µg/L	2	<2	<2	6
Sum of BTEX	µg/L	1	<1	<1	13
Naphthalene	µg/L	5	<5	<5	<5
<b>TPH(V)/BTEX Surrogates</b>					
1,2-Dichloroethane-D4	%	0.1	94.6	94	96.2
Toluene-D8	%	0.1	111	111	118
4-Bromofluorobenzene	%	0.1	110	114	118
<b>Explosives</b>					
HMX	µg/L	20	<20	<20	<20
RDX	µg/L	20	<20	<20	<20
1,3,5-Trinitrobenzene	µg/L	20	<20	<20	<20
1,3-Dinitrobenzene	µg/L	20	<20	<20	<20
Tetryl	µg/L	20	<20	<20	<20
2,4,6-TNT	µg/L	20	<20	<20	<20
4-Amino-2,6-DNT	µg/L	20	<20	<20	<20
2-Amino-4,6-DNT	µg/L	20	<20	<20	<20
4- & 2-AM-DNT(Isomeric Mixture)	µg/L	20	<20	<20	<20
2,4-Dinitrotoluene	µg/L	20	<20	<20	<20
2,6-Dinitrotoluene	µg/L	20	<20	<20	<20
2,4- & 2,6-DNT(Isomeric Mixture)	µg/L	20	<20	<20	<20
Nitrobenzene	µg/L	20	<20	<20	<20
2-Nitrotoluene	µg/L	20	<20	<20	<20
3-Nitrotoluene	µg/L	20	<20	<20	<20
4-Nitrotoluene	µg/L	20	<20	<20	<20
Nitroglycerine	µg/L	200	<200	<200	<200
PETN	µg/L	200	<200	<200	<200
<b>Explosives Surrogate</b>					
o-Dinitrobenzene	%	0.1	92.8	92.8	95.2



**APPENDIX D LEACHATE ANALYSIS**

**Table-D-1 Recent Leachate Analysis**

<b>Leachate Sample Site:</b>	DW2
<b>Sample Type:</b>	REG
<b>Sample ID:</b>	ES1602463014
<b>Sample date:</b>	2/02/2016

Analyte grouping/Analyte	Units	LOR	
pH Value	pH Unit	0.01	7.89
<b>Conductivity by PC Titrator</b>			
Electrical Conductivity @ 25°C	µS/cm	1	16300
<b>Alkalinity by PC Titrator</b>			
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	6080
Total Alkalinity as CaCO <sub>3</sub>	mg/L	1	6080
<b>Sulfate (Turbidimetric) as SO<sub>4</sub><sup>2-</sup> by DA</b>			
Sulfate as SO <sub>4</sub> - Turbidimetric	mg/L	1	16
<b>Chloride by Discrete Analyser</b>			
Chloride	mg/L	1	2220
<b>Dissolved Major Cations</b>			
Calcium	mg/L	1	34
Magnesium	mg/L	1	47
Sodium	mg/L	1	1310
Potassium	mg/L	1	555
<b>Dissolved Metals by ICP-MS</b>			
Cadmium	mg/L	0.0001	<0.0010
Chromium	mg/L	0.001	0.324
Copper	mg/L	0.001	0.013
Lead	mg/L	0.001	0.012
Manganese	mg/L	0.001	0.084
Nickel	mg/L	0.001	0.139
Zinc	mg/L	0.005	0.421
Iron	mg/L	0.05	3.62
<b>Dissolved Trivalent Chromium</b>			
Trivalent Chromium	mg/L	0.01	0.32
<b>Dissolved Hexavalent Chromium</b>			
Hexavalent Chromium	mg/L	0.01	<0.10
<b>Ferrous Iron by Discrete Analyser</b>			

<b>Leachate Sample Site:</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

DW2
REG
ES1602463014
2/02/2016

Analyte grouping/Analyte	Units	LOR	
Ferrous Iron	mg/L	0.05	3.53
<b><i>Dissolved Ferric Iron by ICPMS and DA</i></b>			
Ferric Iron	mg/L	0.05	<0.10
<b><i>Ammonia as N by Discrete Analyser</i></b>			
Ammonia as N	mg/L	0.01	1220
<b><i>Organic Nitrogen as N (TKN-NH<sub>3</sub>) By Discrete Analyser</i></b>			
Organic Nitrogen as N	mg/L	0.1	<25.0
<b><i>Total Kjeldahl Nitrogen By Discrete Analyser</i></b>			
Total Kjeldahl Nitrogen as N	mg/L	0.1	1240
<b><i>Ionic Balance</i></b>			
Total Anions	meq/L	0.01	184
Total Cations	meq/L	0.01	164
Ionic Balance	%	0.01	5.79
<b><i>Total Organic Carbon (TOC)</i></b>			
Total Organic Carbon	mg/L	1	650
<b><i>Oxygen - Dissolved (DO)</i></b>			
Dissolved Oxygen	mg/L	0.1	1.6
<b><i>Chemical Oxygen Demand (Spectrophotometric)</i></b>			
Chemical Oxygen Demand	mg/L	10	2860
<b><i>Biochemical Oxygen Demand (BOD)</i></b>			
Biochemical Oxygen Demand	mg/L	2	105
<b><i>PCB Surrogate</i></b>			
Decachlorobiphenyl	%	0.1	117
<b><i>Phenolic Compounds</i></b>			
Phenol	µg/L	1	3.9
2-Chlorophenol	µg/L	1	<1.0
2-Methylphenol	µg/L	1	20.4
3- & 4-Methylphenol	µg/L	2	8.3
2-Nitrophenol	µg/L	1	<1.0
2,4-Dimethylphenol	µg/L	1	<1.0
2,4-Dichlorophenol	µg/L	1	<1.0
2,6-Dichlorophenol	µg/L	1	<1.0
4-Chloro-3-methylphenol	µg/L	1	<1.0
2,4,6-Trichlorophenol	µg/L	1	<1.0
2,4,5-Trichlorophenol	µg/L	1	<1.0

<b>Leachate Sample Site:</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

DW2
REG
ES1602463014
2/02/2016

Analyte grouping/Analyte	Units	LOR	
Pentachlorophenol	µg/L	2	<2.0
<b>Polynuclear Aromatic Hydrocarbons</b>			
Naphthalene	µg/L	1	1.4
Acenaphthylene	µg/L	1	<1.0
Acenaphthene	µg/L	1	<1.0
Fluorene	µg/L	1	<1.0
Phenanthrene	µg/L	1	<1.0
Anthracene	µg/L	1	<1.0
Fluoranthene	µg/L	1	<1.0
Pyrene	µg/L	1	<1.0
Benz(a)anthracene	µg/L	1	<1.0
Chrysene	µg/L	1	<1.0
Benzo(b+j)fluoranthene	µg/L	1	<1.0
Benzo(k)fluoranthene	µg/L	1	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1	<1.0
Dibenz(a.h)anthracene	µg/L	1	<1.0
Benzo(g,h,i)perylene	µg/L	1	<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	1.4
Benzo(a)pyrene TEQ (zero)	µg/L	0.5	<0.5
<b>Phenolic Compound Surrogates</b>			
Phenol-d6	%	0.1	36.3
2-Chlorophenol-D4	%	0.1	56.6
2.4.6-Tribromophenol	%	0.1	69.8
<b>PAH Surrogates</b>			
2-Fluorobiphenyl	%	0.1	69.4
Anthracene-d10	%	0.1	84.9
4-Terphenyl-d14	%	0.1	48.1
<b>Total Petroleum Hydrocarbons</b>			
C6 - C9 Fraction	µg/L	20	370
C10 - C14 Fraction	µg/L	50	2350
C15 - C28 Fraction	µg/L	100	11000
C29 - C36 Fraction	µg/L	50	80
C10 - C36 Fraction (sum)	µg/L	50	13400
<b>Total Recoverable Hydrocarbons - NEPM 2013 Fractions</b>			
C6 - C10 Fraction	µg/L	20	410
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	250
>C10 - C16 Fraction	µg/L	100	2880
>C16 - C34 Fraction	µg/L	100	10000
>C34 - C40 Fraction	µg/L	100	<100
>C10 - C40 Fraction (sum)	µg/L	100	12900

<b>Leachate Sample Site:</b>
<b>Sample Type:</b>
<b>Sample ID:</b>
<b>Sample date:</b>

DW2
REG
ES1602463014
2/02/2016

Analyte grouping/Analyte	Units	LOR	
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	2870
<b>BTEXN</b>			
Benzene	µg/L	1	2
Toluene	µg/L	2	38
Ethylbenzene	µg/L	2	17
meta- & para-Xylene	µg/L	2	66
ortho-Xylene	µg/L	2	37
Total Xylenes	µg/L	2	103
Sum of BTEX	µg/L	1	160
Naphthalene	µg/L	5	7
<b>TPH(V)/BTEX Surrogates</b>			
1,2-Dichloroethane-D4	%	0.1	93.8
Toluene-D8	%	0.1	98.6
4-Bromofluorobenzene	%	0.1	113
<b>Explosives</b>			
HMX	µg/L	20	<20
RDX	µg/L	20	<20
1,3,5-Trinitrobenzene	µg/L	20	<20
1,3-Dinitrobenzene	µg/L	20	<20
Tetryl	µg/L	20	<20
2,4,6-TNT	µg/L	20	<20
4-Amino-2,6-DNT	µg/L	20	<20
2-Amino-4,6-DNT	µg/L	20	<20
4- & 2-AM-DNT(Isomeric Mixture)	µg/L	20	<20
2,4-Dinitrotoluene	µg/L	20	<20
2,6-Dinitrotoluene	µg/L	20	<20
2,4- & 2,6-DNT(Isomeric Mixture)	µg/L	20	<20
Nitrobenzene	µg/L	20	<20
2-Nitrotoluene	µg/L	20	<20
3-Nitrotoluene	µg/L	20	<20
4-Nitrotoluene	µg/L	20	<20
Nitroglycerine	µg/L	200	<200
PETN	µg/L	200	<200
<b>Explosives Surrogate</b>			
o-Dinitrobenzene	%	0.1	99.7



GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

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## Appendix H2 Groundwater Bore Search

Appendix H2 Groundwater Bore Search

Bore no	Bore name	Bore repor	Status	Yield (L/s)	Yield class	Completion	Completion	Water level	Purpose	Construction	Drilled dep	Test date
RN042231	GW17-12	http://www	Current	0.01	>0.0 - 1.0 L	00:00.0	12	3.4		Constructed&Capped	12	00:00.0
RN039229	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	30		Investigation	Observation	30	
RN039242	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039220	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039243	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039244	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039222	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039245	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	30		Investigation	Observation	30	
RN039224	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039247	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	13.5		Investigation	Observation	13.5	
RN039225	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN024628	DARWIN CITY COUNCIL SHOAL BAY DUMP	http://www	Current	0.5	>0.0 - 1.0 L	00:00.0	0	11	Investigation	Observation	49	00:00.0
RN041643	Shoal Bay Tip	http://www	Current	0 L/s		00:00.0	12	7		Constructed&Capped	12	00:00.0
RN039250	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN024627	DARWIN CITY COUNCIL SHOAL BAY DUMP	http://www	Current	1	>0.0 - 1.0 L	00:00.0	49	0	Investigation	Observation	49	00:00.0
RN039239	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN042232	GW17-3	http://www	Current	0 L/s		00:00.0	3			Constructed&Capped	3	
RN039251	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039230	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039231	Terratoria Civil ( Shoal Bay tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN037984	McMahon (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	10		Investigation	Constructed&Capped	10	
RN039233	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN037986	McMahon (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	10		Investigation	Constructed&Capped	10	
RN037987	McMahon (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	10		Investigation	Constructed&Capped	10	
RN037988	McMahon (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	10		Investigation	Others	10	
RN042234	GW18-3	http://www	Current	0 L/s		00:00.0	3			Constructed&Capped	3	
RN041642	Shoal Bay Tip	http://www	Current	1	>0.0 - 1.0 L	00:00.0	26	7		Constructed&Capped	26	00:00.0
RN042233	GW18-12	http://www	Current	0.01	>0.0 - 1.0 L	00:00.0	12	4.2		Constructed&Capped	12	00:00.0
RN041644	Shoal Bay Tip	http://www	Current	0	0 L/s	00:00.0	3	2		Constructed&Capped	3	00:00.0
RN042230	GW17-30	http://www	Current	0.1	>0.0 - 1.0 L	00:00.0	30	3.2		Constructed&Capped	30	00:00.0
RN024748	DARWIN CITY COUNCIL SHOAL BAY DUMP	http://www	Current	1	>0.0 - 1.0 L	00:00.0	60	15	Production	Constructed&Capped	87	00:00.0
RN039226	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039248	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039227	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039249	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039228	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039240	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039241	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039221	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039232	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN037985	McMahon (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	10		Investigation	Constructed&Capped	10	
RN039223	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039234	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	3		Investigation	Observation	3	
RN039235	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	12		Investigation	Observation	12	
RN039246	Terratoria Civil (Shoal Bay Tip)	http://www	Current	0 L/s		00:00.0	4.5		Investigation	Observation	4.5	

Appendix H2 Groundwater Bore Search

Bore no	Bore name	Test type	Gamma	Locality	Position ac	Monitored	Water data	Latitude	Longitude	UTM zone	Easting	Northing
RN042231	GW17-12	Airlift			GPS			-12.38	130.9258	52	709384	8630672
RN039229	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3804	130.9295	52	709776	8630625
RN039242	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3891	130.9227	52	709038	8629665
RN039220	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3908	130.9285	52	709663	8629471
RN039243	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3872	130.9226	52	709026	8629882
RN039244	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3872	130.9226	52	709026	8629882
RN039222	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3887	130.9306	52	709898	8629709
RN039245	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3872	130.9226	52	709026	8629882
RN039224	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3861	130.9306	52	709900	8629995
RN039247	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3847	130.9226	52	709028	8630157
RN039225	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.384	130.9304	52	709880	8630228
RN024628	DARWIN CITY COUNCIL SHOAL BAY DUMP	Airlift	No	SHOAL BAY DUMP	Surveyed			-12.3853	130.9359	52	710470	8630075
RN041643	Shoal Bay Tip	Airlift						-12.3858	130.9269	52	709494	8630026
RN039250	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3872	130.9224	52	709003	8629875
RN024627	DARWIN CITY COUNCIL SHOAL BAY DUMP	Airlift	No	SHOAL BAY DUMP	Surveyed			-12.3853	130.9341	52	710280	8630075
RN039239	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3905	130.9238	52	709154	8629508
RN042232	GW17-3				GPS			-12.38	130.9259	52	709386	8630672
RN039251	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3872	130.9224	52	709003	8629875
RN039230	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3793	130.9284	52	709662	8630749
RN039231	Terratoria Civil ( Shoal Bay tip)		No	Vanderlin Drive	GPS			-12.3793	130.9284	52	709662	8630749
RN037984	McMahon (Shoal Bay Tip)		No	Shoal Bay Tip	GPS			-12.3817	130.9245	52	709234	8630490
RN039233	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3785	130.9281	52	709635	8630841
RN037986	McMahon (Shoal Bay Tip)		No	Shoal Bay Tip	GPS			-12.3807	130.9245	52	709235	8630600
RN037987	McMahon (Shoal Bay Tip)		No	Shoal Bay Tip	GPS			-12.3806	130.9265	52	709458	8630600
RN037988	McMahon (Shoal Bay Tip)		No	Shoal Bay Tip	GPS			-12.3816	130.9265	52	709451	8630496
RN042234	GW18-3				GPS			-12.3795	130.9265	52	709460	8630729
RN041642	Shoal Bay Tip	Airlift			GPS			-12.3859	130.9269	52	709495	8630022
RN042233	GW18-12	Airlift			GPS			-12.3795	130.9266	52	709461	8630728
RN041644	Shoal Bay Tip	Airlift			GPS			-12.3858	130.9269	52	709494	8630030
RN042230	GW17-30	Airlift			GPS			-12.38	130.9258	52	709381	8630672
RN024748	DARWIN CITY COUNCIL SHOAL BAY DUMP	Airlift	No	SHOAL BAY DUMP	Surveyed			-12.3908	130.9245	52	709225	8629476
RN039226	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.384	130.9304	52	709880	8630228
RN039248	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3847	130.9245	52	709237	8630157
RN039227	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3804	130.9295	52	709776	8630625
RN039249	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3847	130.9245	52	709237	8630157
RN039228	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3804	130.9295	52	709776	8630625
RN039240	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3905	130.9238	52	709154	8629508
RN039241	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3891	130.9227	52	709038	8629665
RN039221	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3887	130.9306	52	709898	8629709
RN039232	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3785	130.9281	52	709635	8630841
RN037985	McMahon (Shoal Bay Tip)		No	Shoal Bay Tip	GPS			-12.3807	130.9225	52	709018	8630598
RN039223	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3861	130.9306	52	709900	8629995
RN039234	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3769	130.9275	52	709567	8631009
RN039235	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3769	130.9275	52	709567	8631009
RN039246	Terratoria Civil (Shoal Bay Tip)		No	Vanderlin Drive	GPS			-12.3847	130.9226	52	709028	8630157

Appendix H2 Groundwater Bore Search

Bore no	Bore name	Dry risk rating	Bore risk cl	Date of Ass	Bore owne	GW resource
RN042231	GW17-12	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039229	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	1			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039242	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039220	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039243	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039244	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039222	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039245	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	1			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039224	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039247	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	1			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039225	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN024628	DARWIN CITY COUNCIL SHOAL BAY DUMP	Bore not assessed	3			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN041643	Shoal Bay Tip	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039250	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN024627	DARWIN CITY COUNCIL SHOAL BAY DUMP	Bore not assessed	1			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039239	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN042232	GW17-3	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039251	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039230	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039231	Terratoria Civil ( Shoal Bay tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN037984	McMahon (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039233	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN037986	McMahon (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN037987	McMahon (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN037988	McMahon (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN042234	GW18-3	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN041642	Shoal Bay Tip	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN042233	GW18-12	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN041644	Shoal Bay Tip	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN042230	GW17-30	Bore not assessed	0			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN024748	DARWIN CITY COUNCIL SHOAL BAY DUMP	Bore not assessed	1			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039226	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039248	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039227	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039249	Terratoria Civil (Shoal Bay tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039228	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039240	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039241	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039221	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039232	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN037985	McMahon (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039223	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039234	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039235	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>
RN039246	Terratoria Civil (Shoal Bay Tip)	Bore not assessed	2			<a href="https://denr.nt.gov.au/knowyourbore">https://denr.nt.gov.au/knowyourbore</a>



## Appendix H3 Hydrogeological Investigation 2016



## Report

# Shoal Bay Waste Disposal Site Hydrogeological Investigation

AUSTRALIA



## Hydrogeological Investigation




26 November 2015  
42214019/R002/0

Prepared for:  
John Holland Pty Ltd

Prepared by URS Australia Pty Ltd



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Hydrogeological Investigation

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## ABBREVIATIONS

Abbreviation	Description
%	percentage
µm	micrometre
AHD	Australian Height Datum
ALS	Australian Laboratory Services
ANZECC	Australian and New Zealand Environment Conservation Council
bgl	below ground level
BOD	biochemical oxygen demand
BoM	Bureau of Meteorology
btoc	below top of casing
CoC	chain of custody
COD	chemical oxygen demand
CSM	Conceptual Site Model
DO	dissolved oxygen
EC	electrical conductivity
EPA	Environmental Protection Authority
EPL	Environmental Protection Licence
ERA	Ecological Risk Assessment
John Holland	John Holland Pty Ltd
km	kilometre
L/sec	litres per second
LOR	limits of reporting
m	metres
Meq/L	milliequivalents per liter
mg/L	milligram per litre
mm	millimetre
mS/cm	milliSiemens per centimetre
mV	milli Volt
NT	Northern Territory
°C	degrees Celsius
ppm	parts per million
QA/QC	quality assurance/quality control
redox	oxygen redox potential
RPD	relative percentage difference
SWL	static water level
TDS	total dissolved solids
TOC	total organic carbon
URS	URS Australia Pty Ltd
UXO	unexploded ordinance
VFA	volatile acids as acetic acid
WMP	Water Monitoring Plan

## 1 INTRODUCTION

URS Australia Pty Ltd (URS) was commissioned by John Holland Pty Ltd (John Holland) to undertake a hydrogeological assessment for the Shoal Bay Waste Disposal Site (the Site), located on Vanderlin Drive, Holmes, Northern Territory (NT) (**Figure 1, Appendix A**). The Site is operated by John Holland (trading as Territoria Civil) under a contract with the City of Darwin (Council) pursuant to an environmental protection licence No: EPL 12 – 08 (Licence) issued by the NT EPA.

The hydrogeological investigation was implemented to inform development of a conceptual site model (CSM) and environmental risk assessment (ERA) as required by the NT EPA 2013 “Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory”. Based on the guidelines, existing landfills require hydrogeological assessment where no current monitoring program exists or the current monitoring program is not adequate to determine whether the landfill is having an impact on the environment.

Identified gaps associated with the groundwater monitoring network included:

- Unexploded ordinance (UXO) area – groundwater bores area required to delineate groundwater flow direction and groundwater quality associated with the Site.
- Nominal leachate storage area –additional bores to the north and east area required to determine groundwater flow and groundwater quality.
- Landfill cells/stages 1-4/green waste areas – groundwater bores are required to delineate groundwater flow direction and groundwater quality in this area.
- Existing bores did not provide targeted screened intervals.

### 1.1 Scope of Work

The scope of work comprises:

- Supervision and lithological logging of 15 sites, comprising shallow and deep bores at each site (30 bores). Karst identification bores to be drilled at three sites (3 bores).
- Groundwater level measurement, sampling and laboratory analysis of up to 33 bores.
- Hydrogeological review of the new datasets and factual bore completion report (this report).
- Incorporate the new datasets into a CSM, ERA and provide a sampling plan methodology for a Water Monitoring Plan (WMP) (separate to this report).

This factual report summarises groundwater assessment works undertaken onsite including lithological logs, survey results, groundwater levels measurement and baseline chemical conditions in groundwater. This data will inform the CSM and ERA, which in turn will inform the WMP.

## 2 SITE DESCRIPTION

### 2.1 Location

The Site is situated approximately 12 kilometres (km) north east of the Darwin Central Business District on Vanderlin Drive, Holmes, NT (**Figure 1, Appendix A**).

### 2.2 Rainfall

Monthly Rainfall data for Darwin Airport (Station No. 014015) from 2013 to 2015 (Bureau of Meteorology [BoM], 2015), and a summary of the long-term rainfall statistics is presented in Table 2-1.

**Table 2-1 Darwin Airport – Monthly Rainfall Data (2013-2015) (BoM, 2015)**

Year	Monthly Rainfall (mm)												Annual Rainfall (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2013 (mm)	219.8	398.4	381.0	101.6	31.6	0.6	0.0	2.6	0.2	98.6	314.2	210.8	1,759.4
2014 (mm)	608.6	369.0	92.4	177.2	8.6	0.0	0.0	0.0	0.0	14.8	165.8	111.0	1,547.4
2015 (mm)	484.6	353.2	230.8	21.2	13.8	0.4	0.0	0.2	3.2	-	-	-	-
Mean* (mm)	427.1	374.3	317.9	101.1	21.1	1.8	1.2	4.8	15.1	69.9	142.1	248.9	1727.2

\* - 1941 to 2015

### 2.3 Geology

Reference to the 1:100,000 scale geological water resources maps of Darwin (Sheet 5073) indicates the presence of Quaternary unconsolidated sand, clayey sand, ferruginous clayey sand, underlain by the Orosirian Burrell Creek formation, which is typically described as siltstone, shale, sandstone and quartz pebble conglomerate metamorphosed to lower greenschist facies.

#### 2.3.1 Hydrogeology:

Groundwater information within the area (1:100,000 Water Resources Map of Darwin [Sheet 5073]) indicates that groundwater may be encountered within unconfined Quaternary sediments (sand, silt and clay) and fractured, weathered bedrock. The groundwater resources in the area are classified as minor with generally low bore yields (less than 0.5 litre per second [L/sec]); however, higher yields with low aquifer storage may be available from sand lenses within the Quaternary sediments, gravel layers that may be present at the interface of the sediments, and fractures and quartz veins within the bedrock. Total dissolved solids (TDS) concentrations less than 1000 milligrams per litre (mg/L) are expected and groundwater is considered suitable for human and animal consumption.

The 1:100,000 Water Resources Map of Darwin [Sheet 5073] identifies a karstic, high yielding aquifer, located in close proximity east of the Site which trends north-west.

### 3 GROUNDWATER DRILLING AND TESTING PROGRAM

#### 3.1 Groundwater Drilling

Thirty two groundwater monitoring bores were installed in August 2015 at fifteen sites (GW1 to GW15) within the Site (**Figure 2, Appendix A**). Drilling was completed by Bores NT drilling contractors with a track-mounted drilling rig using air-rotary and sonic methods (GW4-30 only).

Shallow and deep bores were drilled to approximately 3 and 12 metres (m) below ground level (bgl) (respectively) at sites GW1 to GW8 and GW10 to GW15 and a deep bore (12m bgl) drilled at GW9 as the lithology encountered did not warrant the installation of a shallow bore. Bore names were suffixed with “-3” for shallow bores and “-12” for deep bores at each location. The shallow bores were generally screened 1.5 to 3m bgl and the deeper bores 9 to 12m bgl.

In addition, three karst identification bores were drilled to 30m bgl at GW4, GW6 and GW12. Karst identification bore names were suffixed with “-30” at each location. A 6 m screen was installed at the approximate depth to groundwater (identified during drilling) at GW4-30 and GW6-30; bore GW12-30 was screened 14 to 30m bgl.

The groundwater monitoring bores were constructed using 50 millimetre (mm) nominal diameter uPVC casing. Machine-slotted uPVC was used for the screened section (1mm nominal aperture slots), which was gravel packed with washed filter gravel to 0.5m above the screened section. A cement seal was placed above the gravel pack to ground level. Each bore was fitted with a lockable steel monument extending approximately 0.75m above ground level.

All bores were developed using air lifting techniques.

Bore construction details are summarised in **Table 3-1**. Particularly high groundwater yields were observed during drilling of bores GW4-30 and GW6-30.

**Table 3-1 Bore Construction Details**

Bore	Easting (m)	Northing (m)	Monument Elevation (m AHD)	PVC Elevation (m AHD)	Ground Elevation (m AHD)	Screened Interval (m bgl)	Screened Interval Lithology
GW1-3	709564	8631004	8.71	8.63	8.02	1.5 - 3	Siltstone
GW1-12	709566	8631004	8.71	8.59	8.00	9 - 12	Siltstone
GW2-3	709629	8630835	8.06	7.94	7.33	1.5 - 3	Siltstone
GW2-12	709631	8630835	8.08	7.94	7.28	9 - 12	Siltstone
GW3-3	709652	8630746	9.94	9.80	9.12	1.5 - 3	Siltstone
GW3-12	709654	8630746	9.87	9.82	9.10	9 - 12	Siltstone
GW4-3	709775	8630634	5.65	5.49	4.88	1.5 - 3	Siltstone
GW4-12	709776	8630633	5.61	5.44	5.36	9 - 12	Siltstone
GW4-30	709777	8630631	5.50	5.20	5.33	15 - 21	Gravelly Sand, Sandstone
GW5-3	709880	8630224	5.51	5.41	4.70	1.5 - 3	Siltstone

Bore	Easting (m)	Northing (m)	Monument Elevation (m AHD)	PVC Elevation (m AHD)	Ground Elevation (m AHD)	Screened Interval (m bgl)	Screened Interval Lithology
GW5-12	709880	8630226	5.48	5.33	4.70	9 - 12	Siltstone, Gravelly Clay
GW6-3	709464	8630022	14.39	14.24	13.60	1.5 - 3	Gravelly Sandy Silt, Siltstone
GW6-12	709464	8630021	14.37	14.18	13.66	9 - 12	Siltstone
GW6-30	709464	8630018	14.24	14.12	13.60	17.7 - 23.7	Siltstone, Sandstone
GW7-3	709900	8629992	5.18	5.03	4.33	1.5 - 3	Siltstone
GW7-12	709900	8629994	5.16	5.08	4.33	9 - 12	Siltstone, Sandy Silt
GW8-3	709896	8629708	5.42	5.28	4.65	1.5 - 3	Claystone
GW8-12	709896	8629708	5.37	5.22	4.62	9.1 - 12.1	Claystone, Sandstone
GW9-12	709660	8629469	16.18	15.93	15.44	9 - 12	Siltstone
GW10-3	709147	8629507	18.12	18.06	17.32	1.5 - 3	Siltstone
GW10-12	709149	8629507	18.13	17.98	17.37	9.1 - 12.1	Siltstone
GW11-3	709040	8629671	13.50	13.38	12.72	1.5 - 3	Siltstone
GW11-12	709042	8629671	13.52	13.38	12.84	9 - 12	Siltstone, Sandstone
GW12-3	709024	8629881	12.20	12.07	11.44	1.5 - 3	Siltstone
GW12-12	709024	8629883	12.22	12.04	11.50	9 - 12	Siltstone
GW12-30	709024	8629885	12.21	12.05	11.55	24 - 30	Sandstone
GW13-3	709017	8630175	12.93	12.88	12.32	3 - 4.5	Siltstone
GW13-12	709016	8630174	12.91	12.86	12.25	10 - 13.5	Siltstone
GW14-3	709013	8630423	6.78	6.73	6.09	1.5 - 3	Siltstone
GW14-12	709013	8630424	6.77	6.64	6.08	9 - 12	Siltstone
GW15-3	709230	8630599	11.27	11.06	10.44	1.5 - 3	Siltstone
GW15-12	709233	8630599	11.20	11.04	10.44	9 - 12	Siltstone

Bore logs, presenting descriptions of strata and graphical well construction details, are presented in **Appendix B**.

### 3.2 Groundwater Sampling

Groundwater sampling was carried out between 15 and 17 and 21 September 2015 to assess the groundwater quality characteristics in the Project area.

Prior to sampling, static water levels (SWLs) in each bore were gauged and recorded.

Groundwater samples were collected from bores containing sufficient water quantity (13 bores), primarily using low flow sampling techniques. A peristaltic pump was used at shallow bores and a bladder pump was used at deep and karst identification bores, where bore screened interval depths exceeded the depth range of the peristaltic pump. Where groundwater yields were insufficient to allow employment of low-flow sampling techniques, the

bores were purged dry, allowed to recharge and then sampled using a dedicated, disposable bailer.

During purging, field parameters (dissolved oxygen [DO] electrical conductivity [EC], pH, temperature and oxygen redox potential [redox]) were monitored using a calibrated field instrument and recorded on a field data sheet. Copies of the field data sheets are provided in **Appendix C**. Equipment calibration records for the water meter are provided in **Appendix D**.

Once field parameters had stabilised to within acceptable criteria (United States EPA, 2010), groundwater samples were collected from the monitoring bore, field filtered (0.45 micrometre (µm) membrane) and placed in pre-preserved laboratory supplied bottles matched to the analytes. All samples were labelled and placed on ice in an insulated container prior to delivery to the laboratory for analysis.

For quality assurance / quality control (QA/QC) purposes, field duplicate and triplicate groundwater samples, field blanks and equipment rinsate blanks were collected at the time of sampling.

The primary, duplicate groundwater samples and blank samples were submitted using standard chain of custody (CoC) procedures to Australian Laboratory Services (ALS) laboratories in Smithfield, New South Wales for analytical testing. The triplicate groundwater samples were submitted to Eurofins/ MGT laboratories in Oakleigh, Victoria. Copies of the CoCs are provided in **Appendix E**.

Each of the collected groundwater samples were analysed for:

- Major ions – sodium, potassium, calcium, magnesium, alkalinity, chloride and sulphate
- Nutrients – ammonium as N, nitrate as N, reactive phosphorus as P
- Metals – iron (total), manganese, zinc and copper (dissolved)
- Other leachate indicators – total organic carbon (TOC), chemical oxygen demand (COD), biochemical oxygen demand (BOD), volatile acids as acetic acid (VFA).

### 3.2.1 Groundwater Field Results

Static groundwater levels recorded are summarised in **Table 3-2** and presented graphically in **Figure 3**.

**Table 3-2 Groundwater Levels**

Location ID	Date Gauged	Depth to Groundwater (m btoc)	Groundwater Elevation (m AHD)
GW1-3	15/09/2015	Dry	-
GW1-12	15/09/2015	Dry	-
GW2-3	15/09/2015	Dry	-
GW2-12	15/09/2015	9.97	-2.03
GW3-3	15/09/2015	Dry	-
GW3-12	15/09/2015	11.89	-2.07
GW4-3	15/09/2015	Dry	-

Location ID	Date Gauged	Depth to Groundwater (m btoc)	Groundwater Elevation (m AHD)
GW4-12	15/09/2015	11.85	-6.41
GW4-30	15/09/2015	2.27	2.93
GW5-3	15/09/2015	Dry	-
GW5-12	15/09/2015	2.29	3.04
GW6-3	15/09/2015	3.61	10.63
GW6-12	15/09/2015	4.5	9.68
GW6-30	15/09/2015	9.21	4.91
GW7-3	15/09/2015	Dry	-
GW7-12	15/09/2015	2.48	2.60
GW8-3	15/09/2015	1.65	3.63
GW8-12	15/09/2015	3.2	2.02
GW9-12	15/09/2015	Dry	-
GW10-3	15/09/2015	Dry	-
GW10-12	15/09/2015	Dry	-
GW11-3	15/09/2015	Dry	-
GW11-12	15/09/2015	Dry	-
GW12-3	15/09/2015	Dry	-
GW12-12	15/09/2015	Dry	-
GW12-30	15/09/2015	13.21	-1.16
GW13-3	15/09/2015	Dry	-
GW13-12	15/09/2015	13.78	-0.92
GW14-3	15/09/2015	Dry	-
GW14-12	15/09/2015	7.57	-0.93
GW15-3	15/09/2015	Dry	-
GW15-12	15/09/2015	Dry	-

### 3.3 Groundwater Quality

Groundwater field parameters are presented in **Table 3-4** and analytical results are presented in **Table 3-5**. Certificates of analysis are presented in **Appendix E**.

#### *Analytical Screening Levels*

The Australian and New Zealand Environment Conservation Council (ANZECC) (2000) *Australian and New Zealand Guidelines for Marine and Freshwater quality* trigger values for protection of 95% of marine ecosystems have been adopted for comparison to groundwater analytical results as per the Facilities EPL 12.

These screening levels are relevant to the protection of the environment and do not address potential human health risks.

**Table 3-3 Field Parameter Monitoring Results**

Borehole	Sampled Date	Oxygen (field)	Electrical Conductivity	pH (field)	Redox Potential*	Temperature	Observations
		ppm	mS/cm	pH unit	mV	°C	
GW2-12	16/9/2015	1.56	26.200	5.5	173	33.5	No odour, clear.
GW3-12	17/9/2015	1.50	2.890	5.3	123	30.2	No odour, brown, med turb.
GW4-12	16/9/2015	3.51	10.290	5.75	126	28.7	No odour, clear.
GW4-30	15/9/2015	3.01	2.480	5.94	23	31.5	No odour, clear.
GW5-12	21/9/2015	2.26	3.940	6.13	137	29.8	No odour, clear-brown, low-med turb.
GW6-12	17/9/2015	3.77	79.600	4.85	118	33.1	No odour, brown, low turb.
GW6-30	17/9/2015	5.81	0.248	7.28	51	31.3	No odour, brown, low turb.
GW7-12	21/9/2015	3.72	16.880	6.21	180	31.0	No odour, brown, low-med turb.
GW8-3	21/9/2015	0.20	19.010	5.59	126	31.4	No odour, clear.
GW8-12	21/9/2015	6.17	74.000	6.22	205	33.4	No odour, red-brown, med-low turb.
GW12-30	16/9/2015	3.92	51.500	4.86	161	31.3	No odour, clear-brown, low turb.
GW13-12	17/9/2015	3.08	0.483	5.77	75	27.7	No odour, brown, high turb.
GW14-12	17/9/2015	5.26	16.360	4.47	201	29.3	No odour, brown, turb.

Legend:

ppm = parts per million

mS/cm = milliSiemens per centimetre

mV = millivolts

°C = degrees celcius

\* Redox values (Er) are expressed relative to an Ag/AgCl electrode in a saturated KCL solution, such that  $E_h = E_r + 199$

Table 3-4 Groundwater Analytical Results

Borehole
Sample ID
Date Sampled
Laboratory Report Number
Sample Type

GW2-12	GW3-12	GW4-12	GW4-30	GW4-30	GW4-30	GW5-12	GW6-12	GW6-30	GW7-12
GW2_12_160915	GW3_12_170915	GW4_12_160915	GW4_30_150915	QAQC01_150915	QAQC02_150915	GW5_12_210915	GW6_12_170915	GW6_30_170915	GW_7_12_210915
9/16/2015	17/09/15	16/09/15	15/09/15	15/09/15	15/09/15	15/09/15	17/09/15	17/09/15	21/09/15
ES1531356	ES1531462	ES1531356	ES1531223	ES1531223	472621	ES1531727	ES1531462	ES1531462	ES1531727
Primary	Primary	Primary	Primary	Duplicate	Triplicate	Primary	Primary	Primary	Primary

Chem Group	Chem Name	Unit	LOR	ANZECC 2000 - Maintenance of Ecosystems Marine water 95%	GW2-12	GW3-12	GW4-12	GW4-30	GW4-30	GW4-30	GW5-12	GW6-12	GW6-30	GW7-12
Major Ions	Chloride	mg/L	1		7680	854	3260	690	696	660	1050	12	11	5340
	Calcium	mg/L	1		414	62	117	24	24	23	20	4	35	118
	Magnesium	mg/L	1		529	51	116	30	28	26	33	<1	<1	246
	Potassium	mg/L	1		42	9	49	12	11	11	22	4	8	84
	Sodium	mg/L	1		5020	481	1880	404	400	370	701	8	10	3180
	Sulphate (as SO4-)	mg/L	1		1250	103	467	70	66	25	147	32	18	736
	Total Anions	meq/L	0.01		244	26.4	102	21.8	21.9	-	34	1	2.2	168
	Total Cations	meq/L	0.01		284	28.4	98.4	21.5	21.2	-	34.8	0.74	2.39	167
	Ionic Balance	%	0.01		7.49	3.77	1.66	0.6	1.6	-	1.13	-	-	0.48
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1		68	7	1	44	43	42	65	<1	76	110
	Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<10	<1	<1	<1	<1
	Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	-	<1	<1	<1	<1
	Total Alkalinity as CaCO3	mg/L	1		68	7	1	44	43	42	65	<1	76	110
Nutrients	Ammonium (as N)	mg/L	0.01		0.04	0.03	0.04	0.07	0.05	<0.01	0.04	0.05	0.06	0.34
	Nitrate (as N)	mg/L	0.01		0.03	0.06	0.12	<0.01	<0.01	<0.02	0.08	0.25	0.05	0.16
	Nitrite (as N)	mg/L	0.01		0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01
	Nitrate & Nitrite (as N)	mg/L	0.01		0.04	0.06	0.12	<0.01	<0.01	-	0.08	0.25	0.05	0.16
	Reactive Phosphorus (as P)	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	0.02	<0.01	<0.01	0.02
Metals	Copper (Dissolved)	mg/L	0.001	0.0013	0.08	<0.001	0.039	0.002	0.002	0.002	0.003	0.011	<0.001	0.025
	Iron (Total)	mg/L	0.05		0.52	11	0.64	3.56	3.62	3.6	2.21	1.69	<0.05	10.4
	Manganese (Dissolved)	mg/L	0.001		0.055	0.313	0.489	1.51	1.49	1.6	0.011	0.021	0.258	0.428
	Zinc (Dissolved)	mg/L	0.005	0.015	0.778	0.278	0.389	0.081	0.079	0.067	0.071	0.376	0.093	0.162
Other Leachate Indicators	Total Organic Carbon	mg/L	1		2	6	17	<1	2	<5	<1	1	2	<1
	Biological Oxygen Demand	mg/L	2		<2	<2	4	4	3	<5	<2	<2	<2	<2
	Chemical Oxygen Demand	mg/L	10		50	25	110	16	15	340	50	<10	<10	168
	Volatile Acids as Acetic Acid	mg/L	5		44	16	18	14	14	<10	24	16	16	36

**Legend**  
Exceeds the Adopted Trigger Value  
 [blank] - No trigger value adopted  
 \* LOR exceeds the trigger value

Table 3-4 Groundwater Analytical Results (Continued)

Borehole
Sample ID
Date Sampled
Laboratory Report Number
Sample Type

GW8-3	GW8-12	GW8-12	GW8-12	GW12-30	GW12-30	GW12-30	GW13-12	GW14-12	GW14-12	GW14-12
GW8_3_210915	GW8_12_210915	QAQC07_210915	QAQC08_210915	GW12_30_160915	QAQC03_160915	QAQC04_160915	GW13_12_170915	GW14_12_2_170915	QAQC05_170915	QAQC06_170915
21/09/15	21/09/15	21/09/15	21/09/15	16/09/15	16/09/15	16/09/15	17/09/15	17/09/15	17/09/15	17/09/15
ES1531727	ES1531727	ES1531727	473201	ES1531356	ES1531356	472745	ES1531462	ES1531462	ES1531462	472991
Primary	Primary	Duplicate	Triplicate	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate

Chem Group	Chem Name	Unit	LOR	ANZECC 2000 - Maintenance of Ecosystems Marine water 95%	GW8-3	GW8-12	GW8-12	GW8-12	GW12-30	GW12-30	GW12-30	GW13-12	GW14-12	GW14-12	GW14-12
Major Ions	Chloride	mg/L	1		6470	28,700	31,500	31,000	6	6	6.9	26	5520	5640	5600
	Calcium	mg/L	1		238	1040	1030	910	2	2	2.3	3	165	177	220
	Magnesium	mg/L	1		462	1930	1930	1300	1	1	1.3	1	217	214	320
	Potassium	mg/L	1		99	346	339	360	1	1	1.3	4	62	68	83
	Sodium	mg/L	1		3410	15,200	15,300	14,000	4	4	4	15	3000	2900	3600
	Sulphate (as SO4-)	mg/L	1		1160	3560	3600	1300	6	12	<5	8	653	664	220
	Total Anions	meq/L	0.01		210	889	968	-	0.41	0.42	-	1.02	169	173	-
	Total Cations	meq/L	0.01		201	881	884	-	0.38	0.38	-	0.99	158	154	-
Ionic Balance	%	0.01		2.25	0.46	4.55	-	-	-	-	-	3.41	5.71	-	
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1		165	246	252	260	6	<1	<20	6	<1	2	<20
	Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<10	<1	<1	<10	<1	<1	<1	<10
	Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<10	<1	<1	<10	<1	<1	<1	<10
	Total Alkalinity as CaCO3	mg/L	1		165	246	252	260	6	<1	<20	6	<1	2	<20
Nutrients	Ammonium (as N)	mg/L	0.01		36.7	6.45	6.39	6.7	0.04	0.04	0.01	0.29	0.04	0.04	<0.01
	Nitrate (as N)	mg/L	0.01		1.61	<0.01	0.02	<1	0.03	0.03	<0.02	0.43	0.38	0.37	0.48
	Nitrite (as N)	mg/L	0.01		0.04	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	-
	Nitrate & Nitrite (as N)	mg/L	0.01		1.65	<0.01	0.02	-	0.03	0.03	-	0.43	0.38	0.37	-
	Reactive Phosphorus (as P)	mg/L	0.01		<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05
Metals	Copper (Dissolved)	mg/L	0.001	0.0013	0.005	0.263	0.275	0.27	0.006	0.006	0.006	<0.001	0.005	0.004	0.002
	Iron (Total)	mg/L	0.05		2.6	15.3	11.5	7.8	2.49	2.7	5.5	24.2	62.6	80.2	27
	Manganese (Dissolved)	mg/L	0.001		0.098	0.175	0.174	0.22	0.049	0.047	0.045	0.049	2.7	2.64	2.9
	Zinc (Dissolved)	mg/L	0.005	0.015	0.289	0.257	0.28	0.26	0.159	0.169	0.14	0.101	0.163	0.156	0.15
Other Leachate Indicators	Total Organic Carbon	mg/L	1		16	4	5	9.8	1	<1	<5	4	1	1	<5
	Biological Oxygen Demand	mg/L	2		<2	<2	<2	<5	<2	<2	<5	<2	<2	<2	<10
	Chemical Oxygen Demand	mg/L	10		160	<500	<500	1700	<10	<10	<20	51	118	<10	120
	Volatile Acids as Acetic Acid	mg/L	5		55	103	99	<20	12	14	<10	11	28	25	<10

**Legend**  
Exceeds the Adopted Trigger Value  
 [blank] - No trigger value adopted  
 \* LOR exceeds the trigger value

## *Analytical Data Validation*

To assess the reliability of the laboratory analytical results, the following was examined:

- frequency of laboratory QA/QC
- number of tests reported versus that requested
- sample handling, preservation and holding times;
- use of appropriate laboratory limits of reporting (LORs);
- analysis of blanks;
- relative percentage differences (RPDs) between primary, duplicate and triplicate sample results
- use of matrix spikes and surrogate recoveries.

The data validation findings indicate that the groundwater analytical data can be used as a basis for interpretation, subject to the limitations outlined in the Data Validation Summary Report provided as **Appendix E**.

## 4 CONCLUSIONS

Thirty two bores were installed at 15 targeted locations across the Site in August 2015, comprising 14 shallow (approximately 3m bgl), 15 deep (approximately 12m bgl), and three karst identification bores (30m bgl).

Groundwater level measurements, sampling and laboratory analysis were undertaken in newly installed groundwater bores in September 2015.

The Site is characterised in hydrogeological terms by having:

- aquifers that are present in transmissive fractures in partly to highly weathered bedrock
- variable water table gradients, with groundwater depths indicative of upward hydraulic gradient north east of the stage two landfill, and downward hydraulic gradient in the centre of the Site (between stage one and stage two)
- highly variable terrestrial groundwater quality, with:
  - salinities that range from fresh to hypersaline
  - near-neutral to slightly acidic pH
  - predominantly sodium and chloride water types, with some carbonate/bicarbonate and/or calcium types present at one deep and two karst identification bores located in the centre of the Site (between stage one and stage two) and west of the recycling facility.
  - traces of dissolved metals that sometimes exceed applicable screening levels for marine water ecosystems, with notably greater concentrations of iron and/or zinc in bores west of stage three
  - generally low nutrient concentrations, with the exception of one location east of the stage one landfill that reported occurrences of ammonium and nitrate notably higher than other bores (no screening levels were adopted for these analytes)
  - generally elevated concentrations of leachate indicators COD, VFA and/or TOC, with notably higher concentrations reported in shallow and/or deep bores east of stage one and stage two landfills and north west of stage three landfill

The newly acquired datasets will inform the CSM, ERA and WMP.

## REFERENCES

Australian and New Zealand Environment Conservation Council (ANZECC) 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

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[http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p\\_nccObsCode=139&p\\_display\\_type=da taFile&p\\_startYear=&p\\_c=&p\\_stn\\_num=014015](http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=da taFile&p_startYear=&p_c=&p_stn_num=014015) , accessed 5/5/2015.

Pietsch, B.A. 1983. Darwin 1:100,000 Geological Sheet 5073. 1:100,000 Geological Series. Northern Territory Geological Survey, Darwin.

Verma, M. N. 2004, Water Resources Map of Darwin 1:100,000, Map Sheet 5073, Edition 2, Department of Infrastructure, Planning and the Environment, Darwin.

United States Environmental Protection Agency (EPA) 2010, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW 001, Rev 3, United States Environmental Protection Agency, North Chelmsford, Massachusetts.

## LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of John Holland Pty Ltd (John Holland) and only those third parties who have been authorised in writing by URS to rely on the report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the contract T101-010 variation 8 dated 16 June 2015.

The methodology adopted and sources of information used by URS are outlined in this the Report.

Where this report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information unless required as part of the agreed scope of work. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 17 August 2014 and 6 November 2015. The information in this report is considered to be accurate at the date of issue and is in accordance with conditions at the Site at the dates sampled. Opinions and recommendations presented herein apply to the site existing at the time of our investigation and cannot necessarily apply to site changes of which URS is not aware and has not had the opportunity to evaluate. This document and the information contained herein should only be regarded as validly representing the site conditions at the time of the investigation unless otherwise explicitly stated in a preceding section of this report. URS disclaims responsibility for any changes that may have occurred after this time.

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. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the uniformity of conditions and on the frequency and method of sampling 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 in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

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

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time.

Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Except as required by law, no third party may use or rely on, this Report unless otherwise agreed by URS in writing. Where such agreement is provided, URS will provide a letter of reliance to the agreed third party in the form required by URS.

To the extent permitted by law, URS expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. URS does not admit that any action, liability or claim may exist or be available to any third party.

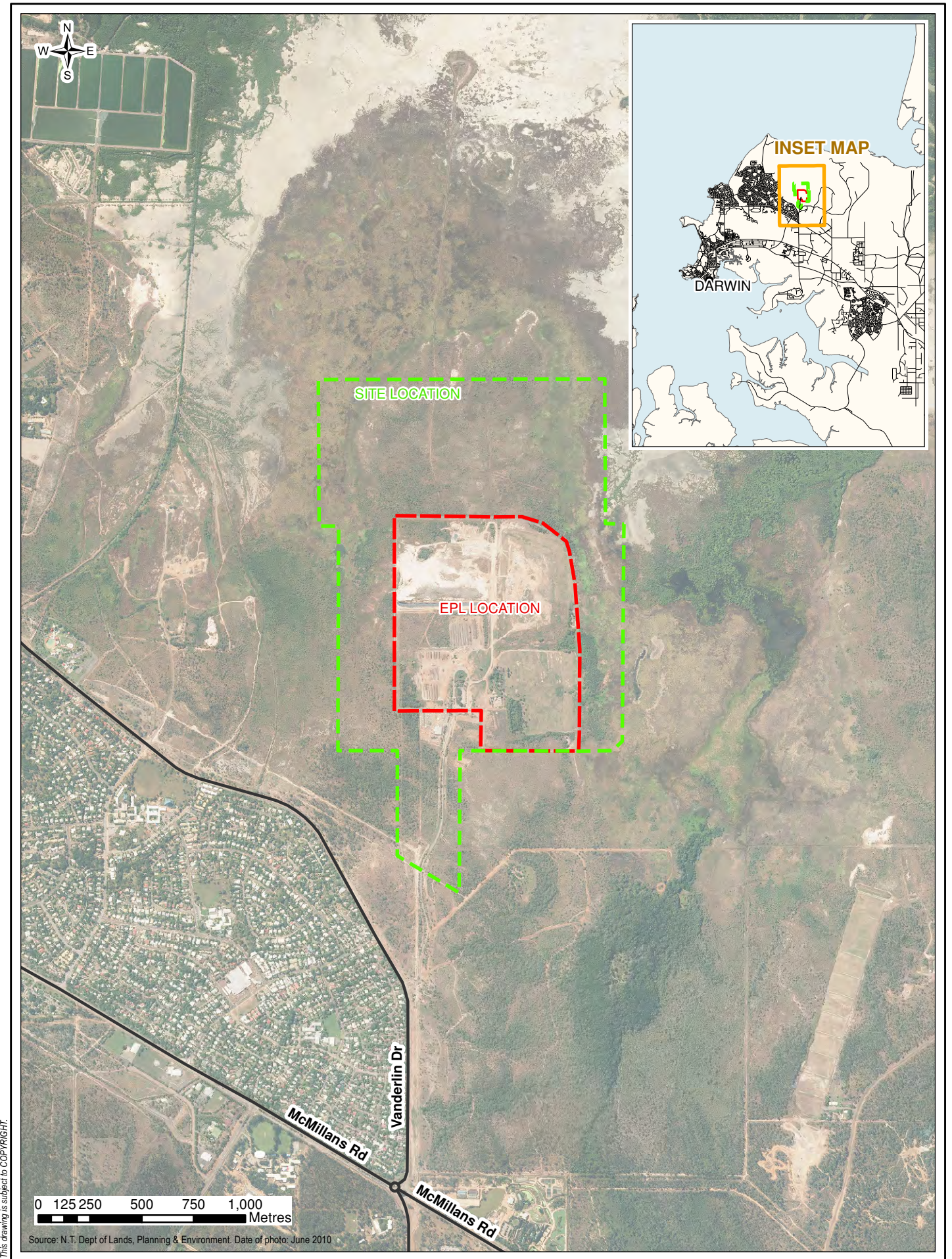
URS does not represent that this Report is suitable for use by any third party.

Except as specifically stated in this section, URS does not authorise the use of this Report by any third party.

It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the relevant property.

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





JOHN HOLLAND

LOCATION MAP



SHOAL BAY LANDFILL

File No: 42213996-001.mxd

Drawn: SS

Approved: KT

Date: 25/11/2015

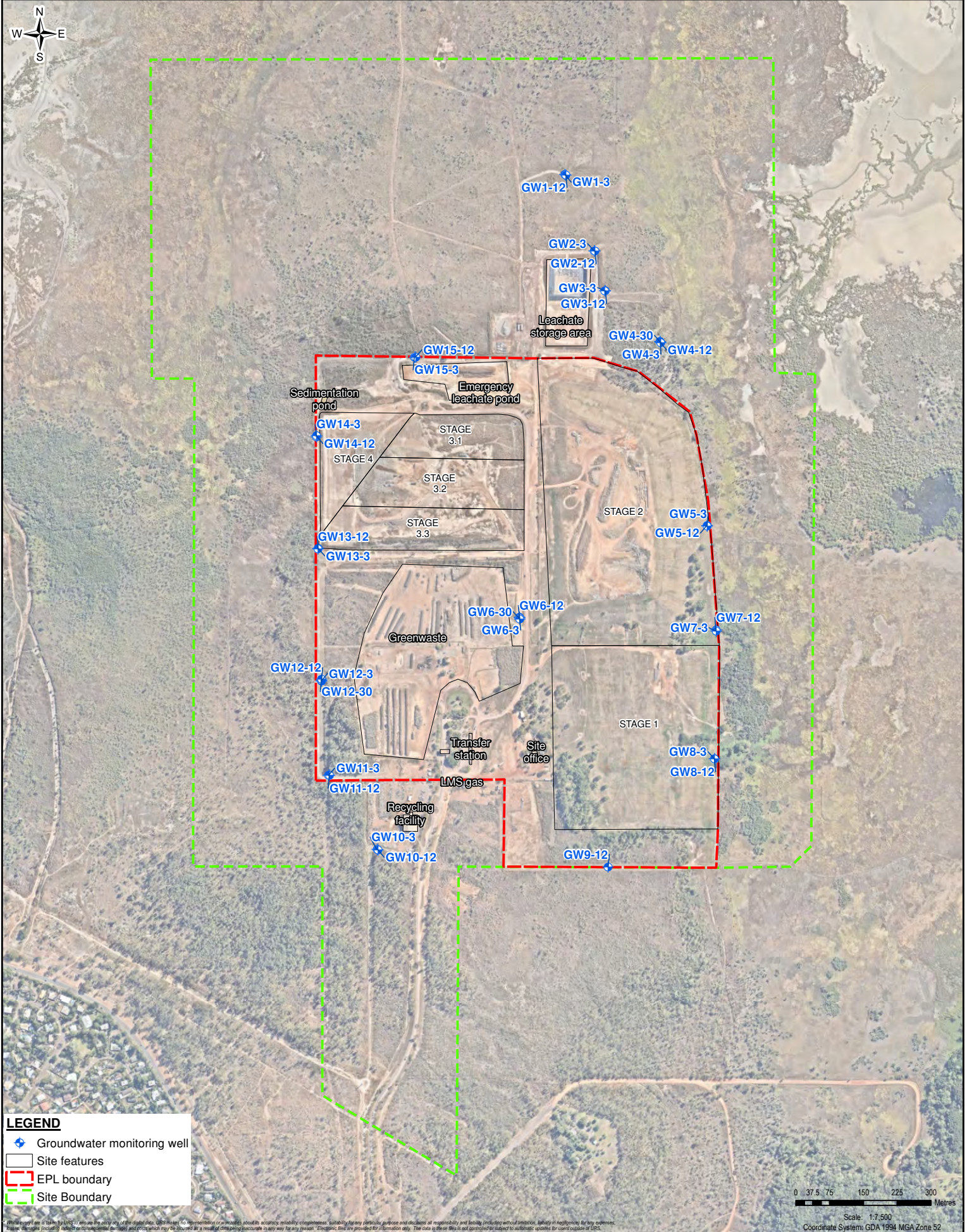
Figure:

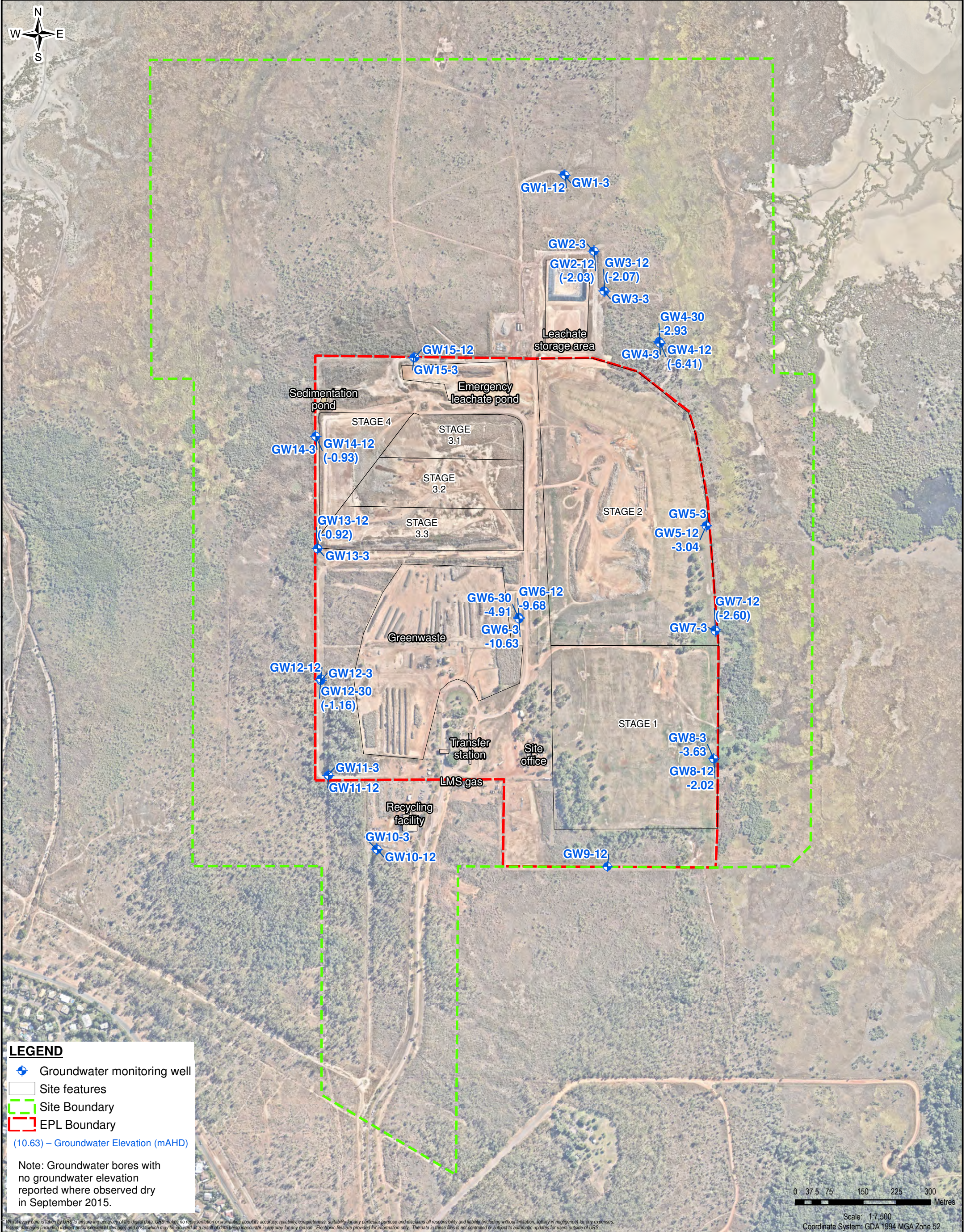
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**APPENDIX B      BORE CONSTRUCTION LOGS**

## MONITORING WELL GW1-3

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project Reference: **Shoal Bay Hydrogeological Drilling**

Client: **John Holland**  
Location: **Shoal Bay Landfill**

Drilling Contractor: **Bores NT**

Project No.: **42214019**

Logged By: **K Treglown**  
Checked By: **C MacHunter**  
Date Started: **18-8-15**  
Date Finished: **18-8-15**

Bore Size: **107 mm**  
Total Depth: **3.00 m**  
Casing Size: **50 mm**

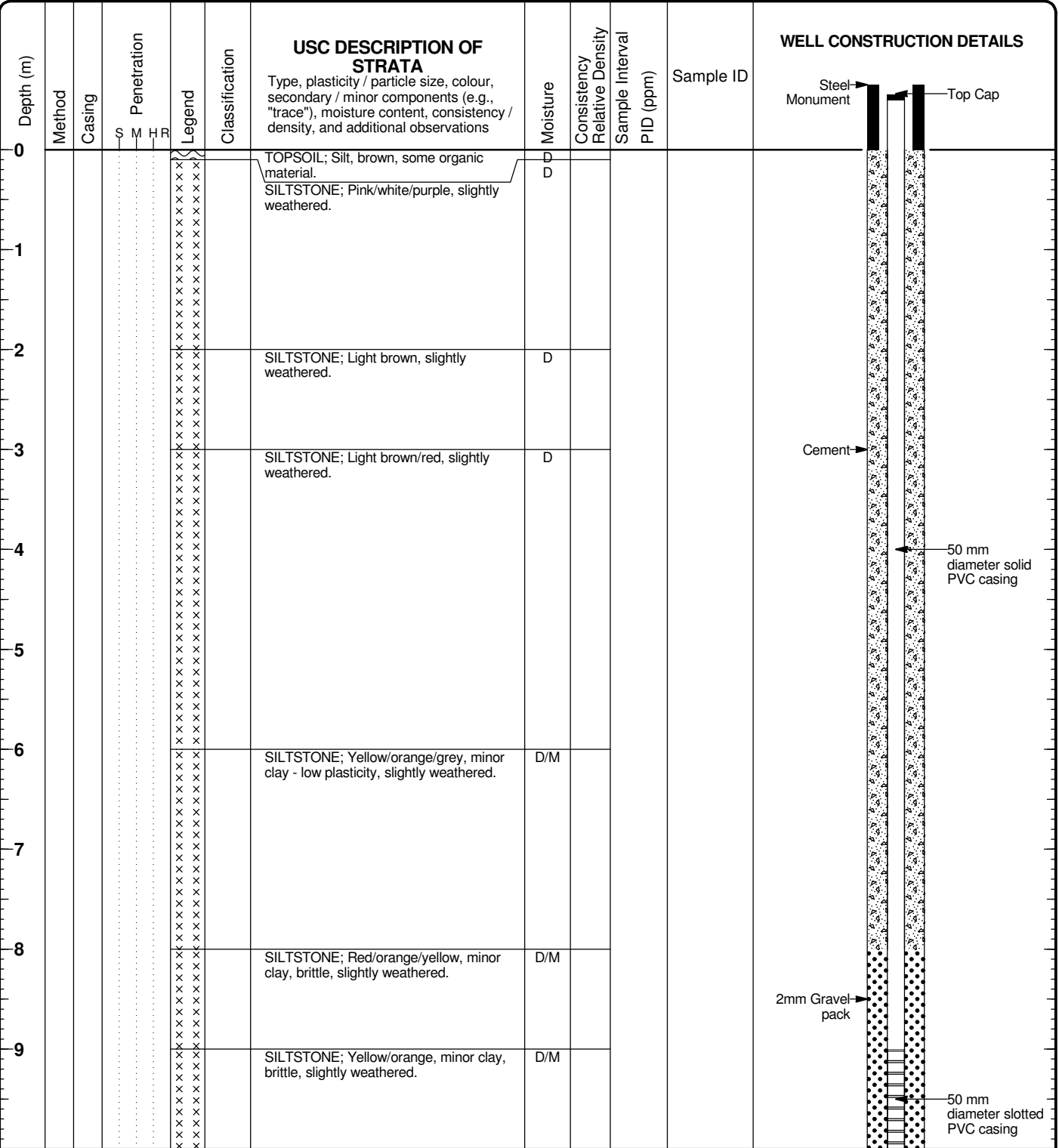
Relative Level: **8.63**  
Coordinates: **8631004.40 mN**  
**709564.36 mE**  
Permit No: **RN39234**

Drill Type: **Air Rotary**  
Drill Model: **Sonic Samp Drill**  
Drill Fluid: **Nil**

Depth (m)	Method	Casing	Penetration S M HR	Legend	Classification	USC DESCRIPTION OF STRATA				Sample ID	WELL CONSTRUCTION DETAILS
						Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density		
0						TOPSOIL; Silt, brown, some organic material.	D				
0-1						SILTSTONE; Pink/white/purple, slightly weathered.	D				
1-2											
2-3						SILTSTONE; Light brown, slightly weathered.	D				
3-4											
4-5											
5-6											
6-7											
7-8											
8-9											

## MONITORING WELL GW1-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>8.59</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8631004.14 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709566.34 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>		Permit No: <b>RN39235</b>		



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## MONITORING WELL GW1-12

 URS Australia Pty Ltd  
 Level 3, 93 Mitchell St DARWIN NT 0800

 Phone (08) 8980 2900  
 Fax (08) 8941 3920

 Project No.: **42214019**

 Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						x x x x x x x x x x x x x x x		SILTSTONE; Orange/white/yellow, minor clay, brittle, slightly weathered.	D/M						
11						x x x x x x x x x x x x x x x		SILTSTONE; Orange/white/yellow, minor clay, brittle, slightly weathered.	D/M						
12															End Cap
13															
14															
15															
16															
17															
18															
19															
20															
21															

## MONITORING WELL GW2-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>7.94</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8630834.63 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>19-8-15</b>	Casing Size: <b>50 mm</b>	<b>709629.19 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>19-8-15</b>		Permit No: <b>RN39232</b>		

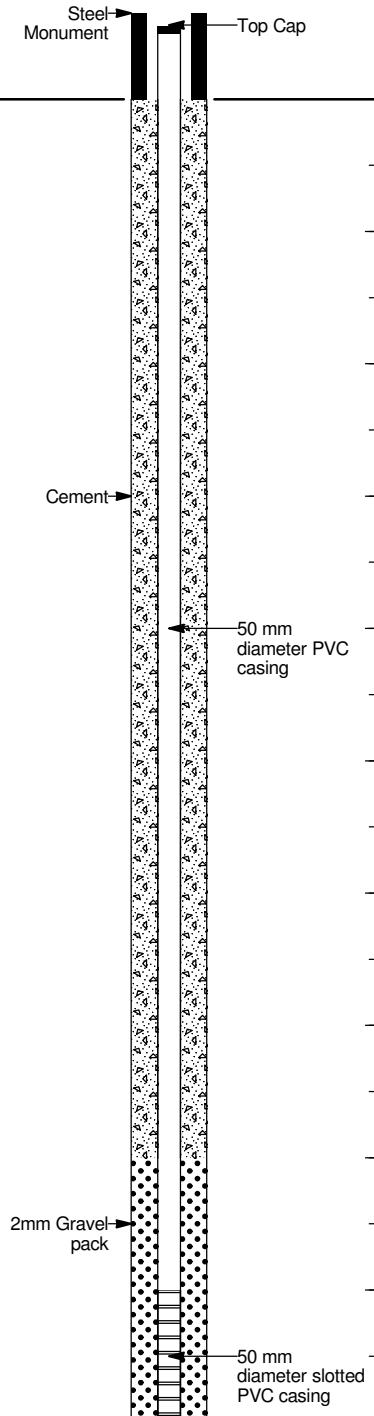
Depth (m)	Method	Casing	Penetration S M HR	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
0						TOPSOIL; Gravelly Silt, brown.	D						
0-1						SILTSTONE; White/minor purple, slightly weathered.	D						
1-2													
2-3						SILTSTONE; Pink/white/purple, slightly weathered.	D						
3-4													
4-5													
5-6													
6-7													
7-8													
8-9													

## MONITORING WELL GW2-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>7.94</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630834.64 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>19-8-15</b>	Casing Size: <b>50 mm</b>	<b>709631.12 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>19-8-15</b>		Permit No: <b>RN39233</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						TOPSOIL; Gravelly Silt, brown. SILTSTONE; Pink/white/purple, slightly weathered.	D								
1															
2															
3						SILTSTONE; Light brown/light red, slightly weathered.	D								
4															
5						SILTSTONE; Red/minor white mottle, slightly weathered.	D								
6						SILTSTONE; Yellow/orange, minor clay, brittle, slightly weathered.	D								
7						SILTSTONE; Red/light purple/yellow, minor clay content, brittle, slightly weathered.	D								
8						SILTSTONE; Yellow/light purple/red, minor clay content, brittle, slightly weathered.	D								
9						SILTSTONE; Orange/yellow, minor clay content, brittle, slightly weathered.	M								

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## MONITORING WELL GW2-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						xxxxx		SILTSTONE; Light yellow/orange, minor clay content, brittle, slightly weathered.	M						
11						xxxxx		SILTSTONE; Black.	M						
12						xxxxx									End Cap
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW3-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920		Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>		Client: <b>John Holland</b>	
Drilling Contractor: <b>Bores NT</b>				Project No.: <b>42214019</b>		Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>		Bore Size: <b>107 mm</b>		Relative Level: <b>9.80</b>		Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>		Total Depth: <b>3.00 m</b>		Coordinates: <b>8630746.18 mN</b>		Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>		Casing Size: <b>50 mm</b>		709652.49 mE		Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>				Permit No.: <b>RN39231</b>			

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS			
			S	M	H										R	Steel Monument	Top Cap	
0						x x x x x		SILTSTONE; Pink/purple/white, minor gravel, slightly weathered.	D							Steel Monument	Top Cap	
1						x x x x x		SILTSTONE; Pink/purple/white, slightly weathered.	D								Cement	50 mm diameter PVC casing
2						x x x x x											2mm Gravel pack	50 mm diameter slotted PVC casing
3						x x x x x												End Cap
4																		
5																		
6																		
7																		
8																		
9																		

## MONITORING WELL GW3-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>9.82</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630746.02 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709654.26 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>		Permit No: <b>RN39230</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										Steel Monument	Top Cap
0						XXXXXX	SILTSTONE; Pink/purple/white, minor gravel, slightly weathered.	D								
1						XXXXXX	SILTSTONE; Red/purple/orange/white, slightly weathered.	D								
2						XXXXXX	SILTSTONE; Red/purple/white, slightly weathered.	D								
3						XXXXXX	SILTSTONE; White/pink, slightly weathered.	D								
4						XXXXXX	SILTSTONE; White/pink/light brown, slightly weathered.	D								
5						XXXXXX	SILTSTONE; White/pink/grey/purple, slightly weathered.	D								
6						XXXXXX										
7						XXXXXX										
8						XXXXXX	SILTSTONE; Orange/ light purple, slightly weathered.	D								
9						XXXXXX										


## MONITORING WELL GW3-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXX		SILTSTONE; Yellow/grey/purple, minor clay content, brittle, slightly weathered.	D/M						
11						XXXXX		SILTSTONE; Yellow/purple, minor clay content, brittle, slightly weathered.	D/M						
12						XXXXX									
13															
14															
15															
16															
17															
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ENVIRO\_WELL\_ADELAIDE\_MCC\_AUS\_GDT J:\DRW\42214019\5 WORKS\LOGS\42214019-BORELOGS.GPJ 23/10/15

## MONITORING WELL GW4-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920		Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>		Client: <b>John Holland</b>	
Drilling Contractor: <b>Bores NT</b>				Project No.: <b>42214019</b>		Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>		Bore Size: <b>107 mm</b>		Relative Level: <b>5.49</b>		Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>		Total Depth: <b>3.00 m</b>		Coordinates: <b>8630634.09 mN</b>		Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>		Casing Size: <b>50 mm</b>		Coordinates: <b>709775.36 mE</b>		Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>				Permit No.: <b>RN39227</b>			

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA				Sample ID	WELL CONSTRUCTION DETAILS		
						Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density		Sample Interval	PID (ppm)	Diagram Labels
0					Gravelly SILT		D					Steel Monument	Top Cap
0-1					SILTSTONE; Orange/white, slightly weathered.		D					Cement	50 mm diameter PVC casing
1-2					SILTSTONE; Orange/white/light red, slightly weathered.		D					2mm Gravel-pack	50 mm diameter slotted PVC casing
2-3													End Cap
3-4													
4-5													
5-6													
6-7													
7-8													
8-9													

ENVIRO\_WELL\_ADELAIDE MCC\_AUS.GDT J:\DRW\42214019\5 WORKS\LOGS\42214019-BORELOGS.GPJ 23/10/15

## MONITORING WELL GW4-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.44</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630632.64 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709776.29 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>		Permit No: <b>RN39228</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										R	Steel Monument
0							SILTSTONE; Light orange, slightly weathered.	D								
1							SILTSTONE; White/light red, slightly weathered.	D								
2																
3							SILTSTONE; White/light red/red, slightly weathered.	D								
4							SILTSTONE; White/light red/orange, slightly weathered.	D								
5							SILTSTONE; White/orange, slightly weathered.	D								
6							SILTSTONE; Orange/brown/red, minor clay, brittle, slightly weathered.	D								
7							SILTSTONE Clay; Orange/red, minor clay, brittle, slightly weathered.	D								
8																
9																


## MONITORING WELL GW4-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXX		SILTSTONE; Yellow/white, minor clay, brittle, slightly weathered.	D						 End Cap
11						XXXXX									
12						XXXXX									
13						XXXXX									
14						XXXXX									
15						XXXXX									
16						XXXXX									
17						XXXXX									
18						XXXXX									
19						XXXXX									
20						XXXXX									
21						XXXXX									

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## MONITORING WELL GW4-30

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown/J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.20</b>	Drill Type: <b>Air Rotary/Sonic</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>30.00 m</b>	Coordinates: <b>8630631.14 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709777.27 mE</b>	Drill Fluid: <b>Drill Mud</b>	
Date Finished: <b>24-8-15</b>		Permit No: <b>RN39229</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										R	Steel Monument
0						XXXXXX	SILTSTONE; Light orange/white, slightly weathered.	D								
1						XXXXXX	SILTSTONE; White/light red, slightly weathered.	D								
2						XXXXXX										
3						XXXXXX	SILTSTONE; White/red/minor purple, slightly weathered.	D								
4						XXXXXX	SILTSTONE; White/red/orange, slightly weathered.	D								
5						XXXXXX										
6						XXXXXX	SILTSTONE; White/orange, slightly weathered.	D								
7						XXXXXX	SILTSTONE; Orange/red, minor clay, brittle, slightly weathered.	D								
8						XXXXXX										
9						XXXXXX	SILTSTONE; Orange/red, minor gravel, sub rounded, slightly weathered.	D								

## MONITORING WELL GW4-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXXX	SILTSTONE; Yellow, minor clay, brittle, slightly weathered.	D							<p>50 mm diameter slotted PVC casing</p> <p>2mm Gravel pack</p>
11						XXXXXX	SILTSTONE; Yellow/white, slightly weathered.	D							
12						XXXXXX									
13						XXXXXX	Clayey SILT; Yellow.	W							
14						XXXXXX	Silty GRAVEL; sub angular, sub rounded.	W							
15						XXXXXX	Gravelly SAND; Yellow, sub rounded gravel to 4cm, coarse sand.	W							
16						XXXXXX	Gravelly SAND; Yellow, rounded/sub rounded gravel to 5-6cm.	W							
17						XXXXXX	SANDSTONE; Yellow, minor sub rounded/rounded gravel, coarse grained sand (~1mm).	W							
18						XXXXXX									
19						XXXXXX	SANDSTONE; Light yellow, coarse grained sand (~1mm).	W							
20						XXXXXX									
21						XXXXXX	SANDSTONE; Orange/yellow.								

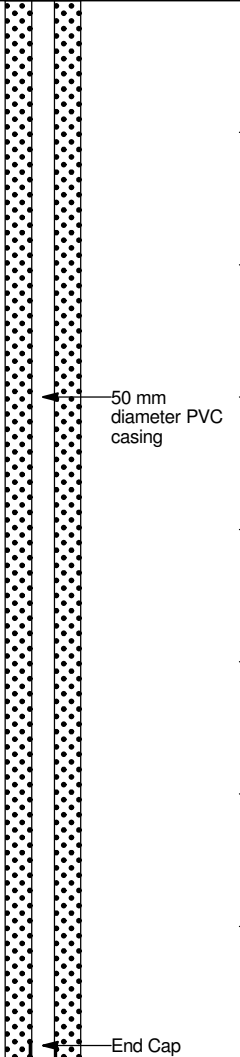
## MONITORING WELL GW4-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency Relative Density	Sample Interval PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H								
22							SANDSTONE; White.						 <p>50 mm diameter PVC casing</p> <p>End Cap</p>
23													
24													
25													
26													
27							SANDSTONE; Light brown.						
28													
29													
30													
31													
32													
33													

## MONITORING WELL GW5-3

 URS Australia Pty Ltd  
 Level 3, 93 Mitchell St DARWIN NT 0800

 Phone (08) 8980 2900  
 Fax (08) 8941 3920

 Project Reference: **Shoal Bay Hydrogeological Drilling**

 Client: **John Holland**  
 Location: **Shoal Bay Landfill**

 Drilling Contractor: **Bores NT**

 Project No.: **42214019**

 Logged By: **K Treglown**  
 Checked By: **C MacHunter**  
 Date Started: **18-8-15**  
 Date Finished: **18-8-15**

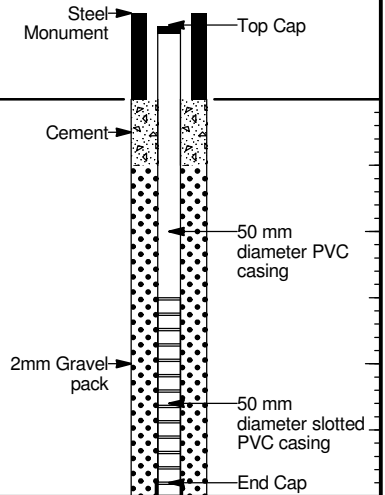
 Bore Size: **107 mm**  
 Total Depth: **3.00 m**  
 Casing Size: **50 mm**

 Relative Level: **5.41**  
 Coordinates: **8630224.39 mN**  
**709880.00 mE**  
 Permit No.: **RN39226**

 Drill Type: **Air Rotary**  
 Drill Model: **Sonic Samp Drill**  
 Drill Fluid: **Nil**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										R	Steel Monument
0						XXXXXX	SILT; Orange, minor clay, minor angular gravel.	D								
1						XXXXXX	SILTSTONE; Yellow/brown/white, slightly weathered.	D								
2						XXXXXX	SILTSTONE; Orange/white, slightly weathered.	D								
3						XXXXXX										
4																
5																
6																
7																
8																
9																

### WELL CONSTRUCTION DETAILS



## MONITORING WELL GW5-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.33</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630226.20 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709879.83 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>		Permit No: <b>RN39225</b>		

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						Clayey SILT; Orange/white, low plasticity clay, minor angular gravel.	D								
1						SILTSTONE; Yellow/brown/white, slightly weathered.	D								
2						SILTSTONE; Orange/white, slightly weathered.	D								
3						SILTSTONE; White/red, slightly weathered.	D								
4						SILTSTONE; Orange/red/grey, minor clay content, brittle, slightly weathered.	D								
5						SILTSTONE; Yellow/orange, slightly weathered.	D								
6						SILTSTONE; White/orange, slightly weathered.	D								
7						SILTSTONE; Orange, minor clay content, brittle, slightly weathered.	D								
8						SILTSTONE; Orange/white, minor clay content, brittle, slightly weathered.	D								
9															


## MONITORING WELL GW5-12

 URS Australia Pty Ltd  
 Level 3, 93 Mitchell St DARWIN NT 0800

 Phone (08) 8980 2900  
 Fax (08) 8941 3920

 Project No.: **42214019**

 Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	<b>USC DESCRIPTION OF STRATA</b> Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H	R									
10								SILTSTONE; Yellow/white, clayey, plastic, slightly weathered.	M						
11							Gravelly CLAY; Orange/brown, minor sand, low - medium plasticity clay, sub angular gravel (some quartz gravel).	M							
12															End Cap
13															
14															
15															
16															
17															
18															
19															
20															
21															

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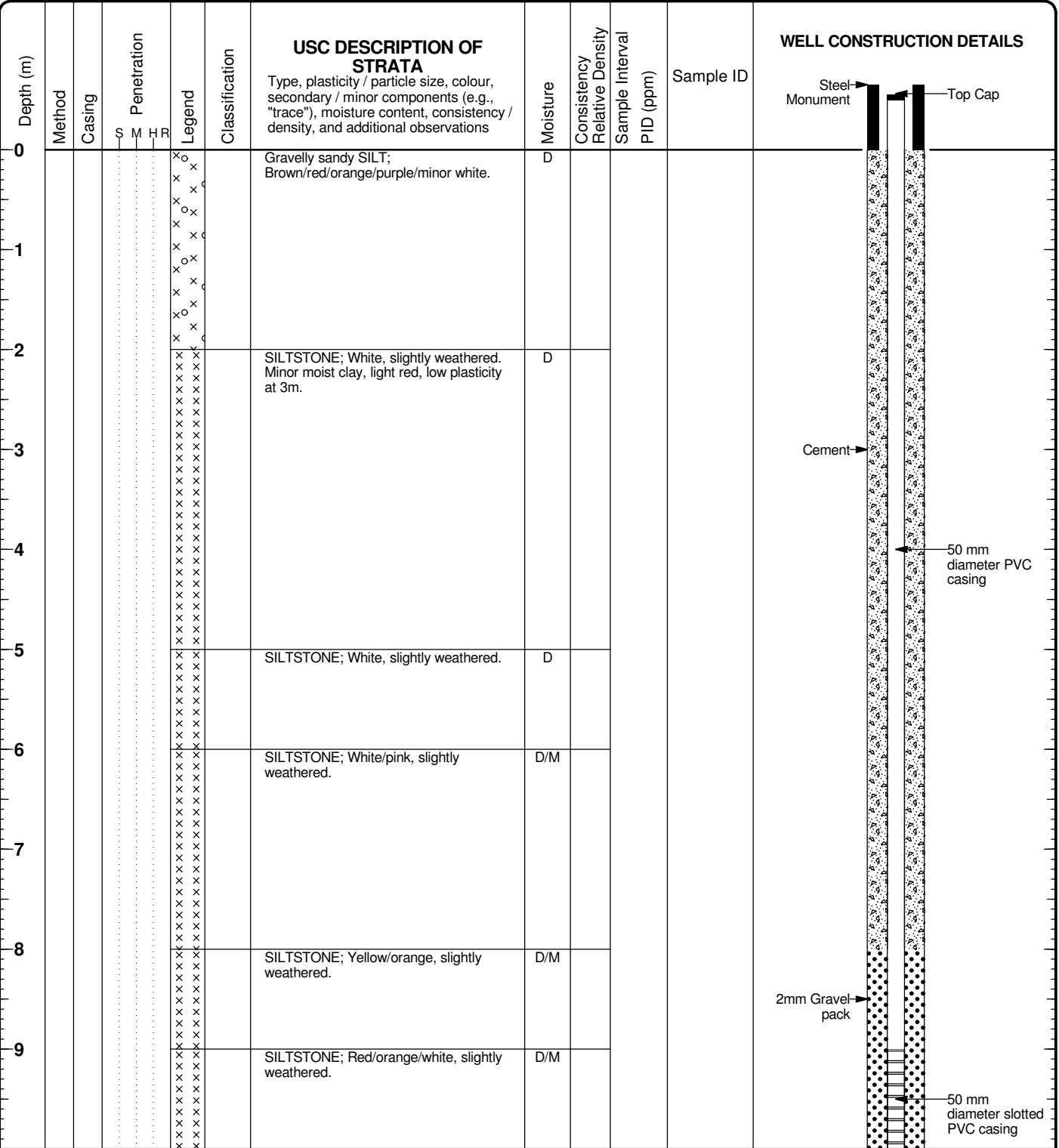
## MONITORING WELL GW6-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>14.24</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8630022.27 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>19-8-15</b>	Casing Size: <b>50 mm</b>	<b>709463.56 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>19-8-15</b>		Permit No: <b>RN39236</b>		

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA				Sample ID	WELL CONSTRUCTION DETAILS		
						Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density			Sample Interval	
0						Gravelly sandy SILT; Brown/red/orange/purple/minor white.	D					Steel Monument	Top Cap
0-2												Cement	
0-2													50 mm diameter PVC casing
2-3						SILTSTONE; White, slightly weathered. Minor moist clay, light red, low plasticity at 3m.	D					2mm Gravel pack	50 mm diameter slotted PVC casing
3-9													End Cap

## MONITORING WELL GW6-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>14.18</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630020.90 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>19-8-15</b>	Casing Size: <b>50 mm</b>	<b>709463.70 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>19-8-15</b>		Permit No: <b>RN39237</b>		



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## MONITORING WELL GW6-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

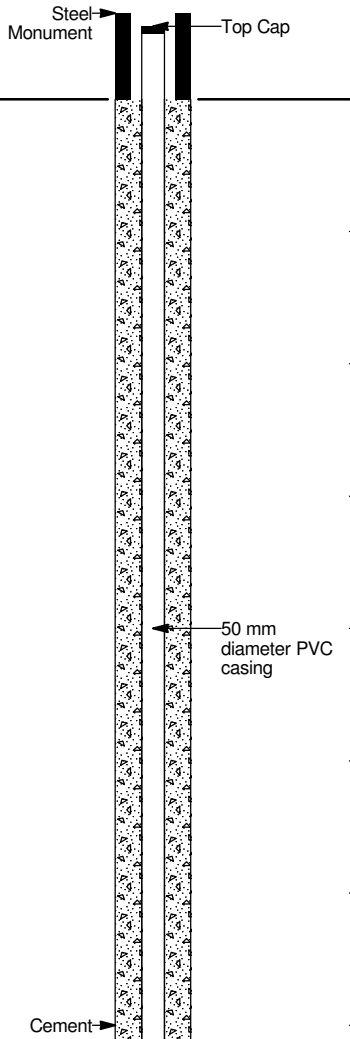
Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXXX		SILTSTONE; Light orange/light red, slightly weathered.	D/M						 <p>End Cap</p>
11						XXXXXX									
12						XXXXXX									
13															
14															
15															
16															
17															
18															
19															
20															
21															

## MONITORING WELL GW6-30

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>14.12</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>29.70 m</b>	Coordinates: <b>8630018.01 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>21-8-15</b>	Casing Size: <b>50 mm</b>	<b>709463.99 mE</b>	Drill Fluid: <b>Drill Mud</b>	
Date Finished: <b>21-8-15</b>		Permit No: <b>RN39238</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						SILTSTONE; Brown/cream, weathered.	D								
1						SILTSTONE; Light brown/cream, weathered.	D								
2						SILTSTONE; Cream, weathered.	D								
3						SILTSTONE; White, dry, brittle, weathered.	D								
4															
5															
6															
7															
8															
9						SILTSTONE; Brown/cream, weathered.	D								

ENVIRO\_WELL\_ADELAIDE\_MCC\_AUS\_GDT J:\DRW\42214019\5 WORKS\LOGS\42214019-BORELOGS.GPJ 23/10/15



## MONITORING WELL GW6-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXXX	SILTSTONE; Brown/red, weathered.	D							<p>2mm Gravel pack</p> <p>50 mm diameter slotted PVC casing</p>
11						XXXXXX	SILTSTONE; Orange, weathered.	D							
12						XXXXXX	SILTSTONE; Orange/yellow, weathered.	D/M							
13						XXXXXX	SILTSTONE; Orange/yellow, weathered.	M							
14						XXXXXX	SILTSTONE; Orange, weathered.	M							
15						XXXXXX									
16						XXXXXX									
17						XXXXXX									
18						XXXXXX	SILTSTONE; Orange, rounded river gravel/rocks, weathered.	W							
19						XXXXXX									
20						XXXXXX	SANDSTONE; Brown/deep brown, weathered.	M							
21						XXXXXX									

ENVIRO\_WELL\_ADELAIDE\_WCC\_AUS\_GDT J:\DRW\42214019\5 WORKS\LOGS\42214019-BORELOGS.GPJ 23/10/15

## MONITORING WELL GW6-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

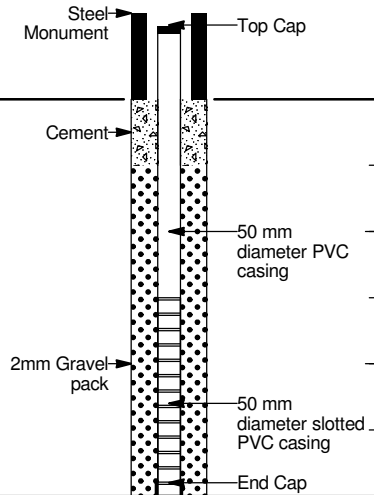
Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency Relative Density	Sample Interval PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H								
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
32													
33													

ENVIRO\_WELL\_ADELAIDE\_WCC\_AUS.GDT J:\DRW\42214019\5 WORKS\LOGS\42214019-BORELOGS.GPJ 23/10/15

## MONITORING WELL GW7-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>			Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.03</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8629991.91 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>18-8-15</b>	Casing Size: <b>50 mm</b>	<b>709900.10 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>18-8-15</b>		Permit No: <b>RN39224</b>		

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						Silty CLAY; White/orange/purple, minor gravel, brittle clay.	D/M								
1						SILTSTONE; Yellow/orange, weathered.	D								
2															
3															
4															
5															
6															
7															
8															
9															



## MONITORING WELL GW7-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.08</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8629993.99 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>17-8-15</b>	Casing Size: <b>50 mm</b>	<b>709900.11 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>17-8-15</b>		Permit No: <b>RN39223</b>		

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						Silty CLAY; White/orange/purple, minor gravel, brittle clay.	D								
1						SILTSTONE; Yellow/white/purple, slightly weathered.	D								
2						SILTSTONE; Yellow/orange, slightly weathered.	D								
3															
4															
5						SILTSTONE; Yellow/orange/white, slightly weathered.	D								
6						SILTSTONE; Yellow/white, minor clay content, brittle, slightly weathered.	M								
7						SILTSTONE; Orange/red, minor clay content, brittle, slightly weathered.	M								
8						SILTSTONE; Yellow/white/minor red, minor clay content, brittle, slightly weathered.	M								
9						SILTSTONE; Yellow/white, minor clay content, plastic, slightly weathered.	M								

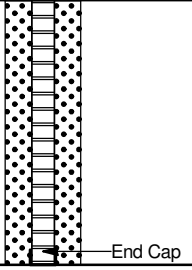
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## MONITORING WELL GW7-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800Phone (08) 8980 2900  
Fax (08) 8941 3920Project No.: **42214019**Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW8-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>			Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.28</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8629707.71 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>17-8-15</b>	Casing Size: <b>50 mm</b>	<b>709896.42 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>17-8-15</b>		Permit No: <b>RN39222</b>		

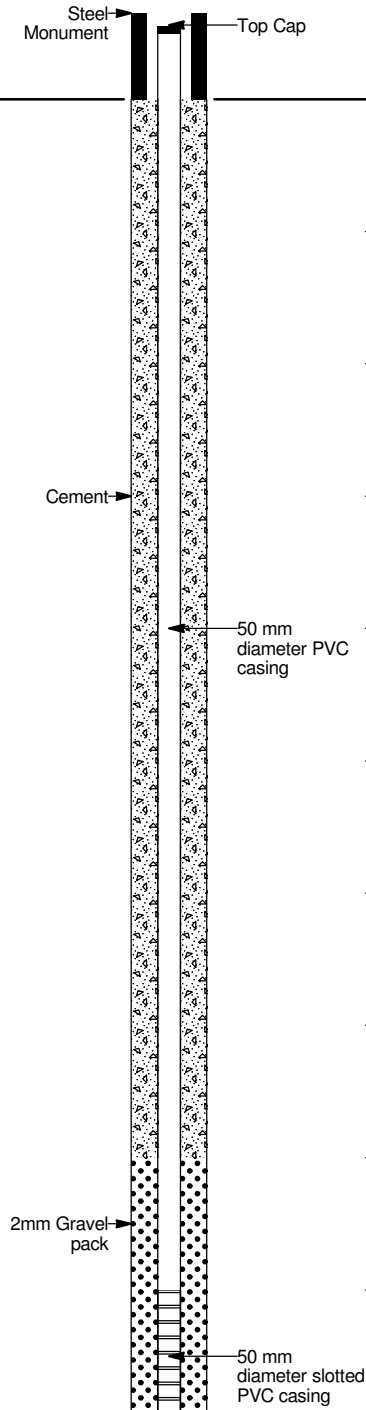
Depth (m)	Method	Casing	Penetration S M HR	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
0						SANDSTONE; Clayey, dark grey, angular gravel.	D						
1						CLAYSTONE; Silty, orange/red/minor grey.	D						
2						CLAYSTONE; Silty, orange/grey.	D						
3													
4													
5													
6													
7													
8													
9													

## MONITORING WELL GW8-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>5.22</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.10 m</b>	Coordinates: <b>8629707.71 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>17-8-15</b>	Casing Size: <b>50 mm</b>	<b>709896.42 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>17-8-15</b>		Permit No.: <b>RN39221</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
													Steel Monument	Top Cap
0						Silty CLAY; Minor gravel, grey/red/brown, plastic clay.	D							
1														
2						Silty CLAY; Orange/brown, plastic clay.	D							
3						CLAY; Grey/orange/grey mottled.	W							
4														
5						CLAY; Grey/red mottled, sub rounded gravel - sub angular.	M/W							
6														
7						CLAYSTONE; Minor silt, minor gravel, minor sands, brown, minor grey mottling, sub rounded, brittle clay.	W							
8														
9														

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## MONITORING WELL GW8-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10															
11							SANDSTONE; Silty/Sand, brown, minor gravel, slightly clayey.	W							
12															 End Cap
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW9-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>K Treglown</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>15.93</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.10 m</b>	Coordinates: <b>8629468.53 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>17-8-15</b>	Casing Size: <b>50 mm</b>	<b>709660.36 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>17-8-15</b>	Permit No:			

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										Steel Monument	Top Cap
0						XXXXXX	SILTSTONE; Light yellow, some dark brown gravel, slightly weathered.	D								
1						XXXXXX	SILTSTONE; White, slightly weathered.	D								
2						XXXXXX	SILTSTONE; Light yellow/white, slightly weathered.	D								
3						XXXXXX	SILTSTONE; White/light purple, slightly weathered.	D								
4						XXXXXX	SILTSTONE; Yellow/brown, slightly weathered.	D								
5						XXXXXX										
6						XXXXXX	SILTSTONE; Yellow, slightly weathered.	D								
7						XXXXXX										
8						XXXXXX										
9						XXXXXX	SILTSTONE; Siltstone/clay, light purple, minor clay content, brittle.	D								


## MONITORING WELL GW9-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						x x	SILTSTONE; Light purple/orange, minor clay content.	D							
11						x x	SILTSTONE; Siltstone/clay, yellow/orange, minor clay content, brittle.	D							
12						x x									
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW10-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>18.06</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8629506.87 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709147.33 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39239</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
0						XXXXXX	SILTSTONE; White/grey, minor clay, minor gravel, weathered.	D							
1						XXXXXX	SILTSTONE; Red/pink, brittle, weathered.	D							
2						XXXXXX	SILTSTONE; Orange/pink, brittle, weathered.	D							
3						XXXXXX									
4															
5															
6															
7															
8															
9															

## MONITORING WELL GW10-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>			Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>17.98</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8629506.66 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709149.41 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39240</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										Steel Monument	Top Cap
0						XXXXXX	SILTSTONE; White/grey, minor clay, minor gravel, weathered.	D								
1						XXXXXX	SILTSTONE; Red/pink, brittle, weathered.	D								
2						XXXXXX	SILTSTONE; Orange/pink, brittle, weathered.	D								
3						XXXXXX	SILTSTONE; Orange/brown, weathered.	D								
4						XXXXXX										
5						XXXXXX										
6						XXXXXX										
7						XXXXXX	SILTSTONE; Yellow/brown, weathered.	D								
8						XXXXXX										
9						XXXXXX										


## MONITORING WELL GW10-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						x x x x		SILTSTONE; Yellow/cream, weathered.	D						 <p>End Cap</p>
11						x x x x									
12						x x x x									
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW11-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920		Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>		Client: <b>John Holland</b>	
Drilling Contractor: <b>Bores NT</b>				Project No.: <b>42214019</b>		Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>		Bore Size: <b>107 mm</b>		Relative Level: <b>13.38</b>		Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>		Total Depth: <b>3.00 m</b>		Coordinates: <b>8629671.24 mN</b>		Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>		Casing Size: <b>50 mm</b>		709039.82 mE		Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>				Permit No.: <b>RN39241</b>			

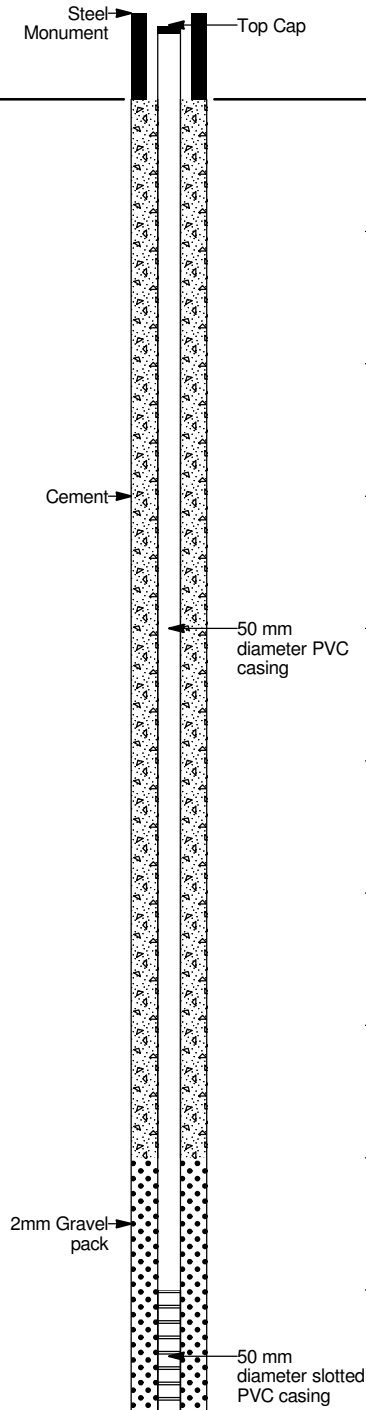
Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
0						XXXXXX	SILTSTONE; Brown, angular gravel, weathered.	D							
1						XXXXXX	SILTSTONE; White/grey, weathered.	D							
2						XXXXXX	SILTSTONE; Red/pink, weathered.	D							
3						XXXXXX									
4															
5															
6															
7															
8															
9															

## MONITORING WELL GW11-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>13.38</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8629671.29 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709041.72 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39242</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						SILTSTONE; Brown, angular gravel, weathered.	D								
1						SILTSTONE; Orange/grey, brittle, weathered.	D								
2															
3						SILTSTONE; Red/pink, weathered.	D								
4															
5						SILTSTONE; Orange/brown, weathered.	D/M								
6															
7						SILTSTONE; Yellow/orange, weathered.	D/M								
8						SILTSTONE; Yellow/purple, weathered.	D/M								
9						SILTSTONE; Cream/purple, weathered.	D/M								

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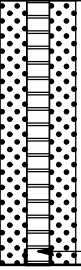
## MONITORING WELL GW11-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g. "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H	R									
10								SILTSTONE; Yellow, weathered.	D/M						
11							SANDSTONE; Brown/grey, fined grained.	D/M						End Cap	
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW12-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920		Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>		Client: <b>John Holland</b>	
Drilling Contractor: <b>Bores NT</b>				Project No.: <b>42214019</b>		Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>		Bore Size: <b>107 mm</b>		Relative Level: <b>12.07</b>		Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>		Total Depth: <b>3.00 m</b>		Coordinates: <b>8629880.90 mN</b>		Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>		Casing Size: <b>50 mm</b>		709023.83 mE		Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>				Permit No.: <b>RN39243</b>			

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
0						x x x x x	SILTSTONE; Brown/red, weathered.	D							
1						x x x x x	SILTSTONE; White, highly weathered.	D							
2						x x x x x	SILTSTONE; White/pink, highly weathered.	D							
3						x x x x x									
4															
5															
6															
7															
8															
9															

## MONITORING WELL GW12-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>12.04</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8629882.77 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709023.84 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39244</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										Steel Monument	Top Cap
0						XXXXXX	SILTSTONE; Brown/red, angular gravel, weathered.	D								
1						XXXXXX	SILTSTONE; Pink/brown, weathered.	D								
2						XXXXXX	SILTSTONE; White/pink, minor gravel, weathered.	D								
3						XXXXXX	SILTSTONE; Red/brown, brittle, weathered.	D								
4						XXXXXX	SILTSTONE; Brown, weathered.	D								
5						XXXXXX										
6						XXXXXX	SILTSTONE; Light brown/yellow, weathered.	D								
7						XXXXXX										
8						XXXXXX										
9						XXXXXX	SILTSTONE; Yellow, highly weathered.	D								

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## MONITORING WELL GW12-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXX		SILTSTONE; Cream, highly weathered.	D						 <p>End Cap</p>
11						XXXXX									
12						XXXXX									
13						XXXXX									
14						XXXXX									
15						XXXXX									
16						XXXXX									
17						XXXXX									
18						XXXXX									
19						XXXXX									
20						XXXXX									
21						XXXXX									

## MONITORING WELL GW12-30

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>12.05</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>30.00 m</b>	Coordinates: <b>8629885.39 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709023.85 mE</b>	Drill Fluid: <b>Water</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39245</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										Steel Monument	Top Cap
0						XXXXXX	SILTSTONE; Red/brown, angular gravel, weathered.	D								
1						XXXXXX	SILTSTONE; White/grey, weathered.	D								
2						XXXXXX	SILTSTONE; Pink/white, weathered.	D								
3						XXXXXX										
4						XXXXXX	SILTSTONE; Brown/pink, weathered.	D								
5						XXXXXX	SILTSTONE; Brown, brittle, weathered.	D								
6						XXXXXX										
7						XXXXXX	SILTSTONE; Orange, brittle, weathered.	D								
8						XXXXXX										
9						XXXXXX	SANDSTONE; Yellow, fine grained.	D								

## MONITORING WELL GW12-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
			S	M	H										R	
10								SANDSTONE; Yellow/cream, fine grained.	D							
11																
12																
13																
14																
15																
16																
17																
18																
19																
20								SANDSTONE; Brown/orange, fine grained.	D							
21																

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## MONITORING WELL GW12-30

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H									
22														<p>2mm Gravel pack</p> <p>50 mm diameter slotted PVC casing</p> <p>End Cap</p>
23														
24														
25														
26														
27							SANDSTONE; Brown/orange, fine grained.	M						
28														
29														
30														
31														
32														
33														

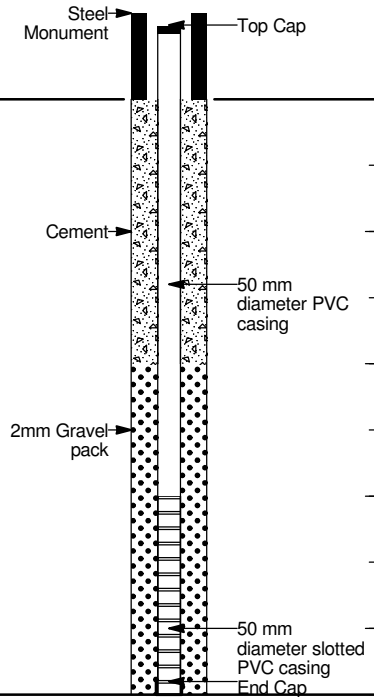
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## MONITORING WELL GW13-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>6.73</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>4.50 m</b>	Coordinates: <b>8630422.68 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>21-8-15</b>	Casing Size: <b>50 mm</b>	<b>709012.75 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>21-8-15</b>		Permit No: <b>RN39250</b>		

Depth (m)	Method Casing	Penetration S M HR	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
												Steel Monument	Top Cap
0					FILL	D							
1													
2					SILTSTONE; Red/grey/brown, weathered.	D							
3					SILTSTONE; Pink/grey.	D							
4					SILTSTONE; Pink/grey, weathered.	D							
5													
6													
7													
8													
9													

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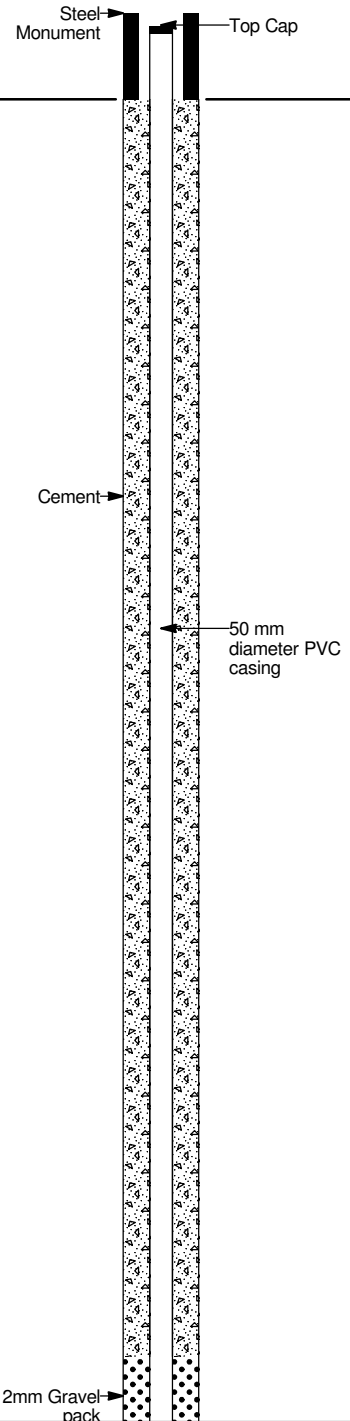


## MONITORING WELL GW13-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>6.64</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>13.50 m</b>	Coordinates: <b>8630424.47 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>21-8-15</b>	Casing Size: <b>50 mm</b>	<b>709012.82 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>21-8-15</b>		Permit No: <b>RN39251</b>		

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS	
													Steel Monument	Top Cap
0					Fill		D							
1														
2					SILTSTONE; Cream/red, weathered.		D							
3					SILTSTONE; Brown/cream, weathered.		D							
4					SILTSTONE; Red/brown/yellow, weathered.		D/M							
5					SILTSTONE; Yellow/brown, weathered.		M							
6														
7														
8					SILTSTONE; Orange/yellow, weathered.		M							
9														

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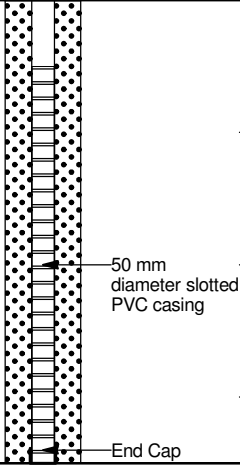
## MONITORING WELL GW13-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency Relative Density	Sample Interval PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H								
10						x x x x x							 <p>50 mm diameter slotted PVC casing</p> <p>End Cap</p>
11						x x x x x							
12						x x x x x							
13						x x x x x							
14						x x x x x							
15						x x x x x							
16						x x x x x							
17						x x x x x							
18						x x x x x							
19						x x x x x							
20						x x x x x							
21						x x x x x							

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## MONITORING WELL GW14-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920		Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>		Client: <b>John Holland</b>	
Drilling Contractor: <b>Bores NT</b>				Project No.: <b>42214019</b>		Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>		Bore Size: <b>107 mm</b>		Relative Level: <b>12.88</b>		Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>		Total Depth: <b>3.00 m</b>		Coordinates: <b>8630175.11 mN</b>		Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>		Casing Size: <b>50 mm</b>		709016.90 mE		Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>				Permit No: <b>RN39246</b>			

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
			S	M	H										R	Steel Monument	Top Cap
0						x x x x x		SILTSTONE; Dark red/brown/grey, angular gravel.	D							Steel Monument	Top Cap
1						x x x x x		SILTSTONE; Red/brown, weathered.	D							Cement	50 mm diameter PVC casing
2						x x x x x		SILTSTONE; Orange/red/brown, weathered.	D							2mm Gravel pack	50 mm diameter slotted PVC casing
3						x x x x x											End Cap
4																	
5																	
6																	
7																	
8																	
9																	

## MONITORING WELL GW14-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>12.86</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630173.67 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709016.49 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39247</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						SILTSTONE; Red/brown, angular gravel, weathered.	D								
1						SILTSTONE; Pink/grey, highly weathered.	D								
2						SILTSTONE; White/pink, brittle, weathered.	D								
3						SILTSTONE; Orange/brown, brittle, weathered.	D								
4															
5						SILTSTONE; Pink/purple, weathered.	D								
6															
7						SILTSTONE; Orange/brown, weathered.	D								
8						SILTSTONE; Pink/brown, weathered.	D/M								
9						SILTSTONE; Yellow/brown, weathered.	D/M								


## MONITORING WELL GW14-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXX	SILTSTONE; Yellow/cream, weathered.	M							
11						XXXXX	SILTSTONE; Grey, minor sand, weathered.	D/M							
12						XXXXX									
13															
14															
15															
16															
17															
18															
19															
20															
21															

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## MONITORING WELL GW15-3

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>			Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>11.06</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>3.00 m</b>	Coordinates: <b>8630599.33 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709230.44 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39248</b>		

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
0						x x x x x	SILTSTONE; Cream/grey, weathered.	D							
1						x x x x x	SILTSTONE; White/cream, weathered.	D							
2						x x x x x	SILTSTONE; Pink/white, brittle, weathered.	D							
3						x x x x x									
4															
5															
6															
7															
8															
9															

## MONITORING WELL GW15-12

URS Australia Pty Ltd Level 3, 93 Mitchell St DARWIN NT 0800		Phone (08) 8980 2900 Fax (08) 8941 3920	Project Reference: <b>Shoal Bay Hydrogeological Drilling</b>	Client: <b>John Holland</b>
Drilling Contractor: <b>Bores NT</b>		Project No.: <b>42214019</b>	Location: <b>Shoal Bay Landfill</b>	
Logged By: <b>J Dwyer</b>	Bore Size: <b>107 mm</b>	Relative Level: <b>11.04</b>	Drill Type: <b>Air Rotary</b>	
Checked By: <b>C MacHunter</b>	Total Depth: <b>12.00 m</b>	Coordinates: <b>8630599.30 mN</b>	Drill Model: <b>Sonic Samp Drill</b>	
Date Started: <b>20-8-15</b>	Casing Size: <b>50 mm</b>	<b>709233.07 mE</b>	Drill Fluid: <b>Nil</b>	
Date Finished: <b>20-8-15</b>		Permit No: <b>RN39249</b>		

Depth (m)	Method	Casing	Penetration S M H R	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	P/D (ppm)	Sample ID	WELL CONSTRUCTION DETAILS		
													Steel Monument	Top Cap	
0						SILTSTONE; Grey/brown, angular gravel, weathered.	D								
1						SILTSTONE; White/pink, brittle, weathered.	D								
2															
3															
4						SILTSTONE; Pink/purple, brittle, weathered.	D								
5															
6						SILTSTONE; Brown/pink, brittle, weathered.	D								
7						SILTSTONE; Brown, brittle, weathered.	D								
8															
9						SILTSTONE; Brown, brittle, weathered.	D/M								

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## MONITORING WELL GW15-12

URS Australia Pty Ltd  
Level 3, 93 Mitchell St DARWIN NT 0800

Phone (08) 8980 2900  
Fax (08) 8941 3920

Project No.: **42214019**

Project Reference: **Shoal Bay Hydrogeological Drilling**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Consistency	Relative Density	Sample Interval	PID (ppm)	Sample ID	WELL CONSTRUCTION DETAILS
			S	M	H										
10						XXXXXX		SILTSTONE; Yellow/brown, brittle, weathered.	M						
11						XXXXXX									
12						XXXXXX									 End Cap
13															
14															
15															
16															
17															
18															
19															
20															
21															

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**APPENDIX C      FIELD SHEETS**

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Bore ID: **GW2-12**

Project Name: Shoal Bay GME	Project Number: 42214019	PM Name: Chris MacHunter	Sample Date: 16/09/15
Client: John Holland	Project Location: Shoal Bay Landfill	Fieldwork Staff: Kim Treglown	Well Development or Well Sampling Event? (circle)

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level: 16/9/15	Bore Radius (mm): 105	Chem Kit Serial No.: 90FLMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate: 250ml/4min	Hydrasleeve Size:	Monitoring sequence followed (number in order):			
Depth to GW (m-pvc): 9.97	Screen Interval (m): 9-12 m bgl	Chem Kit Model:	<input checked="" type="checkbox"/> Dedicated	Intake depth: 12.00	Hydrasleeve Type:	Gauging			
Bore Depth (m-pvc): 12.72	Casing Radius (mm): 50	Corrected Redox: Y / N	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer	<input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):			
Depth to Product (m-pvc): -	Cover Type (gatic/stick up):	(The correction to apply is probe dependent)	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	Hydrasleeve Install time:			
Product Thickness (m): -	Bore Locked (YES/NO):	Parameter method: <input type="checkbox"/> Downhole		<input type="checkbox"/> Other (specify)		Sampling Start Time:			
	Key Type (if applicable):	<input checked="" type="checkbox"/> Retrieved				Hydrasleeve out			
Calculated bore volume (L): -	Includes/ excludes bore annulus (circle) -	# purge volumes removed: -				Parameters			
					Total purged volume (L): 6.25L				

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
10:10	10.14	0.5L	200ml/2min	2.80	25.9	5.50	164	31.3	No odour, clear.
10:18	10.18	1L	250ml/4min	0.77	26.0	5.46	176	31.6	" "
10:26	10.30	1.5L	"	1.14	26.3	5.49	190	32.5	" "
10:32	10.49	2L	"	1.18	26.3	5.51	187	33.6	" "
10:40	10.68	2.5L	"	1.41	26.2	5.51	180	33.7	" "
10:48	10.90	3L	"	1.46	26.2	5.51	174	33.6	" "
10:56	11.07	3.5L	"	1.65	26.1	5.51	173	33.6	" "
11:04	11.13	4L	"	1.54	26.1	5.51	175	33.5	" "
11:12	11.26	4.5L	"	1.56	26.2	5.50	173	33.5	" "
11:32	11.60	6.25L	"						Sample collected @ 11:12m. SWL not stabilising, parameters stable.
									post sampling

Acceptable Parameter Range: ±10% DO, ±3% E.C., ±0.05 pH, ±10 mV Redox, ±0.2 °C Temp, ±10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered: Mn, Zn, Cu	Unfiltered: Na, K, Ca, Mg, HCO <sub>3</sub> , VF, CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> , Fe, TOC, COD, BOR	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	-	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
		x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		Pump set @ slowest setting, SWL not stabilising.

Approval and Distribution

Fieldwork Staff Signature	Date: 15/9/15	Checker Name and Signature	Date: 23/10/15
Project Manager Signature	Date:	Distribution: Project Central File	

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### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

<b>Project Name:</b>	Shoal Bay GME	<b>Project Number:</b>	42214019	<b>PM Name:</b>	Chris MacHunter	<b>Sample Date:</b>	16/9/15 - 17/9/15
<b>Client:</b>	John Holland	<b>Project Location:</b>	Shoal Bay Landfill	<b>Fieldwork Staff:</b>	Kim Treglown	<b>Well Development or Well Sampling Event? (circle)</b>	
<b>GENERAL BORE INFORMATION</b>			<b>PARAMETER INFO.</b>		<b>DECONTAMINATION</b>		<b>SAMPLING METHOD:</b>
Date of GW Level:	16/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMU	<input type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:
Depth to GW (m-pvc):	11.97	Screen Interval (m):	9-12m bgl.	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth:
Bore Depth (m-pvc):	12.76	Casing Radius (mm):	50	<b>Corrected Redox:</b>	Y <input checked="" type="checkbox"/> N	<input type="checkbox"/> Disposable	<input checked="" type="checkbox"/> Bailor <input type="checkbox"/> Hydrasleeve
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra
Product Thickness (m):	-	Bore Locked (YES/NO):	NO	<b>Parameter method:</b>	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Hydrasleeve Install time:
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved		Sampling Start Time:
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L): 2L	

#### WATER QUALITY PARAMETERS

Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or $\mu$ S/cm)	pH	Redox (mV)	Temp $^{\circ}$ C	Odour, Colour, Turbidity
16/9/15 11:22	1L	-	-	1.50	2.89	5.30	123	30.2	Brown, med turb, no odour. Bailed dry after 2L. Bail well dry. - left to recharge.
17/9/15 07:24	-	12.23	-	-	-	-	-	-	Insufficient water to conduct low flow sampling. Samples collected. Insufficient water to collect water quality parameters.
<b>Acceptable Parameter Range:</b>				$\pm 10\%$	$\pm 3\%$	$\pm 0.05$	$\pm 10$ mV	$\pm 0.2$ $^{\circ}$ C	$\pm 10\%$ turbidity (if using a turbidity meter)

<b>ANALYTES SAMPLED FOR:</b>		<b>BOTTLES COLLECTED</b>			<b>QA/QC INFORMATION</b>	<b>FIELD COMMENTS</b>
<b>Field Filtered:</b>	<b>Unfiltered:</b>	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	-	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOD					
<b>Approval and Distribution</b>						
Fieldwork Staff Signature		16/9/15	Date		25/10/15	Date
Project Manager Signature		Date		Distribution: Project Central File		

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	16/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.		
Date of GW Level:	16/9/15	Bore Radius (mm):	80mm (0.5m)	Chem Kit Serial No.:	90FLMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate: 250ml/4m	Hydrasleeve Size:	Monitoring sequence followed (number in order):	
Depth to GW (m-pvc):	11.85	Screen Interval (m):	9-12 mbgl	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth: 12.30	Hydrasleeve Type:		
Bore Depth (m-pvc):	12.53	Casing Radius (mm):	50mm	Corrected Redox:	Y / N	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer	<input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):	-	Cover Type (gate/stick up):	-	(The correction to apply is probe dependent)	-	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):	-	Bore Locked (YES/NO):	-	Parameter method:	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Other (specify)	Sampling Start Time:	Hydrasleeve out	Parameters
		Key Type (if applicable):	-		<input checked="" type="checkbox"/> Retrieved					
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L):	1.25L			

#### WATER QUALITY PARAMETERS

Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
16/9/15 0845	0.5L	12.05	250ml/4min	4.86	10.65	5.22	159	28.2	No odour, clear.
0853	1L	12.12	" "	4.96	10.47	5.71	128	28.5	" "
0857	1.25L	12.30	" "	3.51	10.29	5.75	126	28.7	" "
0859									Grab sample - well pumping dry
									Green plastic collected by bailer. Well dry following sampling. No recharge
17/9/15 0810	-	12.39	-	-	-	-	-	-	Insufficient water to re-sample or collect parameters

Acceptable Parameter Range: ± 10% DO, ± 3% E.C., ± 0.05 pH, ± 10 mV Redox, ± 0.2 °C Temp, ± 10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION		FIELD COMMENTS	
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )			Bore volume calculation, bore condition, fate of tubing, redox correction etc.	
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFAs, CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> , Fe, TOC, COD, BOD	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic				

#### Approval and Distribution

Fieldwork Staff Signature

Date

Checker Name and Signature

Date

Project Manager Signature

Date

Distribution: Project Central File

### FQM-5.05-F1 - GROUNDWATER SAMPLING AND PURGING RECORD

Bore ID: GW4-30

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	15/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMU	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate: 250mL/2min	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):	2.27	Screen Interval (m):	15-21	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth:	Hydrasleeve Type:	
Bore Depth (m-pvc):	30	Casing Radius (mm):	80	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer	<input type="checkbox"/> Hydrasleeve	
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	
Product Thickness (m):	-	Bore Locked (YES/NO):		Parameter method:	<input type="checkbox"/> Downhole		<input type="checkbox"/> Other (specify)		
Calculated bore volume (L):		Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-			Total purged volume (L):	5.8L

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
13:37	0.5L	2.27	250mL/2min	7.42	1730	6.05	-1	34.8	No odour, clear.
13:45	1.5L	2.27	320/2min	6.00	2044	6.05	11	34.7	" "
13:49	2.2L	2.27	320/2min	3.86	2.46	5.97	25	32.4	" "
13:53	3.4L	2.27	320/2min	3.30	2.50	5.96	25	31.7	" "
13:57	4.6L	2.25	"	3.44	2.48	5.95	23	31.7	" "
13:52	5.8L		"	3.01	2.48	5.94	23	31.5	" "
									Sampled

Acceptable Parameter Range: ±10%    ±3%    ±0.05    ±10 mV    ±0.2 °C    ±10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION		FIELD COMMENTS	
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	QA/QC01 (dup) QA/QC02 (trip)	Bore volume calculation, bore condition, fate of tubing, redox correction etc.		
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic				
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>							
	PO <sub>4</sub> , Fe, TOC, COD, BOD							

Approval and Distribution			
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
	15/9/15		23/9/15
Project Manager Signature	Date	Distribution: Project Central File	

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown		

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate: <i>flow</i>	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):		Screen Interval (m):	9-12abgi	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth: <i>4m</i>	Hydrasleeve Type:	
Bore Depth (m-pvc):		Casing Radius (mm):	50mm	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailor <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:	
Product Thickness (m):	-	Bore Locked (YES/NO):		Parameter method:	<input type="checkbox"/> Downhole <input type="checkbox"/> Retrieved		<input type="checkbox"/> Other (specify)	Sampling Start Time:	
Calculated bore volume (L):		Includes/ excludes bore annulus (circle)		# purge volumes removed:		Total purged volume (L): <i>3L</i>		Parameters	

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
0810	0.5L	2.40	250ml/min	3.30	3.64	6.41	138	28.6	No odour, clear
0815	1.0L	2.44	250ml/min	2.61	3.83	6.26	129	29.1	"
0820	1.5L	2.50	250ml/min	2.40	3.96	6.14	137	29.9	clear - brown, low-mod turb
0825	2L	2.49	250ml/min	2.39	3.96	6.12	138	29.7	"
0830	2.5L	2.49	"	2.32	3.91	6.13	137	29.7	"
0834	3L	2.50	"	2.26	3.94	6.13	137	29.8	sampled

Acceptable Parameter Range:	± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	± 10% turbidity (if using a turbidity meter)
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ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	Extra for 100 QA/QC	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOR					

Approval and Distribution			
Fieldwork Staff Signature	Date: 15/9/15	Checker Name and Signature	Date: 23/10/15
Project Manager Signature	Date:	Distribution: Project Central File	

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	17/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	9096MU	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):	9.21	Screen Interval (m):	17.7-21.7mb	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth: 3.70mb	Hydrasleeve Type:	
Bore Depth (m-pvc):	-	Casing Radius (mm):	50mm	Corrected Redox:	Y / N	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):	-	(The correction to apply is probe dependent)	-	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):	-	Bore Locked (YES/NO):	-	Parameter method:	<input type="checkbox"/> Downhole <input checked="" type="checkbox"/> Retrieved	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Other (specify)	Sampling Start Time:	Hydrasleeve out
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L):	3.5L	Parameters	

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
10.35	0.5L	9.29	250ml/2min	4.65	314	8.82	105	31.0	No odour, clear.
10.39	1L	9.30	"	5.36	255	8.01	133	31.1	No odour, brown, low turb
10.43	1.5L	9.31	"	6.19	257	7.40	127	31.2	" " "
10.47	2L	9.30	"	6.05	253	7.28	71	31.3	" " "
10.51	2.5L	9.30	"	5.27	249	7.29	52	31.3	" " "
10.55	3L	9.31	"	5.75	249	7.28	58	31.3	" " "
10.09	3.5L	9.30	"	5.81	248	7.28	51	31.3	" " "
									Sampled

Acceptable Parameter Range: ± 10% DO, ± 3% E.C., ± 0.05 pH, ± 10 mV Redox, ± 0.2 °C Temp, ± 10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	-	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOD					

Approval and Distribution			
Fieldwork Staff Signature:	Date: 17/9/15	Checker Name and Signature:	Date: 23/9/15
Project Manager Signature: _____	Date: _____	Distribution: Project Central File	

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	17/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	165	Chem Kit Serial No.:	90FLMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):		Screen Interval (m):	9-12	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth:	Hydrasleeve Type:	
Bore Depth (m-pvc):		Casing Radius (mm):	50	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):		Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):		Bore Locked (YES/NO):	(NO)	Parameter method:	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Other (specify)	Sampling Start Time:	Hydrasleeve out
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved				Parameters
Calculated bore volume (L):	Includes/ excludes bore annulus (circle)		# purge volumes removed:		Total purged volume (L):				

#### WATER QUALITY PARAMETERS

Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or $\mu$ S/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
1142	0.5L	4.35	250ml/2min	4.01	90.1	5.14	153	33.3	Brown, no odour, low turb.
1150	1.5L	4.50	"	3.45	74.6	5.16	149	34.3	" " "
									Problems with pump. Fixed.
1211	2L	4.75	250ml/4min	2.99	89.3	5.37	128	35.4	Not pumping much water - issue with air pressure
1219	2.5L	5.13	"	2.87	82.7	5.00	103	33.7	
1227	3L	5.52	"	4.00	79.5	4.78	135	33.4	Brown, no odour low turb.
1235	3.5L	5.75	"	3.70	79.7	4.80	116	33.3	" " "
1243	4L	6.00	"	3.68	79.5	4.85	102	33.3	" " "
1251	4.5L	6.20	"	3.83	79.4	4.81	120	33.2	" " "
1259	5L	6.35	"	3.72	79.6	4.85	118	33.1	SWL not stabilising. parameters stable sample collected!
<b>Acceptable Parameter Range:</b>				±10%	±3%	±0.05	±10 mV	±0.2 °C	±10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )		Bore volume calculation, bore condition, fate of tubing, redox correction etc.  Pump set @ slowest setting.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOD					

#### Approval and Distribution

Kim Treglown  
Fieldwork Staff Signature

17/9/15  
Date

Chris MacHunter  
Checker Name and Signature

23/10/15  
Date

Project Manager Signature

Date

Distribution: Project Central File

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Bore ID: GWT-12

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	21/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	905CMU	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):		Screen Interval (m):	9-12	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth: 11m	Hydrasleeve Type:	
Bore Depth (m-pvc):		Casing Radius (mm):	50	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):	-	Bore Locked (YES/NO):		Parameter method:	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Other (specify)	Sampling Start Time:	Hydrasleeve out
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved				Parameters
Calculated bore volume (L):		Includes/ excludes bore annulus (circle)		# purge volumes removed:		Total purged volume (L):			

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
09:45	0.5L	2.70	250ml/2m	2.76	17.32	6.12	172	30.7	No odour, brown, low-mud turb.
09:50	1L	2.82	250ml/4m	1.65	17.47	6.13	175	30.9	" " "
09:55	1.5L	2.93	"	1.40	17.40	6.13	179	30.7	" " "
10:00	2L	3.13	"	1.55	17.38	6.14	183	30.7	" " "
10:05	2.5L	3.20	"	2.20	17.24	6.16	186	30.8	" " "
10:10	3L	3.26	"	2.40	16.91	6.21	157	31.0	" " "
10:15	3.5L	3.30	"	3.26	16.91	6.19	167	31.0	" " "
10:20	4L	3.35	"	2.92	16.85	6.20	175	30.7	" " "
10:25	4.5L	3.30	"	3.54	16.86	6.21	178	30.9	" " "
10:30	5L	3.38	"	3.72	16.88	6.21	180	31.0	" " "
									Spec eventually stabilised. sampled

Acceptable Parameter Range:				± 10%	± 3%	± 0.05	± 10 mV	± 0.2 °C	
ANALYTES SAMPLED FOR:				BOTTLES COLLECTED				QA/QC INFORMATION	
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	-				
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VF	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic					
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> , Fe, TOC, COD, BOD								
Approval and Distribution				Date				FIELD COMMENTS	
Fieldwork Staff Signature		21/9/15		Date		Date		Bore volume calculation, bore condition, fate of tubing, redox correction etc.	
Project Manager Signature		Date		Date		Date		pump set @ slowest setting.	

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	21/9/15			
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)				
GENERAL BORE INFORMATION			PARAMETER INFO.	DECONTAMINATION	SAMPLING METHOD:	HYDRASLEEVE INFO.				
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMU	<input checked="" type="checkbox"/> Decontaminated	<input type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):	
Depth to GW (m-pvc):		Screen Interval (m):	1.5-3 m	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth:	Hydrasleeve Type:		
Bore Depth (m-pvc):		Casing Radius (mm):	50	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	Bailer <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):		Gauging
Depth to Product (m-pvc):		Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input checked="" type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:		Hydrasleeve in
Product Thickness (m):		Bore Locked (YES/NO):	(N)	Parameter method:	<input checked="" type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Other (specify)	Sampling Start Time:		Hydrasleeve out
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved				Parameters	
Calculated bore volume (L):		Includes/ excludes bore annulus (circle)		# purge volumes removed:		Total purged volume (L):				

#### WATER QUALITY PARAMETERS

Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or $\mu$ S/cm)	pH	Redox (mV)	Temp $^{\circ}$ C	Odour, Colour, Turbidity
1120	0.5L	250mL/3m	1.90	2.97	27.2	4.67	192	33.4	No odour, clear.
1125	0.75L	250mL/4m	1.97	0.29	25.1	4.82	202	34.9	"
1130	2L	250mL/5m	2.12	0.13	21.02	5.07	199	33.8	"
1135	2.25L	"	2.21	0.15	20.01	5.36	191	33.3	"
1140	2.5L	"	2.24	0.15	18.97	5.51	171	32.1	"
1145	2.75L	"	2.32	0.07	19.03	5.59	142	31.1	"
1150	3L	"	2.38	0.07	18.97	5.60	134	31.2	"
1155	3.25L	"	2.46	0.3	19.03	5.61	130	31.3	"
1200	3.5L	"	2.55	0.2	19.01	5.59	126	31.4	"
									SWL not stabilising - parameters stable - sampled
Acceptable Parameter Range:				$\pm 10\%$	$\pm 3\%$	$\pm 0.05$	$\pm 10$ mV	$\pm 0.2$ $^{\circ}$ C	$\pm 10\%$ turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	-	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VF	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		pump set @ sloughie setting
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> , Fe, TOC, COD, BOD					
Approval and Distribution						
Fieldwork Staff Signature	21/9/15	Date	CM. Treglown	23/10/15	Checker Name and Signature	Date
Project Manager Signature		Date			Distribution: Project Central File	



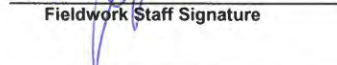
### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

<b>Project Name:</b>	Shoal Bay GME	<b>Project Number:</b>	42214019	<b>PM Name:</b>	Chris MacHunter	<b>Sample Date:</b>	
<b>Client:</b>	John Holland	<b>Project Location:</b>	Shoal Bay Landfill	<b>Fieldwork Staff:</b>	Kim Treglown	<b>Well Development or Well Sampling Event? (circle)</b>	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):		Screen Interval (m):	9-12	Chem Kit Model:		<input checked="" type="checkbox"/> Dedicated	Intake depth: 11m	Hydrasleeve Type:	
Bore Depth (m-pvc):		Casing Radius (mm):	50	<b>Corrected Redox:</b>	Y / N	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailor <input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):		Cover Type (gatic/stick up):		(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump <input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):		Bore Locked (YES/NO):		<b>Parameter method:</b>	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)		Sampling Start Time:	Hydrasleeve out
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved				Parameters
Calculated bore volume (L):		Includes/ excludes bore annulus (circle)		# purge volumes removed:		Total purged volume (L):			

WATER QUALITY PARAMETERS										
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity	
1235	0.5L	3.33	250ml/2m	12.33	70.3	6.67	147	36.5	No odour, clear	
1240	0.5L	3.34	"	11.90	77.7	6.61	161	35.9	No odour, red-brown, med-low turb	
1249	<del>0.5L</del>	3.58	320ml/2m	6.40	75.0	6.24	176	32.5	" "	
1250	1.5L	3.52	250ml/2m	6.38	<del>73.9</del>	6.24	190	33.2	" "	
1254	2L	3.48	"	6.10	<del>73.9</del>	6.23	199	33.6	" "	
1258	2.5L	3.49	"	6.5	74.0	6.22	202	33.4	" "	
1303	3L	3.49	"	6.17	74.0	6.22	205	33.4	" "	
									sampled	
<b>Acceptable Parameter Range:</b>				± 10% ✓	± 3% ✓	± 0.05 ✓	± 10 mV ✓	± 0.2 °C ✓	± 10% turbidity (if using a turbidity meter)	

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION		FIELD COMMENTS	
<b>Field Filtered:</b>	<b>Unfiltered:</b>	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	QA/QC 7 QA/QC 8		Bore volume calculation, bore condition, fate of tubing, redox correction etc.	
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> , Fe, TOC, COD, BOD	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic				

Approval and Distribution			
	21/9/15		23/10/15
Fieldwork Staff Signature	Date	Checker Name and Signature	Date
			
Project Manager Signature	Date	Distribution: Project Central File	

## FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Project Name:	Shoal Bay GME	Project Number:	42214019	PM Name:	Chris MacHunter	Sample Date:	16/9/15
Client:	John Holland	Project Location:	Shoal Bay Landfill	Fieldwork Staff:	Kim Treglown	Well Development or Well Sampling Event? (circle)	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.	
Date of GW Level:	15/9/15	Bore Radius (mm):	108	Chem Kit Serial No.:	901LMV	<input checked="" type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate: 250mL/2m	Hydrasleeve Size:	Monitoring sequence followed (number in order):
Depth to GW (m-pvc):	13.2	Screen Interval (m):	26-30	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth: 29m	Hydrasleeve Type:	
Bore Depth (m-pvc):	-	Casing Radius (mm):	50	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input type="checkbox"/> Bailer	<input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):
Depth to Product (m-pvc):	-	Cover Type (gatic stick up):	-	(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	Hydrasleeve Install time:
Product Thickness (m):	-	Bore Locked (YES/NO):	(N)	Parameter method:	<input type="checkbox"/> Downhole		<input type="checkbox"/> Other (specify)		Sampling Start Time:
		Key Type (if applicable):	-		<input checked="" type="checkbox"/> Retrieved				Parameters
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L):	4.5L		

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc) ←	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
13.19	0.5L	250ml/min	13.23	3.65	98.7	4.97	203	32.4	No odour, clear
13.23	1L	"	13.25	3.29	79.2	4.97	198	32.6	" "
13.27	1.5L	"	13.23	3.31	71.8	4.96	158	32.4	" "
13.31	2L	"	13.23	3.30	67.1	4.92	157	32.4	No odour, clear - brown, low turb
13.35	2.5L	"	13.25	3.45	59.2	4.90	157	32.4	" "
13.39	3L	"	13.23	3.77	52.2	4.90	152	31.5	" "
13.43	3.5L	"	13.24	3.68	51.2	4.89	154	31.3	" "
13.49	4L	"	13.23	3.74	51.4	4.87	159	31.2	" "
13.53	4.5L	"	13.23	3.92	51.5	4.86	161	31.3	Sampled

Acceptable Parameter Range: ±10% DO, ±3% E.C., ±0.05 pH, ±10 mV Redox, ±0.2 °C Temp, ±10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
Field Filtered:	Unfiltered:	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	QAACOB QAACOY	Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOD					

Approval and Distribution			
Fieldwork Staff Signature	16/9/15	Checker Name and Signature	23/10/15
Project Manager Signature	Date	Distribution: Project Central File	Date

## FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

<b>Project Name:</b>	Shoal Bay GME	<b>Project Number:</b>	42214019	<b>PM Name:</b>	Chris MacHunter	<b>Sample Date:</b>	16/9/15 - 17/9/15
<b>Client:</b>	John Holland	<b>Project Location:</b>	Shoal Bay Landfill	<b>Fieldwork Staff:</b>	Kim Treglown	<b>Well Development or Well Sampling Event? (circle)</b>	

GENERAL BORE INFORMATION		PARAMETER INFO.		DECONTAMINATION		SAMPLING METHOD:		HYDRASLEEVE INFO.		
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	90FLMU	<input type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	Monitoring sequence followed (number in order):	
Depth to GW (m-pvc):	13.48	Screen Interval (m):	9-12.6m	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth:	Hydrasleeve Type:		
Bore Depth (m-pvc):	14.22	Casing Radius (mm):	50mm	Corrected Redox:	Y / (N)	<input type="checkbox"/> Disposable	<input checked="" type="checkbox"/> Bailor	<input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):	-	Cover Type (gatic/stick up):	-	(The correction to apply is probe dependent)	-	<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):	-	Bore Locked (YES/NO):	(N)	Parameter method:	<input type="checkbox"/> Downhole		<input type="checkbox"/> Other (specify)		Sampling Start Time:	Hydrasleeve out
		Key Type (if applicable):	-		<input checked="" type="checkbox"/> Retrieved					Parameters
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L):	= 2L			

WATER QUALITY PARAMETERS									
Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
16/9/15 1245	2L	-	-	2.08	483	5.77	75	27.7	Brown, high turb. Bailed dry @ 2L. Await well to recharge.
17/9/15 0920	2L	13.98	-	-	-	-	-	-	Brown, light turb. Insufficient water to collect water quality parameters.

**Acceptable Parameter Range:** ± 10% DO, ± 3% E.C., ± 0.05 pH, ± 10 mV Redox, ± 0.2 °C Temp, ± 10% turbidity (if using a turbidity meter)

ANALYTES SAMPLED FOR:		BOTTLES COLLECTED			QA/QC INFORMATION	FIELD COMMENTS
<b>Field Filtered:</b>	<b>Unfiltered:</b>	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )		Bore volume calculation, bore condition, fate of tubing, redox correction etc.
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic		
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>					
	PO <sub>4</sub> , Fe, TOC, COD, BOD					

**Approval and Distribution**

Fieldwork Staff Signature	17/9/15	Checker Name and Signature	23/10/15
Project Manager Signature	Date	Distribution: Project Central File	Date

### FQM-5.05-F1 – GROUNDWATER SAMPLING AND PURGING RECORD

Bore ID:

GW14-12

<b>Project Name:</b>	Shoal Bay GME	<b>Project Number:</b>	42214019	<b>PM Name:</b>	Chris MacHunter	<b>Sample Date:</b>	16/9/15 - 17/9/15			
<b>Client:</b>	John Holland	<b>Project Location:</b>	Shoal Bay Landfill	<b>Fieldwork Staff:</b>	Kim Treglown	<b>Well Development or Well Sampling Event? (circle)</b>				
<b>GENERAL BORE INFORMATION</b>			<b>PARAMETER INFO.</b>		<b>DECONTAMINATION</b>		<b>SAMPLING METHOD:</b>		<b>HYDRASLEEVE INFO.</b>	
Date of GW Level:	15/9/15	Bore Radius (mm):	105	Chem Kit Serial No.:	Q10FLMV	<input type="checkbox"/> Decontaminated	<input checked="" type="checkbox"/> Low Flow: Pump rate:	Hydrasleeve Size:	<b>Monitoring sequence followed (number in order):</b>	
Depth to GW (m-pvc):	7.57	Screen Interval (m):	9-12mbgl	Chem Kit Model:	-	<input checked="" type="checkbox"/> Dedicated	Intake depth:	Hydrasleeve Type:		
Bore Depth (m-pvc):	12.49	Casing Radius (mm):	50mm	<b>Corrected Redox:</b>	Y / N	<input type="checkbox"/> Disposable	<input checked="" type="checkbox"/> Bailer	<input type="checkbox"/> Hydrasleeve	Sampling Depth (m-pvc):	Gauging
Depth to Product (m-pvc):	-	Cover Type (gating/stick up):	-	(The correction to apply is probe dependent)		<input type="checkbox"/> Other (specify)	<input type="checkbox"/> Peristaltic Pump	<input type="checkbox"/> Waterra	Hydrasleeve Install time:	Hydrasleeve in
Product Thickness (m):	-	Bore Locked (YES/NO):	<input checked="" type="checkbox"/>	<b>Parameter method:</b>	<input type="checkbox"/> Downhole	<input type="checkbox"/> Other (specify)		<input type="checkbox"/> Other (specify)	Sampling Start Time:	Hydrasleeve out
		Key Type (if applicable):			<input checked="" type="checkbox"/> Retrieved					Parameters
Calculated bore volume (L):	-	Includes/ excludes bore annulus (circle)	-	# purge volumes removed:	-	Total purged volume (L):		22L		

#### WATER QUALITY PARAMETERS

Time	Cumulative Vol. Removed (L)	SWL (m-pvc)	Pump Rate	DO (ppm or mg/L)	E.C. (mS/cm or µS/cm)	pH	Redox (mV)	Temp °C	Odour, Colour, Turbidity
16/9/15	7L ↔ 1200	10.94	-	7.60	16.40	4.27	193	27.1	No odour, clear-brown, low-med turb
	20L ↔ 1220	12	-	4.50	16.92	4.73	211	25.8	" " med turb
									Baired day w/ 2/L. await well to recharge
~~~~~									
17/9/15	0845 2L	8.50	-	1.16	16.42	4.72	140	28.4	No odour, clear-brown, low-med turb
									Grab sample collected. Sample not to be analysed
									post collection of 2L for sampling.
	1330 16L	11.58	-	5.20	16.36	4.47	201	29.3	Brown, turbid, no odour.
									SWL 7.79 prior 2nd sample collected GW14-12-2 to purging 16L

Acceptable Parameter Range:

± 10%

± 3%

± 0.05

± 10 mV

± 0.2 °C

± 10% turbidity (Using a turbidity meter)

<b>ANALYTES SAMPLED FOR:</b>		<b>BOTTLES COLLECTED</b>			<b>QA/QC INFORMATION</b>		<b>FIELD COMMENTS</b>	
<b>Field Filtered:</b>	<b>Unfiltered:</b>	x 40 mL Vial (HCl)	x 60 mL Ferrous	x 60 mL metals (HNO <sub>3</sub> )	QAQC05 QAQC06		Bore volume calculation, bore condition, fate of tubing, redox correction etc.  BV = 10L	
Mn, Zn, Cu	Na, K, Ca, Mg, HCO <sub>3</sub> , VFA	x 40 mL Vial (H <sub>2</sub> SO <sub>4</sub> )	x 100 mL Amber	x 250 mL Plastic				
	CO <sub>3</sub> , Cl, SO <sub>4</sub> , NH <sub>4</sub> , NO <sub>3</sub>							
	PO <sub>4</sub> , Fe, TOC, COD, BOT							

#### Approval and Distribution

Fieldwork Staff Signature

Date

Checker Name and Signature

Date

Project Manager Signature

Date

Distribution: Project Central File



**APPENDIX D      CALIBRATION CERTIFICATE**

# RENTALS

## Equipment Certification Report – TPS 90FLMV Water Quality Meter

This Water Quality Meter has been performance checked and calibrated as follows:

Sensor	Concentration	Span 1	Span 2	Traceability Lot #	Pass?
pH	pH 7.00 / pH 4.00	7.00 pH	4.00 pH	1	<input checked="" type="checkbox"/>
Conductivity	12.88mS/cm	0 mS/cm	12.88mS/cm		<input checked="" type="checkbox"/>
TDS	36 ppk	0 ppk	26 ppk		<input checked="" type="checkbox"/>
Dissolved Oxygen	Sodium Sulphite / Air	0 ppm in Sodium Sulphite	9.99 ppm Saturation in Air		<input checked="" type="checkbox"/>

**Check only**

Redox (ORP) *	Electrode operability test	240mV +/- 10%	246 mV	<input checked="" type="checkbox"/>
---------------	----------------------------	---------------	--------	-------------------------------------

\* This meter uses an Ag/AgCl ORP electrode. To convert readings to SHE (Standard Hydrogen Electrode), add 199mV to the mV reading.

- Battery Status 8.1 (min 7.2V)       Temperature 16.1 °C  
 Electrical Safety Tag attached (AS/NZS 3760)       Electrodes Cleaned and checked

Tag No: 135  
Valid to: 15/9/15

Date: 15/9/15  
Signed: \_\_\_\_\_

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum \$30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Returned	Item
<input checked="" type="checkbox"/>	<input type="checkbox"/>	90FLMV Unit. Ops check/Battery status: <u>8.1</u>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	pH sensor with wetting cap, 5m
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Conductivity/TDS/Temperature K=10 sensor, 5m
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Dissolved oxygen YSI5739 sensor with wetting cap, 5m
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Redox (ORP) sensor with wetting cap, 5m
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Power supply 240V to 12V DC 200mA
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Instruction Manual
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Quick Guide
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Syringe with storage solution for pH and ORP sensors
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Carry Case
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Check to confirm electrical safety (tag must be valid)

Date: 15/9/15  
Signed: \_\_\_\_\_

TFS Reference	<u>KIM URS</u>	Return Date:	<u>1 1</u>
Customer Reference		Return Time:	
Equipment ID	<u>90FLMV BE</u>	Condition on return:	
Equipment Serial No.			

"We do more than give you great equipment... We give you great solutions!"

Phone: (Free Call) 1300 735 295		Fax: (Free Call) 1800 675 123		Email: <a href="mailto:RentalsAU@Thermofisher.com">RentalsAU@Thermofisher.com</a>	
Melbourne Branch 5 Caribbean Drive, Scoresby 3179	Sydney Branch Level 1, 4 Talavera Road, North Ryde 2113	Adelaide Branch 27 Beulah Road, Norwood, South Australia 5067	Brisbane Branch Unit 2/5 Ross St Newstead 4006	Perth Branch 121 Beringarra Ave Malaga WA 6090	



**APPENDIX E      CERTIFICATE OF ANALYSIS**

# CHAIN OF CUSTODY DOCUMENTATION

CLIENT: URS Australia	ADDRESS / OFFICE: Level 3, 93 Mitchell Street, Darwin 0800
PROJECT MANAGER (PM): Chris Machhunter	PHONE: _____
PROJECT ID: 422 14019	MOBILE: 0422 088 362
SITE: Shoal Bay Hydrogeological Sampling	EMAIL REPORT TO: kim.treglown@urs.com; chris.machhunter@urs.com
RESULTS REQUIRED (Date):	EMAIL INVOICE TO: (if different to report)
FOR LABORATORY USE ONLY	QUOTE NO.:
COOLER SEAL (grade appropriate)	ANALYSIS REQUIRED INCLUDING SITES (note - suite codes must be listed to attract suite prices)
INTEGRITY	Notes: e.g. Highly contaminated samples
SAMPLE TEMPERATURE	Extra volume for GC or trace LORs etc.
CHILLED: Yes/No	

ALS ID	SAMPLE ID	MATRIX	DATE	TIME	Type / Code	Total bottles
1	GA04-20-150915	W	150915	1430	Vol 1, 58	6
2	BA001-150915	W	150915	1430	" "	6
3	QA001-150915	W	150915	1430	" "	6
4	CC001-150915	W	150915	1430	Vol 1, P	4

NT-1	NT-2	ANIONS: Major (Ca, Mg, Na, K)	ANIONS: Minor (Cl, SO4, Alkalinity)	EK058G (Nitrate)	EK055G-NH4 (Ammonium as N)	EK071 (Reactive Phosphorus as P)	EG020F (Dissolved metals: Mn, Zn, Cu)	EG020T (Total: Fe)	EP005 (TOC)	EP030 (BOD)	EP026 (COD)	EP045 (CH3COOH)
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

HOLD

RECEIVED BY:	RECEIVED BY:
ES1531223	ES1531223
12	12

LAB OF ORIGIN: DARWIN

Telephone : +61-2-6784 8555

NAME: K. Treglown	DATE: 15/09/15	NAME: g. ALS	DATE: 15/09/15
OF: URS	TIME: 14:30	OF: ALS	TIME: 8:30
NAME:	DATE:	NAME:	DATE:
OF:	TIME:	OF:	TIME:
Transport Co:		Transport Co:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulphuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulphuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

# ALS LABORATORY GROUP





SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : ES1531223

Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Contact	: Loren Schiavon
Address	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: kim.treglown@urs.com	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 08 89802900	Telephone	: +61 2 8784 8503
Facsimile	: +61 08 89413920	Facsimile	: +61-2-8784 8500
Project	: 42214019	Page	: 1 of 3
Order number	: ----	Quote number	: ES2014URSNT0273 (EN/001/14)
C-O-C number	: ----	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING		
Sampler	: KIM TREGLOWN		

Dates

Date Samples Received	: 16-Sep-2015 8:30 AM	Issue Date	: 16-Sep-2015
Client Requested Due Date	: 23-Sep-2015	Scheduled Reporting Date	: <b>23-Sep-2015</b>

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: -0.5 - Ice present
Receipt Detail	:	No. of samples received / analysed	: 4 / 4

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.



## Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

## Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020F Dissolved Metals by ICPMS	WATER - EK055G-NH4 Ammonium as N	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - EP030 BOD	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity
ES1531223-001	15-Sep-2015 14:30	GW4_30_150915	✓	✓	✓	✓	✓	✓	✓
ES1531223-002	15-Sep-2015 14:30	QAQC01_150915	✓	✓	✓	✓	✓	✓	✓
ES1531223-003	15-Sep-2015 14:30	QCB01_150915	✓	✓	✓	✓	✓		
ES1531223-004	15-Sep-2015 14:30	QCC01_150915	✓						

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020T Total Recoverable Metals by ICPMS (including	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP045 Volatile Acids as CH3COOH
ES1531223-001	15-Sep-2015 14:30	GW4_30_150915	✓	✓	✓
ES1531223-002	15-Sep-2015 14:30	QAQC01_150915	✓	✓	✓
ES1531223-003	15-Sep-2015 14:30	QCB01_150915	✓	✓	✓
ES1531223-004	15-Sep-2015 14:30	QCC01_150915	✓	✓	

## Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



## Requested Deliverables

### CHRIS Mac HUNTER

- *AU Certificate of Analysis - NATA (COA)	Email	chris.machunter@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	chris.machunter@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	chris.machunter@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	chris.machunter@urs.com
- A4 - AU Tax Invoice (INV)	Email	chris.machunter@urs.com
- Chain of Custody (CoC) (COC)	Email	chris.machunter@urs.com
- EDI Format - ENMRG (ENMRG)	Email	chris.machunter@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	chris.machunter@urs.com
- EDI Format - ESDAT (ESDAT)	Email	chris.machunter@urs.com
- EDI Format - MRED (MRED)	Email	chris.machunter@urs.com

### KIM TREGLOWN

- *AU Certificate of Analysis - NATA (COA)	Email	kim.treglown@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	kim.treglown@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	kim.treglown@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	kim.treglown@urs.com
- A4 - AU Tax Invoice (INV)	Email	kim.treglown@urs.com
- Chain of Custody (CoC) (COC)	Email	kim.treglown@urs.com
- EDI Format - ENMRG (ENMRG)	Email	kim.treglown@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	kim.treglown@urs.com
- EDI Format - ESDAT (ESDAT)	Email	kim.treglown@urs.com
- EDI Format - MRED (MRED)	Email	kim.treglown@urs.com

### RESULTS ADDRESS

- *AU Certificate of Analysis - NATA (COA)	Email	darwin@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	darwin@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	darwin@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	darwin@urs.com
- A4 - AU Tax Invoice (INV)	Email	darwin@urs.com
- Chain of Custody (CoC) (COC)	Email	darwin@urs.com
- EDI Format - ENMRG (ENMRG)	Email	darwin@urs.com
- EDI Format - MRED (MRED)	Email	darwin@urs.com

## CERTIFICATE OF ANALYSIS

<b>Work Order</b> : <b>ES1531223</b> <b>Client</b> : <b>URS AUSTRALIA PTY LTD</b> <b>Contact</b> : <b>KIM TREGLOWN</b> <b>Address</b> : <b>Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801</b>  <b>E-mail</b> : <b>kim.treglown@urs.com</b> <b>Telephone</b> : <b>+61 08 89802900</b> <b>Facsimile</b> : <b>+61 08 89413920</b> <b>Project</b> : <b>42214019</b> <b>Order number</b> : <b>----</b> <b>C-O-C number</b> : <b>----</b> <b>Sampler</b> : <b>KIM TREGLOWN</b> <b>Site</b> : <b>SHOAL BAY HYDROGEOLOGICAL SAMPLING</b>  <b>Quote number</b> : <b>----</b>	<b>Page</b> : 1 of 4 <b>Laboratory</b> : Environmental Division Sydney <b>Contact</b> : Loren Schiavon <b>Address</b> : 277-289 Woodpark Road Smithfield NSW Australia 2164  <b>E-mail</b> : loren.schiavon@alsglobal.com <b>Telephone</b> : +61 2 8784 8503 <b>Facsimile</b> : +61-2-8784 8500 <b>QC Level</b> : NEPM 2013 Schedule B(3) and ALS QCS3 requirement <b>Date Samples Received</b> : 16-Sep-2015 08:30 <b>Date Analysis Commenced</b> : 16-Sep-2015 <b>Issue Date</b> : 24-Sep-2015 15:55  <b>No. of samples received</b> : 4 <b>No. of samples analysed</b> : 4
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This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with  
ISO/IEC 17025.

### *Signatories*

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics



## 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.

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  
∅ = ALS is not NATA accredited for these tests.



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			GW4_30_150915	QAQC01_150915	QCB01_150915	QCC01_150915	----
Client sampling date / time		15-Sep-2015 14:30			15-Sep-2015 14:30	15-Sep-2015 14:30	15-Sep-2015 14:30	15-Sep-2015 14:30	----
Compound	CAS Number	LOR	Unit	ES1531223-001	ES1531223-002	ES1531223-003	ES1531223-004	-----	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	44	43	----	----	----	
Total Alkalinity as CaCO3	----	1	mg/L	44	43	----	----	----	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	70	66	----	----	----	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	690	696	----	----	----	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	24	24	----	----	----	
Magnesium	7439-95-4	1	mg/L	30	28	----	----	----	
Sodium	7440-23-5	1	mg/L	404	400	----	----	----	
Potassium	7440-09-7	1	mg/L	12	11	----	----	----	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	0.002	0.002	<0.001	<0.001	----	
Manganese	7439-96-5	0.001	mg/L	1.51	1.49	<0.001	<0.001	----	
Zinc	7440-66-6	0.005	mg/L	0.081	0.079	<0.005	<0.005	----	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	3.56	3.62	<0.05	<0.05	----	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	0.07	0.05	<0.01	----	----	
<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	----	----	
<b>EK058G: Nitrate as N by Discrete Analyser</b>									
^ Nitrate as N	14797-55-8	0.01	mg/L	<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	<0.01	<0.01	<0.01	----	----	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	21.8	21.9	----	----	----	
^ Total Cations	----	0.01	meq/L	21.5	21.2	----	----	----	
^ Ionic Balance	----	0.01	%	0.60	1.60	----	----	----	



### Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW4_30_150915	QAQC01_150915	QCB01_150915	QCC01_150915	----
Client sampling date / time				15-Sep-2015 14:30	15-Sep-2015 14:30	15-Sep-2015 14:30	15-Sep-2015 14:30	----	----
Compound	CAS Number	LOR	Unit	ES1531223-001	ES1531223-002	ES1531223-003	ES1531223-004	-----	-----
				Result	Result	Result	Result	Result	Result
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	<1	2	<1	<1	----	----
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	16	15	<10	----	----	----
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	4	3	<2	----	----	----
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	14	14	<5	----	----	----



QUALITY CONTROL REPORT

Table with 4 columns: Field, Value, Field, Value. Includes Work Order (ES1531223), Client (URS AUSTRALIA PTY LTD), Laboratory (Environmental Division Sydney), and various contact and project details.

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
• Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
• Matrix Spike (MS) Report; Recovery and Acceptance Limits



NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Table with 3 columns: Signatories, Position, Accreditation Category. Lists Ankit Joshi, Ashesh Patel, and Celine Conceicao with their respective roles and accreditation categories.

Page : 2 of 6  
Work Order : ES1531223  
Client : URS AUSTRALIA PTY LTD  
Project : 42214019

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## **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

Key :  
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot  
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  
RPD = Relative Percentage Difference  
# = Indicates failed QC



## Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 215914)</b>									
ES1531212-010	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	169	170	0.00	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	169	170	0.00	0% - 20%
ES1531224-005	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 216002)</b>									
ES1531265-008	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1850	1930	4.37	0% - 20%
ES1531223-001	GW4_30_150915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	70	70	0.00	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 216003)</b>									
ES1531265-008	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	80	82	1.79	0% - 20%
ES1531223-001	GW4_30_150915	ED045G: Chloride	16887-00-6	1	mg/L	690	692	0.227	0% - 20%
<b>ED093F: Dissolved Major Cations (QC Lot: 216873)</b>									
ES1531254-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	38	39	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	45	46	2.34	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	40	39	0.00	0% - 20%
ES1530949-003	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	11	11	0.00	0% - 50%
		ED093F: Magnesium	7439-95-4	1	mg/L	13	13	0.00	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	77	76	1.53	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	6300	6530	3.65	0% - 20%
<b>EG020F: Dissolved Metals by ICP-MS (QC Lot: 216871)</b>									
ES1531254-001	Anonymous	EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	1.66	1.69	2.01	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.171	0.166	3.01	0% - 20%
ES1530949-003	Anonymous	EG020A-F: Copper	7440-50-8	0.001	mg/L	0.011	<0.010	9.93	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.010	<0.010	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.050	<0.050	0.00	No Limit
<b>EG020T: Total Metals by ICP-MS (QC Lot: 216361)</b>									
ES1531223-001	GW4_30_150915	EG020A-T: Iron	7439-89-6	0.05	mg/L	3.56	3.54	0.439	0% - 20%
ES1531257-003	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 216004)</b>									
ES1531260-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit

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 Work Order : ES1531223  
 Client : URS AUSTRALIA PTY LTD  
 Project : 42214019



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 216004) - continued</b>									
ES1531223-001	GW4_30_150915	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 218027)</b>									
ES1531223-001	GW4_30_150915	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
ES1531356-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.04	0.04	0.00	No Limit
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 216005)</b>									
ES1531303-001	Anonymous	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.01	<0.01	0.00	No Limit
ES1531223-001	GW4_30_150915	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EP005: Total Organic Carbon (TOC) (QC Lot: 217170)</b>									
ES1530918-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	<1	<1	0.00	No Limit
EW1511740-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	2	2	0.00	No Limit
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 220506)</b>									
ES1530949-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	13	13	0.00	No Limit
ES1531303-002	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	858	858	0.00	0% - 20%
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 215572)</b>									
ES1531086-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	5	6	18.2	No Limit
ES1531254-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
<b>EP045: Volatile Acids as CH3COOH (QC Lot: 219344)</b>									
ES1531223-001	GW4_30_150915	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	14	16	12.0	No Limit
ES1531356-003	Anonymous	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	12	12	0.00	No Limit



## Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
				Result	Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 215914)</b>								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	98.6	81	111
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 216002)</b>								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	93.6	86	122
<b>ED045G: Chloride by Discrete Analyser (QCLot: 216003)</b>								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	108	75	123
				<1	1000 mg/L	101	77	119
<b>ED093F: Dissolved Major Cations (QCLot: 216873)</b>								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	93.3	90	114
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	102	90	110
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.5	87	117
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	99.3	82	118
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 216871)</b>								
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	86.5	85	115
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	93.0	85	115
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	89.2	85	115
<b>EG020T: Total Metals by ICP-MS (QCLot: 216361)</b>								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	108	82	120
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 216004)</b>								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	100	82	114
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 218027)</b>								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	105	91	113
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 216005)</b>								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	96.7	85	117
<b>EP005: Total Organic Carbon (TOC) (QCLot: 217170)</b>								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	92.7	76	120
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 220506)</b>								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	94.4	80	120
				<10	500 mg/L	99.6	80	120
<b>EP030: Biochemical Oxygen Demand (BOD) (QCLot: 215572)</b>								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	200 mg/L	92.0	74	110
<b>EP045: Volatile Acids as CH3COOH (QCLot: 219344)</b>								
EP045: Volatile Acids as Acetic Acid	----	5	mg/L	<5	200 mg/L	94.4	88	112



### Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 216002)</b>							
ES1531223-001	GW4_30_150915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
<b>ED045G: Chloride by Discrete Analyser (QCLot: 216003)</b>							
ES1531223-001	GW4_30_150915	ED045G: Chloride	16887-00-6	250 mg/L	89.1	70	130
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 216871)</b>							
ES1530949-004	Anonymous	EG020A-F: Copper	7440-50-8	0.2 mg/L	103	70	130
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	100	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	110	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 216004)</b>							
ES1531223-001	GW4_30_150915	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	94.7	70	130
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 218027)</b>							
ES1531223-001	GW4_30_150915	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	102	70	130
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 216005)</b>							
ES1531223-001	GW4_30_150915	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	98.8	70	130
<b>EP005: Total Organic Carbon (TOC) (QCLot: 217170)</b>							
ES1530918-002	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	95.0	70	130
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 220506)</b>							
ES1530949-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	47.6 mg/L	113	70	130

## QA/QC Compliance Assessment for DQO Reporting

Work Order	: ES1531223	Page	: 1 of 7
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Telephone	: +61 2 8784 8503
Project	: 42214019	Date Samples Received	: 16-Sep-2015
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING	Issue Date	: 24-Sep-2015
Sampler	: KIM TREGLOWN	No. of samples received	: 4
Order number	: ----	No. of samples analysed	: 4

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

### Summary of Outliers

#### Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

#### Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

#### Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



### Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Matrix Spike (MS) Recoveries</b>							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ES1531223--001	GW4_30_150915	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

### Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
<b>Matrix Spikes (MS)</b>					
Total Metals by ICP-MS - Suite A	0	12	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

### Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>ED037P: Alkalinity by PC Titrator</b>								
Clear Plastic Bottle - Natural (ED037-P)								
GW4_30_150915,	15-Sep-2015	QAQC01_150915	----	----	----	16-Sep-2015	29-Sep-2015	✓
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>								
Clear Plastic Bottle - Natural (ED041G)								
GW4_30_150915,	15-Sep-2015	QAQC01_150915	----	----	----	16-Sep-2015	13-Oct-2015	✓
<b>ED045G: Chloride by Discrete Analyser</b>								
Clear Plastic Bottle - Natural (ED045G)								
GW4_30_150915,	15-Sep-2015	QAQC01_150915	----	----	----	16-Sep-2015	13-Oct-2015	✓
<b>ED093F: Dissolved Major Cations</b>								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F)								
GW4_30_150915,	15-Sep-2015	QAQC01_150915	----	----	----	17-Sep-2015	13-Oct-2015	✓
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F)								
GW4_30_150915,	15-Sep-2015	QAQC01_150915,	----	----	----	17-Sep-2015	13-Mar-2016	✓
QCB01_150915,		QCC01_150915						



Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EG020T: Total Metals by ICP-MS</b>								
<b>Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T)</b> GW4_30_150915, QCB01_150915,	QAQC01_150915, QCC01_150915	15-Sep-2015	17-Sep-2015	13-Mar-2016	✓	17-Sep-2015	13-Mar-2016	✓
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Natural (EK057G)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	16-Sep-2015	17-Sep-2015	✓
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Sulfuric Acid (EK059G)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	18-Sep-2015	13-Oct-2015	✓
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>								
<b>Clear Plastic Bottle - Natural (EK071G)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	16-Sep-2015	17-Sep-2015	✓
<b>EP005: Total Organic Carbon (TOC)</b>								
<b>Amber TOC Vial - Sulfuric Acid (EP005)</b> GW4_30_150915, QCB01_150915,	QAQC01_150915, QCC01_150915	15-Sep-2015	----	----	----	17-Sep-2015	13-Oct-2015	✓
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>								
<b>Clear Plastic Bottle - Sulfuric Acid (EP026SP)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	22-Sep-2015	13-Oct-2015	✓
<b>EP030: Biochemical Oxygen Demand (BOD)</b>								
<b>Clear Plastic Bottle - Natural (EP030)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	16-Sep-2015	17-Sep-2015	✓
<b>EP045: Volatile Acids as CH3COOH</b>								
<b>Clear Plastic Bottle - Natural (EP045)</b> GW4_30_150915, QCB01_150915	QAQC01_150915,	15-Sep-2015	----	----	----	21-Sep-2015	29-Sep-2015	✓



## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Reaular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Laboratory Duplicates (DUP)</b>							
Alkalinity by PC Titrator	ED037-P	2	12	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	2	18	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	17	11.76	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	14	14.29	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	16	12.50	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	13	15.38	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	17	11.76	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	12	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	16	12.50	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	2	18	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Laboratory Control Samples (LCS)</b>							
Alkalinity by PC Titrator	ED037-P	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	17	11.76	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	14	14.29	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Method Blanks (MB)</b>							
Biochemical Oxygen Demand (BOD)	EP030	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	14	7.14	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Regular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Method Blanks (MB) - Continued</b>							
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	14	7.14	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	0	12	0.00	5.00	*	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO <sub>4</sub> <sup>2-</sup> by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO <sub>4</sub> . Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO <sub>4</sub> suspension is measured by a photometer and the SO <sub>4</sub> <sup>2-</sup> concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3)  Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3)  Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Ammonium as N	EK055G-NH4	WATER	Ammonium in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH and Temperature. Ammonia is determined by direct colorimetry by Discrete Analyser according to APHA 4500-NH <sub>3</sub> G. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO <sub>2</sub> - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO <sub>3</sub> - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)



<i>Analytical Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	WATER	In house: Referenced to APHA 5220 D. Samples are digested with a known excess of an acidic potassium dichromate solution using silver sulfate as a catalyst. The chromium is reduced from the Cr (VI) oxidation state to the Cr (III) state by the oxygen present in the organic material. Both of these chromium species are coloured and absorb in the visible region of (400nm & 600nm) the spectrum. The oxidisable organic matter can be calculated in terms of oxygen equivalents.
Biochemical Oxygen Demand (BOD)	EP030	WATER	In house: Referenced to APHA 5210 B. The 5-Day BOD test provides an empirical measure of the oxygen consumption capacity of a given water. A portion of the sample is diluted into oxygenated, nutrient rich water, and a seed added to begin biological decay. The initial dissolved oxygen content is measured, then the bottle is sealed and incubated for five days. The remaining dissolved oxygen is measured, and from the difference, the demand for oxygen, by biological decay, is determined. This method is compliant with NEPM (2013) Schedule B(3)
Volatile Acids as CH <sub>3</sub> COOH	EP045	WATER	In house: Referenced to APHA 5560 C. Steam distillable acids are captured in caustic solution and determined titrimetrically. This method is compliant with NEPM (2013) Schedule B(3)
<i>Preparation Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

422621

RELINQUISHED BY: K. Treglowm  
 DATE: 15/9/15 TIME: 14:30  
 RECEIVED BY: T. Brown  
 DATE: 16/9/15 TIME: 8:19 AM

PLEASE SIGN AND FAX TO URS UPON RECEIPT  
 J = Jar; A = Amber Bottle; VH = HCl Preserved Vial; P = Plastic Bottle; N = Nitric Acid Preserved; S = Sulphuric Acid Preserved; C = Sodium Hydroxide Preserved; B = Sterile Bottle; Z = Zinc Acetate Preserved; E = EDTA Preserved; O = Other

LAB ID	SAMPLE ID	DATE	MATRIX	CONTAINER TYPE & PRESERVATIVE	TOTAL NUMBER OF CONTAINERS	Cations: Major (Ca, Mg, Na, K)	Anions: Minor (Cl, SO4, Alkalinity)	Nitrate	Ammonium as N	Reactive Phosphorus as P	Dissolved metals: Mn, Zn, Cu	Total metals: Fe	TOC	BOD	COD	CH3COOH
	042202-150915	15/9/15	Water	VHS.P	7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

ANALYSIS REQUIRED

COMMENTS:

PROJECT NAME: Shoal Bay Hydrogeology  
 PROJECT NO: 42214019  
 PHONE NO:  
 FAX NO:  
 ADDRESS: URS Australia  
 LABORATORY: Eurofins-MGT  
 email address: kim.treglowm@urs.com; chris.machhunter@urs.com  
 PURCHASE ORDER NUMBER:  
 PROJECT MANAGER: Chris Machhunter  
 SAMPERS: K. Treglowm  
 SIGNED: [Signature]

URS - CHAIN OF CUSTODY

FOR LABORATORY USE ONLY

## Sample Receipt Advice

Company name: **URS Australia Pty Ltd NT**  
Contact name: **Chris MacHunter**  
Project name: **SHOAL BAY HYDROGEOLOG**  
Project ID: **42214019**  
COC number: **Not provided**  
Turn around time: **5 Day**  
Date/Time received: **Sep 16, 2015 8:19 AM**  
Eurofins | mgt reference: **472621**

### Sample information

- A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- All samples have been received as described on the above COC.
- COC has been completed correctly.
- Attempt to chill was evident.
- Appropriately preserved sample containers have been used.
- All samples were received in good condition.
- Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- Appropriate sample containers have been used.
- Sample containers for volatile analysis received with zero headspace.
- Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

### Contact notes

If you have any questions with respect to these samples please contact:

Mark Rodriquez on Phone : (+61) 8 8947 1557 or by e.mail: MarkRodriquez@eurofins.com.au

Results will be delivered electronically via e.mail to Chris MacHunter - chris\_machunter@urscorp.com.

*Note: A copy of these results will also be delivered to the general URS Australia Pty Ltd NT email address.*



## Certificate of Analysis

URS Australia Pty Ltd  
 Level 3 93 Mitchell St  
 Darwin  
 NT 801



NATA Accredited  
 Accreditation Number 1261  
 Site Number 1254

Accredited for compliance with ISO/IEC 17025.  
 The results of the tests, calibrations and/or  
 measurements included in this document are traceable  
 to Australian/national standards.

Attention: Chris MacHunter

**Report** 472621-W-V2  
 Project name SHOAL BAY HYDROGEOLOG  
 Project ID 42214019  
 Received Date Sep 16, 2015

Client Sample ID			QAQC02_1509 15
Sample Matrix			Water
Eurofins   mgt Sample No.			M15-Se15721
Date Sampled			Sep 15, 2015
Test/Reference	LOR	Unit	
Acetic Acid*	10	mg/L	< 10
Ammonia (as N)	0.01	mg/L	< 0.01
Ammonium Ion (as N)	0.01	mg/L	< 0.01
Biochemical Oxygen Demand (BOD-5 Day)	5	mg/L	< 5
Chemical Oxygen Demand (COD)	20	mg/L	340
Phosphorus reactive (as P)	0.05	mg/L	< 0.05
Total Organic Carbon	5	mg/L	< 5
<b>Major Anions</b>			
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	20	mg/L	42
Carbonate Alkalinity (as CaCO <sub>3</sub> )	10	mg/L	< 10
Chloride	1	mg/L	660
Nitrate (as N)	0.02	mg/L	< 0.02
Sulphate (as S)	5	mg/L	25
<b>Heavy Metals</b>			
Copper (filtered)	0.001	mg/L	0.002
Iron	0.05	mg/L	3.6
Manganese (filtered)	0.005	mg/L	1.6
Zinc (filtered)	0.001	mg/L	0.067
<b>Alkali Metals</b>			
Calcium	0.5	mg/L	23
Magnesium	0.5	mg/L	26
Potassium	0.5	mg/L	11
Sodium	0.5	mg/L	370

## Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported. A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acetic Acid* - Method: Acetic Acid by HPLC	Melbourne	Sep 18, 2015	7 Day
Ammonium Ion (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Oct 08, 2015	7 Day
Biochemical Oxygen Demand (BOD-5 Day) - Method: LTM-INO-4010	Melbourne	Sep 16, 2015	2 Day
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Melbourne	Sep 16, 2015	28 Day
Phosphorus reactive (as P) - Method: APHA4500-PO4	Melbourne	Sep 16, 2015	2 Day
Total Organic Carbon - Method: APHA 5310B Total Organic Carbon	Melbourne	Sep 17, 2015	28 Day
<b>Major Anions</b>			
Bicarbonate Alkalinity (as CaCO <sub>3</sub> ) - Method: APHA 2320 Alkalinity by Titration	Melbourne	Sep 17, 2015	14 Day
Carbonate Alkalinity (as CaCO <sub>3</sub> ) - Method: APHA 2320 Alkalinity by Titration	Melbourne	Sep 17, 2015	14 Day
Chloride - Method: MGT 1100A	Melbourne	Sep 17, 2015	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Melbourne	Sep 17, 2015	7 Day
Sulphate (as S) - Method: In house MGT1110A (SO <sub>4</sub> by Discrete Analyser)	Melbourne	Sep 17, 2015	28 Day
Heavy Metals (filtered) - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 16, 2015	180 Day
Heavy Metals - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 16, 2015	180 Day
<b>Major Cations</b>			
Ammonia (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Sep 17, 2015	28 Day
Alkali Metals - Method: USEPA 6010 Alkali Metals	Melbourne	Sep 16, 2015	180 Day

## Eurofins | mgt Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis. 7. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

**\*\*NOTE:** pH duplicates are reported as a range NOT as RPD

### UNITS

**mg/kg:** milligrams per Kilogram

**mg/l:** milligrams per litre

**ug/l:** micrograms per litre

**ppm:** Parts per million

**ppb:** Parts per billion

**%:** Percentage

**org/100ml:** Organisms per 100 millilitres

**NTU:** Nephelometric Turbidity Units

**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

### TERMS

<b>Dry</b>	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
<b>LOR</b>	Limit of Reporting.
<b>SPIKE</b>	Addition of the analyte to the sample and reported as percentage recovery.
<b>RPD</b>	Relative Percent Difference between two Duplicate pieces of analysis.
<b>LCS</b>	Laboratory Control Sample - reported as percent recovery
<b>CRM</b>	Certified Reference Material - reported as percent recovery
<b>Method Blank</b>	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
<b>Surr - Surrogate</b>	The addition of a like compound to the analyte target and reported as percentage recovery.
<b>Duplicate</b>	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
<b>Batch Duplicate</b>	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>Batch SPIKE</b>	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>USEPA</b>	United States Environmental Protection Agency
<b>APHA</b>	American Public Health Association
<b>ASLP</b>	Australian Standard Leaching Procedure (AS4439.3)
<b>TCLP</b>	Toxicity Characteristic Leaching Procedure
<b>COC</b>	Chain of Custody
<b>SRA</b>	Sample Receipt Advice
<b>CP</b>	Client Parent - QC was performed on samples pertaining to this report
<b>NCP</b>	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within
<b>TEQ</b>	Toxic Equivalency Quotient

### QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

### QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
9. For Matrix Spikes and LCS results a dash " - " in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data.

## Quality Control Results

Test	Units	Result 1		Acceptance Limits	Pass Limits	Qualifying Code
<b>Method Blank</b>						
Acetic Acid*	mg/L	< 10		10	Pass	
Ammonia (as N)	mg/L	< 0.01		0.01	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	mg/L	< 5		5	Pass	
Chemical Oxygen Demand (COD)	mg/L	< 20		20	Pass	
Phosphorus reactive (as P)	mg/L	< 0.05		0.05	Pass	
Total Organic Carbon	mg/L	< 5		5	Pass	
<b>Method Blank</b>						
<b>Major Anions</b>						
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	mg/L	< 20		20	Pass	
Carbonate Alkalinity (as CaCO <sub>3</sub> )	mg/L	< 10		10	Pass	
Chloride	mg/L	< 1		1	Pass	
Nitrate (as N)	mg/L	< 0.02		0.02	Pass	
Sulphate (as S)	mg/L	< 5		5	Pass	
<b>Method Blank</b>						
<b>Heavy Metals</b>						
Copper (filtered)	mg/L	< 0.001		0.001	Pass	
Iron	mg/L	< 0.05		0.05	Pass	
Manganese (filtered)	mg/L	< 0.005		0.005	Pass	
Zinc (filtered)	mg/L	< 0.001		0.001	Pass	
<b>Method Blank</b>						
<b>Alkali Metals</b>						
Calcium	mg/L	< 0.5		0.5	Pass	
Magnesium	mg/L	< 0.5		0.5	Pass	
Potassium	mg/L	< 0.5		0.5	Pass	
Sodium	mg/L	< 0.5		0.5	Pass	
<b>LCS - % Recovery</b>						
Acetic Acid*	%	74		70-130	Pass	
Ammonia (as N)	%	96		70-130	Pass	
Chemical Oxygen Demand (COD)	%	95		70-130	Pass	
Total Organic Carbon	%	87		70-130	Pass	
<b>LCS - % Recovery</b>						
<b>Major Anions</b>						
Chloride	%	106		70-130	Pass	
Nitrate (as N)	%	107		70-130	Pass	
Sulphate (as S)	%	100		70-130	Pass	
<b>LCS - % Recovery</b>						
<b>Heavy Metals</b>						
Copper (filtered)	%	94		80-120	Pass	
Manganese (filtered)	%	94		80-120	Pass	
Zinc (filtered)	%	95		80-120	Pass	
<b>LCS - % Recovery</b>						
<b>Alkali Metals</b>						
Calcium	%	96		70-130	Pass	
Magnesium	%	100		70-130	Pass	
Potassium	%	90		70-130	Pass	
Sodium	%	89		70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Spike - % Recovery</b>									
				Result 1					
Acetic Acid*	M15-Se08493	NCP	%	91			70-130	Pass	
Ammonia (as N)	M15-Se16129	NCP	%	95			70-130	Pass	
Chemical Oxygen Demand (COD)	M15-Se10731	NCP	%	77			70-130	Pass	
Phosphorus reactive (as P)	B15-Se14872	NCP	%	95			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Major Anions</b>									
				Result 1					
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	M15-Se16116	NCP	%	108			70-130	Pass	
Chloride	M15-Se15816	NCP	%	110			70-130	Pass	
Nitrate (as N)	M15-Se16129	NCP	%	105			70-130	Pass	
Sulphate (as S)	M15-Se16755	NCP	%	108			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Heavy Metals</b>									
				Result 1					
Copper (filtered)	M15-Se15271	NCP	%	88			70-130	Pass	
Manganese (filtered)	M15-Se15271	NCP	%	92			70-130	Pass	
Zinc (filtered)	M15-Se15271	NCP	%	81			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkali Metals</b>									
				Result 1					
Calcium	M15-Se15721	CP	%	93			70-130	Pass	
Magnesium	M15-Se15721	CP	%	108			70-130	Pass	
Potassium	M15-Se15721	CP	%	87			70-130	Pass	
Sodium	M15-Se15721	CP	%	108			70-130	Pass	
Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Duplicate</b>									
				Result 1	Result 2	RPD			
Acetic Acid*	M15-Se05769	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Ammonia (as N)	M15-Se16129	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	M15-Se15696	NCP	mg/L	46	40	14	30%	Pass	
Chemical Oxygen Demand (COD)	B15-Au23190	NCP	mg/L	1100	1200	4.0	30%	Pass	
Phosphorus reactive (as P)	B15-Se14872	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Total Organic Carbon	B15-Se14872	NCP	mg/L	< 5	< 5	<1	30%	Pass	
<b>Duplicate</b>									
<b>Major Anions</b>									
				Result 1	Result 2	RPD			
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	M15-Se16115	NCP	mg/L	740	750	1.0	30%	Pass	
Carbonate Alkalinity (as CaCO <sub>3</sub> )	M15-Se16115	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Chloride	M15-Se15816	NCP	mg/L	220	220	<1	30%	Pass	
Nitrate (as N)	M15-Se16129	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Sulphate (as S)	M15-Se16755	NCP	mg/L	27	27	<1	30%	Pass	
<b>Duplicate</b>									
<b>Heavy Metals</b>									
				Result 1	Result 2	RPD			
Copper (filtered)	M15-Se15271	NCP	mg/L	0.023	0.022	5.0	30%	Pass	
Manganese (filtered)	M15-Se15271	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc (filtered)	M15-Se15271	NCP	mg/L	0.12	0.11	5.0	30%	Pass	
<b>Duplicate</b>									
<b>Alkali Metals</b>									
				Result 1	Result 2	RPD			
Calcium	M15-Se15721	CP	mg/L	23	22	3.0	30%	Pass	
Magnesium	M15-Se17336	NCP	mg/L	200	220	8.0	30%	Pass	
Potassium	M15-Se15721	CP	mg/L	11	10	10	30%	Pass	
Sodium	M15-Se16923	NCP	mg/L	26	25	3.0	30%	Pass	

**Comments**

v2: Ammonium as N results added.

**Sample Integrity**

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

**Authorised By**

Mark Rodriguez	Analytical Services Manager
Carroll Lee	Senior Analyst-Organic (VIC)
Emily Rosenberg	Senior Analyst-Metal (VIC)
Huong Le	Senior Analyst-Inorganic (VIC)



**Glenn Jackson**

**National Operations Manager**

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

\* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

Eurofins | mgt shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins | mgt be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

# CHAIN OF CUSTODY DOCUMENTATION



ALS Laboratory Group

CLIENT: URS Australia

SAMPLER: Kim Treglown

ADDRESS / OFFICE: Level 3, 93 Mitchell Street, Darwin 0800

MOBILE: ~~###~~ 0422 088 362

PROJECT MANAGER (PM): Chris MacHunter

PHONE:

PROJECT ID: 42214019

EMAIL REPORT TO: kim.treglown@urs.com; chris.machunter@urs.com

SITE: Shoal Bay Hydrogeological Sampling P.O. NO.:

EMAIL INVOICE TO: (if different to report)

RESULTS REQUIRED (Date): QUOTE NO.:

ANALYSIS REQUIRED including SUITES (note - suite codes must be listed to attract suite prices)

FOR LABORATORY USE ONLY  
 COOLER SEAL (tick appropriate)  
 Intact:  Yes  No  
 SAMPLE TEMPERATURE  
 CHILLED:  Yes  No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

NT-1 (Cations: Major (Ca, Mg, Na, K))	NT-2 (Anions: Minor (Cl, SO4, Alkalinity))	EK058G (Nitrate)	EK055G-NH4 (Ammonium as N)	EK071 (Reactive Phosphorus as P)	EG020F (Dissolved metals: Mn, Zn, Cu)	EG020T (Total: Fe)	EP005 (TOC)	EP030 (BOD)	EP026 (COD)	EP045 (CH3COOH)	HOLD
------------------------------------------	-----------------------------------------------	------------------	----------------------------	----------------------------------	------------------------------------------	--------------------	-------------	-------------	-------------	-----------------	------

Notes: e.g. Highly contaminated samples e.g. "High PAHs expected".  
 Extra volume for QC or trace LORs etc.

SAMPLE INFORMATION (note: S = Soil, W=Water) CONTAINER INFORMATION

ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles	NT-1	NT-2	EK058G	EK055G-NH4	EK071	EG020F	EG020T	EP005	EP030	EP026	EP045	HOLD	
1	GW4-12-160915	W	16/9/15	900	VH1, P, SP	6													
2	GW2-12-160915	W	16/9/15	1030	VH1, P, SP	7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	GW12-12-160915	W	16/9/15	1430	VH1, P, SP	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	QAQ03-160915	W	16/9/15	1430	VH1, P, SP	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	QCR02-160915	W	16/9/15	1430	VH1, P, SP	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
						31	a	9	4	4	4	4	4	4	4	4	4	7	

LAB OF ORIGIN:  
DARWIN

ES1531356

Environmental Division  
 Sydney  
 Work Order Reference  
**ES1531356**



Telephone : +61-2-8784 8555

RELINQUISHED BY:

RECEIVED BY:

METHOD OF SHIPMENT

Name: K. Treglown. Date: 16/9/15  
 Of: URS Time: 15:30

Name: Kim Pham Date: 17/9/15  
 Of: ALS Sydney Time: 12:00

Con' Note No:  
 Transport Co:

**Water Container Codes:** P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved;  
 V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;  
 Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.



SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : ES1531356

Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Contact	: Loren Schiavon
Address	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: kim.treglown@urs.com	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 08 89802900	Telephone	: +61 2 8784 8503
Facsimile	: +61 08 89413920	Facsimile	: +61-2-8784 8500
Project	: 42214019	Page	: 1 of 3
Order number	: ----	Quote number	: ES2014URSNT0273 (EN/001/14)
C-O-C number	: ----	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING		
Sampler	: KIM TREGLOWN		

Dates

Date Samples Received	: 17-Sep-2015 12:00 PM	Issue Date	: 18-Sep-2015
Client Requested Due Date	: 24-Sep-2015	Scheduled Reporting Date	: <b>24-Sep-2015</b>

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 3.2' C SYD - Ice present
Receipt Detail	:	No. of samples received / analysed	: 5 / 5

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.



## Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

## Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020F Dissolved Metals by ICPMS	WATER - EK055G-NH4 Ammonium as N	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - EP030 BOD	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity
ES1531356-001	16-Sep-2015 09:00	GW4_12_160915	✓	✓	✓	✓	✓	✓	✓
ES1531356-002	16-Sep-2015 10:30	GW2_12_160915	✓	✓	✓	✓	✓	✓	
ES1531356-003	16-Sep-2015 14:30	GW12_12_160915	✓	✓	✓	✓	✓	✓	
ES1531356-004	16-Sep-2015 14:30	QAQC03_160915	✓	✓	✓	✓	✓	✓	
ES1531356-005	16-Sep-2015 14:30	QCB02_160915	✓	✓	✓	✓	✓	✓	

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020T Total Recoverable Metals by ICPMS (including	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP045 Volatile Acids as CH3COOH
ES1531356-001	16-Sep-2015 09:00	GW4_12_160915	✓	✓	✓
ES1531356-002	16-Sep-2015 10:30	GW2_12_160915	✓	✓	✓
ES1531356-003	16-Sep-2015 14:30	GW12_12_160915	✓	✓	✓
ES1531356-004	16-Sep-2015 14:30	QAQC03_160915	✓	✓	✓
ES1531356-005	16-Sep-2015 14:30	QCB02_160915	✓	✓	✓

## Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



## Requested Deliverables

### CHRIS Mac HUNTER

- *AU Certificate of Analysis - NATA (COA)	Email	chris.machunter@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	chris.machunter@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	chris.machunter@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	chris.machunter@urs.com
- A4 - AU Tax Invoice (INV)	Email	chris.machunter@urs.com
- Chain of Custody (CoC) (COC)	Email	chris.machunter@urs.com
- EDI Format - ENMRG (ENMRG)	Email	chris.machunter@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	chris.machunter@urs.com
- EDI Format - ESDAT (ESDAT)	Email	chris.machunter@urs.com
- EDI Format - MRED (MRED)	Email	chris.machunter@urs.com

### KIM TREGLOWN

- *AU Certificate of Analysis - NATA (COA)	Email	kim.treglown@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	kim.treglown@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	kim.treglown@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	kim.treglown@urs.com
- A4 - AU Tax Invoice (INV)	Email	kim.treglown@urs.com
- Chain of Custody (CoC) (COC)	Email	kim.treglown@urs.com
- EDI Format - ENMRG (ENMRG)	Email	kim.treglown@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	kim.treglown@urs.com
- EDI Format - ESDAT (ESDAT)	Email	kim.treglown@urs.com
- EDI Format - MRED (MRED)	Email	kim.treglown@urs.com

### RESULTS ADDRESS

- *AU Certificate of Analysis - NATA (COA)	Email	darwin@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	darwin@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	darwin@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	darwin@urs.com
- A4 - AU Tax Invoice (INV)	Email	darwin@urs.com
- Chain of Custody (CoC) (COC)	Email	darwin@urs.com
- EDI Format - ENMRG (ENMRG)	Email	darwin@urs.com
- EDI Format - MRED (MRED)	Email	darwin@urs.com



CERTIFICATE OF ANALYSIS

Work Order : ES1531356
Client : URS AUSTRALIA PTY LTD
Contact : KIM TREGLOWN
Address : Supplier ID number - 1179447 G P O BOX 2005
DARWIN NT, AUSTRALIA 0801
E-mail : kim.treglown@urs.com
Telephone : +61 08 89802900
Facsimile : +61 08 89413920
Project : 42214019
Order number : ----
C-O-C number : ----
Sampler : KIM TREGLOWN
Site : SHOAL BAY HYDROGEOLOGICAL SAMPLING
Quote number : ----

Page : 1 of 4
Laboratory : Environmental Division Sydney
Contact : Loren Schiavon
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail : loren.schiavon@alsglobal.com
Telephone : +61 2 8784 8503
Facsimile : +61-2-8784 8500
QC Level : NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Date Samples Received : 17-Sep-2015 12:00
Date Analysis Commenced : 17-Sep-2015
Issue Date : 24-Sep-2015 17:29
No. of samples received : 5
No. of samples analysed : 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
Analytical Results



NATA Accredited Laboratory 825
Accredited for compliance with
ISO/IEC 17025.

Signatories

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

Table with 3 columns: Signatories, Position, Accreditation Category. Rows include Ankit Joshi (Inorganic Chemist, Sydney Inorganics), Ashesh Patel (Inorganic Chemist, Sydney Inorganics), and Celine Conceicao (Senior Spectroscopist, Sydney Inorganics).



## 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.

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  
∅ = ALS is not NATA accredited for these tests.

- EG020: Poor matrix spike recovery was obtained for Zinc on sample ES1531356 - #002 due to matrix interference. Confirmed by reanalysis.
-



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW4_12_160915	GW2_12_160915	GW12_12_160915	QAQC03_160915	QCB02_160915
Client sampling date / time				16-Sep-2015 09:00	16-Sep-2015 10:30	16-Sep-2015 14:30	16-Sep-2015 14:30	16-Sep-2015 14:30	
Compound	CAS Number	LOR	Unit	ES1531356-001	ES1531356-002	ES1531356-003	ES1531356-004	ES1531356-005	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1	68	6	<1	<1	
Total Alkalinity as CaCO3	----	1	mg/L	1	68	6	<1	<1	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	467	1250	6	12	<1	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	3260	7680	6	6	<1	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	117	414	2	2	<1	
Magnesium	7439-95-4	1	mg/L	116	529	1	1	<1	
Sodium	7440-23-5	1	mg/L	1880	5020	4	4	<1	
Potassium	7440-09-7	1	mg/L	49	42	1	1	<1	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	0.039	0.080	0.006	0.006	<0.001	
Manganese	7439-96-5	0.001	mg/L	0.489	0.055	0.049	0.047	<0.001	
Zinc	7440-66-6	0.005	mg/L	0.389	0.778	0.159	0.169	<0.005	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	0.64	0.52	2.49	2.70	<0.05	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	0.04	0.04	0.04	0.04	<0.01	
<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	0.12	0.03	0.03	0.03	<0.01	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.01	mg/L	0.12	0.04	0.03	0.03	<0.01	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	102	244	0.41	0.42	<0.01	
^ Total Cations	----	0.01	meq/L	98.4	284	0.38	0.38	<0.01	
^ Ionic Balance	----	0.01	%	1.66	7.49	----	----	----	



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW4_12_160915	GW2_12_160915	GW12_12_160915	QAQC03_160915	QCB02_160915
Client sampling date / time				16-Sep-2015 09:00	16-Sep-2015 10:30	16-Sep-2015 14:30	16-Sep-2015 14:30	16-Sep-2015 14:30	
Compound	CAS Number	LOR	Unit	ES1531356-001	ES1531356-002	ES1531356-003	ES1531356-004	ES1531356-005	
				Result	Result	Result	Result	Result	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	17	2	1	<1	<1	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	110	50	<10	<10	<10	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	4	<2	<2	<2	<2	
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	18	44	12	14	5	

## QUALITY CONTROL REPORT

<b>Work Order</b>	: <b>ES1531356</b>	<b>Page</b>	: 1 of 8
<b>Client</b>	: <b>URS AUSTRALIA PTY LTD</b>	<b>Laboratory</b>	: Environmental Division Sydney
<b>Contact</b>	: <b>KIM TREGLOWN</b>	<b>Contact</b>	: Loren Schiavon
<b>Address</b>	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	<b>Address</b>	: 277-289 Woodpark Road Smithfield NSW Australia 2164
<b>E-mail</b>	: kim.treglown@urs.com	<b>E-mail</b>	: loren.schiavon@alsglobal.com
<b>Telephone</b>	: +61 08 89802900	<b>Telephone</b>	: +61 2 8784 8503
<b>Facsimile</b>	: +61 08 89413920	<b>Facsimile</b>	: +61-2-8784 8500
<b>Project</b>	: 42214019	<b>QC Level</b>	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Order number</b>	: ----	<b>Date Samples Received</b>	: 17-Sep-2015
<b>C-O-C number</b>	: ----	<b>Date Analysis Commenced</b>	: 17-Sep-2015
<b>Sampler</b>	: <b>KIM TREGLOWN</b>	<b>Issue Date</b>	: 24-Sep-2015
<b>Site</b>	: <b>SHOAL BAY HYDROGEOLOGICAL SAMPLING</b>	<b>No. of samples received</b>	: 5
<b>Quote number</b>	: ----	<b>No. of samples analysed</b>	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits



NATA Accredited  
Laboratory 825

Accredited for  
compliance with  
ISO/IEC 17025.

### *Signatories*

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics

Page : 2 of 8  
Work Order : ES1531356  
Client : URS AUSTRALIA PTY LTD  
Project : 42214019

---



### **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

Key :  
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot  
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  
RPD = Relative Percentage Difference  
# = Indicates failed QC



## Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 218289)</b>									
ES1531356-001	GW4_12_160915	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1	2	52.5	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1	2	52.5	No Limit
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 218468)</b>									
ES1531356-002	GW2_12_160915	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	68	67	2.67	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	68	67	2.67	0% - 20%
ES1531591-002	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	37	37	0.00	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	37	37	0.00	0% - 20%
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 218709)</b>									
ES1531551-008	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	85	85	0.00	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	85	85	0.00	0% - 20%
ES1531551-001	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	26	28	7.94	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	26	28	7.94	0% - 20%
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 217343)</b>									
ES1531323-010	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<10	<10	0.00	No Limit
ES1531356-002	GW2_12_160915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1250	1260	0.922	0% - 20%
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 218294)</b>									
ES1531575-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.00	No Limit
ES1531356-001	GW4_12_160915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	467	464	0.669	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 217344)</b>									
ES1531323-010	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	15	15	0.00	0% - 50%
ES1531356-002	GW2_12_160915	ED045G: Chloride	16887-00-6	1	mg/L	7680	7880	2.63	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 218293)</b>									
ES1531575-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	481	500	3.89	0% - 20%
ES1531356-001	GW4_12_160915	ED045G: Chloride	16887-00-6	1	mg/L	3260	3280	0.653	0% - 20%



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>ED093F: Dissolved Major Cations (QC Lot: 218162)</b>									
ES1531356-001	GW4_12_160915	ED093F: Calcium	7440-70-2	1	mg/L	117	121	2.95	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	116	122	5.56	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	49	50	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	1880	1920	2.26	0% - 20%
<b>EG020F: Dissolved Metals by ICP-MS (QC Lot: 218163)</b>									
EW1511713-005	Anonymous	EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.021	0.021	0.00	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
ES1531356-001	GW4_12_160915	EG020A-F: Copper	7440-50-8	0.001	mg/L	0.039	0.040	0.00	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.489	0.506	3.58	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.389	0.388	0.00	0% - 20%
<b>EG020T: Total Metals by ICP-MS (QC Lot: 219985)</b>									
ES1527946-013	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.22	0.22	0.00	No Limit
ES1531356-004	QAQC03_160915	EG020A-T: Iron	7439-89-6	0.05	mg/L	2.70	2.78	2.92	0% - 20%
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 217345)</b>									
ES1531356-002	GW2_12_160915	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.01	<0.01	0.00	No Limit
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 218295)</b>									
EW1511780-002	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
ES1531356-001	GW4_12_160915	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 218027)</b>									
ES1531223-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
ES1531356-002	GW2_12_160915	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.04	0.04	0.00	No Limit
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 217346)</b>									
ES1531356-002	GW2_12_160915	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.01	0.00	No Limit
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 218296)</b>									
ES1531356-001	GW4_12_160915	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EP005: Total Organic Carbon (TOC) (QC Lot: 218056)</b>									
ES1531313-051	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	4	4	0.00	No Limit
ES1531313-061	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	7	7	0.00	No Limit
<b>EP005: Total Organic Carbon (TOC) (QC Lot: 218057)</b>									
ES1531356-002	GW2_12_160915	EP005: Total Organic Carbon	----	1	mg/L	2	<1	88.4	No Limit
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 221828)</b>									
EP1513943-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	3490	3500	0.229	0% - 20%
ES1531443-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	1200	1230	2.96	0% - 20%
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 217313)</b>									
ES1531356-002	GW2_12_160915	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	5	85.7	No Limit
ES1531460-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 218557)</b>									

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 Work Order : ES1531356  
 Client : URS AUSTRALIA PTY LTD  
 Project : 42214019



Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 218557) - continued</b>									
ES1531356-001	GW4_12_160915	EP030: Biochemical Oxygen Demand	----	2	mg/L	4	3	28.6	No Limit
ES1531462-006	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
<b>EP045: Volatile Acids as CH3COOH (QC Lot: 219344)</b>									
ES1531223-001	Anonymous	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	14	16	12.0	No Limit
ES1531356-003	GW12_12_160915	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	12	12	0.00	No Limit



## Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report				
				Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
						LCS	Low	High	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 218289)</b>									
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	94.3	81	111	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 218468)</b>									
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	100.0	81	111	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 218709)</b>									
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	92.3	81	111	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 217343)</b>									
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	106	86	122	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 218294)</b>									
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	98.2	86	122	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 217344)</b>									
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	107	75	123	
				<1	1000 mg/L	91.7	77	119	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 218293)</b>									
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	111	75	123	
				<1	1000 mg/L	95.5	77	119	
<b>ED093F: Dissolved Major Cations (QCLot: 218162)</b>									
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	106	90	114	
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	107	90	110	
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	104	87	117	
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	106	82	118	
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 218163)</b>									
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	92.3	85	115	
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	91.6	85	115	
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	94.6	85	115	
<b>EG020T: Total Metals by ICP-MS (QCLot: 219985)</b>									
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	104	82	120	
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 217345)</b>									
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	91.8	82	114	
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 218295)</b>									
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	98.4	82	114	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 218027)</b>									
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	105	91	113	



Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report				
					Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
						LCS	Low	High	
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 217346)</b>									
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	108	85	117	
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 218296)</b>									
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	94.8	85	117	
<b>EP005: Total Organic Carbon (TOC) (QCLot: 218056)</b>									
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	86.3	76	120	
<b>EP005: Total Organic Carbon (TOC) (QCLot: 218057)</b>									
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	85.2	76	120	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 221828)</b>									
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	92.0	80	120	
				<10	500 mg/L	96.0	80	120	
<b>EP030: Biochemical Oxygen Demand (BOD) (QCLot: 217313)</b>									
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	200 mg/L	94.5	74	110	
<b>EP030: Biochemical Oxygen Demand (BOD) (QCLot: 218557)</b>									
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	200 mg/L	84.5	74	110	
<b>EP045: Volatile Acids as CH3COOH (QCLot: 219344)</b>									
EP045: Volatile Acids as Acetic Acid	----	5	mg/L	<5	200 mg/L	94.4	88	112	

### Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report				
				Spike Concentration	Spike Recovery(%)		Recovery Limits (%)	
					MS	Low	High	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 217343)</b>								
ES1531356-002	GW2_12_160915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 218294)</b>								
ES1531356-001	GW4_12_160915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 217344)</b>								
ES1531356-002	GW2_12_160915	ED045G: Chloride	16887-00-6	250 mg/L	# Not Determined	70	130	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 218293)</b>								
ES1531356-001	GW4_12_160915	ED045G: Chloride	16887-00-6	250 mg/L	# Not Determined	70	130	



Sub-Matrix: WATER

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 218163)</b>							
ES1531356-002	GW2_12_160915	EG020A-F: Copper	7440-50-8	0.2 mg/L	92.7	70	130
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	91.0	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	# 44.8	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 217345)</b>							
ES1531356-002	GW2_12_160915	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	96.2	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 218295)</b>							
ES1531356-001	GW4_12_160915	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	95.0	70	130
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 218027)</b>							
ES1531223-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	102	70	130
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 217346)</b>							
ES1531356-002	GW2_12_160915	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	99.9	70	130
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 218296)</b>							
ES1531356-001	GW4_12_160915	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	100	70	130
<b>EP005: Total Organic Carbon (TOC) (QCLot: 218056)</b>							
ES1531313-052	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	93.5	70	130
<b>EP005: Total Organic Carbon (TOC) (QCLot: 218057)</b>							
ES1531356-003	GW12_12_160915	EP005: Total Organic Carbon	----	100 mg/L	93.0	70	130
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 221828)</b>							
EP1513943-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	47.6 mg/L	75.9	70	130

## QA/QC Compliance Assessment for DQO Reporting

Work Order	: ES1531356	Page	: 1 of 8
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Telephone	: +61 2 8784 8503
Project	: 42214019	Date Samples Received	: 17-Sep-2015
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING	Issue Date	: 24-Sep-2015
Sampler	: KIM TREGLOWN	No. of samples received	: 5
Order number	: ----	No. of samples analysed	: 5

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

### Summary of Outliers

#### Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

#### Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

#### Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



### Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Matrix Spike (MS) Recoveries</b>							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ES1531356--002	GW2_12_160915	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ES1531356--001	GW4_12_160915	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
ED045G: Chloride by Discrete Analyser	ES1531356--002	GW2_12_160915	Chloride	16887-00-6	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
ED045G: Chloride by Discrete Analyser	ES1531356--001	GW4_12_160915	Chloride	16887-00-6	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EG020F: Dissolved Metals by ICP-MS	ES1531356--002	GW2_12_160915	Zinc	7440-66-6	44.8 %	70-130%	Recovery less than lower data quality objective

### Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
<b>Matrix Spikes (MS)</b>					
Total Metals by ICP-MS - Suite A	0	6	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

### Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
<b>ED037P: Alkalinity by PC Titrator</b>							
<b>Clear Plastic Bottle - Natural (ED037-P)</b>							
GW4_12_160915, GW12_12_160915, QCB02_160915	16-Sep-2015	---	---	---	18-Sep-2015	30-Sep-2015	✓



Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>								
Clear Plastic Bottle - Natural (ED041G) GW2_12_160915, QAQC03_160915,	GW12_12_160915, QCB02_160915	16-Sep-2015	----	----	----	17-Sep-2015	14-Oct-2015	✓
Clear Plastic Bottle - Natural (ED041G) GW4_12_160915		16-Sep-2015	----	----	----	18-Sep-2015	14-Oct-2015	✓
<b>ED045G: Chloride by Discrete Analyser</b>								
Clear Plastic Bottle - Natural (ED045G) GW2_12_160915, QAQC03_160915,	GW12_12_160915, QCB02_160915	16-Sep-2015	----	----	----	17-Sep-2015	14-Oct-2015	✓
Clear Plastic Bottle - Natural (ED045G) GW4_12_160915		16-Sep-2015	----	----	----	18-Sep-2015	14-Oct-2015	✓
<b>ED093F: Dissolved Major Cations</b>								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	19-Sep-2015	14-Oct-2015	✓
<b>EG020F: Dissolved Metals by ICP-MS</b>								
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F) GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	19-Sep-2015	14-Mar-2016	✓
<b>EG020T: Total Metals by ICP-MS</b>								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	21-Sep-2015	14-Mar-2016	✓	21-Sep-2015	14-Mar-2016	✓
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
Clear Plastic Bottle - Natural (EK057G) GW2_12_160915, QAQC03_160915,	GW12_12_160915, QCB02_160915	16-Sep-2015	----	----	----	17-Sep-2015	18-Sep-2015	✓
Clear Plastic Bottle - Natural (EK057G) GW4_12_160915		16-Sep-2015	----	----	----	18-Sep-2015	18-Sep-2015	✓
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
Clear Plastic Bottle - Sulfuric Acid (EK059G) GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	18-Sep-2015	14-Oct-2015	✓



Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>								
<b>Clear Plastic Bottle - Natural (EK071G)</b> GW2_12_160915, QAQC03_160915,	GW12_12_160915, QCB02_160915	16-Sep-2015	----	----	----	17-Sep-2015	18-Sep-2015	✓
<b>Clear Plastic Bottle - Natural (EK071G)</b> GW4_12_160915		16-Sep-2015	----	----	----	18-Sep-2015	18-Sep-2015	✓
<b>EP005: Total Organic Carbon (TOC)</b>								
<b>Amber TOC Vial - Sulfuric Acid (EP005)</b> GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	18-Sep-2015	14-Oct-2015	✓
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>								
<b>Clear Plastic Bottle - Sulfuric Acid (EP026SP)</b> GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	23-Sep-2015	14-Oct-2015	✓
<b>EP030: Biochemical Oxygen Demand (BOD)</b>								
<b>Clear Plastic Bottle - Natural (EP030)</b> GW2_12_160915, QAQC03_160915,	GW12_12_160915, QCB02_160915	16-Sep-2015	----	----	----	17-Sep-2015	18-Sep-2015	✓
<b>Clear Plastic Bottle - Natural (EP030)</b> GW4_12_160915		16-Sep-2015	----	----	----	18-Sep-2015	18-Sep-2015	✓
<b>EP045: Volatile Acids as CH3COOH</b>								
<b>Clear Plastic Bottle - Natural (EP045)</b> GW4_12_160915, GW12_12_160915, QCB02_160915	GW2_12_160915, QAQC03_160915,	16-Sep-2015	----	----	----	21-Sep-2015	30-Sep-2015	✓



## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Reaular	Actual	Expected	Evaluation	
<b>Laboratory Duplicates (DUP)</b>							
Alkalinity by PC Titrator	ED037-P	1	9	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	2	19	10.53	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	7	28.57	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	6	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	16	12.50	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	4	25.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	4	25.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	6	33.33	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	2	18	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Laboratory Control Samples (LCS)</b>							
Alkalinity by PC Titrator	ED037-P	1	9	11.11	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	7	14.29	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Method Blanks (MB)</b>							
Biochemical Oxygen Demand (BOD)	EP030	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	7	14.29	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Regular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Method Blanks (MB) - Continued</b>							
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	7	14.29	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	4	25.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	0	6	0.00	5.00	*	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO <sub>4</sub> <sup>2-</sup> by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO <sub>4</sub> . Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO <sub>4</sub> suspension is measured by a photometer and the SO <sub>4</sub> <sup>2-</sup> concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3)  Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3)  Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Ammonium as N	EK055G-NH4	WATER	Ammonium in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH and Temperature. Ammonia is determined by direct colorimetry by Discrete Analyser according to APHA 4500-NH <sub>3</sub> G. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO <sub>2</sub> - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO <sub>3</sub> - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)



<i>Analytical Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	WATER	In house: Referenced to APHA 5220 D. Samples are digested with a known excess of an acidic potassium dichromate solution using silver sulfate as a catalyst. The chromium is reduced from the Cr (VI) oxidation state to the Cr (III) state by the oxygen present in the organic material. Both of these chromium species are coloured and absorb in the visible region of (400nm & 600nm) the spectrum. The oxidisable organic matter can be calculated in terms of oxygen equivalents.
Biochemical Oxygen Demand (BOD)	EP030	WATER	In house: Referenced to APHA 5210 B. The 5-Day BOD test provides an empirical measure of the oxygen consumption capacity of a given water. A portion of the sample is diluted into oxygenated, nutrient rich water, and a seed added to begin biological decay. The initial dissolved oxygen content is measured, then the bottle is sealed and incubated for five days. The remaining dissolved oxygen is measured, and from the difference, the demand for oxygen, by biological decay, is determined. This method is compliant with NEPM (2013) Schedule B(3)
Volatile Acids as CH <sub>3</sub> COOH	EP045	WATER	In house: Referenced to APHA 5560 C. Steam distillable acids are captured in caustic solution and determined titrimetrically. This method is compliant with NEPM (2013) Schedule B(3)
<i>Preparation Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)



## Sample Receipt Advice

Company name: **URS Australia Pty Ltd NT**  
Contact name: **Kim Treglown**  
Project name: **SHOAL BAY HYDROGEOLOG**  
Project ID: **42214019**  
COC number: **Not provided**  
Turn around time: **5 Day**  
Date/Time received: **Sep 17, 2015 8:30 AM**  
Eurofins | mgt reference: **472745**

### Sample information

- A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- All samples have been received as described on the above COC.
- COC has been completed correctly.
- Attempt to chill was evident.
- Appropriately preserved sample containers have been used.
- All samples were received in good condition.
- Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- Appropriate sample containers have been used.
- Sample containers for volatile analysis received with zero headspace.
- Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

### Contact notes

If you have any questions with respect to these samples please contact:

Mark Rodriquez on Phone : (+61) 8 8947 1557 or by e.mail: MarkRodriquez@eurofins.com.au

Results will be delivered electronically via e.mail to Kim Treglown - kim.treglown@urs.com.

*Note: A copy of these results will also be delivered to the general URS Australia Pty Ltd NT email address.*

**Company Name:** URS Australia Pty Ltd NT  
**Address:** Level 3 93 Mitchell St  
 Darwin  
 NT 801  
**Project Name:** SHOAL BAY HYDROGEOLOG  
**Project ID:** 42214019

**Order No.:**  
**Report #:** 472745  
**Phone:** 08 8980 2900  
**Fax:**

**Received:** Sep 17, 2015 8:30 AM  
**Due:** Sep 24, 2015  
**Priority:** 5 Day  
**Contact Name:** Kim Treglown

**Eurofins | mgt Client Manager: Mark Rodriquez**

**Sample Detail**

Alkali Metals																			
Zinc (filtered)																			
Total Organic Carbon																			
Total Alkalinity (as CaCO3)																			
Sulphate (as S)																			
Phosphorus reactive (as P)																			
Nitrate (as N)																			
Manganese (filtered)																			
Iron																			
Copper (filtered)																			
Chloride																			
Chemical Oxygen Demand (COD)																			
Biochemical Oxygen Demand (BOD-5 Day)																			
Ammonium Ion (as N)																			
Ammonia (as N)																			
Acetic Acid*																			

**Laboratory where analysis is conducted**

Melbourne Laboratory - NATA Site # 1254 & 14271	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																			
Brisbane Laboratory - NATA Site # 20794																			
Internal Laboratory																			

Sample ID	Sample Date	Sampling Time	Matrix	LAB ID															
AQC04_1609	Sep 16, 2015		Water	M15-Se16885	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

0015 085 521 e.mail : EnviroSales@eurofins.com.au

## Certificate of Analysis

URS Australia Pty Ltd  
 Level 3 93 Mitchell St  
 Darwin  
 NT 801



NATA Accredited  
 Accreditation Number 1261  
 Site Number 1254

Accredited for compliance with ISO/IEC 17025.  
 The results of the tests, calibrations and/or  
 measurements included in this document are traceable  
 to Australian/national standards.

**Attention:** Kim Treglown

**Report** 472745-W-V2  
 Project name SHOAL BAY HYDROGEOLOG  
 Project ID 42214019  
 Received Date Sep 17, 2015

Client Sample ID			QAQC04_1609 15
Sample Matrix			Water
Eurofins   mgt Sample No.			M15-Se16885
Date Sampled			Sep 16, 2015
Test/Reference	LOR	Unit	
Acetic Acid*	10	mg/L	< 10
Ammonia (as N)	0.01	mg/L	0.01
Ammonium Ion (as N)	0.01	mg/L	0.01
Biochemical Oxygen Demand (BOD-5 Day)	5	mg/L	< 5
Chemical Oxygen Demand (COD)	20	mg/L	< 20
Chloride	1	mg/L	6.9
Nitrate (as N)	0.02	mg/L	< 0.02
Phosphorus reactive (as P)	0.05	mg/L	< 0.05
Sulphate (as S)	5	mg/L	< 5
Total Organic Carbon	5	mg/L	< 5
<b>Alkalinity</b>			
Total Alkalinity (as CaCO3)	20	mg/L	< 20
<b>Heavy Metals</b>			
Copper (filtered)	0.001	mg/L	0.006
Iron	0.05	mg/L	5.5
Manganese (filtered)	0.005	mg/L	0.045
Zinc (filtered)	0.001	mg/L	0.14
<b>Alkali Metals</b>			
Calcium	0.5	mg/L	2.3
Magnesium	0.5	mg/L	1.3
Potassium	0.5	mg/L	1.3
Sodium	0.5	mg/L	4.0

## Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported. A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acetic Acid* - Method: Acetic Acid by HPLC	Melbourne	Sep 21, 2015	7 Day
Ammonia (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Sep 17, 2015	28 Day
Ammonium Ion (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Oct 09, 2015	7 Day
Biochemical Oxygen Demand (BOD-5 Day) - Method: LTM-INO-4010	Melbourne	Sep 17, 2015	2 Day
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Melbourne	Sep 17, 2015	28 Day
Chloride - Method: MGT 1100A	Melbourne	Sep 17, 2015	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Melbourne	Sep 17, 2015	7 Day
Phosphorus reactive (as P) - Method: APHA4500-PO4	Melbourne	Sep 17, 2015	2 Day
Sulphate (as S) - Method: In house MGT1110A (SO4 by Discrete Analyser)	Melbourne	Sep 17, 2015	28 Day
Total Organic Carbon - Method: APHA 5310B Total Organic Carbon	Melbourne	Sep 21, 2015	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Melbourne	Sep 17, 2015	14 Day
Heavy Metals (filtered) - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 17, 2015	180 Day
Heavy Metals - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 17, 2015	180 Day
Alkali Metals - Method: USEPA 6010 Alkali Metals	Melbourne	Sep 17, 2015	180 Day

## Eurofins | mgt Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis. 7. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

**\*\*NOTE:** pH duplicates are reported as a range NOT as RPD

### UNITS

**mg/kg:** milligrams per Kilogram

**mg/l:** milligrams per litre

**ug/l:** micrograms per litre

**ppm:** Parts per million

**ppb:** Parts per billion

**%:** Percentage

**org/100ml:** Organisms per 100 millilitres

**NTU:** Nephelometric Turbidity Units

**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

### TERMS

<b>Dry</b>	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
<b>LOR</b>	Limit of Reporting.
<b>SPIKE</b>	Addition of the analyte to the sample and reported as percentage recovery.
<b>RPD</b>	Relative Percent Difference between two Duplicate pieces of analysis.
<b>LCS</b>	Laboratory Control Sample - reported as percent recovery
<b>CRM</b>	Certified Reference Material - reported as percent recovery
<b>Method Blank</b>	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
<b>Surr - Surrogate</b>	The addition of a like compound to the analyte target and reported as percentage recovery.
<b>Duplicate</b>	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
<b>Batch Duplicate</b>	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>Batch SPIKE</b>	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>USEPA</b>	United States Environmental Protection Agency
<b>APHA</b>	American Public Health Association
<b>ASLP</b>	Australian Standard Leaching Procedure (AS4439.3)
<b>TCLP</b>	Toxicity Characteristic Leaching Procedure
<b>COC</b>	Chain of Custody
<b>SRA</b>	Sample Receipt Advice
<b>CP</b>	Client Parent - QC was performed on samples pertaining to this report
<b>NCP</b>	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within
<b>TEQ</b>	Toxic Equivalency Quotient

### QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

### QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
9. For Matrix Spikes and LCS results a dash " - " in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data.

**Quality Control Results**

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Method Blank</b>							
Acetic Acid*	mg/L	< 10			10	Pass	
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	mg/L	< 5			5	Pass	
Chemical Oxygen Demand (COD)	mg/L	< 20			20	Pass	
Chloride	mg/L	< 1			1	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Phosphorus reactive (as P)	mg/L	< 0.05			0.05	Pass	
Sulphate (as S)	mg/L	< 5			5	Pass	
Total Organic Carbon	mg/L	< 5			5	Pass	
<b>Method Blank</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	mg/L	< 20			20	Pass	
<b>Method Blank</b>							
<b>Heavy Metals</b>							
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.001			0.001	Pass	
<b>Method Blank</b>							
<b>Alkali Metals</b>							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
<b>LCS - % Recovery</b>							
Acetic Acid*	%	87			70-130	Pass	
Ammonia (as N)	%	93			70-130	Pass	
Chemical Oxygen Demand (COD)	%	96			70-130	Pass	
Chloride	%	106			70-130	Pass	
Nitrate (as N)	%	91			70-130	Pass	
Sulphate (as S)	%	100			70-130	Pass	
Total Organic Carbon	%	87			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	%	104			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Heavy Metals</b>							
Copper (filtered)	%	94			80-120	Pass	
Manganese (filtered)	%	94			80-120	Pass	
Zinc (filtered)	%	95			80-120	Pass	
<b>LCS - % Recovery</b>							
<b>Alkali Metals</b>							
Calcium	%	110			70-130	Pass	
Magnesium	%	110			70-130	Pass	
Potassium	%	101			70-130	Pass	
Sodium	%	102			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Spike - % Recovery</b>									
				Result 1					
Acetic Acid*	M15-Se08493	NCP	%	91			70-130	Pass	
Ammonia (as N)	M15-Se17179	NCP	%	97			70-130	Pass	
Chemical Oxygen Demand (COD)	M15-Se16885	CP	%	96			70-130	Pass	
Chloride	M15-Se16145	NCP	%	96			70-130	Pass	
Nitrate (as N)	M15-Se17179	NCP	%	84			70-130	Pass	
Phosphorus reactive (as P)	M15-Se16885	CP	%	97			70-130	Pass	
Sulphate (as S)	M15-Se16649	NCP	%	94			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkalinity</b>				Result 1					
Total Alkalinity (as CaCO3)	M15-Se16183	NCP	%	123			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Heavy Metals</b>				Result 1					
Copper (filtered)	M15-Se15271	NCP	%	88			70-130	Pass	
Manganese (filtered)	M15-Se15271	NCP	%	92			70-130	Pass	
Zinc (filtered)	M15-Se15271	NCP	%	81			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkali Metals</b>				Result 1					
Calcium	M15-Se16885	CP	%	115			70-130	Pass	
Magnesium	M15-Se16885	CP	%	108			70-130	Pass	
Potassium	M15-Se16885	CP	%	107			70-130	Pass	
Sodium	M15-Se16885	CP	%	114			70-130	Pass	
Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Duplicate</b>									
				Result 1	Result 2	RPD			
Acetic Acid*	M15-Se05769	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Ammonia (as N)	M15-Se17179	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	M15-Se16177	NCP	mg/L	< 5	< 5	<1	30%	Pass	
Chemical Oxygen Demand (COD)	M15-Au23674	NCP	mg/L	68	32	72	30%	Fail	Q15
Chloride	M15-Se16921	NCP	mg/L	78	76	1.5	30%	Pass	
Nitrate (as N)	M15-Se17179	NCP	mg/L	22	22	1.0	30%	Pass	
Phosphorus reactive (as P)	M15-Se16885	CP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Sulphate (as S)	M15-Se16642	NCP	mg/L	< 5	< 5	<1	30%	Pass	
Total Organic Carbon	M15-Se17656	NCP	mg/L	5.4	5.1	5.0	30%	Pass	
<b>Duplicate</b>									
<b>Alkalinity</b>				Result 1	Result 2	RPD			
Total Alkalinity (as CaCO3)	M15-Se16923	NCP	mg/L	< 20	< 20	<1	30%	Pass	
<b>Duplicate</b>									
<b>Heavy Metals</b>				Result 1	Result 2	RPD			
Copper (filtered)	M15-Se15271	NCP	mg/L	0.023	0.022	5.0	30%	Pass	
Manganese (filtered)	M15-Se15271	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc (filtered)	M15-Se15271	NCP	mg/L	0.12	0.11	5.0	30%	Pass	
<b>Duplicate</b>									
<b>Alkali Metals</b>				Result 1	Result 2	RPD			
Calcium	M15-Se19452	NCP	mg/L	22	22	<1	30%	Pass	
Magnesium	M15-Se19452	NCP	mg/L	11	10	2.0	30%	Pass	
Potassium	M15-Se16900	NCP	mg/L	3.0	3.1	2.0	30%	Pass	
Sodium	M15-Se19452	NCP	mg/L	100	95	6.0	30%	Pass	

**Comments**

v2: Ammonium (as N) results added to report.

**Sample Integrity**

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

**Qualifier Codes/Comments**

Code	Description
Q15	The RPD reported passes Eurofins   mgt's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

**Authorised By**

Mark Rodriguez	Analytical Services Manager
Carroll Lee	Senior Analyst-Organic (VIC)
Emily Rosenberg	Senior Analyst-Metal (VIC)
Huong Le	Senior Analyst-Inorganic (VIC)



**Glenn Jackson**

**National Operations Manager**

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

\* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

Eurofins | mgt shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins | mgt be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

ALS LABORATORY GROUP

CHAIN OF CUSTODY DOCUMENTATION

CLIENT: URS Australia  
 ADDRESS / OFFICE: Level 3, 93 Mitchell Street, Darwin 0800  
 PROJECT MANAGER (PM): Chris Machhunter  
 PROJECT ID: 42214019  
 SITE: Shoal Bay Hydrogeological Sampling  
 P.O. NO.:  
 QUOTE NO.:  
 RESULTS REQUIRED (Date):  
 COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:  
 LABORATORY USE ONLY  
 COOLER SEAL (circle appropriate)  
 INTER: Yes / No / N/A  
 SAMPLE TEMPERATURE  
 GHI, LED: Yes / No

SAMPLER: Kim Treglown  
 MOBILE: 0422088362  
 PHONE: #  
 EMAIL REPORT TO: kim.treglown@urs.com; chris.machhunter@urs.com  
 EMAIL INVOICE TO: (if different to report)

ANALYSIS REQUIRED INCLUDING SUITES (note - suite codes must be listed to attract suite prices)  
 Notes: e.g. Highly contaminated samples e.g. "High PAHs expected".  
 Extra volume for QC or trace LORS etc.

EP045 (CH3COOH)  
 EP026 (COD)  
 EP030 (BOD)  
 EP005 (TOC)  
 EG020F (Dissolved metals: Mn, Zn, Cu)  
 EG020T (Total: Fe)  
 EK056G (Nitrate)  
 EK056G-NH4 (Ammonium as N)  
 EK071 (Reactive Phosphorus as P)  
 NT-1 (Cations: Major (Ca, Mg, Na, K))  
 NT-2 (Anions: Minor (Cl, SO4, Alkalinity))

ALS ID	SAMPLE ID	MATRIX	DATE	TIME	Type / Code	Total bottles
1	GW13-12-170915	W	170915	0730	USR1	6
2	GW14-12-170915	W	0845	0920		6
3	GW13-12-170915	W	1115	0920		6
4	GW6-30-170915	W	1310	1400		6
5	GW6-12-170915	W	1310	1400		6
6	GW14-12-170915	W	1400	1400		6
7	GW05-170915	W	1400	1400		6

RECEIVED BY: [Signature] Date: 17/9/15 Time: 2:50pm  
 Name: Kim Treglown  
 OF: URS Date: 17/9/15 Time: 1450

REQUISITIONED BY: [Signature] Date: 18/9/15 Time: 1:00  
 Name: Holly ALS  
 OF: Transport Co. Date: 18/9/15 Time: 1:00

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulphuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulphuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division  
 Sydney  
 Work Order Reference  
**ES1531462**  
 Telephone: +61-2-8784 8555



LAB OF ORIGIN: DARWIN

ES1531462





SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : ES1531462

Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Contact	: Loren Schiavon
Address	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: kim.treglown@urs.com	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 08 89802900	Telephone	: +61 2 8784 8503
Facsimile	: +61 08 89413920	Facsimile	: +61-2-8784 8500
Project	: 42214019	Page	: 1 of 3
Order number	: ----	Quote number	: ES2014URSNT0273 (EN/001/14)
C-O-C number	: ----	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING		
Sampler	:		

Dates

Date Samples Received	: 18-Sep-2015 1:00 PM	Issue Date	: 18-Sep-2015
Client Requested Due Date	: 25-Sep-2015	Scheduled Reporting Date	: <b>25-Sep-2015</b>

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 7.6 - Ice present
Receipt Detail	:	No. of samples received / analysed	: 7 / 6

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.



## Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

## Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020F Dissolved Metals by ICPMS	WATER - EK055G-NH4 Ammonium as N	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - EP030 BOD	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity
ES1531462-001	17-Sep-2015 07:30	GW3_12_170915	✓	✓	✓	✓	✓	✓	✓
ES1531462-003	17-Sep-2015 09:20	GW13_12_170915	✓	✓	✓	✓	✓	✓	✓
ES1531462-004	17-Sep-2015 11:15	GW6_30_170915	✓	✓	✓	✓	✓	✓	✓
ES1531462-005	17-Sep-2015 13:10	GW6_12_170915	✓	✓	✓	✓	✓	✓	✓
ES1531462-006	17-Sep-2015 14:00	GW14_12_2_170915	✓	✓	✓	✓	✓	✓	✓
ES1531462-007	17-Sep-2015 14:20	QAQC05_170915	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	(On Hold) WATER No analysis requested	WATER - EG020T Total Recoverable Metals by ICPMS (including	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP045 Volatile Acids as CH3COOH
ES1531462-001	17-Sep-2015 07:30	GW3_12_170915		✓	✓	✓
ES1531462-002	17-Sep-2015 08:45	GW14_12_170915	✓			
ES1531462-003	17-Sep-2015 09:20	GW13_12_170915		✓	✓	✓
ES1531462-004	17-Sep-2015 11:15	GW6_30_170915		✓	✓	✓
ES1531462-005	17-Sep-2015 13:10	GW6_12_170915		✓	✓	✓
ES1531462-006	17-Sep-2015 14:00	GW14_12_2_170915		✓	✓	✓
ES1531462-007	17-Sep-2015 14:20	QAQC05_170915		✓	✓	✓

## Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



## Requested Deliverables

### CHRIS Mac HUNTER

- *AU Certificate of Analysis - NATA (COA)	Email	chris.machunter@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	chris.machunter@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	chris.machunter@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	chris.machunter@urs.com
- A4 - AU Tax Invoice (INV)	Email	chris.machunter@urs.com
- Chain of Custody (CoC) (COC)	Email	chris.machunter@urs.com
- EDI Format - ENMRG (ENMRG)	Email	chris.machunter@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	chris.machunter@urs.com
- EDI Format - ESDAT (ESDAT)	Email	chris.machunter@urs.com
- EDI Format - MRED (MRED)	Email	chris.machunter@urs.com

### KIM TREGLOWN

- *AU Certificate of Analysis - NATA (COA)	Email	kim.treglown@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	kim.treglown@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	kim.treglown@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	kim.treglown@urs.com
- A4 - AU Tax Invoice (INV)	Email	kim.treglown@urs.com
- Chain of Custody (CoC) (COC)	Email	kim.treglown@urs.com
- EDI Format - ENMRG (ENMRG)	Email	kim.treglown@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	kim.treglown@urs.com
- EDI Format - ESDAT (ESDAT)	Email	kim.treglown@urs.com
- EDI Format - MRED (MRED)	Email	kim.treglown@urs.com

### RESULTS ADDRESS

- *AU Certificate of Analysis - NATA (COA)	Email	darwin@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	darwin@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	darwin@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	darwin@urs.com
- A4 - AU Tax Invoice (INV)	Email	darwin@urs.com
- Chain of Custody (CoC) (COC)	Email	darwin@urs.com
- EDI Format - ENMRG (ENMRG)	Email	darwin@urs.com
- EDI Format - MRED (MRED)	Email	darwin@urs.com

## CERTIFICATE OF ANALYSIS

<b>Work Order</b>	: <b>ES1531462</b>	<b>Page</b>	: 1 of 6
<b>Client</b>	: <b>URS AUSTRALIA PTY LTD</b>	<b>Laboratory</b>	: Environmental Division Sydney
<b>Contact</b>	: KIM TREGLOWN	<b>Contact</b>	: Loren Schiavon
<b>Address</b>	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	<b>Address</b>	: 277-289 Woodpark Road Smithfield NSW Australia 2164
<b>E-mail</b>	: kim.treglown@urs.com	<b>E-mail</b>	: loren.schiavon@alsglobal.com
<b>Telephone</b>	: +61 08 89802900	<b>Telephone</b>	: +61 2 8784 8503
<b>Facsimile</b>	: +61 08 89413920	<b>Facsimile</b>	: +61-2-8784 8500
<b>Project</b>	: 42214019	<b>QC Level</b>	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Order number</b>	: ----	<b>Date Samples Received</b>	: 18-Sep-2015 13:00
<b>C-O-C number</b>	: ----	<b>Date Analysis Commenced</b>	: 18-Sep-2015
<b>Sampler</b>	: ----	<b>Issue Date</b>	: 25-Sep-2015 13:50
<b>Site</b>	: SHOAL BAY HYDROGEOLOGICAL SAMPLING	<b>No. of samples received</b>	: 7
<b>Quote number</b>	: ----	<b>No. of samples analysed</b>	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with  
ISO/IEC 17025.

### *Signatories*

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics



## 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.

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  
∅ = ALS is not NATA accredited for these tests.

- EG020A-T: (Iron) results for samples (ES1531462 - #006 & #007) confirmed by re-digestion and reanalysis.



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW3_12_170915	GW13_12_170915	GW6_30_170915	GW6_12_170915	GW14_12_2_170915
Client sampling date / time				17-Sep-2015 07:30	17-Sep-2015 09:20	17-Sep-2015 11:15	17-Sep-2015 13:10	17-Sep-2015 14:00	
Compound	CAS Number	LOR	Unit	ES1531462-001	ES1531462-003	ES1531462-004	ES1531462-005	ES1531462-006	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	7	6	76	<1	<1	
Total Alkalinity as CaCO3	----	1	mg/L	7	6	76	<1	<1	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	103	8	18	32	653	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	854	26	11	12	5520	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	62	3	35	4	165	
Magnesium	7439-95-4	1	mg/L	51	1	<1	<1	217	
Sodium	7440-23-5	1	mg/L	481	15	10	8	3000	
Potassium	7440-09-7	1	mg/L	9	4	8	4	62	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	0.011	0.005	
Manganese	7439-96-5	0.001	mg/L	0.313	0.049	0.258	0.021	2.70	
Zinc	7440-66-6	0.005	mg/L	0.278	0.101	0.093	0.376	0.163	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	11.0	24.2	<0.05	1.69	62.6	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	0.03	0.29	0.06	0.05	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	<0.01	
<b>EK058G: Nitrate as N by Discrete Analyser</b>									
^ Nitrate as N	14797-55-8	0.01	mg/L	0.06	0.43	0.05	0.25	0.38	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.01	mg/L	0.06	0.43	0.05	0.25	0.38	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	26.4	1.02	2.20	1.00	169	
Total Cations	----	0.01	meq/L	----	----	----	0.74	----	
^ Total Cations	----	0.01	meq/L	28.4	0.99	2.39	----	158	



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW3_12_170915	GW13_12_170915	GW6_30_170915	GW6_12_170915	GW14_12_2_170915
Client sampling date / time				17-Sep-2015 07:30	17-Sep-2015 09:20	17-Sep-2015 11:15	17-Sep-2015 13:10	17-Sep-2015 14:00	
Compound	CAS Number	LOR	Unit	ES1531462-001	ES1531462-003	ES1531462-004	ES1531462-005	ES1531462-006	
				Result	Result	Result	Result	Result	
<b>EN055: Ionic Balance - Continued</b>									
^ Ionic Balance	----	0.01	%	3.77	----	----	----	3.41	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	6	4	2	1	1	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	25	51	<10	<10	118	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	<2	<2	<2	<2	<2	
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	16	11	16	16	28	



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			QAQC05_170915	----	----	----	----
Client sampling date / time		17-Sep-2015 14:20			----	----	----	----	
Compound	CAS Number	LOR	Unit	ES1531462-007	-----	-----	-----	-----	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	2	----	----	----	----	
Total Alkalinity as CaCO3	----	1	mg/L	2	----	----	----	----	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	664	----	----	----	----	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	5640	----	----	----	----	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	177	----	----	----	----	
Magnesium	7439-95-4	1	mg/L	214	----	----	----	----	
Sodium	7440-23-5	1	mg/L	2900	----	----	----	----	
Potassium	7440-09-7	1	mg/L	68	----	----	----	----	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	0.004	----	----	----	----	
Manganese	7439-96-5	0.001	mg/L	2.64	----	----	----	----	
Zinc	7440-66-6	0.005	mg/L	0.156	----	----	----	----	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	80.2	----	----	----	----	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	0.04	----	----	----	----	
<b>EK057G: Nitrite as N by Discrete Analyser</b>									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----	
<b>EK058G: Nitrate as N by Discrete Analyser</b>									
^ Nitrate as N	14797-55-8	0.01	mg/L	0.37	----	----	----	----	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.01	mg/L	0.37	----	----	----	----	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	----	----	----	----	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	173	----	----	----	----	
Total Cations	----	0.01	meq/L	----	----	----	----	----	
^ Total Cations	----	0.01	meq/L	154	----	----	----	----	



### Analytical Results

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID			QAQC05_170915	----	----	----	----
Client sampling date / time		17-Sep-2015 14:20			----	----	----	----	
Compound	CAS Number	LOR	Unit	ES1531462-007	-----	-----	-----	-----	
				Result	Result	Result	Result	Result	
<b>EN055: Ionic Balance - Continued</b>									
^ Ionic Balance	----	0.01	%	5.71	----	----	----	----	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	1	----	----	----	----	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	<10	----	----	----	----	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	<2	----	----	----	----	
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	25	----	----	----	----	

## QUALITY CONTROL REPORT

<b>Work Order</b>	<b>: ES1531462</b>	<b>Page</b>	: 1 of 6
<b>Client</b>	<b>: URS AUSTRALIA PTY LTD</b>	<b>Laboratory</b>	: Environmental Division Sydney
<b>Contact</b>	: KIM TREGLOWN	<b>Contact</b>	: Loren Schiavon
<b>Address</b>	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	<b>Address</b>	: 277-289 Woodpark Road Smithfield NSW Australia 2164
<b>E-mail</b>	: kim.treglown@urs.com	<b>E-mail</b>	: loren.schiavon@alsglobal.com
<b>Telephone</b>	: +61 08 89802900	<b>Telephone</b>	: +61 2 8784 8503
<b>Facsimile</b>	: +61 08 89413920	<b>Facsimile</b>	: +61-2-8784 8500
<b>Project</b>	: 42214019	<b>QC Level</b>	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Order number</b>	: ----	<b>Date Samples Received</b>	: 18-Sep-2015
<b>C-O-C number</b>	: ----	<b>Date Analysis Commenced</b>	: 18-Sep-2015
<b>Sampler</b>	: ----	<b>Issue Date</b>	: 25-Sep-2015
<b>Site</b>	: SHOAL BAY HYDROGEOLOGICAL SAMPLING	<b>No. of samples received</b>	: 7
<b>Quote number</b>	: ----	<b>No. of samples analysed</b>	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits



NATA Accredited  
Laboratory 825

Accredited for  
compliance with  
ISO/IEC 17025.

### *Signatories*

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics



### **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

Key :  
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot  
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  
RPD = Relative Percentage Difference  
# = Indicates failed QC



## Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 218484)</b>									
ES1531579-001	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	147	157	6.67	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	147	157	6.67	0% - 20%
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 218477)</b>									
ES1531466-004	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	110	110	0.00	0% - 20%
ES1531462-001	GW3_12_170915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	103	101	1.80	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 218478)</b>									
ES1531466-004	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	837	831	0.782	0% - 20%
ES1531462-001	GW3_12_170915	ED045G: Chloride	16887-00-6	1	mg/L	854	851	0.447	0% - 20%
<b>ED093F: Dissolved Major Cations (QC Lot: 220552)</b>									
ES1530943-032	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	50	50	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	70	69	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	28	29	4.07	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	591	600	1.43	0% - 20%
ES1531462-003	GW13_12_170915	ED093F: Calcium	7440-70-2	1	mg/L	3	3	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	1	1	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	4	3	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	15	14	7.33	0% - 50%
<b>EG020F: Dissolved Metals by ICP-MS (QC Lot: 220553)</b>									
ES1531462-003	GW13_12_170915	EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.049	0.047	4.32	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.101	0.101	0.00	0% - 20%
<b>EG020T: Total Metals by ICP-MS (QC Lot: 220249)</b>									
ES1531387-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	79.9	82.5	3.24	0% - 20%
ES1531399-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.28	<0.05	140	No Limit
<b>EG020T: Total Metals by ICP-MS (QC Lot: 220250)</b>									
ES1531462-006	GW14_12_2_170915	EG020A-T: Iron	7439-89-6	0.05	mg/L	62.6	69.8	10.8	0% - 20%
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 218479)</b>									
EN1513071-003	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.02	0.02	0.00	No Limit
ES1531462-001	GW3_12_170915	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 220299)</b>									
ES1531315-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.28	0.31	9.59	0% - 20%
ES1531462-007	QAQC05_170915	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.37	0.35	4.86	0% - 20%

Page : 4 of 6  
 Work Order : ES1531462  
 Client : URS AUSTRALIA PTY LTD  
 Project : 42214019



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 218480)</b>									
ES1531462-001	GW3_12_170915	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EP005: Total Organic Carbon (TOC) (QC Lot: 221295)</b>									
ES1531462-001	GW3_12_170915	EP005: Total Organic Carbon	----	1	mg/L	6	6	0.00	No Limit
ES1531627-003	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	12	7	45.2	0% - 50%
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 221828)</b>									
EP1513943-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	3490	3500	0.229	0% - 20%
ES1531443-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	1200	1230	2.96	0% - 20%
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 218557)</b>									
ES1531356-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	4	3	28.6	No Limit
ES1531462-006	GW14_12_2_170915	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
<b>EP045: Volatile Acids as CH3COOH (QC Lot: 219344)</b>									
ES1531223-001	Anonymous	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	14	16	12.0	No Limit
ES1531356-003	Anonymous	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	12	12	0.00	No Limit



## Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
				Result	Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 218484)</b>								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	91.9	81	111
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 218477)</b>								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	97.8	86	122
<b>ED045G: Chloride by Discrete Analyser (QCLot: 218478)</b>								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	105	75	123
				<1	1000 mg/L	103	77	119
<b>ED093F: Dissolved Major Cations (QCLot: 220552)</b>								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	99.6	90	114
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	108	90	110
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	101	87	117
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	103	82	118
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 220553)</b>								
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	90.5	85	115
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	92.8	85	115
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	90.9	85	115
<b>EG020T: Total Metals by ICP-MS (QCLot: 220249)</b>								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	82	120
<b>EG020T: Total Metals by ICP-MS (QCLot: 220250)</b>								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.9	82	120
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 218479)</b>								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	88.4	82	114
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 220299)</b>								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	96.8	91	113
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 218480)</b>								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	96.2	85	117
<b>EP005: Total Organic Carbon (TOC) (QCLot: 221295)</b>								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	86.3	76	120
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 221828)</b>								
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	92.0	80	120
				<10	500 mg/L	96.0	80	120
<b>EP030: Biochemical Oxygen Demand (BOD) (QCLot: 218557)</b>								
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	200 mg/L	84.5	74	110



Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
						LCS	Low	High
<b>EP045: Volatile Acids as CH3COOH (QCLot: 219344)</b>								
EP045: Volatile Acids as Acetic Acid	----	5	mg/L	<5	200 mg/L	94.4	88	112

### Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%)	
					Low	High	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 218477)</b>							
ES1531462-001	GW3_12_170915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
<b>ED045G: Chloride by Discrete Analyser (QCLot: 218478)</b>							
ES1531462-001	GW3_12_170915	ED045G: Chloride	16887-00-6	250 mg/L	82.4	70	130
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 220553)</b>							
ES1531462-003	GW13_12_170915	EG020A-F: Copper	7440-50-8	0.2 mg/L	95.2	70	130
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	89.5	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	99.3	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 218479)</b>							
ES1531462-001	GW3_12_170915	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	95.4	70	130
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 220299)</b>							
ES1531315-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	95.9	70	130
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 218480)</b>							
ES1531462-001	GW3_12_170915	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	89.8	70	130
<b>EP005: Total Organic Carbon (TOC) (QCLot: 221295)</b>							
ES1531462-003	GW13_12_170915	EP005: Total Organic Carbon	----	100 mg/L	97.1	70	130
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 221828)</b>							
EP1513943-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	47.6 mg/L	75.9	70	130

## QA/QC Compliance Assessment for DQO Reporting

Work Order	: ES1531462	Page	: 1 of 8
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Telephone	: +61 2 8784 8503
Project	: 42214019	Date Samples Received	: 18-Sep-2015
Site	: SHOAL BAY HYDROGEOLOGICAL SAMPLING	Issue Date	: 25-Sep-2015
Sampler	: ----	No. of samples received	: 7
Order number	: ----	No. of samples analysed	: 6

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

### Summary of Outliers

#### Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

#### Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

#### Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



### Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Matrix Spike (MS) Recoveries</b>							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ES1531462--001	GW3_12_170915	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

### Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
<b>Matrix Spikes (MS)</b>					
Total Metals by ICP-MS - Suite A	0	15	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

### Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>ED037P: Alkalinity by PC Titrator</b>								
<b>Clear Plastic Bottle - Natural (ED037-P)</b>								
GW3_12_170915, GW6_30_170915, GW14_12_2_170915,	GW13_12_170915, GW6_12_170915, QAQC05_170915	17-Sep-2015	----	----	----	21-Sep-2015	01-Oct-2015	✓
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>								
<b>Clear Plastic Bottle - Natural (ED041G)</b>								
GW3_12_170915, GW6_30_170915, GW14_12_2_170915,	GW13_12_170915, GW6_12_170915, QAQC05_170915	17-Sep-2015	----	----	----	18-Sep-2015	15-Oct-2015	✓
<b>ED045G: Chloride by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Natural (ED045G)</b>								
GW3_12_170915, GW6_30_170915, GW14_12_2_170915,	GW13_12_170915, GW6_12_170915, QAQC05_170915	17-Sep-2015	----	----	----	18-Sep-2015	15-Oct-2015	✓



Matrix: **WATER** Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
<b>ED093F: Dissolved Major Cations</b>							
<b>Clear Plastic Bottle - Filtered; Lab-acidified (ED093F)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>22-Sep-2015</b>	15-Oct-2015	✓
<b>EG020F: Dissolved Metals by ICP-MS</b>							
<b>Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>22-Sep-2015</b>	15-Mar-2016	✓
<b>EG020T: Total Metals by ICP-MS</b>							
<b>Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	<b>21-Sep-2015</b>	15-Mar-2016	✓	<b>21-Sep-2015</b>	15-Mar-2016	✓
<b>EK057G: Nitrite as N by Discrete Analyser</b>							
<b>Clear Plastic Bottle - Natural (EK057G)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>18-Sep-2015</b>	19-Sep-2015	✓
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>							
<b>Clear Plastic Bottle - Sulfuric Acid (EK059G)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>21-Sep-2015</b>	15-Oct-2015	✓
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>							
<b>Clear Plastic Bottle - Natural (EK071G)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>18-Sep-2015</b>	19-Sep-2015	✓
<b>EP005: Total Organic Carbon (TOC)</b>							
<b>Amber TOC Vial - Sulfuric Acid (EP005)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>22-Sep-2015</b>	15-Oct-2015	✓
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>							
<b>Clear Plastic Bottle - Sulfuric Acid (EP026SP)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915, GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>23-Sep-2015</b>	15-Oct-2015	✓

Page : 4 of 8  
 Work Order : ES1531462  
 Client : URS AUSTRALIA PTY LTD  
 Project : 42214019



Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>								
<b>Clear Plastic Bottle - Natural (EP030)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915,	GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>18-Sep-2015</b>	19-Sep-2015	✓
<b>EP045: Volatile Acids as CH3COOH</b>								
<b>Clear Plastic Bottle - Natural (EP045)</b> GW3_12_170915, GW6_30_170915, GW14_12_2_170915,	GW13_12_170915, GW6_12_170915, QAQC05_170915	<b>17-Sep-2015</b>	----	----	----	<b>21-Sep-2015</b>	01-Oct-2015	✓



## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Reaular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Laboratory Duplicates (DUP)</b>							
Alkalinity by PC Titrator	ED037-P	1	7	14.29	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	2	19	10.53	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	6	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	13	15.38	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	19	10.53	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	15	13.33	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	10	20.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	2	18	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Laboratory Control Samples (LCS)</b>							
Alkalinity by PC Titrator	ED037-P	1	7	14.29	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	15	6.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Method Blanks (MB)</b>							
Biochemical Oxygen Demand (BOD)	EP030	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Regular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Method Blanks (MB) - Continued</b>							
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	15	6.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	16.67	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	0	15	0.00	5.00	*	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO <sub>4</sub> <sup>2-</sup> by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO <sub>4</sub> . Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO <sub>4</sub> suspension is measured by a photometer and the SO <sub>4</sub> <sup>2-</sup> concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3)  Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3)  Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Ammonium as N	EK055G-NH4	WATER	Ammonium in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH and Temperature. Ammonia is determined by direct colorimetry by Discrete Analyser according to APHA 4500-NH <sub>3</sub> G. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO <sub>2</sub> - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO <sub>3</sub> - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)



<i>Analytical Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	WATER	In house: Referenced to APHA 5220 D. Samples are digested with a known excess of an acidic potassium dichromate solution using silver sulfate as a catalyst. The chromium is reduced from the Cr (VI) oxidation state to the Cr (III) state by the oxygen present in the organic material. Both of these chromium species are coloured and absorb in the visible region of (400nm & 600nm) the spectrum. The oxidisable organic matter can be calculated in terms of oxygen equivalents.
Biochemical Oxygen Demand (BOD)	EP030	WATER	In house: Referenced to APHA 5210 B. The 5-Day BOD test provides an empirical measure of the oxygen consumption capacity of a given water. A portion of the sample is diluted into oxygenated, nutrient rich water, and a seed added to begin biological decay. The initial dissolved oxygen content is measured, then the bottle is sealed and incubated for five days. The remaining dissolved oxygen is measured, and from the difference, the demand for oxygen, by biological decay, is determined. This method is compliant with NEPM (2013) Schedule B(3)
Volatile Acids as CH <sub>3</sub> COOH	EP045	WATER	In house: Referenced to APHA 5560 C. Steam distillable acids are captured in caustic solution and determined titrimetrically. This method is compliant with NEPM (2013) Schedule B(3)
<i>Preparation Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)



## Sample Receipt Advice

Company name: **URS Australia Pty Ltd NT**  
Contact name: **Kim Treglown**  
Project name: **SHOAL BAY HYDROGEOLOG**  
Project ID: **42214019**  
COC number: **Not provided**  
Turn around time: **5 Day**  
Date/Time received: **Sep 18, 2015 11:52 AM**  
Eurofins | mgt reference: **472991**

### Sample information

- A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- All samples have been received as described on the above COC.
- COC has been completed correctly.
- Attempt to chill was evident.
- Appropriately preserved sample containers have been used.
- All samples were received in good condition.
- Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- Appropriate sample containers have been used.
- Sample containers for volatile analysis received with zero headspace.
- Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

### Contact notes

If you have any questions with respect to these samples please contact:

Mark Rodriquez on Phone : (+61) 8 8947 1557 or by e.mail: MarkRodriquez@eurofins.com.au

Results will be delivered electronically via e.mail to Kim Treglown - kim.treglown@urs.com.

*Note: A copy of these results will also be delivered to the general URS Australia Pty Ltd NT email address.*

**Company Name:** URS Australia Pty Ltd NT  
**Address:** Level 3 93 Mitchell St  
 Darwin  
 NT 801  
**Project Name:** SHOAL BAY HYDROGEOLOG  
**Project ID:** 42214019

**Order No.:**  
**Report #:** 472991  
**Phone:** 08 8980 2900  
**Fax:**

**Received:** Sep 18, 2015 11:52 AM  
**Due:** Sep 25, 2015  
**Priority:** 5 Day  
**Contact Name:** Kim Treglown

**Euofins | mgt Client Manager: Mark Rodriquez**

**Sample Detail**

Sample ID	Sample Date	Sampling Time	Matrix	LAB ID	Acetic Acid*	Ammonia (as N)	Ammonium Ion (as N)	Biochemical Oxygen Demand (BOD-5 Day)	Chemical Oxygen Demand (COD)	Chloride	Copper (filtered)	Iron	Manganese (filtered)	Nitrate (as N)	Phosphorus reactive (as P)	Sulphate (as S)	Total Alkalinity (as CaCO3)	Total Organic Carbon	Zinc (filtered)	Alkali Metals	
<b>Laboratory where analysis is conducted</b>																					
<b>Melbourne Laboratory - NATA Site # 1254 &amp; 14271</b>					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<b>Sydney Laboratory - NATA Site # 18217</b>																					
<b>Brisbane Laboratory - NATA Site # 20794</b>																					
<b>Internal Laboratory</b>																					
AQC06_1709	Sep 17, 2015		Water	M15-Se18540	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

URS Australia Pty Ltd  
 Level 3 93 Mitchell St  
 Darwin  
 NT 801



NATA Accredited  
 Accreditation Number 1261  
 Site Number 1254

Accredited for compliance with ISO/IEC 17025.  
 The results of the tests, calibrations and/or  
 measurements included in this document are traceable  
 to Australian/national standards.

Attention: Kim Treglown

Report 472991-W-V3  
 Project name SHOAL BAY HYDROGEOLOG  
 Project ID 42214019  
 Received Date Sep 18, 2015

Client Sample ID			QAQC06_1709 15
Sample Matrix			Water
Eurofins   mgt Sample No.			M15-Se18540
Date Sampled			Sep 17, 2015
Test/Reference	LOR	Unit	
Acetic Acid*	10	mg/L	< 10
Ammonia (as N)	0.01	mg/L	< 0.01
Ammonium Ion (as N)	0.01	mg/L	< 0.01
Biochemical Oxygen Demand (BOD-5 Day)	5	mg/L	<sup>G01</sup> < 10
Chemical Oxygen Demand (COD)	20	mg/L	120
Chloride	1	mg/L	5600
Nitrate (as N)	0.02	mg/L	0.48
Phosphorus reactive (as P)	0.05	mg/L	< 0.05
Sulphate (as S)	5	mg/L	220
Total Organic Carbon <sup>M10</sup>	5	mg/L	< 5
<b>Alkalinity</b>			
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	20	mg/L	< 20
Carbonate Alkalinity (as CaCO <sub>3</sub> )	10	mg/L	< 10
Hydroxide Alkalinity (as CaCO <sub>3</sub> )	10	mg/L	< 10
Total Alkalinity (as CaCO <sub>3</sub> )	20	mg/L	< 20
<b>Heavy Metals</b>			
Copper (filtered)	0.001	mg/L	0.002
Iron	0.05	mg/L	27
Manganese (filtered)	0.005	mg/L	2.9
Zinc (filtered)	0.001	mg/L	0.15
<b>Alkali Metals</b>			
Calcium	0.5	mg/L	220
Magnesium	0.5	mg/L	320
Potassium	0.5	mg/L	83
Sodium	0.5	mg/L	3600

## Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported. A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acetic Acid* - Method: Acetic Acid by HPLC	Melbourne	Sep 21, 2015	7 Day
Ammonia (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Sep 21, 2015	28 Day
Ammonium Ion (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Oct 09, 2015	7 Day
Biochemical Oxygen Demand (BOD-5 Day) - Method: LTM-INO-4010	Melbourne	Sep 19, 2015	2 Day
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Melbourne	Sep 18, 2015	28 Day
Chloride - Method: MGT 1100A	Melbourne	Sep 21, 2015	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Melbourne	Sep 21, 2015	7 Day
Phosphorus reactive (as P) - Method: APHA4500-PO4	Melbourne	Sep 21, 2015	2 Day
Sulphate (as S) - Method: In house MGT1110A (SO4 by Discrete Analyser)	Melbourne	Sep 21, 2015	28 Day
Total Organic Carbon - Method: APHA 5310B Total Organic Carbon	Melbourne	Sep 21, 2015	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Melbourne	Oct 13, 2015	14 Day
Heavy Metals (filtered) - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 22, 2015	180 Day
Heavy Metals - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 22, 2015	180 Day
Alkali Metals - Method: USEPA 6010 Alkali Metals	Melbourne	Sep 18, 2015	180 Day

## Eurofins | mgt Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis. 7. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

**\*\*NOTE:** pH duplicates are reported as a range NOT as RPD

### UNITS

**mg/kg:** milligrams per Kilogram

**mg/l:** milligrams per litre

**ug/l:** micrograms per litre

**ppm:** Parts per million

**ppb:** Parts per billion

**%:** Percentage

**org/100ml:** Organisms per 100 millilitres

**NTU:** Nephelometric Turbidity Units

**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

### TERMS

<b>Dry</b>	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
<b>LOR</b>	Limit of Reporting.
<b>SPIKE</b>	Addition of the analyte to the sample and reported as percentage recovery.
<b>RPD</b>	Relative Percent Difference between two Duplicate pieces of analysis.
<b>LCS</b>	Laboratory Control Sample - reported as percent recovery
<b>CRM</b>	Certified Reference Material - reported as percent recovery
<b>Method Blank</b>	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
<b>Surr - Surrogate</b>	The addition of a like compound to the analyte target and reported as percentage recovery.
<b>Duplicate</b>	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
<b>Batch Duplicate</b>	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>Batch SPIKE</b>	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>USEPA</b>	United States Environmental Protection Agency
<b>APHA</b>	American Public Health Association
<b>ASLP</b>	Australian Standard Leaching Procedure (AS4439.3)
<b>TCLP</b>	Toxicity Characteristic Leaching Procedure
<b>COC</b>	Chain of Custody
<b>SRA</b>	Sample Receipt Advice
<b>CP</b>	Client Parent - QC was performed on samples pertaining to this report
<b>NCP</b>	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within
<b>TEQ</b>	Toxic Equivalency Quotient

### QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

### QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
9. For Matrix Spikes and LCS results a dash " - " in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data.

**Quality Control Results**

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Method Blank</b>							
Acetic Acid*	mg/L	< 10			10	Pass	
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	mg/L	< 5			5	Pass	
Chemical Oxygen Demand (COD)	mg/L	< 20			20	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Phosphorus reactive (as P)	mg/L	< 0.05			0.05	Pass	
Sulphate (as S)	mg/L	< 5			5	Pass	
Total Organic Carbon	mg/L	< 5			5	Pass	
<b>Method Blank</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	mg/L	< 20			20	Pass	
<b>Method Blank</b>							
<b>Heavy Metals</b>							
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.001			0.001	Pass	
<b>Method Blank</b>							
<b>Alkali Metals</b>							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
<b>LCS - % Recovery</b>							
Acetic Acid*	%	74			70-130	Pass	
Ammonia (as N)	%	97			70-130	Pass	
Chemical Oxygen Demand (COD)	%	96			70-130	Pass	
Chloride	%	102			70-130	Pass	
Nitrate (as N)	%	106			70-130	Pass	
Sulphate (as S)	%	94			70-130	Pass	
Total Organic Carbon	%	87			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	%	103			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Heavy Metals</b>							
Copper (filtered)	%	96			80-120	Pass	
Manganese (filtered)	%	98			80-120	Pass	
Zinc (filtered)	%	97			80-120	Pass	
<b>LCS - % Recovery</b>							
<b>Alkali Metals</b>							
Calcium	%	98			70-130	Pass	
Magnesium	%	105			70-130	Pass	
Potassium	%	91			70-130	Pass	
Sodium	%	94			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Spike - % Recovery</b>									
				Result 1					
Acetic Acid*	M15-Se08493	NCP	%	91			70-130	Pass	
Ammonia (as N)	M15-Se18208	NCP	%	95			70-130	Pass	
Chemical Oxygen Demand (COD)	B15-Se12706	NCP	%	85			70-130	Pass	
Chloride	M15-Se22295	NCP	%	116			70-130	Pass	
Nitrate (as N)	M15-Se18208	NCP	%	109			70-130	Pass	
Phosphorus reactive (as P)	M15-Se18212	NCP	%	112			70-130	Pass	
Sulphate (as S)	M15-Se22295	NCP	%	94			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Heavy Metals</b>				Result 1					
Copper (filtered)	M15-Se17090	NCP	%	88			70-130	Pass	
Manganese (filtered)	M15-Se17090	NCP	%	93			70-130	Pass	
Zinc (filtered)	M15-Se17090	NCP	%	92			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkali Metals</b>				Result 1					
Calcium	M15-Se17655	NCP	%	100			70-130	Pass	
Magnesium	M15-Se17655	NCP	%	96			70-130	Pass	
Potassium	M15-Se17655	NCP	%	87			70-130	Pass	
Sodium	M15-Se17655	NCP	%	95			70-130	Pass	
Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Duplicate</b>									
				Result 1	Result 2	RPD			
Acetic Acid*	M15-Se05769	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Ammonia (as N)	M15-Se18198	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Chemical Oxygen Demand (COD)	M15-Se19202	NCP	mg/L	1100	1100	5.0	30%	Pass	
Chloride	M15-Se22607	NCP	mg/L	87	86	<1	30%	Pass	
Nitrate (as N)	M15-Se18198	NCP	mg/L	0.11	0.10	3.0	30%	Pass	
Phosphorus reactive (as P)	M15-Se18212	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Sulphate (as S)	M15-Se22295	NCP	mg/L	< 5	< 5	<1	30%	Pass	
Total Organic Carbon	M15-Se17656	NCP	mg/L	5.4	5.1	5.0	30%	Pass	
<b>Duplicate</b>									
<b>Heavy Metals</b>				Result 1	Result 2	RPD			
Copper (filtered)	M15-Se17090	NCP	mg/L	0.003	0.003	2.0	30%	Pass	
Iron	S15-Se20682	NCP	mg/L	0.31	0.31	<1	30%	Pass	
Manganese (filtered)	M15-Se17090	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Zinc (filtered)	M15-Se17090	NCP	mg/L	0.006	0.006	2.0	30%	Pass	
<b>Duplicate</b>									
<b>Alkali Metals</b>				Result 1	Result 2	RPD			
Calcium	M15-Se17655	NCP	mg/L	97	110	12	30%	Pass	
Magnesium	M15-Se17655	NCP	mg/L	8.2	9.2	11	30%	Pass	
Potassium	M15-Se17417	NCP	mg/L	22	24	6.0	30%	Pass	
Sodium	M15-Se17655	NCP	mg/L	36	39	8.0	30%	Pass	

**Comments**

v2: Ammonium (as N) results added to report.  
 v3: Speciated Alkalinity results added to report.

**Sample Integrity**

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

**Qualifier Codes/Comments**

Code	Description
G01	The LORs have been raised due to matrix interference
M10	NATA accreditation does not cover the performance of this service in soil matrices

**Authorised By**

Mark Rodriquez	Analytical Services Manager
Carroll Lee	Senior Analyst-Organic (VIC)
Emily Rosenberg	Senior Analyst-Metal (VIC)
Huong Le	Senior Analyst-Inorganic (VIC)



**Glenn Jackson**

**National Operations Manager**

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

\* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

Eurofins | mgt shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall Eurofins | mgt be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

**CHAIN OF CUSTODY DOCUMENTATION**

CLIENT: URS Australia

ADDRESS / OFFICE: Level 3, 93 Mitchell Street, Darwin 0800

PROJECT MANAGER (PM): Chris Mach Hunter

PROJECT ID: 42214019

SITE: Shoal Bay Hydrogeological Sampling

RESULTS REQUIRED (date): QUOTE NO.:

FOR LABORATORY USE ONLY  
COOLER SEAL (where appropriate)  
In fact Yes No N/A  
SAMPLE TEMPERATURE  
CHILLED Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)

CONTAINER INFORMATION

ALS ID SAMPLE ID MATRIX DATE TIME Type / Code Total bottles

ALS ID	SAMPLE ID	MATRIX	DATE	TIME	Type / Code	Total bottles
1	GW5-12-210915	W	21/9/15	0840	P.V, SP	6
2	GW7-12-210915	W	1030	1200		6
3	GW8-3-210915	W		1200		6
4	GW8-12-210915	W	1310			6
5	QAC007-210915	W	-			6
6	QAC01-210915	W				2
7	QCC01-210915	W				2

ANALYSIS REQUIRED including SUITES (note - suite codes must be listed to attract suite prices)

Suite	NT-1 (cations: Major (Ca, Mg, Na, K))	NT-2 (Anions: Minor (Cl, SO4, Alkalinity))	EK050G (Nitrate)	EK055G-NH4 (Ammonium as N)	EK071 (Reactive Phosphorus as P)	EG020F (Dissolved metals: Mn, Zn, Cu)	EG020T (Total: Fe)	EP005 (TOC)	EP030 (BOD)	EP028 (COD)	EP045 (CH3COOH)
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Extra volume for lab QC

Notes: e.g. Highly contaminated samples e.g. "High PAts expected", Extra volume for GC or trace LORs etc.

SAMPLER: Kim Treglowm MOBILE: 0422088362 PHONE: EMAIL REPORT TO: kim.treglowm@urs.com; chris.machhunter@urs.com EMAIL INVOICE TO: (if different to report)

AL5 Laboratory Group



Environmental Division  
Sydney  
Work Order Reference  
ES1531727



Telephone : + 61-2-8784 8555

RECEIVED BY

RELINQUISHED BY:

Name:	Date:	Time:	Name:	Date:	Time:
K. Treglowm	21/9/15	1400	g T	21/9/15	3:00
			Dolly	22/9/15	8:30

METHOD OF SHIPMENT

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulphuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulphuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

**AL5 LABORATORY GROUP**

FS1531727



SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : ES1531727

Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Contact	: Loren Schiavon
Address	: Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: kim.treglown@urs.com	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 08 89802900	Telephone	: +61 2 8784 8503
Facsimile	: +61 08 89413920	Facsimile	: +61-2-8784 8500
Project	: 42214019	Page	: 1 of 3
Order number	: ----	Quote number	: ES2014URSNT0273 (EN/001/14)
C-O-C number	: ----	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Site	: shoal bay hydrogeological sampling		
Sampler	: KIM TREGLOWN		

Dates

Date Samples Received	: 22-Sep-2015 8:30 AM	Issue Date	: 22-Sep-2015
Client Requested Due Date	: 29-Sep-2015	Scheduled Reporting Date	: <b>29-Sep-2015</b>

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 3	Temperature	: -0.8 - Ice present
Receipt Detail	:	No. of samples received / analysed	: 7 / 7

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- Please direct any queries you have regarding this work order to the above ALS laboratory contact.
- Analytical work for this work order will be conducted at ALS Sydney.
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.



## Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method Client sample ID	Sample Container Received	Preferred Sample Container for Analysis
<b>Dissolved Metals by ICP-MS - Suite A : EG020A-F</b>		
GW5_12_210915	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
GW_7_12_210915	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
GW8_3_210915	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
GW8_12_210915	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
QAQC07_210915	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered

## Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020F Dissolved Metals by ICPMS	WATER - EK055G-NH4 Ammonium as N	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser	WATER - EP026SP Chemical Oxygen Demand (COD)	WATER - EP030 BOD	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity
ES1531727-001	21-Sep-2015 08:40	GW5_12_210915	✓	✓	✓	✓	✓	✓	✓
ES1531727-002	21-Sep-2015 10:30	GW_7_12_210915	✓	✓	✓	✓	✓	✓	
ES1531727-003	21-Sep-2015 12:00	GW8_3_210915	✓	✓	✓	✓	✓	✓	
ES1531727-004	21-Sep-2015 13:10	GW8_12_210915	✓	✓	✓	✓	✓	✓	
ES1531727-005	[ 21-Sep-2015 ]	QAQC07_210915	✓	✓	✓	✓	✓	✓	
ES1531727-006	[ 22-Sep-2015 ]	QCB01_210915	✓						
ES1531727-007	[ 22-Sep-2015 ]	QCC01_210915	✓						

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EG020T Total Recoverable Metals by ICPMS (including	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP045 Volatile Acids as CH3COOH
ES1531727-001	21-Sep-2015 08:40	GW5_12_210915	✓	✓	✓
ES1531727-002	21-Sep-2015 10:30	GW_7_12_210915	✓	✓	✓
ES1531727-003	21-Sep-2015 12:00	GW8_3_210915	✓	✓	✓
ES1531727-004	21-Sep-2015 13:10	GW8_12_210915	✓	✓	✓
ES1531727-005	[ 21-Sep-2015 ]	QAQC07_210915	✓	✓	✓
ES1531727-006	[ 22-Sep-2015 ]	QCB01_210915	✓		
ES1531727-007	[ 22-Sep-2015 ]	QCC01_210915	✓		

## Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



## Requested Deliverables

### CHRIS Mac HUNTER

- *AU Certificate of Analysis - NATA (COA)	Email	chris.machunter@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	chris.machunter@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	chris.machunter@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	chris.machunter@urs.com
- A4 - AU Tax Invoice (INV)	Email	chris.machunter@urs.com
- Chain of Custody (CoC) (COC)	Email	chris.machunter@urs.com
- EDI Format - ENMRG (ENMRG)	Email	chris.machunter@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	chris.machunter@urs.com
- EDI Format - ESDAT (ESDAT)	Email	chris.machunter@urs.com
- EDI Format - MRED (MRED)	Email	chris.machunter@urs.com

### KIM TREGLOWN

- *AU Certificate of Analysis - NATA (COA)	Email	kim.treglown@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	kim.treglown@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	kim.treglown@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	kim.treglown@urs.com
- A4 - AU Tax Invoice (INV)	Email	kim.treglown@urs.com
- Chain of Custody (CoC) (COC)	Email	kim.treglown@urs.com
- EDI Format - ENMRG (ENMRG)	Email	kim.treglown@urs.com
- EDI Format - EQUIS V5 URS (EQUIS_V5_URS)	Email	kim.treglown@urs.com
- EDI Format - ESDAT (ESDAT)	Email	kim.treglown@urs.com
- EDI Format - MRED (MRED)	Email	kim.treglown@urs.com

### RESULTS ADDRESS

- *AU Certificate of Analysis - NATA (COA)	Email	darwin@urs.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	darwin@urs.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	darwin@urs.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	darwin@urs.com
- A4 - AU Tax Invoice (INV)	Email	darwin@urs.com
- Chain of Custody (CoC) (COC)	Email	darwin@urs.com
- EDI Format - ENMRG (ENMRG)	Email	darwin@urs.com
- EDI Format - MRED (MRED)	Email	darwin@urs.com

## CERTIFICATE OF ANALYSIS

<b>Work Order</b> : <b>ES1531727</b> <b>Client</b> : <b>URS AUSTRALIA PTY LTD</b> <b>Contact</b> : <b>KIM TREGLOWN</b> <b>Address</b> : <b>Supplier ID number - 1179447 G P O BOX 2005 DARWIN NT, AUSTRALIA 0801</b>  <b>E-mail</b> : <b>kim.treglown@urs.com</b> <b>Telephone</b> : <b>+61 08 89802900</b> <b>Facsimile</b> : <b>+61 08 89413920</b> <b>Project</b> : <b>42214019</b> <b>Order number</b> : <b>----</b> <b>C-O-C number</b> : <b>----</b> <b>Sampler</b> : <b>KIM TREGLOWN</b> <b>Site</b> : <b>shoal bay hydrogeological sampling</b>  <b>Quote number</b> : <b>----</b>	<b>Page</b> : 1 of 6 <b>Laboratory</b> : Environmental Division Sydney <b>Contact</b> : Loren Schiavon <b>Address</b> : 277-289 Woodpark Road Smithfield NSW Australia 2164  <b>E-mail</b> : loren.schiavon@alsglobal.com <b>Telephone</b> : +61 2 8784 8503 <b>Facsimile</b> : +61-2-8784 8500 <b>QC Level</b> : NEPM 2013 Schedule B(3) and ALS QCS3 requirement <b>Date Samples Received</b> : 22-Sep-2015 08:30 <b>Date Analysis Commenced</b> : 22-Sep-2015 <b>Issue Date</b> : 01-Oct-2015 14:40  <b>No. of samples received</b> : 7 <b>No. of samples analysed</b> : 7
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This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with  
ISO/IEC 17025.

### *Signatories*

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

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Shobhna Chandra	Metals Coordinator	Sydney Inorganics



## 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.

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  
∅ = ALS is not NATA accredited for these tests.

- EG020/ED093: LOR's have been raised due to matrix interference. (High Total Dissolved Solids)
- EP026SP : LOR was raised for COD for sample ID GW8\_12\_210915 and QAQC07\_210915 due to sample matrix.



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW5_12_210915	GW_7_12_210915	GW8_3_210915	GW8_12_210915	QAQC07_210915
Client sampling date / time				21-Sep-2015 08:40	21-Sep-2015 10:30	21-Sep-2015 12:00	21-Sep-2015 13:10	[21-Sep-2015]	
Compound	CAS Number	LOR	Unit	ES1531727-001	ES1531727-002	ES1531727-003	ES1531727-004	ES1531727-005	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	65	110	165	246	252	
Total Alkalinity as CaCO3	----	1	mg/L	65	110	165	246	252	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	147	736	1160	3560	3600	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	1050	5340	6470	28700	31500	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	20	118	238	1040	1030	
Magnesium	7439-95-4	1	mg/L	33	246	462	1930	1930	
Sodium	7440-23-5	1	mg/L	701	3180	3410	15200	15300	
Potassium	7440-09-7	1	mg/L	22	84	99	346	339	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	0.003	0.025	0.005	0.263	0.275	
Manganese	7439-96-5	0.001	mg/L	0.011	0.428	0.098	0.175	0.174	
Zinc	7440-66-6	0.005	mg/L	0.071	0.162	0.289	0.257	0.280	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	2.21	10.4	2.60	15.3	11.5	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	0.04	0.34	36.7	6.45	6.39	
<b>EK057G: Nitrite as N by Discrete Analyser</b>									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<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	0.08	0.16	1.61	<0.01	0.02	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.01	mg/L	0.08	0.16	1.65	<0.01	0.02	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.02	0.02	<0.01	<0.01	<0.01	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	34.0	168	210	889	968	
^ Total Cations	----	0.01	meq/L	34.8	167	201	881	884	
^ Ionic Balance	----	0.01	%	1.13	0.48	2.25	0.46	4.55	



### Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GW5_12_210915	GW_7_12_210915	GW8_3_210915	GW8_12_210915	QAQC07_210915
Client sampling date / time				21-Sep-2015 08:40	21-Sep-2015 10:30	21-Sep-2015 12:00	21-Sep-2015 13:10	[21-Sep-2015]	
Compound	CAS Number	LOR	Unit	ES1531727-001	ES1531727-002	ES1531727-003	ES1531727-004	ES1531727-005	
				Result	Result	Result	Result	Result	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	<1	<1	16	4	5	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	50	168	160	<500	<500	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	<2	<2	<2	<2	<2	
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	24	36	55	103	99	



## Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	QCB01_210915	QCC01_210915	----	----	----
Client sampling date / time				[22-Sep-2015]	[22-Sep-2015]	----	----	----	
Compound	CAS Number	LOR	Unit	ES1531727-006	ES1531727-007	-----	-----	-----	
				Result	Result	Result	Result	Result	
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	----	----	----	----	----	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	----	----	----	----	----	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	----	----	----	----	----	
Total Alkalinity as CaCO3	----	1	mg/L	----	----	----	----	----	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	----	----	----	----	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	16887-00-6	1	mg/L	----	----	----	----	----	
<b>ED093F: Dissolved Major Cations</b>									
Calcium	7440-70-2	1	mg/L	----	----	----	----	----	
Magnesium	7439-95-4	1	mg/L	----	----	----	----	----	
Sodium	7440-23-5	1	mg/L	----	----	----	----	----	
Potassium	7440-09-7	1	mg/L	----	----	----	----	----	
<b>EG020F: Dissolved Metals by ICP-MS</b>									
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----	
Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	----	----	----	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	----	----	----	
<b>EG020T: Total Metals by ICP-MS</b>									
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----	
<b>EK055G-NH4: Ammonium as N by DA</b>									
^ Ammonium as N	----	0.01	mg/L	----	----	----	----	----	
<b>EK057G: Nitrite as N by Discrete Analyser</b>									
Nitrite as N	14797-65-0	0.01	mg/L	----	----	----	----	----	
<b>EK058G: Nitrate as N by Discrete Analyser</b>									
^ Nitrate as N	14797-55-8	0.01	mg/L	----	----	----	----	----	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	----	0.01	mg/L	----	----	----	----	----	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	----	----	----	----	----	
<b>EN055: Ionic Balance</b>									
^ Total Anions	----	0.01	meq/L	----	----	----	----	----	
^ Total Cations	----	0.01	meq/L	----	----	----	----	----	
^ Ionic Balance	----	0.01	%	----	----	----	----	----	



**Analytical Results**

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	QCB01_210915	QCC01_210915	----	----	----
Client sampling date / time				[22-Sep-2015]	[22-Sep-2015]	----	----	----	
Compound	CAS Number	LOR	Unit	ES1531727-006	ES1531727-007	-----	-----	-----	
				Result	Result	Result	Result	Result	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	----	1	mg/L	----	----	----	----	----	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>									
Chemical Oxygen Demand	----	10	mg/L	----	----	----	----	----	
<b>EP030: Biochemical Oxygen Demand (BOD)</b>									
Biochemical Oxygen Demand	----	2	mg/L	----	----	----	----	----	
<b>EP045: Volatile Acids as CH3COOH</b>									
Volatile Acids as Acetic Acid	----	5	mg/L	----	----	----	----	----	



QUALITY CONTROL REPORT

Table with 4 columns: Field Name, Value, Field Name, Value. Includes Work Order: ES1531727, Client: URS AUSTRALIA PTY LTD, Laboratory: Environmental Division Sydney, etc.

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
• Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
• Matrix Spike (MS) Report; Recovery and Acceptance Limits



NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Table with 3 columns: Signatories, Position, Accreditation Category. Lists Ankit Joshi, Ashesh Patel, Celine Conceicao, and Shobhna Chandra.

Page : 2 of 7  
Work Order : ES1531727  
Client : URS AUSTRALIA PTY LTD  
Project : 42214019

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## **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

Key :  
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot  
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  
RPD = Relative Percentage Difference  
# = Indicates failed QC



## Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 221538)</b>									
ME1510472-001	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	73	75	2.83	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	73	75	2.83	0% - 20%
ME1510472-010	Anonymous	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	51	53	4.09	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	22	18	19.3	0% - 20%
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	73	72	2.43	0% - 20%
<b>ED037P: Alkalinity by PC Titrator (QC Lot: 221542)</b>									
ES1531727-003	GW8_3_210915	ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	165	163	1.39	0% - 20%
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	165	163	1.39	0% - 20%
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 221545)</b>									
ME1510472-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	55	56	1.99	0% - 20%
ME1510472-010	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.00	No Limit
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 221549)</b>									
EW1511799-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	24	26	6.96	0% - 20%
ES1531727-005	QAQC07_210915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3600	3600	0.00	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 221546)</b>									
ME1510472-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	46	46	0.00	0% - 20%
ME1510472-010	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	217	215	0.695	0% - 20%
<b>ED045G: Chloride by Discrete Analyser (QC Lot: 221548)</b>									
ES1531727-005	QAQC07_210915	ED045G: Chloride	16887-00-6	1	mg/L	31500	31800	0.793	0% - 20%
<b>ED093F: Dissolved Major Cations (QC Lot: 224411)</b>									
ES1531727-001	GW5_12_210915	ED093F: Calcium	7440-70-2	1	mg/L	20	20	0.00	0% - 50%
		ED093F: Magnesium	7439-95-4	1	mg/L	33	33	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	22	22	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	701	698	0.361	0% - 20%
ES1531795-003	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	7	7	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	5	5	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	59	60	1.95	0% - 20%
<b>EG020F: Dissolved Metals by ICP-MS (QC Lot: 224412)</b>									



Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
<b>EG020F: Dissolved Metals by ICP-MS (QC Lot: 224412) - continued</b>									
ES1531727-001	GW5_12_210915	EG020A-F: Copper	7440-50-8	0.001	mg/L	0.003	0.004	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.011	0.012	0.00	0% - 50%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.071	0.074	3.99	0% - 50%
ES1531795-003	Anonymous	EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.043	0.042	3.14	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
<b>EG020T: Total Metals by ICP-MS (QC Lot: 223746)</b>									
ES1531727-001	GW5_12_210915	EG020A-T: Iron	7439-89-6	0.05	mg/L	2.21	2.20	0.542	0% - 20%
ES1531733-004	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 221543)</b>									
ME1510472-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
ME1510472-010	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EK057G: Nitrite as N by Discrete Analyser (QC Lot: 221550)</b>									
ES1531791-004	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.05	0.05	0.00	No Limit
ES1531727-005	QAQC07_210915	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 221556)</b>									
ES1531727-001	GW5_12_210915	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.08	0.07	0.00	No Limit
ES1531643-003	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	2.91	2.95	1.49	0% - 20%
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 221547)</b>									
ES1531786-004	Anonymous	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.10	<0.10	0.00	No Limit
ES1531727-005	QAQC07_210915	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
<b>EP005: Total Organic Carbon (TOC) (QC Lot: 222591)</b>									
ES1531695-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	102	102	0.00	0% - 20%
ES1531771-008	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	2	1	0.00	No Limit
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QC Lot: 224692)</b>									
ES1531727-001	GW5_12_210915	EP026SP: Chemical Oxygen Demand	----	10	mg/L	50	56	11.3	No Limit
ES1531743-001	Anonymous	EP026SP: Chemical Oxygen Demand	----	10	mg/L	96	96	0.00	No Limit
<b>EP030: Biochemical Oxygen Demand (BOD) (QC Lot: 222615)</b>									
ES1531727-001	GW5_12_210915	EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	<2	0.00	No Limit
ES1531818-001	Anonymous	EP030: Biochemical Oxygen Demand	----	2	mg/L	906	941	3.79	0% - 20%
<b>EP045: Volatile Acids as CH3COOH (QC Lot: 227815)</b>									
ES1531727-001	GW5_12_210915	EP045: Volatile Acids as Acetic Acid	----	5	mg/L	24	21	15.2	No Limit



## Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report				
				Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
						LCS	Low	High	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 221538)</b>									
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	93.1	81	111	
<b>ED037P: Alkalinity by PC Titrator (QCLot: 221542)</b>									
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	91.9	81	111	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 221545)</b>									
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	101	86	122	
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 221549)</b>									
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	100	86	122	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 221546)</b>									
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	111	75	123	
				<1	1000 mg/L	100	77	119	
<b>ED045G: Chloride by Discrete Analyser (QCLot: 221548)</b>									
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	111	75	123	
				<1	1000 mg/L	100	77	119	
<b>ED093F: Dissolved Major Cations (QCLot: 224411)</b>									
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	101	90	114	
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	110	90	110	
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	106	87	117	
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	107	82	118	
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 224412)</b>									
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	92.2	85	115	
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	93.8	85	115	
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	89.7	85	115	
<b>EG020T: Total Metals by ICP-MS (QCLot: 223746)</b>									
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	110	82	120	
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 221543)</b>									
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	91.8	82	114	
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 221550)</b>									
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	94.9	82	114	
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 221556)</b>									
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	95.5	91	113	
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 221547)</b>									
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	95.5	85	117	



Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report				
					Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
						LCS	Low	High	
<b>EP005: Total Organic Carbon (TOC) (QCLot: 222591)</b>									
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	89.1	76	120	
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 224692)</b>									
EP026SP: Chemical Oxygen Demand	----	10	mg/L	<10	50 mg/L	90.0	80	120	
				<10	500 mg/L	96.0	80	120	
<b>EP030: Biochemical Oxygen Demand (BOD) (QCLot: 222615)</b>									
EP030: Biochemical Oxygen Demand	----	2	mg/L	<2	200 mg/L	85.5	74	110	
<b>EP045: Volatile Acids as CH3COOH (QCLot: 227815)</b>									
EP045: Volatile Acids as Acetic Acid	----	5	mg/L	<5	200 mg/L	95.9	88	112	

### Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%)	
						Low	High
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 221545)</b>							
ME1510472-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 221549)</b>							
ES1531727-005	QAQC07_210915	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
<b>ED045G: Chloride by Discrete Analyser (QCLot: 221546)</b>							
ME1510472-001	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	109	70	130
<b>ED045G: Chloride by Discrete Analyser (QCLot: 221548)</b>							
ES1531727-005	QAQC07_210915	ED045G: Chloride	16887-00-6	250 mg/L	# Not Determined	70	130
<b>EG020F: Dissolved Metals by ICP-MS (QCLot: 224412)</b>							
ES1531727-001	GW5_12_210915	EG020A-F: Copper	7440-50-8	0.2 mg/L	95.6	70	130
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	91.1	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	90.2	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 221543)</b>							
ME1510472-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	93.7	70	130
<b>EK057G: Nitrite as N by Discrete Analyser (QCLot: 221550)</b>							
ES1531727-005	QAQC07_210915	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	100	70	130
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 221556)</b>							



Sub-Matrix: **WATER**

				<i>Matrix Spike (MS) Report</i>			
				<i>Spike</i>	<i>SpikeRecovery(%)</i>	<i>Recovery Limits (%)</i>	
<i>Laboratory sample ID</i>	<i>Client sample ID</i>	<i>Method: Compound</i>	<i>CAS Number</i>	<i>Concentration</i>	<i>MS</i>	<i>Low</i>	<i>High</i>
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 221556) - continued</b>							
ES1531727-001	GW5_12_210915	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	95.9	70	130
<b>EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 221547)</b>							
ES1531727-005	QAQC07_210915	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	97.9	70	130
<b>EP005: Total Organic Carbon (TOC) (QCLot: 222591)</b>							
ES1531718-008	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	98.8	70	130
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric) (QCLot: 224692)</b>							
ES1531727-001	GW5_12_210915	EP026SP: Chemical Oxygen Demand	----	47.6 mg/L	119	70	130

## QA/QC Compliance Assessment for DQO Reporting

Work Order	: ES1531727	Page	: 1 of 8
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: KIM TREGLOWN	Telephone	: +61 2 8784 8503
Project	: 42214019	Date Samples Received	: 22-Sep-2015
Site	: shoal bay hydrogeological sampling	Issue Date	: 01-Oct-2015
Sampler	: KIM TREGLOWN	No. of samples received	: 7
Order number	: ----	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

### Summary of Outliers

#### Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

#### Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

#### Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



### Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: WATER

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
<b>Matrix Spike (MS) Recoveries</b>							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ME1510472--001	Anonymous	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ES1531727--005	QAQC07_210915	Sulfate as SO4 - Turbidimetric	14808-79-8	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
ED045G: Chloride by Discrete Analyser	ES1531727--005	QAQC07_210915	Chloride	16887-00-6	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

### Outliers : Frequency of Quality Control Samples

Matrix: WATER

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
<b>Matrix Spikes (MS)</b>					
Total Metals by ICP-MS - Suite A	0	20	0.00	5.00	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

### Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: WATER

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
<b>ED037P: Alkalinity by PC Titrator</b>							
<b>Clear Plastic Bottle - Natural (ED037-P)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	21-Sep-2015	----	----	----	22-Sep-2015	05-Oct-2015	✓
<b>ED041G: Sulfate (Turbidimetric) as SO4 2- by DA</b>							
<b>Clear Plastic Bottle - Natural (ED041G)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	21-Sep-2015	----	----	----	22-Sep-2015	19-Oct-2015	✓



Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>ED045G: Chloride by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Natural (ED045G)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	22-Sep-2015	19-Oct-2015	✓
<b>ED093F: Dissolved Major Cations</b>								
<b>Clear Plastic Bottle - Natural (ED093F)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	26-Sep-2015	28-Sep-2015	✓
<b>EG020F: Dissolved Metals by ICP-MS</b>								
<b>Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F)</b> QCB01_210915,	QCC01_210915	22-Sep-2015	----	----	----	26-Sep-2015	20-Mar-2016	✓
<b>Clear Plastic Bottle - Natural (EG020A-F)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	26-Sep-2015	19-Mar-2016	✓
<b>EG020T: Total Metals by ICP-MS</b>								
<b>Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	24-Sep-2015	19-Mar-2016	✓	26-Sep-2015	19-Mar-2016	✓
<b>Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T)</b> QCB01_210915,	QCC01_210915	22-Sep-2015	24-Sep-2015	20-Mar-2016	✓	26-Sep-2015	20-Mar-2016	✓
<b>EK057G: Nitrite as N by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Natural (EK057G)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	22-Sep-2015	23-Sep-2015	✓
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>								
<b>Clear Plastic Bottle - Sulfuric Acid (EK059G)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	22-Sep-2015	19-Oct-2015	✓
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>								
<b>Clear Plastic Bottle - Natural (EK071G)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	22-Sep-2015	23-Sep-2015	✓



Matrix: **WATER**

Evaluation: \* = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis			
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
<b>EP005: Total Organic Carbon (TOC)</b>								
<b>Amber TOC Vial - Sulfuric Acid (EP005)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	23-Sep-2015	19-Oct-2015	✓
<b>EP026SP: Chemical Oxygen Demand (Spectrophotometric)</b>								
<b>Clear Plastic Bottle - Sulfuric Acid (EP026SP)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	25-Sep-2015	19-Oct-2015	✓
<b>EP030: Biochemical Oxygen Demand (BOD)</b>								
<b>Clear Plastic Bottle - Natural (EP030)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	23-Sep-2015	23-Sep-2015	✓
<b>EP045: Volatile Acids as CH3COOH</b>								
<b>Clear Plastic Bottle - Natural (EP045)</b> GW5_12_210915, GW8_3_210915, QAQC07_210915	GW_7_12_210915, GW8_12_210915,	21-Sep-2015	----	----	----	29-Sep-2015	05-Oct-2015	✓



## Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Reaular	Actual	Expected	Evaluation	
<b>Laboratory Duplicates (DUP)</b>							
Alkalinity by PC Titrator	ED037-P	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	2	18	11.11	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	13	15.38	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	9	22.22	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	17	11.76	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	12	16.67	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	10	20.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	16	12.50	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	8	12.50	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Laboratory Control Samples (LCS)</b>							
Alkalinity by PC Titrator	ED037-P	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Biochemical Oxygen Demand (BOD)	EP030	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	2	13	15.38	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	9	11.11	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	8	12.50	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Method Blanks (MB)</b>							
Biochemical Oxygen Demand (BOD)	EP030	1	18	5.56	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	9	11.11	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	17	5.88	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



Matrix: **WATER** Evaluation: \* = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type	Method	Count		Rate (%)			Quality Control Specification
		QC	Regular	Actual	Expected	Evaluation	
<b>Analytical Methods</b>							
<b>Method Blanks (MB) - Continued</b>							
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Volatile Acids as CH3COOH	EP045	1	8	12.50	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
<b>Matrix Spikes (MS)</b>							
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	1	13	7.69	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	9	11.11	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	10	10.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	0	20	0.00	5.00	*	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	16	6.25	5.00	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement



## Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO <sub>4</sub> <sup>2-</sup> by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO <sub>4</sub> . Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO <sub>4</sub> suspension is measured by a photometer and the SO <sub>4</sub> <sup>2-</sup> concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3)  Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3)  Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Ammonium as N	EK055G-NH4	WATER	Ammonium in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH and Temperature. Ammonia is determined by direct colorimetry by Discrete Analyser according to APHA 4500-NH <sub>3</sub> G. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO <sub>2</sub> - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO <sub>3</sub> - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)



<i>Analytical Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Nitrite and Nitrate as N (NO <sub>x</sub> ) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO <sub>3</sub> - F. Combined oxidised Nitrogen (NO <sub>2</sub> +NO <sub>3</sub> ) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO <sub>4</sub> DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Chemical Oxygen Demand (COD) (Spectrophotometric)	EP026SP	WATER	In house: Referenced to APHA 5220 D. Samples are digested with a known excess of an acidic potassium dichromate solution using silver sulfate as a catalyst. The chromium is reduced from the Cr (VI) oxidation state to the Cr (III) state by the oxygen present in the organic material. Both of these chromium species are coloured and absorb in the visible region of (400nm & 600nm) the spectrum. The oxidisable organic matter can be calculated in terms of oxygen equivalents.
Biochemical Oxygen Demand (BOD)	EP030	WATER	In house: Referenced to APHA 5210 B. The 5-Day BOD test provides an empirical measure of the oxygen consumption capacity of a given water. A portion of the sample is diluted into oxygenated, nutrient rich water, and a seed added to begin biological decay. The initial dissolved oxygen content is measured, then the bottle is sealed and incubated for five days. The remaining dissolved oxygen is measured, and from the difference, the demand for oxygen, by biological decay, is determined. This method is compliant with NEPM (2013) Schedule B(3)
Volatile Acids as CH <sub>3</sub> COOH	EP045	WATER	In house: Referenced to APHA 5560 C. Steam distillable acids are captured in caustic solution and determined titrimetrically. This method is compliant with NEPM (2013) Schedule B(3)
<i>Preparation Methods</i>	<i>Method</i>	<i>Matrix</i>	<i>Method Descriptions</i>
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)



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## Sample Receipt Advice

Company name: **URS Australia Pty Ltd NT**  
Contact name: **Chris MacHunter**  
Project name: **SHOAL BAY HYDROGEOLOGIST**  
Project ID: **42214019**  
COC number: **Not provided**  
Turn around time: **5 Day**  
Date/Time received: **Sep 22, 2015 8:22 AM**  
Eurofins | mgt reference: **473201**

### Sample information

- A detailed list of analytes logged into our LIMS, is included in the attached summary table.
- All samples have been received as described on the above COC.
- COC has been completed correctly.
- Attempt to chill was evident.
- Appropriately preserved sample containers have been used.
- All samples were received in good condition.
- Samples have been provided with adequate time to commence analysis in accordance with the relevant holding times.
- Appropriate sample containers have been used.
- Sample containers for volatile analysis received with zero headspace.
- Some samples have been subcontracted.
- N/A Custody Seals intact (if used).

### Contact notes

If you have any questions with respect to these samples please contact:

Mark Rodriquez on Phone : (+61) 8 8947 1557 or by e.mail: MarkRodriquez@eurofins.com.au

Results will be delivered electronically via e.mail to Chris MacHunter - chris\_machunter@urscorp.com.

*Note: A copy of these results will also be delivered to the general URS Australia Pty Ltd NT email address.*

**Company Name:** URS Australia Pty Ltd NT  
**Address:** Level 3 93 Mitchell St  
 Darwin  
 NT 801  
**Project Name:** SHOAL BAY HYDROGEOLOGIST  
**Project ID:** 42214019

**Order No.:**  
**Report #:** 473201  
**Phone:** 08 8980 2900  
**Fax:**

**Received:** Sep 22, 2015 8:22 AM  
**Due:** Sep 29, 2015  
**Priority:** 5 Day  
**Contact Name:** Chris MacHunter

**Eurofins | mgt Client Manager: Mark Rodriquez**

**Sample Detail**

Sample ID	Sample Date	Sampling Time	Matrix	LAB ID	Acetic Acid*	Ammonium Ion (as N)	Biochemical Oxygen Demand (BOD-5 Day)	Calcium	Chemical Oxygen Demand (COD)	Chloride	Copper (filtered)	Iron	Magnesium	Manganese (filtered)	Nitrate (as N)	Phosphorus filterable reactive (as P)	Potassium	Sodium	Sulphate (as S)	Total Alkalinity (as CaCO3)	Total Organic Carbon	Zinc (filtered)		
<b>Laboratory where analysis is conducted</b>																								
<b>Melbourne Laboratory - NATA Site # 1254 &amp; 14271</b>					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<b>Sydney Laboratory - NATA Site # 18217</b>																								
<b>Brisbane Laboratory - NATA Site # 20794</b>																								
<b>Internal Laboratory</b>																								
AQC08_2109	Sep 21, 2015		Water	M15-Se19985	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

web : www.eurofins.com.au  
 e.mail : EnviroSales@eurofins.com.au

0015 085 521

URS Australia Pty Ltd  
 Level 3 93 Mitchell St  
 Darwin  
 NT 801



NATA Accredited  
 Accreditation Number 1261  
 Site Number 1254

Accredited for compliance with ISO/IEC 17025.  
 The results of the tests, calibrations and/or  
 measurements included in this document are traceable  
 to Australian/national standards.

Attention: Chris MacHunter

**Report** 473201-W-V3  
 Project name SHOAL BAY HYDROGEOLOGIST  
 Project ID 42214019  
 Received Date Sep 22, 2015

Client Sample ID			QAQC08_2109 15
Sample Matrix			Water
Eurofins   mgt Sample No.			M15-Se19985
Date Sampled			Sep 21, 2015
Test/Reference	LOR	Unit	
Acetic Acid*	10	mg/L	< 20
Ammonium Ion (as N)	0.01	mg/L	6.7
Biochemical Oxygen Demand (BOD-5 Day)	5	mg/L	< 5
Chemical Oxygen Demand (COD)	20	mg/L	1700
Chloride	1	mg/L	31000
Nitrate (as N)	0.02	mg/L	<sup>G01</sup> 0.04
Phosphorus filterable reactive (as P)	0.05	mg/L	< 0.05
Sulphate (as S)	5	mg/L	1300
Total Organic Carbon <sup>M10</sup>	5	mg/L	9.8
<b>Alkalinity</b>			
Bicarbonate Alkalinity (as CaCO <sub>3</sub> )	20	mg/L	260
Carbonate Alkalinity (as CaCO <sub>3</sub> )	10	mg/L	< 10
Hydroxide Alkalinity (as CaCO <sub>3</sub> )	10	mg/L	< 10
Total Alkalinity (as CaCO <sub>3</sub> )	20	mg/L	260
<b>Heavy Metals</b>			
Copper (filtered)	0.001	mg/L	0.27
Iron	0.05	mg/L	7.8
Manganese (filtered)	0.005	mg/L	0.22
Zinc (filtered)	0.001	mg/L	0.26
<b>Alkali Metals</b>			
Calcium	0.5	mg/L	910
Magnesium	0.5	mg/L	1300
Potassium	0.5	mg/L	360
Sodium	0.5	mg/L	14000

## Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported. A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acetic Acid* - Method: Acetic Acid by HPLC	Melbourne	Sep 22, 2015	7 Day
Ammonium Ion (as N) - Method: APHA 4500-NH3 Ammonia Nitrogen by FIA	Melbourne	Sep 22, 2015	7 Day
Biochemical Oxygen Demand (BOD-5 Day) - Method: LTM-INO-4010	Melbourne	Sep 22, 2015	2 Day
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Melbourne	Sep 22, 2015	28 Day
Chloride - Method: MGT 1100A	Melbourne	Sep 22, 2015	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Melbourne	Sep 22, 2015	7 Day
Phosphorus filterable reactive (as P) - Method: APHA 4500-P Phosphate (filterable reactive)	Melbourne	Sep 22, 2015	2 Day
Sulphate (as S) - Method: In house MGT1110A (SO4 by Discrete Analyser)	Melbourne	Sep 22, 2015	28 Day
Total Organic Carbon - Method: APHA 5310B Total Organic Carbon	Melbourne	Sep 23, 2015	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Melbourne	Oct 13, 2015	14 Day
Heavy Metals (filtered) - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 22, 2015	180 Day
Heavy Metals - Method: LTM-MET-3040 Metals in Waters by ICP-MS	Melbourne	Sep 22, 2015	180 Day
Alkali Metals - Method: USEPA 6010 Alkali Metals	Melbourne	Sep 22, 2015	180 Day

## Eurofins | mgt Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis. 7. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

**\*\*NOTE:** pH duplicates are reported as a range NOT as RPD

### UNITS

**mg/kg:** milligrams per Kilogram

**mg/l:** milligrams per litre

**ug/l:** micrograms per litre

**ppm:** Parts per million

**ppb:** Parts per billion

**%:** Percentage

**org/100ml:** Organisms per 100 millilitres

**NTU:** Nephelometric Turbidity Units

**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

### TERMS

<b>Dry</b>	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
<b>LOR</b>	Limit of Reporting.
<b>SPIKE</b>	Addition of the analyte to the sample and reported as percentage recovery.
<b>RPD</b>	Relative Percent Difference between two Duplicate pieces of analysis.
<b>LCS</b>	Laboratory Control Sample - reported as percent recovery
<b>CRM</b>	Certified Reference Material - reported as percent recovery
<b>Method Blank</b>	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
<b>Surr - Surrogate</b>	The addition of a like compound to the analyte target and reported as percentage recovery.
<b>Duplicate</b>	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
<b>Batch Duplicate</b>	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>Batch SPIKE</b>	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
<b>USEPA</b>	United States Environmental Protection Agency
<b>APHA</b>	American Public Health Association
<b>ASLP</b>	Australian Standard Leaching Procedure (AS4439.3)
<b>TCLP</b>	Toxicity Characteristic Leaching Procedure
<b>COC</b>	Chain of Custody
<b>SRA</b>	Sample Receipt Advice
<b>CP</b>	Client Parent - QC was performed on samples pertaining to this report
<b>NCP</b>	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within
<b>TEQ</b>	Toxic Equivalency Quotient

### QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

### QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
9. For Matrix Spikes and LCS results a dash " - " in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data.

**Quality Control Results**

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Method Blank</b>							
Acetic Acid*	mg/L	< 10			10	Pass	
Ammonium Ion (as N)	mg/L	< 0.01			0.01	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	mg/L	< 5			5	Pass	
Chemical Oxygen Demand (COD)	mg/L	< 20			20	Pass	
Chloride	mg/L	< 1			1	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Phosphorus filterable reactive (as P)	mg/L	< 0.05			0.05	Pass	
Sulphate (as S)	mg/L	< 5			5	Pass	
Total Organic Carbon	mg/L	< 5			5	Pass	
<b>Method Blank</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	mg/L	< 20			20	Pass	
<b>Method Blank</b>							
<b>Heavy Metals</b>							
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Iron	mg/L	< 0.05			0.05	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.001			0.001	Pass	
<b>Method Blank</b>							
<b>Alkali Metals</b>							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
<b>LCS - % Recovery</b>							
Acetic Acid*	%	87			70-130	Pass	
Chemical Oxygen Demand (COD)	%	108			70-130	Pass	
Chloride	%	98			70-130	Pass	
Nitrate (as N)	%	106			70-130	Pass	
Sulphate (as S)	%	106			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Alkalinity</b>							
Total Alkalinity (as CaCO <sub>3</sub> )	%	102			70-130	Pass	
<b>LCS - % Recovery</b>							
<b>Heavy Metals</b>							
Copper (filtered)	%	97			80-120	Pass	
Iron	%	87			80-120	Pass	
Manganese (filtered)	%	97			80-120	Pass	
Zinc (filtered)	%	97			80-120	Pass	
<b>LCS - % Recovery</b>							
<b>Alkali Metals</b>							
Calcium	%	113			70-130	Pass	
Magnesium	%	115			70-130	Pass	
Potassium	%	104			70-130	Pass	
Sodium	%	106			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Spike - % Recovery</b>									
				Result 1					
Acetic Acid*	M15-Se08493	NCP	%	91			70-130	Pass	
Chemical Oxygen Demand (COD)	M15-Se17701	NCP	%	85			70-130	Pass	
Chloride	M15-Se20130	NCP	%	96			70-130	Pass	
Nitrate (as N)	M15-Se19995	NCP	%	107			70-130	Pass	
Phosphorus filterable reactive (as P)	M15-Se20131	NCP	%	102			70-130	Pass	
Sulphate (as S)	M15-Se20130	NCP	%	99			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkalinity</b>				Result 1					
Total Alkalinity (as CaCO <sub>3</sub> )	M15-Se20069	NCP	%	130			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Heavy Metals</b>				Result 1					
Copper (filtered)	M15-Se19728	NCP	%	87			70-130	Pass	
Manganese (filtered)	M15-Se19728	NCP	%	79			70-130	Pass	
Zinc (filtered)	M15-Se19728	NCP	%	87			70-130	Pass	
<b>Spike - % Recovery</b>									
<b>Alkali Metals</b>				Result 1					
Calcium	S15-Se24620	NCP	%	112			70-130	Pass	
Magnesium	S15-Se24620	NCP	%	109			70-130	Pass	
Potassium	S15-Se24620	NCP	%	104			70-130	Pass	
Sodium	S15-Se24620	NCP	%	114			70-130	Pass	
Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
<b>Duplicate</b>									
				Result 1	Result 2	RPD			
Acetic Acid*	M15-Se05769	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Ammonium Ion (as N)	M15-Se19995	NCP	mg/L	0.81	0.81	1.0	30%	Pass	
Biochemical Oxygen Demand (BOD-5 Day)	M15-Se19985	CP	mg/L	< 5	< 5	<1	30%	Pass	
Chemical Oxygen Demand (COD)	S15-Se10421	NCP	mg/L	84	110	30	30%	Pass	
Chloride	M15-Se20130	NCP	mg/L	3.4	3.6	4.2	30%	Pass	
Nitrate (as N)	M15-Se19995	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Phosphorus filterable reactive (as P)	M15-Se19961	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Sulphate (as S)	M15-Se20130	NCP	mg/L	< 5	< 5	<1	30%	Pass	
Total Organic Carbon	B15-Se18162	NCP	mg/L	46	46	1.0	30%	Pass	
<b>Duplicate</b>									
<b>Alkalinity</b>				Result 1	Result 2	RPD			
Total Alkalinity (as CaCO <sub>3</sub> )	M15-Se20055	NCP	mg/L	1100	1100	2.0	30%	Pass	
<b>Duplicate</b>									
<b>Heavy Metals</b>				Result 1	Result 2	RPD			
Copper (filtered)	M15-Se19728	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Iron	M15-Se19462	NCP	mg/L	0.34	0.36	4.0	30%	Pass	
Manganese (filtered)	M15-Se19728	NCP	mg/L	0.28	0.28	2.0	30%	Pass	
Zinc (filtered)	M15-Se19728	NCP	mg/L	0.022	0.022	<1	30%	Pass	
<b>Duplicate</b>									
<b>Alkali Metals</b>				Result 1	Result 2	RPD			
Calcium	M15-Se25742	NCP	mg/L	47	46	2.0	30%	Pass	
Magnesium	M15-Se25742	NCP	mg/L	110	110	3.0	30%	Pass	
Potassium	M15-Se21079	NCP	mg/L	1.1	1.2	12	30%	Pass	
Sodium	S15-Se24620	NCP	mg/L	210	200	8.0	30%	Pass	

**Comments**

v2: Speciated alkalinity results added to report.  
 v3: Ammonium result amended.

**Sample Integrity**

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

**Qualifier Codes/Comments**

Code	Description
G01	The LORs have been raised due to matrix interference
M10	NATA accreditation does not cover the performance of this service in soil matrices

**Authorised By**

Mark Rodriquez	Analytical Services Manager
Carroll Lee	Senior Analyst-Organic (VIC)
Emily Rosenberg	Senior Analyst-Metal (VIC)
Huong Le	Senior Analyst-Inorganic (VIC)



**Glenn Jackson**

**National Operations Manager**

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

\* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

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# DATA VALIDATION REPORT

<b>Project number:</b>	42214019	<b>Validation by:</b>	Kim Treglown	<b>Date:</b>	12/10/15
<b>Client:</b>	John Holland				
<b>Site:</b>	Shoal Bay Waste Facility				
<b>Matrix type:</b>	Water	<b>Data verified by:</b>	Emma Carling	<b>Date:</b>	20/10/15
<b>Primary samples:</b>	13				
<b>Laboratory:</b>	ALS / Eurofin/MGT				
<b>Lab reference:</b>	ES1531223/472621	<b>Project Manager:</b>	Karen Telford		
	ES1531356/472745				
	ES1531462/472991				
	ES1531727/473201				

**Key Issues:** No QA/QC issues were identified in the field or laboratory datasets that could have a material implication to decision-making on the project.

## Field Quality Assurance and Quality Control

**Sampling personnel** All sampling was conducted by Kim Treglown on 15 to 17 September 2015, and 21 September 2015.

**Sampling Methodology** Samples were collected using the following techniques:

- bailer technique at GW3-12, GW13-12 and GW14-12
- a combination of low flow (bladder pump) and bailer techniques at GW4-12
- low flow (bladder pump) technique at GW2-12, GW4-30, GW5-12, GW6-12, GW6-30, GW7-12, GW8-12 and GW12-30, and
- low flow (peristaltic pump) technique at GW8-3.

**Chain of Custody (COC)** Chain of custody documents completed.

**Field Blank** Field blank samples were collected at a frequency of one per day of sampling with the following exception:

- Field blanks were not collected on 16 and 17 September 2015 due to insufficient laboratory supplied water (however, a rinsate blank was collected on 16 September 2015).

Where field blanks were requested for analysis, concentrations were reported below the limit of reporting (LOR) for all analytes tested (dissolved and total metals).

The potential for incidental or accidental cross-contamination cannot be directly assessed for samples collected on 17 September 2015 (boreholes GW3-12, GW13-12, GW14-12, GW6-12 and GW6-30). The potential for cross-contamination is considered minimal due to consistent field sampling techniques conducted throughout the sampling program (sampling, transport, sample preparation and analysis), with available field and/or rinsate blanks collected on 15, 16 and 21 September 2015 reporting concentrations below the LOR for all analytes tested. However, due to this lack of definitive data the potential for cross-contamination should be taken into consideration when interpreting metal results of samples collected on 17 September 2015 for quantitative purposes.

**Rinsate Blank** Rinsate blank samples were collected at a frequency of one per day of sampling with the following exception:

- A rinsate blank was not collected on 17 September 2015 due to insufficient laboratory supplied water.

Where rinsate blanks were requested for analysis, concentrations were reported below the limit of reporting (LOR) for all analytes tested (dissolved and total metals). The rinsate samples were collected off the interface probe which was decontaminated between sample locations.

The potential for cross-contamination due to insufficient decontamination procedures cannot be assessed for samples collected on 17 September 2015 (boreholes GW3-12, GW13-12, GW14-12, GW6-12 and GW6-30). It should be noted that dedicated well

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<b>Client:</b>	John Holland				
<b>Site:</b>	Shoal Bay Waste Facility				
<b>Matrix type:</b>	Water	<b>Data verified by:</b>	Emma Carling	<b>Date:</b>	20/10/15
<b>Primary samples:</b>	13				
<b>Laboratory:</b>	ALS / Eurofin/MGT				
<b>Lab reference:</b>	ES1531223/472621	<b>Project Manager:</b>	Karen Telford		
	ES1531356/472745				
	ES1531462/472991				
	ES1531727/473201				

sampling equipment was used at GW3-12, GW13-12 and GW14-12 (disposable bailers), and a combination of dedicated and properly decontaminated equipment was used at GW6-12 and GW6-30 (bladder pump) for sample collection. The potential for cross-contamination is considered minimal due to the use of dedicated sampling equipment and/or consistent decontamination techniques conducted throughout the sampling program, with available rinsate blanks collected on 15, 16 and 21 September 2015 reporting concentrations below the LOR for all analytes tested. However, due to this lack of definitive data the potential for cross-contamination should be taken into consideration when interpreting metal results of samples collected on 17 September 2015 for quantitative purposes.

Trip Blank	As per project specifications; trip blanks were not analysed.
Frequency of field QC	Field duplicate and triplicates (inter-laboratory duplicates) were collected at a frequency of one in twenty primary samples per laboratory batch (four of each in total).
Handling and preservation	<p>Primary, duplicate and triplicate groundwater samples were received preserved and chilled at the laboratory, with the following exception:</p> <ul style="list-style-type: none"> <li>Sample receipt temperature (-0.5°C and -0.7°C) was slightly below the recommended range (<math>4 \pm 2^\circ\text{C}</math>) in primary batches ES1531223 and ES1531727. As the low temperature did not result in damage to sample containers, there should not have been any associated effect on analyte concentrations in the samples.</li> <li>Sample receipt temperature (7.6°C) was slightly above the recommended range (<math>4 \pm 2^\circ\text{C}</math>) in primary batch ES1531462. It should be noted that the ambient temperature across the site throughout the year and at the time of sampling is <math>&gt;30^\circ\text{C}</math>. Samples were chilled in the field on ice and transported to the laboratory with an appropriate cooling medium. Samples remain chilled while cooling medium is present; however, over the 24 hour transit period to the laboratory the cooling medium will melt and samples may warm. Due to the initial sample temperature and subsequent appropriate cooling of samples, losses due to volatilisation are considered to be limited.</li> </ul>

## Laboratory QA/QC

Tests requested/reported	Samples were analysed and reported as requested on the Chain Of Custody (COC).
Holding time compliance	Samples were extracted and analysed within recommended holding times.
Laboratory Accreditation	The laboratory analysis was conducted by ALS Environmental Pty Ltd (Sydney) a National Association of Testing Authorities (NATA) accredited laboratory. The triplicate sample was analysed at Eurofins/MGT (Melbourne), also a NATA accredited laboratory.
Frequency of laboratory QC	The laboratory reported a sufficient frequency of quality control samples to assess whether the results have been reported to an acceptable accuracy and precision, with

### DQM-1-F1

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<b>Client:</b>	John Holland				
<b>Site:</b>	Shoal Bay Waste Facility				
<b>Matrix type:</b>	Water	<b>Data verified by:</b>	Emma Carling	<b>Date:</b>	20/10/15
<b>Primary samples:</b>	13				
<b>Laboratory:</b>	ALS / Eurofin/MGT				
<b>Lab reference:</b>	ES1531223/472621	<b>Project Manager:</b>	Karen Telford		
	ES1531356/472745				
	ES1531462/472991				
	ES1531727/473201				

the following exception:

- Matrix spikes where not conducted for total iron, biological oxygen demand (BOD) and volatile acids as acetic acid (VFA).

The accuracy of the results for these analytes is assessed as acceptable based on the presence of other laboratory quality control data, including LCS recoveries.

Method Blank

Method blank concentrations were not detected above the LOR for all analytes tested.

Laboratory duplicate RPDs

Laboratory duplicate Relative Percentage Differences (RPD) were within control limits. The laboratory duplicate RPDs are presented in the laboratory Quality Control Report.

Laboratory control spike recovery

Laboratory Control Spikes (LCS) recoveries were within control limits.

Matrix spike recovery

The matrix spike recovery was not determined due to background levels being greater than or equal to four times the spike level for sulfate as SO<sub>4</sub> in all primary batches and chloride in primary batches ES1531356 and ES1531727 only. This lack of data does not represent method bias and the accuracy of the results for these analytes is assessed as acceptable based on the presence of other laboratory quality control data, including LCS recoveries and the available chloride matrix spike recovery (ES1531727).

All URS matrix spike recoveries (where reported) were within control limits, with the following exception:

Laboratory Batch	Analyte	Recovery (%)	LCL (%)	UCL (%)	Comment
ES1531356	Zinc	44.8	70	130	Recovery less than lower data quality objective.

The matrix spike recovery was reported less than the lower data quality objective of 70% for zinc in laboratory batch ES1531356; hence, there is potential for reported concentrations of zinc to be under-reported by up to 66% in batch ES1531356. The poor matrix spike recovery was obtained for zinc due to matrix spike interference; this was confirmed by reanalysis. As zinc results reported were well above the adopted guideline value at all sample locations sampled in batch ES1531356, this potential lack of accuracy is not expected to affect the interpretation of the results.

It should be noted that matrix spike recoveries were reported only on anonymous samples for the following analytes:

- Dissolved metals (copper, manganese and zinc), total organic carbon (TOC) and chemical oxygen demand (COD) in primary batch ES1531223
- The sum of nitrite and nitrate and COD in primary batches ES1531356 and ES1531462, and
- Total organic carbon (TOC) in primary batch ES1531727

Where matrix spike recoveries were conducted on an anonymous sample, the matrix

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<b>Client:</b>	John Holland				
<b>Site:</b>	Shoal Bay Waste Facility				
<b>Matrix type:</b>	Water	<b>Data verified by:</b>	Emma Carling	<b>Date:</b>	20/10/15
<b>Primary samples:</b>	13				
<b>Laboratory:</b>	ALS / Eurofin/MGT				
<b>Lab reference:</b>	ES1531223/472621	<b>Project Manager:</b>	Karen Telford		
	ES1531356/472745				
	ES1531462/472991				
	ES1531727/473201				

spike recovery may not be considered representative of the URS field sample.

Surrogate spike recovery      Surrogate spike recoveries were within control limits.

## QA/QC Data Evaluation

Comparison of Field Observations and Laboratory Results      No anomalous results between field observations and analysis results were noted.

Data transcription      A random 10% check of the laboratory results identified no anomalies within the electronic data, the laboratory reports, and tables generated by URS.

Limits of reporting      LORs were sufficiently low to enable assessment against adopted guideline criteria.

Field duplicate RPDs      Field duplicate RPDs were reported within control limits, with the following exceptions (Samples with higher reported concentrations are in bold):

Analyte	Primary Batch	Primary Sample	Duplicate Sample	Recovery (%)
Sulphate (as SO <sub>4</sub> <sup>-</sup> )	ES1531356	GW12_30_160915	<b>QAQC03_160915</b>	67
COD	ES1531462	<b>GW14_12_2_170915</b>	QAQC05_170915	169

There is potential that the reported sulphate (as SO<sub>4</sub><sup>-</sup>) concentrations are biased low in batch ES1531356 and the reported COD concentrations are biased high in batch ES1531462. No guideline values have been adopted for the above listed analytes; however care should be taken when using these results for interpretive purposes.

Field triplicate RPDs      Field triplicate RPDs were reported within control limits, with the following exceptions (Samples with higher reported concentrations are in bold):

Analyte	Primary Batch	Primary Sample	Duplicate Sample	Recovery (%)
Magnesium	ES1531462	GW14_12_2_170915	<b>QAQC06_170915</b>	38
	ES1531727	<b>GW8_12_210915</b>	QAQC08_210915	39
Sulphate (as SO <sub>4</sub> <sup>-</sup> )	ES1531223	<b>GW4_30_150915</b>	QAQC02_150915	95
	ES1531462	<b>GW14_12_2_170915</b>	QAQC06_170915	99
	ES1531727	<b>GW8_12_210915</b>	QAQC08_210915	93
Iron (Total)	ES1531356	GW12_30_160915	<b>QAQC04_160915</b>	75
	ES1531462	<b>GW14_12_2_170915</b>	QAQC06_170915	79
	ES1531727	<b>GW8_12_210915</b>	QAQC08_210915	65

### DQM-1-F1

# DATA VALIDATION REPORT

<b>Project number:</b> 42214019	<b>Validation by:</b> Kim Treglown	<b>Date:</b> 12/10/15
<b>Client:</b> John Holland		
<b>Site:</b> Shoal Bay Waste Facility		
<b>Matrix type:</b> Water	<b>Data verified by:</b> Emma Carling	<b>Date:</b> 20/10/15
<b>Primary samples:</b> 13		
<b>Laboratory:</b> ALS / Eurofin/MGT		
<b>Lab reference:</b> ES1531223/472621	<b>Project Manager:</b> Karen Telford	
ES1531356/472745		
ES1531462/472991		
ES1531727/473201		

Analyte	Primary Batch	Primary Sample	Duplicate Sample	Recovery (%)
COD	ES1531223	GW4_30_150915	QAQC02_150915	182
	ES1531727	GW8_12_210915	QAQC08_210915	109
Volatile Acids as Acetic Acid	ES1531223	<b>GW4_30_150915</b>	QAQC02_150915	33
	ES1531727	<b>GW8_12_210915</b>	QAQC08_210915	135

There is potential that the reported concentrations for the following analytes are biased low:

- Magnesium in batch ES1531462
- COD in batches ES1531727 and ES1531223.
- Iron (total) in batch ES1531356.

There is potential that the reported concentrations for the following analytes are biased high:

- Iron (total) and sulphate (as SO<sub>4</sub><sup>-</sup>) in batch ES1531462
- Magnesium, sulphate (as SO<sub>4</sub><sup>-</sup>), iron (total) and volatile acids as acetic acid in batch ES1531727.
- Sulphate (as SO<sub>4</sub><sup>-</sup>) and volatile acids as acetic acid in batches ES1531223.

No guideline values have been adopted for the above listed analytes; however care should be taken when using these results in respective batches for interpretive purposes.

## Chromatograms

NA

## Other

<b>ES1531462</b>	Iron (total) results for primary sample GW4_12_2_170915 and duplicate sample QAQC05_170915 was confirmed by re-digestion and reanalysis.
<b>ES1531727</b>	LORs were raised for COD for primary sample GW8_12_210915 and duplicate sample QAQC07_210915 due to sample matrix.

### DQM-1-F1

**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531223/472621

Analytical Method	Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Number of Primary Samples	Holding Times (a)	Limits of Reporting (b)	Field Blank (1 per event)		Rinsate (1 per event)		Method Blank (1 per batch)	
							Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Major Ions	Chloride	3	3	1	✓	✓	0	0	0	0	1	1
	Calcium	3	3	1	✓	✓	0	0	0	0	1	1
	Magnesium	3	3	1	✓	✓	0	0	0	0	1	1
	Potassium	3	3	1	✓	✓	0	0	0	0	1	1
	Sodium	3	3	1	✓	✓	0	0	0	0	1	1
	Sulphate (as SO4-)	3	3	1	✓	✓	0	0	0	0	1	1
Alkalinity	Bicarbonate Alkalinity as CaCO3	3	3	1	✓	✓	0	0	0	0	0	0
	Carbonate Alkalinity as CaCO3	3	3	1	✓	✓	0	0	0	0	0	0
	Hydroxide Alkalinity as CaCO3	2	2	1	✓	✓	0	0	0	0	0	0
	Total Alkalinity as CaCO3	3	3	1	✓	✓	0	0	0	0	0	0
Nutrients	Ammonium (as N)	4	4	1	✓	✓	0	0	0	1	0	0
	Nitrite (as N)	3	3	1	✓	✓	0	0	0	1	1	1
	Nitrate (as N)	4	4	1	✓	✓	0	0	0	1	0	0
	Nitrate & Nitrite (as N)	3	3	1	✓	✓	0	0	0	1	1	1
	Reactive Phosphorus (as P)	4	4	1	✓	✓	0	0	0	1	1	1
Metals	Copper (Dissolved)	5	5	1	✓	✓	0	1	1	1	1	1
	Iron (Total)	5	5	1	✓	✓	0	1	1	1	1	1
	Manganese (Dissolved)	5	5	1	✓	✓	0	1	1	1	1	1
	Zinc (Dissolved)	5	5	1	✓	✓	0	1	1	1	1	1
Other Leachate Indicators	Total Organic Carbon	4	4	1	✓	✓	0	1	0	1	1	1
	Biological Oxygen Demand	4	4	1	✓	✓	0	0	0	1	1	1
	Chemical Oxygen Demand	4	4	1	✓	✓	0	0	0	1	1	1
	Volatile Acids as Acetic Acid	4	4	1	✓	✓	0	0	0	1	1	1

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**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531223/472621

Analytical Method	Analytical Parameter	Intra-Laboratory Duplicate Sample (1 in 20)		Inter-Laboratory Duplicate Sample (1 in 20)		Lab Duplicate (1 in 10)		Matrix Spike (1 in 20)		LCS (1 per batch)		Surrogates (GC-MS organics)	
		Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Reported	OK
Major Ions	Chloride	1	1	1	1	1	2	1	1	1	1	-	-
	Calcium	1	1	1	1	1	2	0	0	1	1	-	-
	Magnesium	1	1	1	1	1	2	0	0	1	1	-	-
	Potassium	1	1	1	1	1	2	0	0	1	1	-	-
	Sodium	1	1	1	1	1	2	0	0	1	1	-	-
	Sulphate (as SO4-)	1	1	1	1	1	2	1	1	1	1	-	-
Alkalinity	Bicarbonate Alkalinity as CaCO3	1	1	1	1	1	2	0	0	0	0	-	-
	Carbonate Alkalinity as CaCO3	1	1	1	1	1	2	0	0	0	0	-	-
	Hydroxide Alkalinity as CaCO3	1	1	1	0	1	2	0	0	0	0	-	-
	Total Alkalinity as CaCO3	1	1	1	1	1	2	0	0	1	1	-	-
Nutrients	Ammonium (as N)	1	1	1	0	0	0	0	0	0	0	-	-
	Nitrite (as N)	1	1	0	0	1	2	1	1	1	1	-	-
	Nitrate (as N)	1	1	1	1	0	0	0	0	0	0	-	-
	Nitrate & Nitrite (as N)	1	1	0	0	1	2	1	1	1	1	-	-
	Reactive Phosphorus (as P)	1	1	1	1	1	2	1	1	1	1	-	-
Metals	Copper (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Iron (Total)	1	1	1	1	1	2	1	0	1	1	-	-
	Manganese (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Zinc (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
Other Leachate Indicators	Total Organic Carbon	1	1	1	1	1	2	1	1	1	1	-	-
	Biological Oxygen Demand	1	1	1	1	1	2	1	0	1	1	-	-
	Chemical Oxygen Demand	1	1	1	1	1	2	1	1	1	1	-	-
	Volatile Acids as Acetic Acid	1	1	1	1	1	2	1	0	1	1	-	-

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**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531356/472745

Analytical Method	Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Number of Primary Samples	Holding Times (a)	Limits of Reporting (b)	Field Blank (1 per event)		Rinsate (1 per event)		Method Blank (1 per batch)	
							Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Major Ions	Chloride	5	5	3	✓	✓	0	0	0	0	1	2
	Calcium	5	5	3	✓	✓	0	0	0	0	1	1
	Magnesium	5	5	3	✓	✓	0	0	0	0	1	1
	Potassium	5	5	3	✓	✓	0	0	0	0	1	1
	Sodium	5	5	3	✓	✓	0	0	0	0	1	1
	Sulphate (as SO4-)	5	5	3	✓	✓	0	0	0	0	1	2
Alkalinity	Bicarbonate Alkalinity as CaCO3	5	5	3	✓	✓	0	0	0	0	0	0
	Carbonate Alkalinity as CaCO3	5	5	3	✓	✓	0	0	0	0	0	0
	Hydroxide Alkalinity as CaCO3	5	5	3	✓	✓	0	0	0	0	0	0
	Total Alkalinity as CaCO3	5	5	3	✓	✓	0	0	0	0	0	0
Nutrients	Ammonium (as N)	6	6	3	✓	✓	0	0	0	1	0	0
	Nitrite (as N)	5	5	3	✓	✓	0	0	0	1	1	2
	Nitrate (as N)	6	6	3	✓	✓	0	0	0	1	0	0
	Nitrate & Nitrite (as N)	5	5	3	✓	✓	0	0	0	1	1	1
	Reactive Phosphorus (as P)	6	6	3	✓	✓	0	0	0	1	1	2
Metals	Copper (Dissolved)	6	6	3	✓	✓	0	0	1	1	1	1
	Iron (Total)	6	6	3	✓	✓	0	0	1	1	1	1
	Manganese (Dissolved)	6	6	3	✓	✓	0	0	1	1	1	1
	Zinc (Dissolved)	6	6	3	✓	✓	0	0	1	1	1	1
Other Leachate Indicators	Total Organic Carbon	6	6	3	✓	✓	0	0	0	1	1	2
	Biological Oxygen Demand	6	6	3	✓	✓	0	0	0	1	1	2
	Chemical Oxygen Demand	6	6	3	✓	✓	0	0	0	1	1	1
	Volatile Acids as Acetic Acid	6	6	3	✓	✓	0	0	0	1	1	1

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**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531356/472745

Analytical Method	Analytical Parameter	Intra-Laboratory Duplicate Sample (1 in 20)		Inter-Laboratory Duplicate Sample (1 in 20)		Lab Duplicate (1 in 10)		Matrix Spike (1 in 20)		LCS (1 per batch)		Surrogates (GC-MS organics)	
		Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Reported	OK
Major Ions	Chloride	1	1	1	1	1	4	1	2	1	2	-	-
	Calcium	1	1	1	1	1	1	0	0	1	1	-	-
	Magnesium	1	1	1	1	1	1	0	0	1	1	-	-
	Potassium	1	1	1	1	1	1	0	0	1	1	-	-
	Sodium	1	1	1	1	1	1	0	0	1	1	-	-
	Sulphate (as SO4-)	1	1	1	1	1	4	1	2	1	2	-	-
Alkalinity	Bicarbonate Alkalinity as CaCO3	1	1	1	1	1	5	0	0	0	0	-	-
	Carbonate Alkalinity as CaCO3	1	1	1	1	1	5	0	0	0	0	-	-
	Hydroxide Alkalinity as CaCO3	1	1	1	1	1	5	0	0	0	0	-	-
	Total Alkalinity as CaCO3	1	1	1	1	1	5	0	0	1	3	-	-
Nutrients	Ammonium (as N)	1	1	1	0	0	0	0	0	0	0	-	-
	Nitrite (as N)	1	1	0	0	1	3	1	2	1	2	-	-
	Nitrate (as N)	1	1	1	1	0	0	0	0	0	0	-	-
	Nitrate & Nitrite (as N)	1	1	0	0	1	2	1	1	1	1	-	-
	Reactive Phosphorus (as P)	1	1	1	1	1	2	1	2	1	2	-	-
Metals	Copper (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Iron (Total)	1	1	1	1	1	2	1	0	1	1	-	-
	Manganese (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Zinc (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
Other Leachate Indicators	Total Organic Carbon	1	1	1	1	1	3	1	1	1	2	-	-
	Biological Oxygen Demand	1	1	1	1	1	4	1	0	1	2	-	-
	Chemical Oxygen Demand	1	1	1	1	1	2	1	1	1	1	-	-
	Volatile Acids as Acetic Acid	1	1	1	1	1	1	1	0	1	1	-	-

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**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531462/472991

Analytical Method	Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Number of Primary Samples	Holding Times (a)	Limits of Reporting (b)	Field Blank (1 per event)		Rinsate (1 per event)		Method Blank (1 per batch)	
							Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Major Ions	Chloride	7	7	5	✓	✓	0	0	0	0	1	1
	Calcium	7	7	5	✓	✓	0	0	0	0	1	1
	Magnesium	7	7	5	✓	✓	0	0	0	0	1	1
	Potassium	7	7	5	✓	✓	0	0	0	0	1	1
	Sodium	7	7	5	✓	✓	0	0	0	0	1	1
	Sulphate (as SO4-)	7	7	5	✓	✓	0	0	0	0	1	1
Alkalinity	Bicarbonate Alkalinity as CaCO3	7	7	5	✓	✓	0	0	0	0	0	0
	Carbonate Alkalinity as CaCO3	7	7	5	✓	✓	0	0	0	0	0	0
	Hydroxide Alkalinity as CaCO3	7	7	5	✓	✓	0	0	0	0	0	0
	Total Alkalinity as CaCO3	7	7	5	✓	✓	0	0	0	0	0	0
Nutrients	Ammonium (as N)	7	7	5	✓	✓	0	0	0	0	0	0
	Nitrite (as N)	7	7	5	✓	✓	0	0	0	0	1	1
	Nitrate (as N)	7	7	5	✓	✓	0	0	0	0	0	0
	Nitrate & Nitrite (as N)	7	7	5	✓	✓	0	0	0	0	1	1
	Reactive Phosphorus (as P)	7	7	5	✓	✓	0	0	0	0	1	1
Metals	Copper (Dissolved)	7	7	5	✓	✓	0	0	1	0	1	1
	Iron (Total)	7	7	5	✓	✓	0	0	1	0	1	2
	Manganese (Dissolved)	7	7	5	✓	✓	0	0	1	0	1	1
	Zinc (Dissolved)	7	7	5	✓	✓	0	0	1	0	1	1
Other Leachate Indicators	Total Organic Carbon	7	7	5	✓	✓	0	0	0	0	1	1
	Biological Oxygen Demand	7	7	5	✓	✓	0	0	0	0	1	1
	Chemical Oxygen Demand	7	7	5	✓	✓	0	0	0	0	1	1
	Volatile Acids as Acetic Acid	7	7	5	✓	✓	0	0	0	0	1	1

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**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531462/472991

Analytical Method	Analytical Parameter	Intra-Laboratory Duplicate Sample (1 in 20)		Inter-Laboratory Duplicate Sample (1 in 20)		Lab Duplicate (1 in 10)		Matrix Spike (1 in 20)		LCS (1 per batch)		Surrogates (GC-MS organics)	
		Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Reported	OK
Major Ions	Chloride	1	1	1	1	1	2	1	1	1	1	-	-
	Calcium	1	1	1	1	1	2	0	0	1	1	-	-
	Magnesium	1	1	1	1	1	2	0	0	1	1	-	-
	Potassium	1	1	1	1	1	2	0	0	1	1	-	-
	Sodium	1	1	1	1	1	2	0	0	1	1	-	-
	Sulphate (as SO4-)	1	1	1	1	1	2	1	1	1	1	-	-
Alkalinity	Bicarbonate Alkalinity as CaCO3	1	1	1	1	1	1	0	0	0	0	-	-
	Carbonate Alkalinity as CaCO3	1	1	1	1	1	1	0	0	0	0	-	-
	Hydroxide Alkalinity as CaCO3	1	1	1	1	1	1	0	0	0	0	-	-
	Total Alkalinity as CaCO3	1	1	1	1	1	1	0	0	1	1	-	-
Nutrients	Ammonium (as N)	1	1	1	0	0	0	0	0	0	0	-	-
	Nitrite (as N)	1	1	0	0	1	2	1	1	1	1	-	-
	Nitrate (as N)	1	1	1	1	0	0	0	0	0	0	-	-
	Nitrate & Nitrite (as N)	1	1	0	0	1	2	1	1	1	1	-	-
	Reactive Phosphorus (as P)	1	1	1	1	1	1	1	1	1	1	-	-
Metals	Copper (Dissolved)	1	1	1	1	1	1	1	1	1	1	-	-
	Iron (Total)	1	1	1	1	1	3	1	0	1	2	-	-
	Manganese (Dissolved)	1	1	1	1	1	1	1	1	1	1	-	-
	Zinc (Dissolved)	1	1	1	1	1	1	1	1	1	1	-	-
Other Leachate Indicators	Total Organic Carbon	1	1	1	1	1	2	1	1	1	1	-	-
	Biological Oxygen Demand	1	1	1	1	1	2	1	0	1	1	-	-
	Chemical Oxygen Demand	1	1	1	1	1	2	1	1	1	1	-	-
	Volatile Acids as Acetic Acid	1	1	1	1	1	2	1	0	1	1	-	-

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**Site Name** Shoal Bay Waste Management Facility  
**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531727/473201

Analytical Method	Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Number of Primary Samples	Holding Times (a)	Limits of Reporting (b)	Field Blank (1 per event)		Rinsate (1 per event)		Method Blank (1 per batch)	
							Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Major Ions	Chloride	6	6	4	✓	✓	0	0	0	0	1	2
	Calcium	6	6	4	✓	✓	0	0	0	0	1	1
	Magnesium	6	6	4	✓	✓	0	0	0	0	1	1
	Potassium	6	6	4	✓	✓	0	0	0	0	1	1
	Sodium	6	6	4	✓	✓	0	0	0	0	1	1
	Sulphate (as SO4-)	6	6	4	✓	✓	0	0	0	0	1	2
Alkalinity	Bicarbonate Alkalinity as CaCO3	6	6	4	✓	✓	0	0	0	0	0	0
	Carbonate Alkalinity as CaCO3	6	6	4	✓	✓	0	0	0	0	0	0
	Hydroxide Alkalinity as CaCO3	6	6	4	✓	✓	0	0	0	0	0	0
	Total Alkalinity as CaCO3	6	6	4	✓	✓	0	0	0	0	0	0
Nutrients	Ammonium (as N)	6	6	4	✓	✓	0	0	0	0	0	0
	Nitrite (as N)	6	6	4	✓	✓	0	0	0	0	1	2
	Nitrate (as N)	6	6	4	✓	✓	0	0	0	0	0	0
	Nitrate & Nitrite (as N)	6	6	4	✓	✓	0	0	0	0	1	1
	Reactive Phosphorus (as P)	6	6	4	✓	✓	0	0	0	0	1	1
Metals	Copper (Dissolved)	8	8	4	✓	✓	0	1	1	1	1	1
	Iron (Total)	8	8	4	✓	✓	0	1	1	1	1	1
	Manganese (Dissolved)	8	8	4	✓	✓	0	1	1	1	1	1
	Zinc (Dissolved)	8	8	4	✓	✓	0	1	1	1	1	1
Other Leachate Indicators	Total Organic Carbon	6	6	4	✓	✓	0	0	0	0	1	1
	Biological Oxygen Demand	6	6	4	✓	✓	0	0	0	0	1	1
	Chemical Oxygen Demand	6	6	4	✓	✓	0	0	0	0	1	1
	Volatile Acids as Acetic Acid	6	6	4	✓	✓	0	0	0	0	1	1

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**Project No.** 42214019  
**Project Manager** Chris Machunter  
**Matrix** Groundwater  
**Laboratory** ALS Sydney / Eurofins/MGT  
**Batch File Number** ES1531727/473201

Analytical Method	Analytical Parameter	Intra-Laboratory Duplicate Sample (1 in 20)		Inter-Laboratory Duplicate Sample (1 in 20)		Lab Duplicate (1 in 10)		Matrix Spike (1 in 20)		LCS (1 per batch)		Surrogates (GC-MS organics)	
		Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Reported	OK
Major Ions	Chloride	1	1	1	1	1	3	1	2	1	2	-	-
	Calcium	1	1	1	1	1	2	0	0	1	1	-	-
	Magnesium	1	1	1	1	1	2	0	0	1	1	-	-
	Potassium	1	1	1	1	1	2	0	0	1	1	-	-
	Sodium	1	1	1	1	1	2	0	0	1	1	-	-
	Sulphate (as SO4-)	1	1	1	1	1	4	1	2	1	2	-	-
Alkalinity	Bicarbonate Alkalinity as CaCO3	1	1	1	1	1	3	0	0	0	0	-	-
	Carbonate Alkalinity as CaCO3	1	1	1	1	1	3	0	0	0	0	-	-
	Hydroxide Alkalinity as CaCO3	1	1	1	1	1	3	0	0	0	0	-	-
	Total Alkalinity as CaCO3	1	1	1	1	1	3	0	0	1	2	-	-
Nutrients	Ammonium (as N)	1	1	1	0	0	0	0	0	0	0	-	-
	Nitrite (as N)	1	1	0	0	1	2	1	2	1	2	-	-
	Nitrate (as N)	1	1	1	1	0	0	0	0	0	0	-	-
	Nitrate & Nitrite (as N)	1	1	0	0	1	4	1	1	1	1	-	-
	Reactive Phosphorus (as P)	1	1	1	1	1	2	1	1	1	1	-	-
Metals	Copper (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Iron (Total)	1	1	1	1	1	2	1	0	1	1	-	-
	Manganese (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
	Zinc (Dissolved)	1	1	1	1	1	2	1	1	1	1	-	-
Other Leachate Indicators	Total Organic Carbon	1	1	1	1	1	2	1	1	1	1	-	-
	Biological Oxygen Demand	1	1	1	1	1	2	1	0	1	1	-	-
	Chemical Oxygen Demand	1	1	1	1	1	2	1	1	1	1	-	-
	Volatile Acids as Acetic Acid	1	1	1	1	1	1	1	0	1	1	-	-

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SDG Field ID Sample Type Sampled Date	ES1531223		472621		RPD	Category <sup>1</sup>	ES1531356		472745		RPD	Category <sup>1</sup>
	GW4_30_150915		QAQC02_150915				GW12_30_160915		QAQC04_160915			
	Primary		Duplicate				Primary		Duplicate			
	15/9/2015		15/9/2015				16/9/2015		16/9/2015			

Chem Group	Chem Name	Unit	LOR									
Major Ions	Chloride	mg/L	1 : 1	690	660	4	Pass	6	6.9	14	Pass	
	Calcium	mg/L	1 : 0.5	24	23	4	Pass	2	2.3	14	Pass	
	Magnesium	mg/L	1 : 0.5	30	26	14	Pass	1	1.3	26	Pass	
	Potassium	mg/L	1 : 0.5	12	11	9	Pass	1	1.3	26	Pass	
	Sodium	mg/L	1 : 0.5	404	370	9	Pass	4	4	0	Pass	
	Sulphate (as SO4-)	mg/L	1 : 5	70	25	95	Fail	6	<5	18	Pass	
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1 : 20	44	42	5	Pass	6	<20	108	Pass-1	
	Carbonate Alkalinity as CaCO3	mg/L	1 : 10	<1	<10	0	Pass	<1	<10	0	Pass	
	Hydroxide Alkalinity as CaCO3	mg/L	1 :	<1	-	-	-	<1	<10	0	Pass	
	Total Alkalinity as CaCO3	mg/L	1 : 10	44	42	5	Pass	6	<20	108	Pass-1	
Nutrients	Ammonium (as N)	mg/L	0.01	0.07	<0.01	150	Pass-1	0.04	0.01	120	Pass-1	
	Nitrate (as N)	mg/L	0.01 : 0.02	<0.01	<0.02	0	Pass	0.03	<0.02	40	Pass-1	
	Nitrite (as N)	mg/L	0.01	<0.01	-	-	-	<0.01	-	-	-	
	Nitrate & Nitrite (as N)	mg/L	0.01	<0.01	-	-	-	0.03	-	-	-	
	Reactive Phosphorus (as P)	mg/L	0.01 : 0.05	<0.01	<0.05	0	Pass	<0.01	<0.05	0	Pass	
Metals	Copper (Dissolved)	mg/L	0.001	0.002	0.002	0	Pass	0.006	0.006	0	Pass	
	Iron (Total)	mg/L	0.05	3.56	3.6	1	Pass	2.49	5.5	75	Fail	
	Manganese (Dissolved)	mg/L	0.001 : 0.005	1.51	1.6	6	Pass	0.049	0.045	9	Pass	
	Zinc (Dissolved)	mg/L	0.005 : 0.001	0.081	0.067	19	Pass	0.159	0.14	13	Pass	
Other Leachate Indicators	Total Organic Carbon	mg/L	1 : 5	<1	<5	0	Pass	1	<5	133	Pass-1	
	Biological Oxygen Demand	mg/L	2 : 5	4	<5	22	Pass	<2	<5	0	Pass	
	Chemical Oxygen Demand	mg/L	10 : 20	16	340	182	Fail	<10	<20	0	Pass	
	Volatile Acids as Acetic Acid	mg/L	5 : 10	14	<10	33	Pass-1	12	<10	18	Pass	

<sup>1</sup> Category

- Pass** RPD <= 30%
- Pass-1** RPD > 30%, Analysis result < 10 times LOR
- Pass-2** RPD <= 50%, Analysis result > 10 times LOR and < 20 times LOR

SDG Field ID Sample Type Sampled Date	ES1531462	472991	RPD	Category <sup>1</sup>	ES1531727	473201	RPD	Category <sup>1</sup>
	GW14_12_2_170915	QAQC06_170915			GW8_12_210915	QAQC08_210915		
	Primary	Duplicate			Primary	Duplicate		
	17/9/2015	17/9/2015			21/9/2015	21/9/2015		

Chem Group	Chem Name	Unit	LOR								
Major Ions	Chloride	mg/L	1 : 1	5520	5600	1	Pass	28,700	31,000	8	Pass
	Calcium	mg/L	1 : 0.5	165	220	29	Pass	1040	910	13	Pass
	Magnesium	mg/L	1 : 0.5	217	320	38	Fail	1930	1300	39	Fail
	Potassium	mg/L	1 : 0.5	62	83	29	Pass	346	360	4	Pass
	Sodium	mg/L	1 : 0.5	3000	3600	18	Pass	15,200	14,000	8	Pass
	Sulphate (as SO4-)	mg/L	1 : 5	653	220	99	Fail	3560	1300	93	Fail
Alkalinity	Bicarbonate Alkalinity as CaCO3	mg/L	1 : 20	<1	<20	-	Pass	246	260	6	Pass
	Carbonate Alkalinity as CaCO3	mg/L	1 : 10	<1	<10	-	Pass	<1	<10	-	Pass
	Hydroxide Alkalinity as CaCO3	mg/L	1 :	<1	<10	-	Pass	<1	<10	-	Pass
	Total Alkalinity as CaCO3	mg/L	1 : 10	<1	<20	0	Pass	246	260	6	Pass
Nutrients	Ammonium (as N)	mg/L	0.01	0.04	<0.01	120	Pass-1	6.45	6.7	4	Pass
	Nitrate (as N)	mg/L	0.01 : 0.02	0.38	0.48	23	Pass	<0.01	<1	0	Pass
	Nitrite (as N)	mg/L	0.01	<0.01	-	-	-	<0.01	-	-	-
	Nitrate & Nitrite (as N)	mg/L	0.01	0.38	-	-	-	<0.01	-	-	-
	Reactive Phosphorus (as P)	mg/L	0.01 : 0.05	<0.01	<0.05	0	Pass	<0.01	<0.05	0	Pass
Metals	Copper (Dissolved)	mg/L	0.001	0.005	0.002	86	Pass-1	0.263	0.27	3	Pass
	Iron (Total)	mg/L	0.05	62.6	27	79	Fail	15.3	7.8	65	Fail
	Manganese (Dissolved)	mg/L	0.001 : 0.005	2.7	2.9	7	Pass	0.175	0.22	23	Pass
	Zinc (Dissolved)	mg/L	0.005 : 0.001	0.163	0.15	8	Pass	0.257	0.26	1	Pass
Other Leachate Indicators	Total Organic Carbon	mg/L	1 : 5	1	<5	133	Pass-1	4	9.8	84	Pass-1
	Biological Oxygen Demand	mg/L	2 : 5	<2	<10	0	Pass	<2	<5	0	Pass
	Chemical Oxygen Demand	mg/L	10 : 20	118	120	2	Pass	<500	1700	109	Fail
	Volatile Acids as Acetic Acid	mg/L	5 : 10	28	<10	95	Pass-1	103	<20	135	Fail

<sup>1</sup> Category

- Pass** RPD <= 30%
- Pass-1** RPD > 30%, Analysis result < 10 times LOR
- Pass-2** RPD <= 50%, Analysis result > 10 times LOR and < 20 times LC

Feild QAQC Analytical Results  
Shoal Bay Waste Management Facility

<b>Sample ID</b>
<b>Simple Date</b>
<b>Laboratory Report Number</b>
<b>Sample Type</b>

QCC01_150915	QCB01_150915	QCB02_160915	QCB01_210915	QCC01_210915
15/9/2015	15/9/2015	16/9/2015	21/9/2015	21/9/2015
ES1531223	ES1531223	ES1531356	ES1531727	ES1531727
Field Blank	Rinsate	Rinsate	Field Blank	Rinsate

Chem Group	Chem Name	Unit	LOR					
	Ammonium (as N)	mg/L	0.01	-	<0.01	<0.01	-	-
	Nitrate (as N)	mg/L	0.01	-	<0.01	<0.01	-	-
	Nitrite (as N)	mg/L	0.01	-	<0.01	<0.01	-	-
	Nitrate & Nitrite (as N)	mg/L	0.01	-	<0.01	<0.01	-	-
	Reactive Phosphorus (as P)	mg/L	0.01	-	<0.01	<0.01	-	-
Metals	Copper (Dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Iron (Total)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Manganese (Dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Zinc (Dissolved)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Other Leachate Indicators	Total Organic Carbon	mg/L	1	<1	<1	<1	-	-
	Biological Oxygen Demand	mg/L	2	-	<2	<2	-	-
	Chemical Oxygen Demand	mg/L	10	-	<10	<10	-	-
	Volatile Acids as Acetic Acid	mg/L	5	-	<5	5	-	-



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## Appendix H4 Water Quality Review (2016-2020)



# Shoal Bay Waste Management Facility

## Water quality monitoring data review 2016 - 2020

Report prepared for City of Darwin



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## **Appendices**

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WATER MONITORING**

**APPENDIX B    WATER QUALITY TREND ANALYSIS GRAPHS**

# ACRONYMS AND ABBREVIATIONS

---

<b>ANZECC</b>	Australian and New Zealand Environment and Conservation Council
<b>BOD</b>	biochemical oxygen demand
<b>BoM</b>	Bureau of Meteorology
<b>BTEXN</b>	benzene, toluene, ethylbenzene, xylene, naphthalene
<b>Chl-a</b>	chlorophyll a
<b>CoD</b>	City of Darwin
<b>COD</b>	chemical oxygen demand
<b>DO</b>	dissolved oxygen
<b>EC</b>	electrical conductivity
<b>EPL</b>	Environment Protection Licence
<b>FRP</b>	filterable reactive phosphorus
<b>L/N</b>	ratio of ions associated with leachate to ions associated with natural groundwater
<b>NATA</b>	National Association of Testing Authorities
<b>NH<sub>3</sub></b>	ammonia
<b>NH<sub>3</sub> as N</b>	total concentration of nitrogen as ammonia in all forms (NH <sub>3</sub> and NH <sub>4</sub> <sup>+</sup> )
<b>NH<sub>4</sub><sup>+</sup></b>	ammonium ion
<b>NO<sub>x</sub></b>	nitrate NO <sub>3</sub> + nitrite NO <sub>2</sub>
<b>NT</b>	Northern Territory
<b>NT EPA</b>	Northern Territory Environment Protection Authority
<b>PAH</b>	polycyclic aromatic hydrocarbons
<b>PCBs</b>	polychlorinated biphenyls
<b>pH</b>	power of hydrogen
<b>PFAS</b>	per and poly-fluoroalkyl substances
<b>PFBA</b>	perfluorobutanoic acid (
<b>PFBS</b>	perfluorobutane sulfonic acid
<b>PFHxA</b>	perfluorohexanoic acid
<b>PFHxS</b>	perfluorohexane sulfonic acid
<b>PFOA</b>	perfluorooctanoic acid
<b>PFOS</b>	perfluorooctane sulfonic acid
<b>RDX</b>	cyclotrimethylenetrinitramine (type of explosive)
<b>SBWMF</b>	Shoal Bay Waste Management Facility
<b>SO<sub>4</sub></b>	sulfate
<b>SOP</b>	standard operating procedure
<b>SSTV</b>	site specific trigger value
<b>SWL</b>	standing water level
<b>TDS</b>	total dissolved solids
<b>TN</b>	total nitrogen
<b>TNT</b>	trinitramine (type of explosive)
<b>TOC</b>	total organic content
<b>TON</b>	total organic nitrogen
<b>TP</b>	Total phosphorus
<b>TSS</b>	total suspended solids
<b>TP</b>	total phosphorus

<b>TPH/TRH</b>	total petroleum hydrocarbons/total recoverable hydrocarbons
<b>VFA</b>	Volatile acids as acetic acid
<b>WMPC Act</b>	Northern Territory <i>Waste Management and Pollution Control Act</i>

# 1 INTRODUCTION

---

City of Darwin (CoD) operate the Shoal Bay Waste Management Facility (SBWMF) located approximately 12 km north-east of Darwin city (Figure 1-1). This facility is the main municipal waste resource recovery and disposal site servicing domestic and commercial customers in the Darwin area.

Water quality monitoring is undertaken on a regular basis (predominantly monthly) at the SBWMF, to detect if contaminants from the landfills, or associated operations, are present in groundwater or surface water. CoD engaged EcOz Environmental Consultants (EcOz) to review all data collected as part of the SBWMF water quality monitoring program since its inception in July 2016 to the present (March 2020). The aim of this review is to characterise the groundwater, surface water and landfill leachate quality across the site, including any seasonal trends. This can in turn help identify and assess any water quality concerns, and inform water management measures for minimising any potential offsite environmental impacts.

## 1.1 Purpose

The SBWMF is licenced to receive and manage waste in accordance with Environment Protection Licence 188 (EPL188) issued by the Northern Territory Environment Protection Authority (NT EPA) under the *NT Waste Management and Pollution Control Act (WMPC Act)*. As per EPL188 and the *WMPC Act*, CoD has a duty to not cause environmental harm and to minimise any offsite impacts from the facility to groundwater aquifers, natural surface water bodies, natural ecosystems, or users of groundwater or surface waters downstream. Of particular importance, is to prevent the migration of leachate from landfill cells into groundwater aquifers or surface water bodies that then flow offsite.

Groundwater, surface water and landfill leachate water quality monitoring is undertaken across the SBWMF in accordance with the conditions of EPL188 and the *Shoal Bay Disposal Site Water Monitoring Plan* (URS 2016a). In regards to water monitoring results, the NT EPA must be notified of any contaminant concentrations exceeding the criteria specified in Condition 62 of EPL188 (i.e. 'non-conformances'), and the risk of any potential environmental harm assessed. A Monitoring Report must also be prepared annually, that presents all water quality monitoring data for the previous 12-months and assesses any potential environmental impacts from the facility.

This water quality monitoring data review, covering the period July 2016 – March 2020, is not a specific requirement of EPL188, but the information gained can be used as a basis for assessing potential environmental impacts in any future non-conformance notifications, and when preparing annual Monitoring Reports. It can also assist in informing water management measures at the facility in continuing to comply with the water quality criteria specified in Condition 62 of EPL188.

This review also considers how the monitoring program design (parameters measured, frequency of sampling, sampling sites etc.) could be better streamlined and targeted towards detecting water quality impacts at an early stage. Any changes to the monitoring program would require submission of an updated Water Quality Monitoring Program and amendment to EPL188 approved by the NT EPA.

## 1.2 Scope

This water quality monitoring data review has been developed to achieve the following:

- Summarise the leachate, surface water and groundwater monitoring activities undertaken from July 2016 – March 2020;
- Analyse the monitoring data and highlight the trends occurring for the three water types (leachate, surface water and groundwater), with particular consideration for indications of leachate ingress, or deteriorating water quality in certain areas of SBWMF;
- Discuss the potential environmental impacts to surface water and groundwater, and receiving offsite environments;

- Discuss the implications of these water quality monitoring results for improving water and leachate management at the SBWMF, and
- Review the on-going water quality monitoring program and suggest improvements.

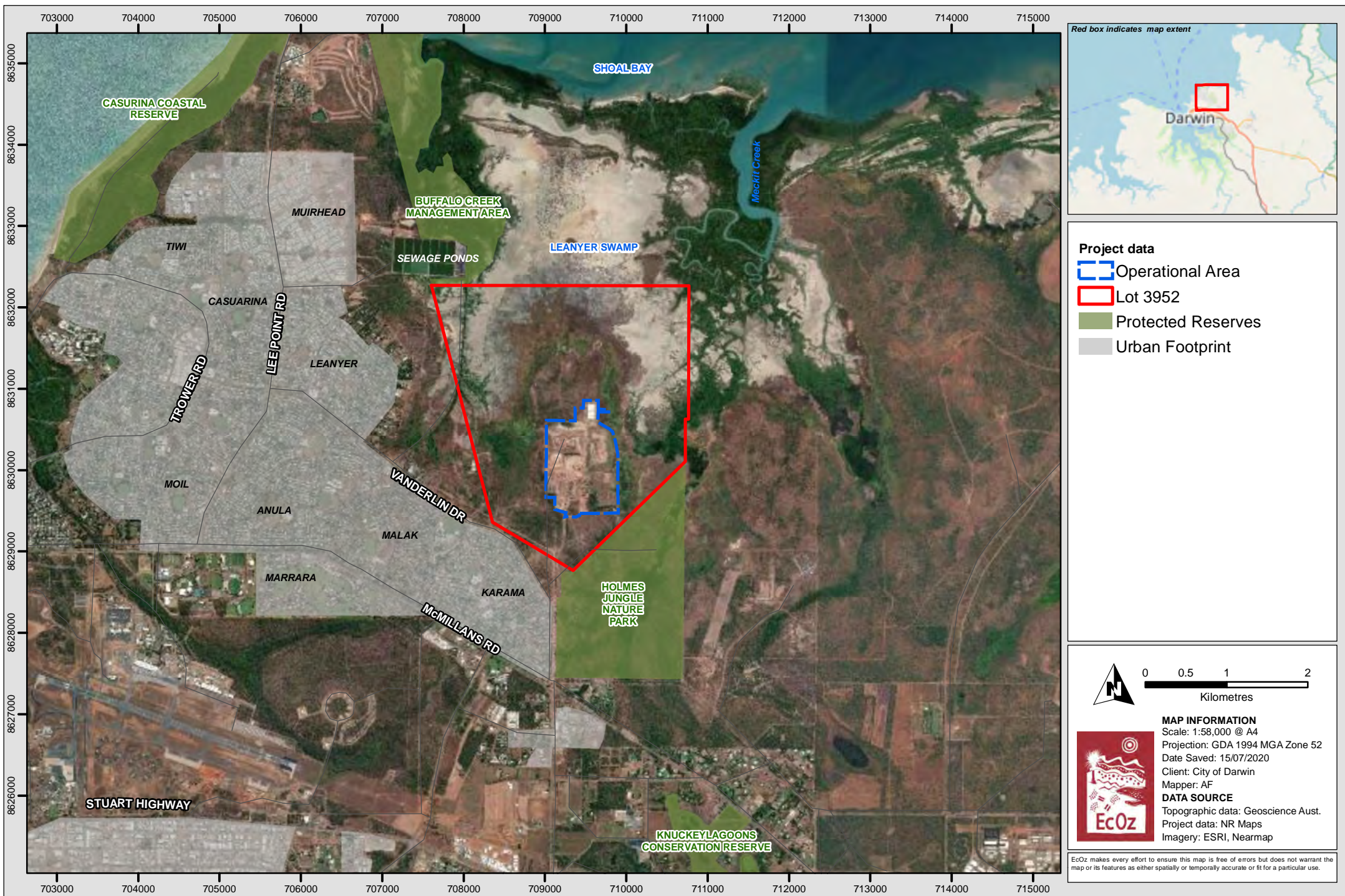


Figure 1-1. Map of SBWMF location

## 2 SBWMF OPERATIONS

---

The SBWMF lies within Lot 3952, Town of Sanderson (red boundary in Figure 1-1). CoD lease the entire property area from the Commonwealth Department of Defence. Under the terms and conditions of the lease, the property is designated as a Waste Management Project Area in which CoD is authorised to conduct waste management and ancillary activities.

The SBWMF is currently licenced under EPL188 to accept putrescible waste (commercial and domestic), green waste, and construction and demolition waste. More specifically, the facility is licenced to accept the following wastes, which are classified as 'listed wastes' under the NT *WMPC Act*:

- Animal effluent and residues
- Asbestos
- Clinical and related wastes
- Sewerage sludge and residues including nightsoil and septic tank sludge
- Soils contaminated with a listed waste
- Tyres.

The SBWMF also accepts the following 'listed wastes' for storage and subsequent collection by external operators for resource recovery/disposal at external facilities:

- Acidic solutions or acids in solid form
- Lead, lead compounds
- Waste from the production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish
- Waste mineral oils unfit for their original use
- Domestic batteries
- Empty domestic gas bottles
- Domestic paint and chemical containers
- Fluorescent tubes.

Other materials accepted for storage and subsequent collection by external parties for resource recovery/disposal include:

- Green waste (accepted from domestic and commercial customers, mulched/processed on-site, then sold to the public)
- Metal
- Plastic containers
- Paper and cardboard.

Figure 2-1 provides a general site layout, which includes the currently used putrescible waste landfill cell (Stage 5), inert waste landfill cell (Stage 2), waste transfer station, recycle shop, mulching/processing facility for green waste, leachate management system and landfill gas management system.

The Stages 3 and 4 putrescible waste landfill cells reached capacity and were capped with interim capping in 2016/2017 (final capping is currently in the design stage). The Stage 5 cell is expected to reach capacity soon (early 2021) after which the waste will go to the Stage 6 landfill cells currently under construction.

The Stage 3, 4, and 5 landfill cells are lined and have a leachate collection system. The leachate collected is irrigated back onto the cells, when possible. Leachate storage ponds store excess leachate until it can be applied back onto the landfill cells.

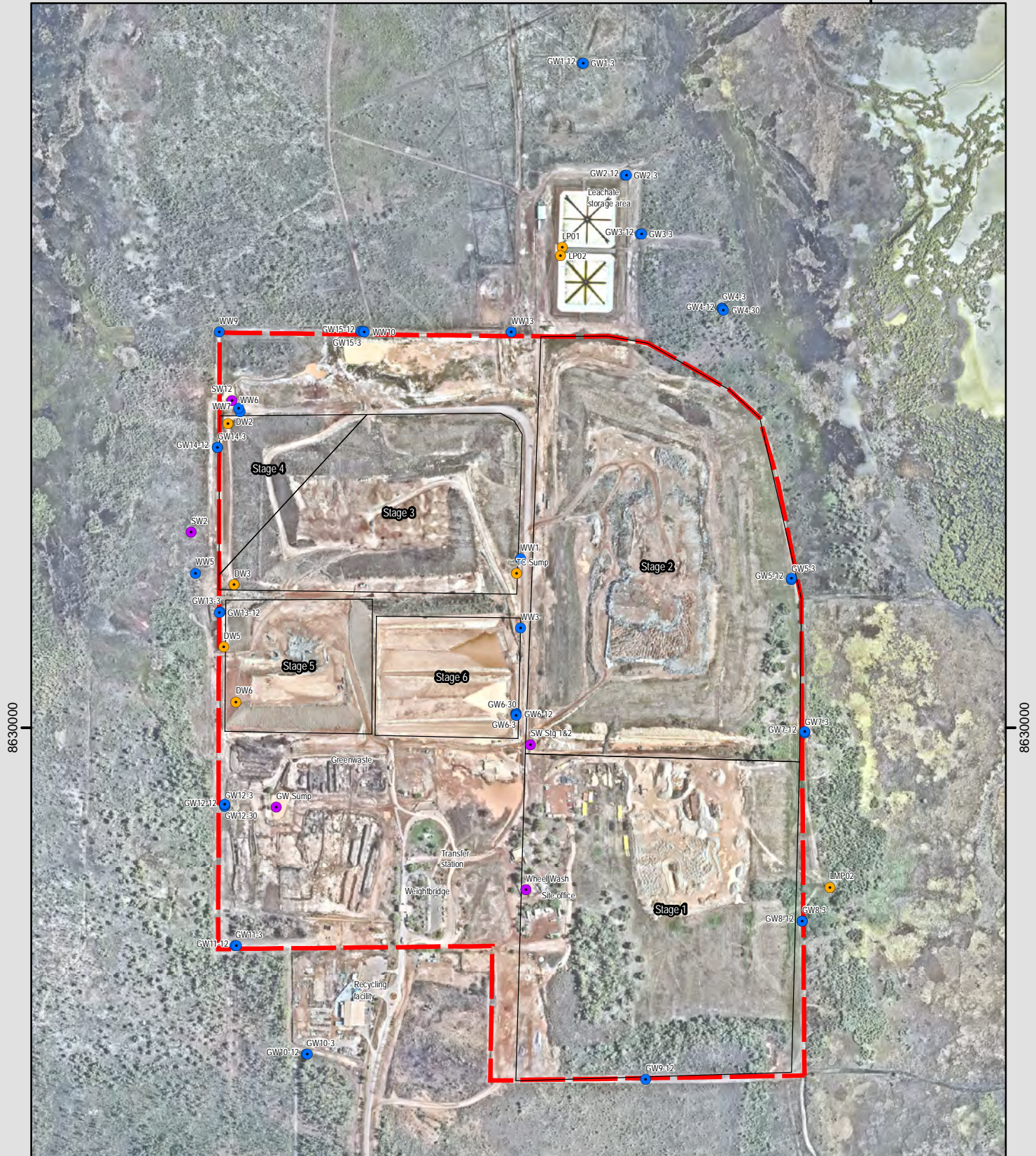
Stage 2 (north-east) is unlined and accepts inert waste (construction and demolition including asbestos). Stage 1 (south-east) is a historic unlined landfill, which is capped and not in use. Leachate from the unlined Stage 1 and 2 landfill cells is intercepted in an underground drain running north-south along the eastern edge of the cells. This then drains into a collection chamber 'LMP02', where it is pumped out and irrigated onto the capped Stage 1 cell.

Green waste storage and mulching occurs on a pad south of Stage 5.

A facility for the short-term storage of chemicals is located at the southern end of the site, within the transfer station.

Renewable energy is generated on site using landfill gas (methane) and provided to Darwin's power grid. The landfill gas management system involves capturing methane gas emissions from the landfill via a gas extraction system comprising vertical and horizontal wells drilled into the waste cells connected to a reticulation system. Condensate from the gas extraction system is pumped to disposal trenches within the Stage 2 landfill.

For more detail on the disposal, storage and handling of different waste types refer to the SBWMF *Environmental Management Plan* (CoD 2016), Sections 5.4 and 5.5, and for more detail on landfill leachate management and gas management, refer to the SBWMF *Environmental Management Plan* (CoD 2016), Section 5.6 *Water Quality Management* and Figure A5.



**Sampling type**

- Groundwater
- Surface water
- Leachate
- Stage Areas
- Lot boundary

0      120      240

Metres

**MAP INFORMATION**  
 Scale: 1:8,000 @ A4  
 Projection: GDA 1994 MGA Zone 52  
 Date Saved: 19/06/2020  
 Client: City of Darwin  
 Mapper: DC/AF

**DATA SOURCE**  
 Topographic data: Geoscience Aust.  
 Project data: EcOz  
 Imagery: Shaded relief, Landsat

**Figure 2-1. Map of SBWMF layout and sampling site locations.**

## 3 ENVIRONMENTAL SETTING

---

### 3.1 Climate

The regional climate is tropical monsoonal with a distinct wet season (Nov-April) and dry season (May-Oct). Average yearly rainfall is 1,723 mm, with most of this (around 80%) occurring between December and March; taken from the nearest Bureau of Meteorology (BoM) Station with consistent long-term data, Darwin Airport No. 14015.

Rainfall during the period covered by this review (July 2016 - March 2020) is outlined in Section 5 below.

### 3.2 Surrounding land use

The SBWMF is surrounded by bushland, floodplains, wetlands and mangroves to the north, east and west (Figure 1-1). The Holmes Jungle Nature Park is located to the south. The nearest residential area to the SBWMF is the suburb of Karama, about 1 km to the south-west with a bushland buffer in between.

### 3.3 Surface water flows

Surface water from the eastern portions of the SBWMF flows towards the Meckitt Creek floodplain (Figure 1-1). Flows from the western portion of the site are towards the Leanyer Swamp and Buffalo Creek. Both Meckitt Creek and Buffalo Creek are mangrove-lined tidal inlets of Shoal Bay; a coastal embayment with extensive sand and mud flats (Figure 1-1).

For more detail on surface water flows and water management across the site, refer to the SBWMP *Environmental Management Plan* (CoD 2016), Section 5.6 *Water Quality Management*.

### 3.4 Groundwater

Groundwater aquifers beneath the site are described in the *Shoal Bay Waste Disposal Site, Hydrogeological Investigation* (URS 2015). Lithology encountered during groundwater bore drilling for the investigation comprised top soils (silts and clays), generally underlain by weathered (lateritised) siltstone over most of the site, and claystone east of Stage 1. Beneath this, sandstone was encountered at depths of 9 to 20 m below the surface across most of the site. Groundwater exists within the unconsolidated overlying sediments, and fractured and weathered underlying bedrock. Bore yields are generally very poor; less than 5 L/sec.

The shallow (water table) aquifer is recharged by the direct infiltration of rainfall and runoff, and groundwater levels vary seasonally in accordance with rainfall totals. Seasonal groundwater standing water levels (SWLs), measured as part of the SBWMF water quality monitoring program since 2016, are greater than 12 m below ground level at the end of the dry season, and usually less than 2 m from the ground surface during the peak of the wet season (see Section 6 below for more detail).

Groundwater down gradient of the SBWMF is saline due to its close proximity to the coast and tidal saline intrusion; see the *Groundwater Resources of the Darwin Area* map (DIPE 2003). There are no groundwater bores or groundwater users down gradient of the SBWMF; although an important environmental consideration is the supply of groundwater seepage into wetlands and tidal inlets during the dry season.

Higher yielding weathered and fractured carbonate rock aquifers occur in the wider region, with yields commonly greater than 5 L/sec. The *Groundwater Supply Prospects and Hydrogeology of the Cox Peninsula Region* map (NRETA 2008) identifies a high yielding carbonate aquifer south-east of the SBWMF, trending in a northerly direction. Groundwater from this aquifer discharges to the surface within the Holmes Jungle Nature Park and maintains streamflow through the dry season. This spring and associated shallow groundwater support the Holmes Jungle rainforest. Further to the south-east around the Knuckey Lagoon

area, a large number of bores draw groundwater from this carbonate aquifer for domestic and agricultural purposes.

The carbonate rock aquifer and associated springs, Holmes Jungle rainforest and groundwater users are all located up gradient of the SBWMF. No significant areas of carbonate rock aquifer are located down gradient of the SBWMF and no carbonate rocks were encountered when drilling the 32 groundwater bores, to depths of up to 30 m below ground level, across the site for the hydrogeological investigation (URS 2015).

For detailed analysis of potential contamination pathways for leachate and other pollutants from the SBWMF towards potential human health and environmental receptors see the *Shoal Bay Waste Disposal Site Conceptual Site Model* (URS 2016b).

### 3.5 Environmental values

EPL188 lists the following 'Environment Protection Objectives' (Part 4 of the *WMPC Act*), 'Beneficial Uses and Water Quality Standards' (section 73 of the *NT Water Act*) and 'environmental interests' that apply to the site and surrounding areas:

- *Declared Beneficial Uses for the Darwin Harbour Area: Water Quality Objectives*, NTG Gazette 27, July 2010; these include the beneficial uses of: environment, agriculture, cultural and rural stock and domestic. Of these, the 'environmental' beneficial use is the stringent in regards to water quality requirements given aquatic organisms are the most sensitive of these beneficial uses to water quality changes.
- *Darwin Harbour Site of Conservation Significance (SOC 6)*

Shoal Bay and its associated shoreline tidal habitats and inland freshwater habitats have ecological values, as well as cultural and recreational values (e.g. fishing).

The SBWMF lies within the *Shoal Bay Site of Conservation Significance (SOC 8)*; see Factsheet available on the *NT Government information and services* website: <https://nt.gov.au/environment/environment-data-maps/important-biodiversity-conservation-sites/conservation-significance-list>

An ecological risk assessment was undertaken for the SBWMF in 2016 that assessed the potential for ecological receptors to be impacted by contaminants from the site (see URS 2016c). The assessment included a survey of ecological values at three outfall sites: Stage 1 leachate pump outfall (LMP02), Stage 3 drain (SW2) and the Green Waste Sump (GW Sump), where it overflows offsite. The survey found that the immediate SBWMF surrounds are heavily infested with introduced weeds and the native habitats around each of the outfall areas does not provide optimum habitat for threatened species.

## 4 MONITORING UNDERTAKEN

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### 4.1 SBWMF water monitoring program

Groundwater, surface water and leachate water quality monitoring has been undertaken at the SBWMF as per the URS (2016a) Water Monitoring Plan since July 2016, when EPL188 was issued. The water monitoring program design was informed by the conceptual site model (URS 2016b), which identified potential contaminant sources (i.e. landfill leachate, green waste leachate and other potential sources), potential contaminant pathways (into groundwater and surface water) and potential receptors (such as wetland habitats down-gradient of the site, groundwater users, and on site personnel). The aims of the water monitoring program, as specified in URS (2016a), are to:

- Determine baseline environmental conditions
- Monitor leachate production and composition
- Determine the effects on the environment due to the landfill on groundwater and surface water
- Check compliance with regulatory requirements
- Identify the need for remedial/mitigation measures.

The sections below outline the water monitoring program sampling methods, monitoring sites, sampling frequency, physical and chemical parameters measured, and assessment criteria applied to monitoring results.

### 4.2 Sampling methods

Throughout the period June 2016 to March 2020, CoD commissioned EcOz Environmental Consultants (EcOz), assisted by Larrakia Nation Rangers, to carry out the monitoring program. EcOz developed a specific standard operating procedure (SOP) for the SBWMF (provided as Appendix A), which is always followed. This SOP aims to ensure that samples are collected in a consistent, quality controlled, and safe manner, and follow best-practice procedures in accordance with the relevant standards and guidelines. This SOP also aims to ensure all monitoring information requirements of EPL188 are recorded and retained i.e. those outlined in EPL188 Condition 54. Please refer to the SOP for all specifics relating to sampling procedures.

### 4.3 Monitoring sites

Monitoring sites routinely sampled since July 2016, include 40 groundwater bores, 5 surface water sites and up to 8 leachate sites (originally 6 sites, then 2 additional sites related to Stage 5 landfill were added in June and November 2019 respectively). Figure 2-1 shows monitoring site locations. These sites include all those, as per the URS (2016a) Water Monitoring Plan, with some minor alterations and additional sites; as noted in Sections 4.3.1 to 4.3.3 below.

#### 4.3.1 Groundwater monitoring bores

The 40 groundwater monitoring bores are detailed in Table 4-1. This bore network aims to allow detection of landfill leachate, or other contaminants, migrating from the site in groundwater to areas down-gradient. Groundwater monitoring bores surround the entire site; both up-gradient (south) and down-gradient (west, north and east). There are also some bores centrally located within the site. Most bore locations include a shallow bore, screened between 1.5 and 3 m below ground level (mBGL), and a deeper bore, screened between 9 and 12 mBGL. Some sites also include a deep bore up to 30 m deep. This network comprises bores installed during two separate drilling campaigns as outlined below.

***Bores installed in 2015 to inform the URS (2015) hydrogeological investigation:***

Includes a total of 32 bores at 15 locations across the site, with up to 3 bores at each location at different depths. Generally, each of the 15 locations includes a shallow bore screened between 1.5 and 3 mBGL, and a deeper bore screened between 9 and 12 mBGL. Three of the locations have a third bore screened at a deeper level; the deepest being 30 mBGL. The ID's for these bores are prefixed with a 'GW' and suffixed with a -3, -12 or -30 to indicate the bore depth.

All these bores are included in the URS (2016a) Water Monitoring Plan.

***Bores installed in 2012:***

Includes 8 bores with the prefix 'WW' at varying depths; all less than 10 m, except for WW3 and WW6, which are 20.3 m and 20.4 m deep respectively. All bores are at different locations, except for WW6 and WW7, which are at the same location but have different depths (20.4 m and 5.8 m respectively).

All these bores are included in the URS (2016a) Water Monitoring Plan, except for WW6, which is additional to the plan.

### **4.3.2 Surface water sites**

Surface water monitoring aims to detect any land fill leachate, or other contaminants, in surface water runoff that could potentially flow offsite to environments downstream. Surface water monitoring sites comprise the following:

- 'Wheelwash' sump that collects wash-down water from the bunded area used to wash commercial waste disposal vehicles
- 'GW Sump' that collects surface water drainage from the green waste processing and storage area
- 'SW12' catchment dam that receives surface water runoff (and potentially seepage) from the northern and western sides of the Stage 3 and 4 landfill cells
- 'STG1&2' surface water drain that receives surface water runoff from central areas of the waste management facility
- 'SW2' that was included in the URS (2016a) Water Monitoring Program reportedly as a site potentially receiving seepage during the wet season from the Stage 3/4 landfill cells. This site however, has only had enough surface water to be sampled once since monitoring began (i.e. in November 2016). As such, this site is excluded from any further discussions in the sections below.

Further surface water monitoring site details are provided in Table 4-2.

### **4.3.3 Leachate sites**

Leachate sampling aims to allow the characterisation of contaminant concentrations in leachate for comparison with groundwater and surface water results. Leachate sampling sites comprise the following:

- 'DW2' de-leaching well that collects leachate from the south-west corner of the Stage 3/4 landfill
- 'DW3' de-leaching well that collects leachate from the north-west corner of the Stage 3/4 landfill
- 'TC Sump' that collects leachate from the eastern side of the Stage 3/4 landfill
- 'DW5' de-leaching well that collects leachate from the western side of the Stage 5 landfill
- 'DW6' de-leaching well that collects leachate from the south-west corner of the Stage 5 landfill
- 'LP01' northern leachate storage pond
- 'LP02' southern leachate storage pond

- 'LMP02' sump at the end of a trench that runs along the western side of the Stage 1 and Stage 2, landfills and collects leachate from these landfills.

Leachate monitoring sites DW2 and LMP02 are the only sites listed in the original URS (2016a) Water Monitoring Plan. TC Sump, LP01 and LP02 were added to the monitoring program when it started in July 2016. DW5 was added to the program in June 2019, and DW6 in November 2019, following establishment of the Stage 5 landfill.

The leachate monitoring site DW1, listed in the URS (2016a) Water Monitoring Plan was never operational and never sampled.

Further leachate monitoring site details are provided in Table 4-2.

**Table 4-1. Groundwater monitoring bore details.**

<sup>1</sup> “Time of year sampling usually possible”, is based on average, to above average, rainfall year i.e. 2016/17 and 2017/18 wet seasons. The 2018/19 and 2019/20 wet seasons were below average.

<sup>2</sup> Top of casing (TOC) PVC bore casing; standing water levels (SWLs) measured during monitoring rounds are measured from this point.

<sup>3</sup> Top of outer steel casing around PVC bore casing to protect the top of the bore.

Bore ID	Easting	Northing	Location	TOC <sup>3</sup> outer elevation mAHD	TOC <sup>2</sup> elevation mAHD	Ground elevation mAHD	Screened interval mBGL	Screened lithology	Time of year sampling usually possible <sup>1</sup>	Exceptions to usual sampling
GW1-3	709564	8631004	On floodplain, 190 m north of leachate storage area	8.71	8.63	8.02	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2019/20 wet season.
GW1-12	709566	8631004		8.71	8.59	8.00	9-12	Siltstone	All wet season (December-May)	
GW2-3	709629	8630835	On north-east corner of leachate storage area	8.06	7.94	7.33	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2018/19 and 2019/20 wet seasons.
GW2-12	709631	8630835		8.08	7.94	7.28	9-12	Siltstone	All wet season and early dry season (November-July)	
GW3-3	709652	8630746	East of leachate storage area	9.94	9.80	9.12	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2018/19 and 2019/20 wet seasons.
GW3-12	709654	8630746		9.87	9.82	9.10	9-12	Siltstone	All wet season and early dry season (November-July)	
GW4-3	709775	8630634	On floodplain, north of Stage 2 landfill	5.65	5.49	4.88	1.5-3	Siltstone	All wet season (December-April)	GW4 bores were inaccessible due to wet ground conditions and could not be sampled January 2019, January 2020 and March 2020.
GW4-12	709776	8630633		5.61	5.44	5.36	9-12	Siltstone	All wet season and early dry season (November-July)	
GW4-30	709777	8630631		5.50	5.20	5.33	15-21	Gravelly sand, Sandstone	Throughout the year Groundwater is usually at top of casing or overflowing during wet season (December – May)	
GW5-3	709880	8630224	East of Stage 2 landfill	5.51	5.41	4.70	1.5-3	Siltstone	All wet season (December-April)	Bore was dry most of 2018/19 and 2019/20 wet seasons and could only be sampled March 2019, February 2020 and March 2020.
GW5-12	709880	8630226		5.48	5.33	4.70	9-12	Siltstone, Gravelly Clay	Throughout the year Groundwater is usually at top of casing or overflowing during wet season (December – May)	

Bore ID	Easting	Northing	Location	TOC <sup>3</sup> outer elevation mAHD	TOC <sup>2</sup> elevation mAHD	Ground elevation mAHD	Screened interval mBGL	Screened lithology	Time of year sampling usually possible <sup>1</sup>	Exceptions to usual sampling
GW6-3	709464	8630022	Centre of SBWMF, south of Stage 3, south-west of Stage 2 and north-west of Stage 1	14.39	14.24	13.60	1.5-3	Gravelly Sandy Silt, Siltstone	All wet season (December-April)	Bore was dry most of 2018/19 wet season and could only be sampled March 2019. Decommissioned in early Sept 2019, and not sampled during 2019/20 wet season.
GW6-12	709464	8630021		14.37	14.18	13.66	9-12	Siltstone	Throughout the year	Can be dry at end of long dry season. Was dry August 2019. Decommissioned in early Sept 2019, so not sampled during 2019/20 wet season.
GW6-30	709464	8630018		14.24	14.12	13.60	17.7-23.7	Siltstone, Sandstone	Throughout the year	Can be dry at end of long dry season. Was dry December 2017 and December 2018. Decommissioned in early Sept 2019, and not sampled during 2019/20 wet season.
GW7-3	709900	8629992	South-east of Stage 2 and north-east of Stage 1	5.18	5.03	4.33	1.5-3	Siltstone	All wet season (November - April)	GW7 bores were inaccessible due to wet ground conditions and could not be sampled January 2020
GW7-12	709900	8629994		5.16	5.08	4.33	9-12	Siltstone, Sandy Silt	Throughout the year Groundwater is usually at top of casing or overflowing during wet season (December – May)	
GW8-3	709896	8629708	East of Stage 1	5.42	5.28	4.65	1.5-3	Claystone	All wet season and early dry season (November–July) Groundwater can be at top of casing or overflowing during mid-wet season (January - March)	
GW8-12	709896	8629708		5.37	5.22	4.62	9.1-12.1	Claystone, Sandstone	Throughout the year	
GW9-12	709660	8629469	On southern boundary of SBWMF – up-gradient of all SBWMF operations and infrastructure	16.18	15.93	15.44	9-12	Siltstone	All wet season (November - April)	Bore was dry most of 2019/20 wet season and could only be sampled March 2020.
GW10-3	709147	8629507	South of SBWMF – up-gradient of all SBWMF operations and infrastructure	18.12	18.06	17.32	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2019/20 wet season.
GW10-12	709149	8629507		18.13	17.98	17.37	9.1-12.1	Siltstone	All wet season (November - April)	Bore was dry most of 2018/19 and 2019/20 wet seasons and could only be sampled March 2019 and March 2020.

Bore ID	Easting	Northing	Location	TOC <sup>3</sup> outer elevation mAHD	TOC <sup>2</sup> elevation mAHD	Ground elevation mAHD	Screened interval mBGL	Screened lithology	Time of year sampling usually possible <sup>1</sup>	Exceptions to usual sampling
GW11-3	709040	8629671	South-west corner of SBWMF	13.50	13.38	12.72	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2019/20 wet season.
GW11-12	709042	8629671		13.52	13.38	12.84	9-12	Siltstone, Sandstone	All wet season and early dry season (November-July)	
GW12-3	709024	8629881	West of green waste area	12.20	12.07	11.44	1.5-3	Siltstone	All wet season (December - April)	Bore was dry for entire 2019/20 wet season.
GW12-12	709024	8629883		12.22	12.04	11.50	9-12	Siltstone	All wet season and early dry season (November-June)	
GW12-30	709024	8629885		12.21	12.05	11.55	24-30	Sandstone	Throughout the year	Bore was dry in December 2018.
GW13-3	709017	8630175	On south-west corner of Stage 3/4 and north-west corner of Stage 5 landfills	12.93	12.88	12.32	3-4.5	Siltstone	Only mid wet season (January-March)	Bore was dry for entire 2018/19 and 2019/20 wet seasons.
GW13-12	709016	8630174		12.91	12.86	12.25	10-13.5	Siltstone	All wet season and early dry season (November-June)	Bore was dry most of 2018/19 and 2019/20 wet seasons and could only be sampled March 2019 and January 2020.
GW14-3	709013	8630423	West of Stage 4 landfill	6.78	6.73	6.09	1.5-3	Siltstone	All wet season (December - April)	Bore was dry most of 2018/19 wet season and could only be sampled March 2019. Bore was dry for entire 2019/20 wet season.
GW14-12	709013	8630424		6.77	6.64	6.08	9-12	Siltstone	Throughout the year	Bore was dry between September 2018 and January 2019. Also dry between June 2019 and January 2020.
GW15-3	709230	8630599	North of Stage 3/4 landfill	11.27	11.06	10.44	1.5-3	Siltstone	Only mid wet season (January-March)	Bore was dry most of 2018/19 and 2019/20 wet seasons and could only be sampled March 2019 and March 2020.
GW15-12	709233	8630599		11.20	11.04	10.44	9-12	Siltstone	All wet season and early dry season (November-June)	
WW1	709471	8630151	Between Stage 3 and Stage 2 landfills		16.60	15.90	0-6.3	-	Usually always dry	Bore could be sampled after very wet periods in January 2017, January 2018 and March 2018.
WW3	709471	8630151	South-east corner of Stage 3 and west of Stage 2		16.38	15.68	0-20.3	-	Only mid wet season (January-March)	Bore was dry most of 2018/19 and 2019/20 wet seasons and could only be sampled March 2019 and March 2020.
WW5	708980	8630234	West of Stage 3/4 landfill		8.34	7.64	0-6.0	-	All wet season (December - April)	Bore was dry for entire 2018/19 and 2019/20 wet seasons.
WW6	709047	8630478	North-west corner of Stage 3/4 landfill		7.46	6.76	0-20.4	-	Throughout the year	
WW7	709045	8630483		7.45	6.75	0-5.8	-	All wet season (December - April)	Bore was dry most of 2018/19 wet season and could only be sampled March 2019. Bore was dry for entire 2019/20 wet season.	

Bore ID	Easting	Northing	Location	TOC <sup>3</sup> outer elevation mAHD	TOC <sup>2</sup> elevation mAHD	Ground elevation mAHD	Screened interval mBGL	Screened lithology	Time of year sampling usually possible <sup>1</sup>	Exceptions to usual sampling
WW9	709016	8630598	North-west corner of SBWMF		7.09	6.39	1-9.8	Siltstone	All wet season and early dry season (November–July)	Bore could not be accessed for sampling February 2017. Was dry early wet season in 2018/19 and 2019/20, and could only be sampled January and March 2019 and January and March 2020.
WW10	709235	8630598	On northern boundary of SBWMF		10.92	10.21	1-9.7	Siltstone	All wet season and early dry season (November–June)	Bore was dry most of 2018/19 wet season and could only be sampled January and March 2019. Bore was dry for entire 2019/20 wet season.
WW13	709457	8630598	On northern boundary of SBWMF	+0.8	+0.7	Not available	1-10	Siltstone	All wet season (January -April)	Bore was dry for entire 2018/19 wet season and could only be sampled once during 2019/20 wet season (March 2020).

**Table 4-2. Surface water and leachate sampling site details.**

\*“Time of year sampling usually possible” is based on average, to above average, rainfall year i.e. 2016/17 and 2017/18 wet seasons. The 2018/19 and 2019/20 wet seasons were below average.

^ During the period September 2017 to June 2019, EcOz was advised not to sample the leachate sites DW2, DW3, TC Sump, LP01 and LP02, and were being sampled by a different contractor as part of an investigation into leachate management options. EcOz has not been able to obtain any data for this period.

Site ID	Easting	Northing	Location	Context	Time of year sampling usually possible*	Exceptions to usual sampling
<b>Surface Water Sites</b>						
Wheel Wash	709479	8629775	Sump within vehicle wash-down bay	Receives wash-down water from large commercial waste transport vehicles	Throughout the year	Sump was dry on one occasion; April 2017.
STG1&2	709448	8629979	Surface drain between Stage 1 and Stage 2	Receives surface water runoff from central SBWMF areas	Only flows during or immediately after rain. Usually can only be sampled during mid-wet season (January and February)	Site was dry during all sampling occasions during 2018/19 and 2019/20 wet seasons.
GW Sump	709102	8629880	Sump within green waste processing and storage area	Receives surface water runoff from green waste processing and storage area. Possibly also surface runoff from the Stage 3 and 5 landfills.	All wet season (October - April)	
SW2	708973	8630296	West of Stage 3/4 landfill	Receives seepage from Stage 3/4 landfill	Usually always dry	Site has only had water flows and been able to be sampled once since July 2016. This was in November 2016.
SW12	709035	8630495	Catchment dam at base of northwest corner of Stage 3/4 landfill	Receives surface water runoff (and potentially seepage) from the northern and western sides of the Stage 3/4 landfill cells	Catchment dam contains water and can be sampled for most of the year (October to June) and only dries out mid to late dry season	Dam had been pumped out and was dry in March 2020.
<b>Leachate Sites</b>						
DW2	709029	8630459	Deleaching well on southwest corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells	Throughout the year	Site was not sampled Sept 2017 to June 2019^
DW3	709038	8630216	Deleaching well on northwest corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells	Throughout the year	Site was dry and could not be sampled May 2017. Site was not sampled Sept 2017 to June 2019^.
DW5	709023	8630122	Deleaching well on west side of Stage 5 landfill	Represents leachate from Stage 5 landfill cell	Site has only been monitored since June 2019, and typical sampling regime is not yet known. Site has had water available for sampling on all monitoring occasions since June 2019, except for Sept and Oct 2019.	
DW6	709041	8630039	Deleaching well on southwest corner of Stage 5 landfill	Represents leachate from Stage 5 landfill cell	Site has only been monitored since November 2019, and typical sampling regime is not yet known. Site has had water available for sampling on all monitoring occasions since November 2019, except for March 2020.	

Site ID	Easting	Northing	Location	Context	Time of year sampling usually possible*	Exceptions to usual sampling
TC Sump	709465	8630233	Sump on southeast corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells	Throughout the year	Site was not sampled Sept 2017 to June 2019^.
LMP02	709938	8629759	East of Stage 1	Sump that receives leachate from Stage 1 and 2 landfills via an interception trench that runs north-south along the eastern edge of the Stage 1 and 2 landfills.	Throughout the year	
LP01	709534	8630726	Northern leachate storage pond	Represents leachate in northern storage pond	Throughout the year	Could not be sampled March 2020. Site was not sampled Sept 2017 to June 2019^.
LP02	709531	8630713	Southern leachate storage pond	Represents leachate in southern storage pond	Throughout the year	Could not be sampled January 2020. Site was not sampled Sept 2017 to June 2019^.

## 4.4 Sampling frequency

The URS (2016a) Water Monitoring Plan requires monthly sampling of all monitoring sites. Many monitoring sites however, are dry for various periods of the year and cannot always be sampled. The surface water site STG1&2 only has water during, and immediately after, heavy rainfall, and the catchment dam SW12 and GW Sump can dry up during the dry season. Also, during the dry season, the lowering of groundwater levels means that many groundwater bores become dry.

The typical availability of each monitoring site for sampling throughout the year is outlined in Table 4-1 and Table 4-2. These tables also outline for the monitoring period June 2016 to March 2020, where exceptions to the typical availability of sites for sampling occurred, such as when sites were inaccessible due to wet ground conditions, or drier for longer due to below average rainfall.

Sampling is carried out during the first week of each month, and this is taken to represent water quality of the previous month e.g. sampling during the first week of July is taken to represent the month of 'June'.

The required monthly schedule of sampling was adhered to consistently for the two years between July 2016 and June 2018. Sampling was then undertaken less frequently between July 2018 and August 2019 due to the program being in a state of review. During this period, sampling was undertaken for September 2018, December 2018, January 2019, March 2019 and June 2019. From August 2019 onwards, sampling returned to monthly.

During the period September 2017 to June 2019, EcOz was advised not to sample the leachate sites DW2, DW3, TC Sump, LP01 and LP02, as these were being sampled by a different contractor as part of an investigation into leachate management options. EcOz has not been able to obtain any data for this period.

## 4.5 Parameters measured

The physical parameters pH, temperature, electrical conductivity (EC) and dissolved oxygen (DO) are measured at all groundwater, surface water and leachate sampling sites during all monthly monitoring rounds. These are measured in the field using hand-held meters.

The standing water level (SWL) is always measured in each groundwater monitoring bore prior to the commencement of pumping and sampling. The SWL is measured starting from the top of the bore casing (TOC) i.e. the top of the PVC bore casing, not the outer steel protective casing.

A differing suite of laboratory parameters is analysed on a monthly, quarterly and annual basis; as outlined in Table 4-3. Table 4-4 provides which parameter suite was analysed during each monitoring round from July 2016 to March 2020.

A ratio of L/N is used to determine if additional parameters are analysed for groundwater bores, when they record a L/N ration greater than 10. The L/N ratio indicates the degree of impact on groundwater from leachate; as explained in Section 4.6 below. Additional parameters are added to the next monitoring round where a bore records an L/N greater than 10.

Per and poly-fluoroalkyl substances (PFAS), including 28 different species, were added to the quarterly parameter suite for groundwater and leachate sites in June 2019. As such, PFAS have only to date, been measured on three occasions; June 2019, October 2019 and January 2020.

**Table 4-3. Water quality monitoring parameters and schedule.**

For parameter acronyms and abbreviations refer to the list at the front of this document.

\*PFAS (including 28 species) were added to quarterly suite from June 2019 onwards.

Frequency	Sample type	Standard suite	If L/N >10
Monthly	Groundwater	<b>Field parameters:</b> SWL, pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), NH <sub>4</sub> , TDS, COD, TOC	NA
	Surface water	<b>Field parameters:</b> pH, EC, DO, temperature <b>Lab parameters:</b> alkalinity, SO <sub>4</sub> , NH <sub>4</sub> , Cl, COD, TOC	NA
	Leachate	<b>Field parameters:</b> pH, EC, DO, temperature <b>Lab parameters:</b> TOC, COD	NA
Quarterly	Groundwater	<b>Field parameters:</b> SWL, pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), nutrients (NH <sub>4</sub> , TON, nitrate as N, reactive phosphorus as P), metals (dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), TRHs, PAHs, COD, TOC, PFAS*	BTEXN, total phenolics
	Leachate	<b>Field parameters:</b> pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), nutrients (NH <sub>4</sub> , TON, nitrate as N, reactive phosphorus as P), metals (dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), COD, TOC, TRHs, PAHs, BTEXN, total phenolics, PFAS*	NA
Annual (wet season)	Groundwater	<b>Field parameters:</b> SWL, pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), nutrients (NH <sub>4</sub> , TON, Nitrate as N, reactive phosphorus as P), metals (Dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), COD, TOC	TRHs, PAHs, BTEXN, total phenolics, other leachate indicators, PCB, TNT, RDX
	Surface water	<b>Field parameters:</b> pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), nutrients (NH <sub>4</sub> , TON, Nitrate as N, reactive phosphorus as P), metals (Dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), COD, TOC	TRHs, PAHs, BTEXN, total phenolics, other leachate indicators, PCB, TNT, RDX
	Leachate	<b>Field parameters:</b> pH, EC, DO, temperature <b>Lab parameters:</b> major ions (Na, K, Ca, Mg, alkalinity, chloride, SO <sub>4</sub> ), nutrients (NH <sub>4</sub> , TON, nitrate as N, reactive phosphorus as P), metals (dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), TRHs, PAHs, BTEXN, total phenolics, other leachate indicators, PCB, TNT, RDX, COD, TOC	NA

**Table 4-4. Parameter suite analysed during each monitoring round June 2016 to March 2020.**

Date	Suite analysed	Date	Suite analysed
July 2016	Monthly	January 2018	Annual
August 2016	Monthly	February 2018	Monthly
September 2016	Quarterly	March 2018	Quarterly
October 2016	Monthly	April 2018	Monthly
November 2016	Monthly	May 2018	Monthly
December 2016	Quarterly	June 2018	Quarterly
January 2017	Annual	September 2018	Quarterly
February 2017	Monthly	December 2018	Quarterly
March 2017	Quarterly	January 2019	Annual
April 2017	Monthly	March 2019	Quarterly
May 2017	Monthly	June 2019	Quarterly
June 2017	Quarterly	August 2019	Monthly
July 2017	Monthly	September 2019	Monthly
August 2017	Monthly	October 2019	Quarterly
September 2017	Quarterly	November 2019	Monthly
October 2017	Monthly	December 2019	Monthly
November 2017	Monthly	January 2020	Quarterly
December 2017	Quarterly	February 2020	Annual
		March 2020	Monthly

## 4.6 Assessment criteria

The assessment criteria applied to water quality monitoring results at the SBWMF aims to minimise the risk of impacts to the environmental values/beneficial uses listed in Section 3.5 above from leachate, or other potential pollutants, or operational activities at the facility.

Aquatic organisms in the estuarine and marine waters of Shoal Bay are the most sensitive potential environmental receptor downstream of the SBWMF. In regards to this, EPL188 Condition 61 specifies the assessment criteria to be applied to monitoring results; as the *Australian and New Zealand Guidelines for Marine and Freshwater Quality* (ANZECC 2000) trigger values for 90% species protection in marine waters. Usually, the more conservative 95% species protection level is required in most other areas in the NT. However, given the degree of urbanisation and development in the catchment of the SBWMF, the level of protection is set at the lower 90% species protection.

ANZECC (2000) trigger values are only available for toxicant parameters (i.e. dissolved metals, ammonia, PAHs etc.). Assessment criteria for physical parameters and nutrients e.g. pH, total nitrogen (TN), nitrate+nitrite (NO<sub>x</sub>), total phosphorus (TP) and filterable reactive phosphorus (FRP), are therefore taken from the *Water Quality Objectives for the Darwin Harbour Region – Background Document* (NRETAS 2010) for the 'Upper Estuary'. These are the only available local guidelines.

In regards to per and poly-fluoroalkyl substances (PFAS), assessment criteria are taken from the *PFAS National Environmental Management Plan* (NEMP). The human-health guidance values for 'recreational water' are used, noting these values are more conservative than the PFAS NEMP aquatic ecosystems 90% species protection values.

The water monitoring plan utilises a leachate impact indicator to detect the degree of leachate in groundwater. The indicator involves comparing the concentrations of ions typically associated with leachate (K<sup>+</sup>, NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup>) to ions typically associated with natural groundwater (Ca<sup>2+</sup>, Na<sup>+</sup>, Mg<sup>2+</sup>). The leachate (L) to natural groundwater (N) ratio is determined as follows:

$$L/N = (K^+ + NH_4^+ + NO_3^-) / (Ca^{2+} + Na^+ + Mg^{2+}) \times 100$$

The L/N ratio is generally less than 10 for natural groundwater and greater than 10 for leachate impacted groundwater. An L/N ratio greater than 10 is a trigger for further investigation.

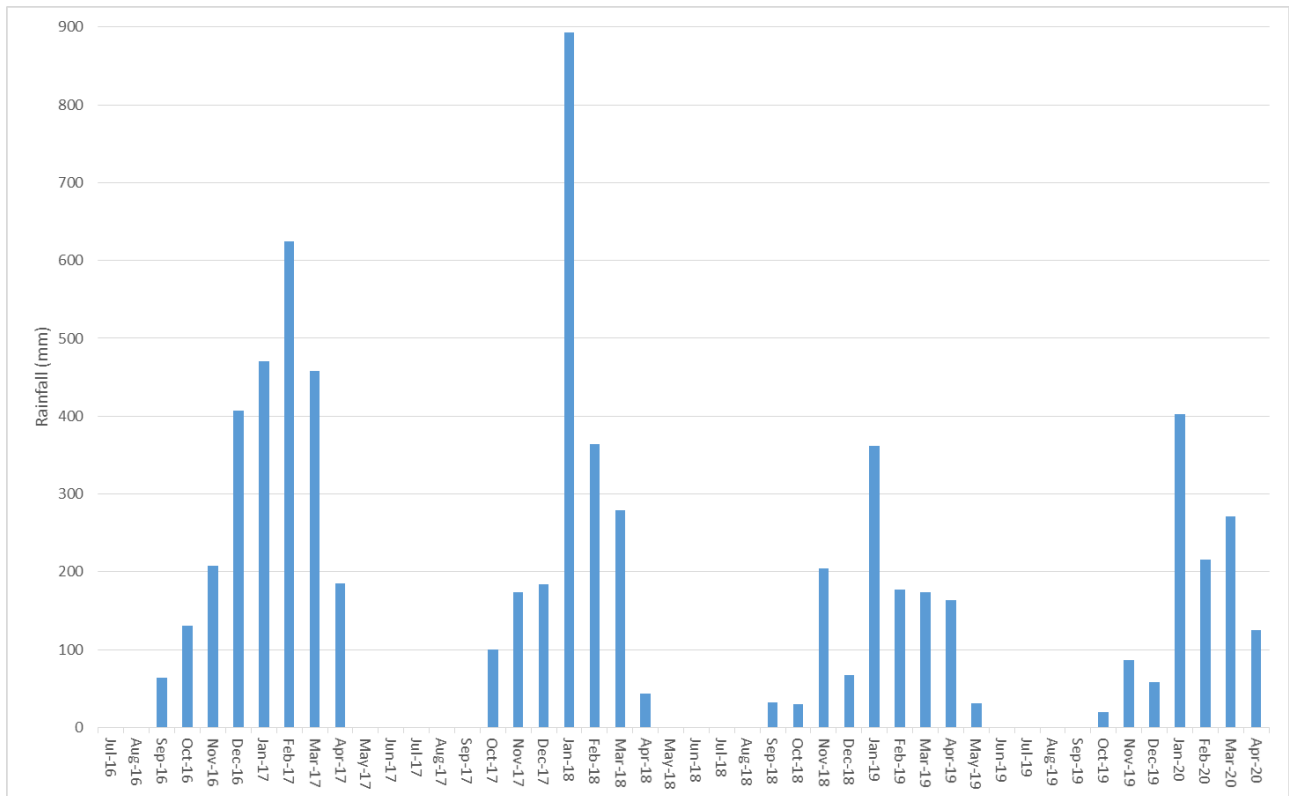
# 5 RAINFALL AND SITE CONDITIONS

The availability of water for sampling at a number of groundwater and surface water sites is dependent on rainfall (see Table 4-1 and Table 4-2 above). Groundwater recharge is via direct infiltration of rainfall and runoff, and groundwater levels in the shallow aquifer are highly responsive to rainfall totals. Surface water only flows in stormwater drains across the site during and immediately after rainfall. Whereas surface water storages such as SW12 and GW Sump contain water for longer periods. The wheel wash site receives vehicle wash-down water sourced from the Darwin reticulated water supply and is not dependent on rainfall.

The amount of rainfall may also influence the extent of contaminant migration; for example, during an above average wet season, higher groundwater levels, and extensive surface water flows may potentially mean contaminants travel further downstream of the site; although concentrations may also be more diluted.

Figure 5-1 shows monthly rainfalls from July 2016 to March 2020, for the nearest BoM station with consistent, reliable rainfall data (Darwin Airport Station No. 014015). The average annual rainfall for this station is 1,723 mm. The 2016/17 wet season rainfall, between the months of September and May, was above average (2,549 mm). The 2017/18 wet season rainfall total for the same period was also above average (2,039 mm). The 2018/19 wet season was below average (1,242 mm) and the 2019/20 wet season also below average (1,180 mm). February 2017 and January 2018 experienced extremely high rainfall, with monthly totals of 625 mm and 893 mm respectively.

During and after the below average 2018/19 and 2019/20 wet seasons, groundwater levels were lower and bores became dry earlier compared to the previous two wet seasons (see Table 4-1 above). Similarly, surface water sites were able to be sampled less frequently and dried out earlier compared to the previous two wet seasons.



**Figure 5-1. Monthly rainfall totals between July 2016 and April 2020.**  
Taken from the Darwin Airport BoM Station (No. 014015).

## 6 GROUNDWATER LEVELS AND FLOWS

The analysis of groundwater levels and flows has been divided into the following two sections;

- Investigation of groundwater levels across the site and connectivity between shallow and deeper aquifers
- Analysis of groundwater flow directions across the site and potential implications for leachate migration.

As discussed in Section 3.4 detailed analysis of the lithology that lay beneath SBWMF, is discussed in detail in the *Shoal Bay Waste Disposal Site, Hydrogeological Investigation* (URS 2015). Geology of the site is generally comprised top soils (silts and clays), generally underlain by weathered (lateritised) siltstone over most of the site, and claystone east of Stage 1. Beneath this, sandstone was encountered at depths of 9 to 20 m below the surface across most of the site. Groundwater exists within the unconsolidated overlying sediments, and fractured and weathered underlying bedrock.

The shallow (water table) aquifer is recharged by the direct infiltration of rainfall and runoff, and groundwater levels vary seasonally in accordance with rainfall totals. The higher yielding weathered and fractured carbonate rock aquifers that occur in the wider region commonly yield greater than 5 L/sec.

### 6.1 Seasonal groundwater levels and connectivity

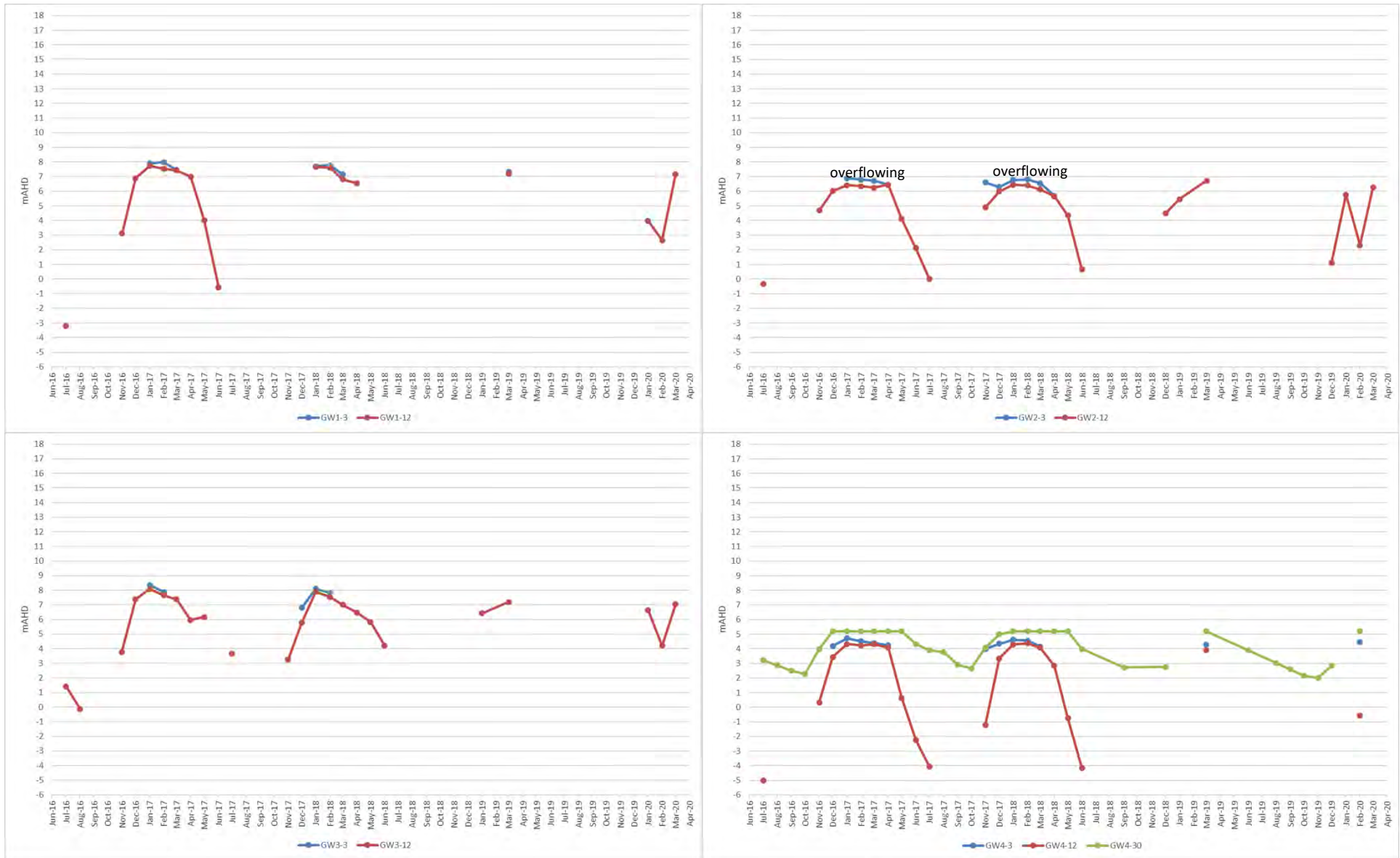
As part of the monitoring program, the standing water levels (SWLs) were measured in the bores below the top of casing (TOC). For the purposes of this report, these values have been converted to mAHD to allow for a comparison of groundwater levels across the site. Figure 6-1 shows the graphed groundwater levels in mAHD at each set of bores from July 2016 and March 2020. Analysis of these graphs identifies three key patterns, which are summarised in Table 6-1, below.

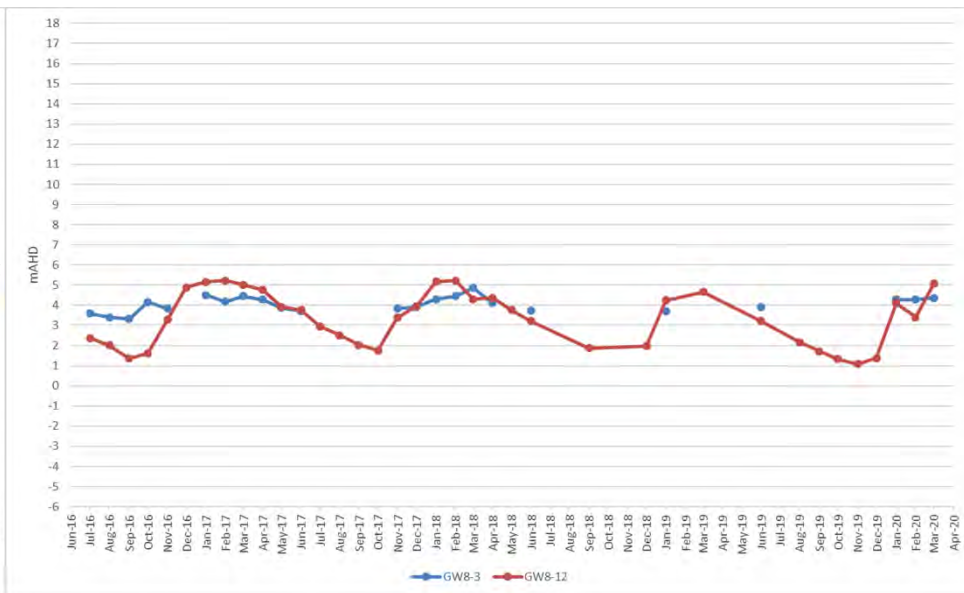
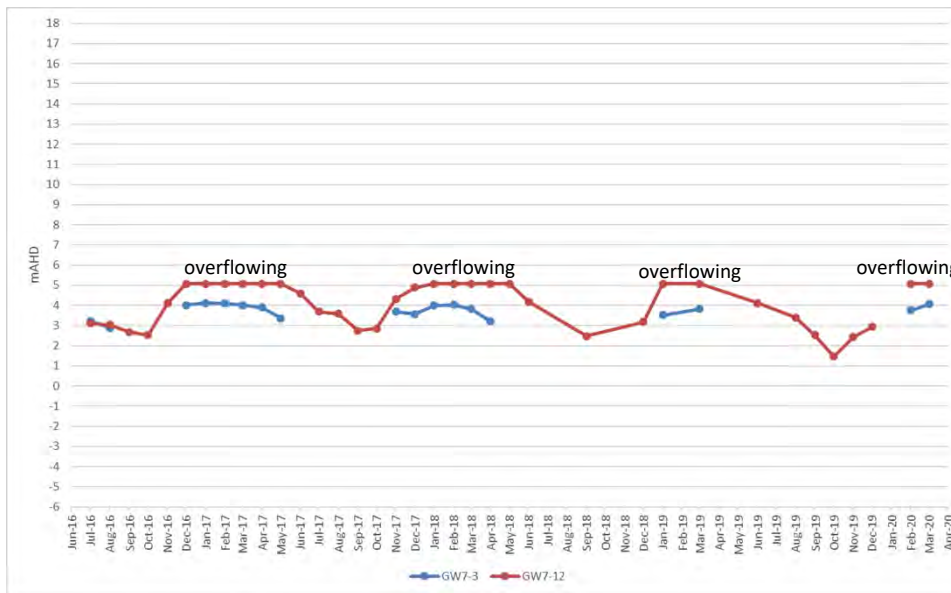
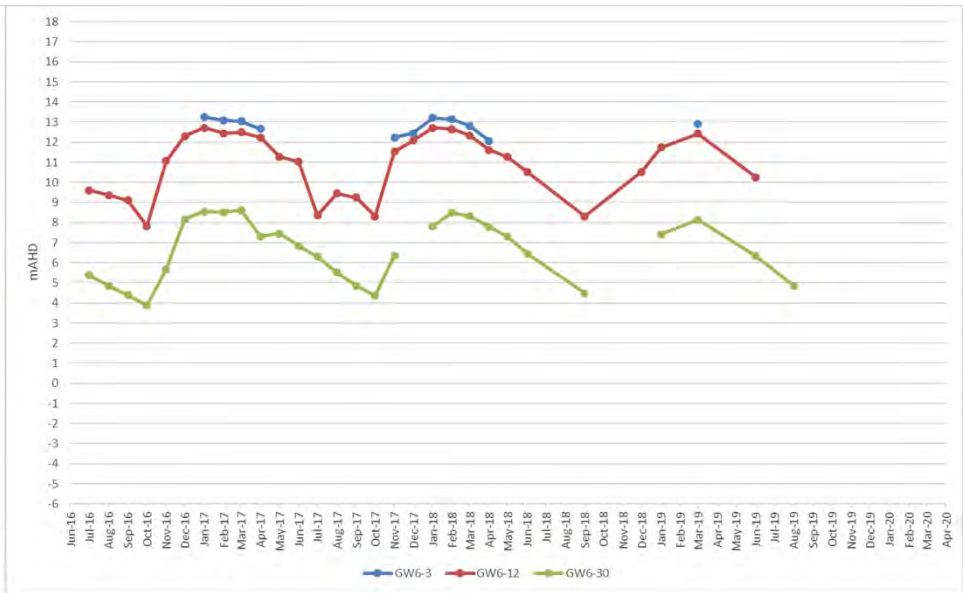
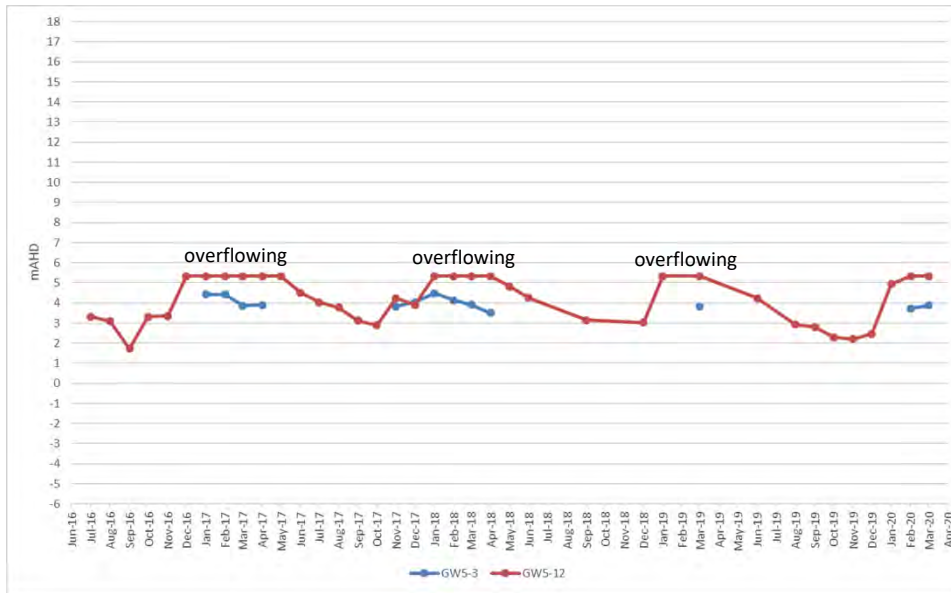
**Table 6-1. Seasonal groundwater level trends**

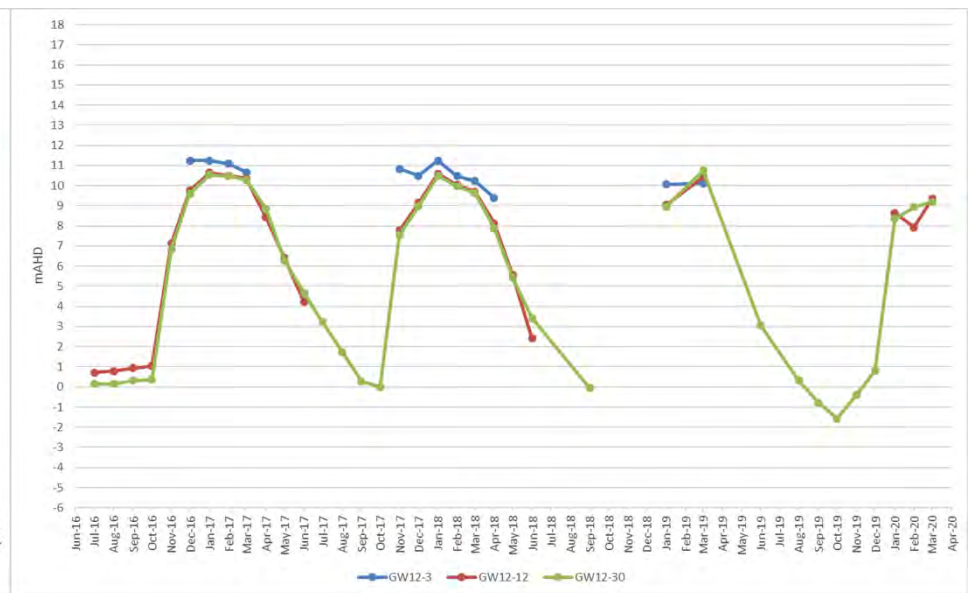
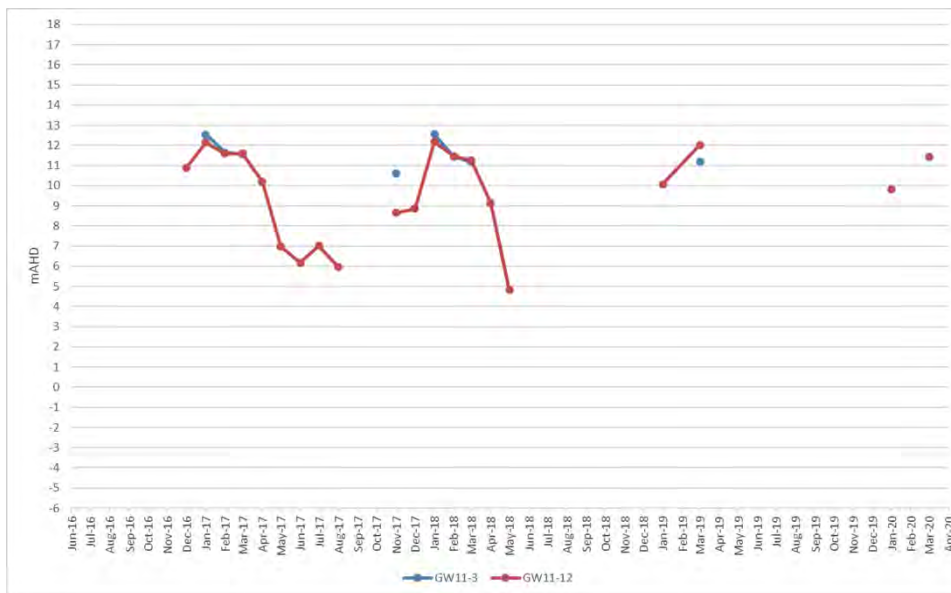
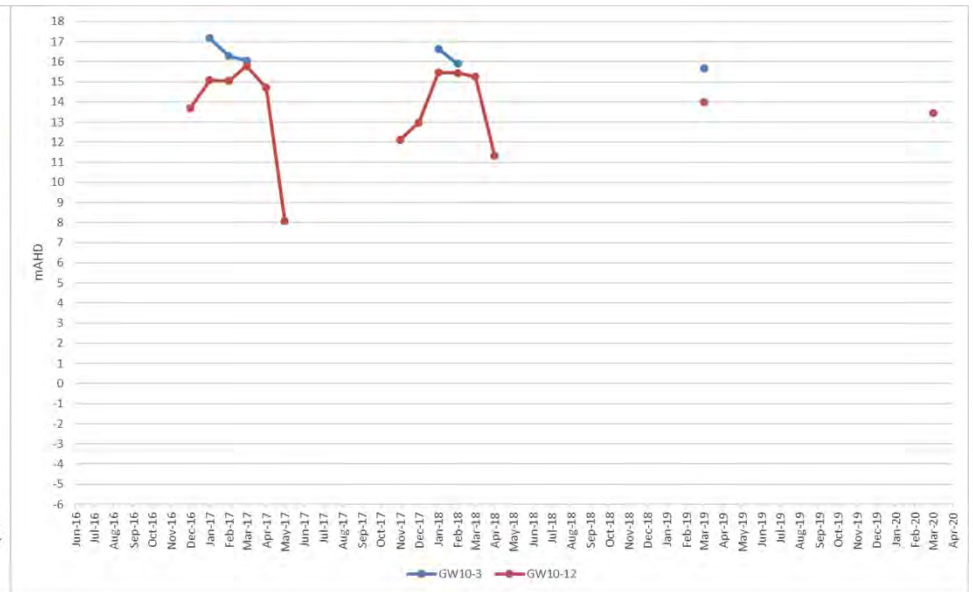
Bores	Trend	Explanation
GW1-3, GW1-12, GW2-3, GW2-12, GW3-3, GW3-12, GW4-3, GW5-3, GW6-3, GW7-3, GW8-3, GW9-12, GW10-3, GW10-12, GW11-3, GW11-12, GW12-3, GW13-3, GW13-12, GW14-3, GW14-12, GW15-3, GW15-12, WW1, WW3, WW5, WW6, WW7, WW9 and WW10	Constantly dry in the dry season, with recharge occurring in the wet season.	These bores are located in the shallow surface water aquifer, whereby recharge occurs via direct infiltration from rainfall and runoff. Water levels are higher during the wet season, with a sharp drop once dry season begins, impacting both the 3 m and 12 m bores.
GW5-12, GW7-12 and GW8-12	12 m bores that are rarely dry and follow distinctive seasonal trend.	All bores are located on the eastern boundary of SBWMF and are likely to be impacted by the fractured carbonate rock aquifers, located south-east of the site. These 12 m bores are rarely dry and during the wet season, water levels reach 5 mAHD and in the dry season sit between 1-2 mAHD. GW5-12 and GW7-12 consistently overflow in wet season, likely due to their topographic positioning. The 3 m bores nested at these sites are listed above and are dry during the dry season and therefore do not follow the same seasonal trend.

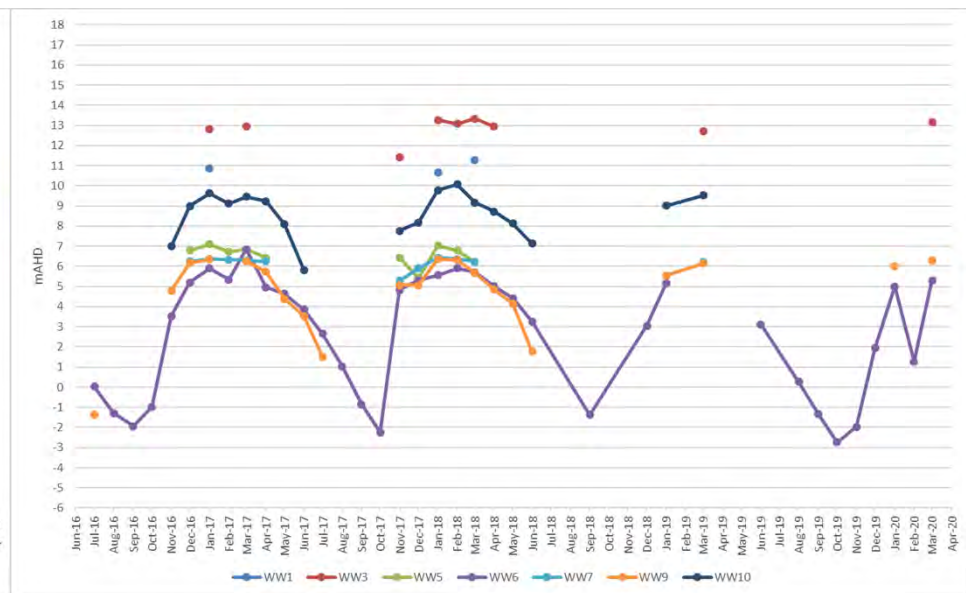
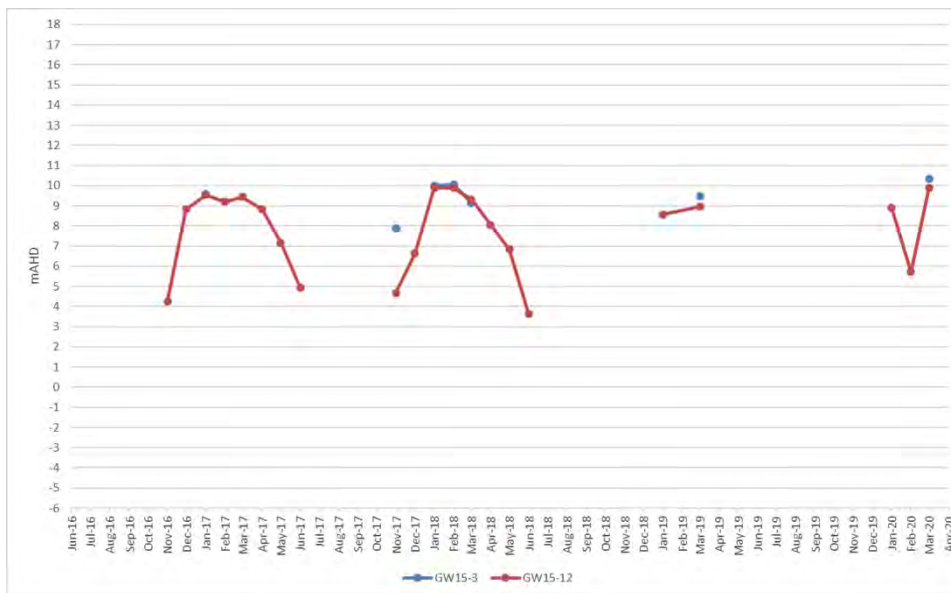
Bores	Trend	Explanation
<p>GW4-12, GW4-30, GW6-12, GW6-30 (now decommissioned) and GW12-12, GW12-30</p>	<p>Distinctive seasonal patterns are observed for these 12 m and 30 m bores. Bore are never dry throughout the year.</p>	<p>These bores are scattered across the site. The three 30 m bores are located within a sandstone aquifer.</p> <p>Bore logs for GW4-30 show a clear confining clay layer, which applies pressure to the groundwater under this layer, creating higher hydraulic head within the bore itself, causing it to consistently overflow during heavy rainfall events.</p> <p>GW6-30 and GW12-30 do not have the same confining layer and therefore do not overflow. GW6-30 is observed to be located in a different aquifer than GW6-3 and GW6-12. The difference in water levels during the wet season are significantly lower (approximately 4.5 m).</p> <p>The 3 m bores nested at these sites are listed above and are dry during the dry season and therefore do not follow the same seasonal trend.</p>

Figure 6-1. Graphs of groundwater levels in mAHD measured in all bores July 2016 to March 2020









## 6.2 Groundwater flow direction

Groundwater level and flow maps were developed to display the hydraulic behaviour of groundwater using the 12 m deep bores, during the mid-wet season (January 2017) and mid-dry season (June 2017). SBWMF topographically, sits on a low-lying peninsula with tributaries from the Leanyer Swamp located on the western and eastern boundaries of the site.

General patterns observed in Figure 6-2 and Figure 6-3, illustrate that the groundwater contours mimic the topography of the site, with higher groundwater levels through the centre of the site (i.e. GW6, GW10, GW15, WW3 and WW10) and lower levels on the eastern and western boundaries (i.e. GW4, GW5, GW7, GW8, GW14). Groundwater is flowing in a western, eastern and north-eastern direction, towards the Leanyer Swamp tributaries.

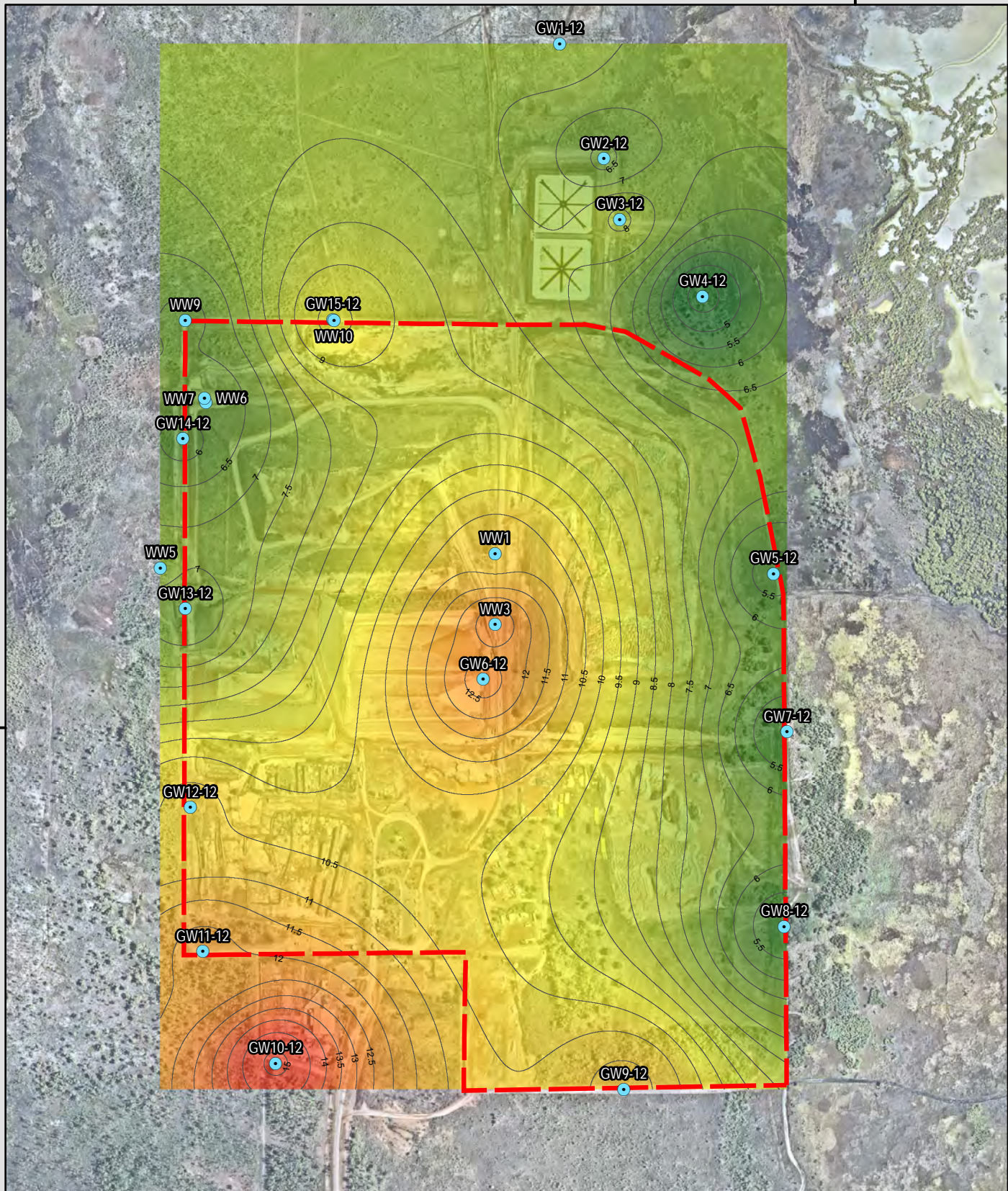
Figure 6-2 illustrates the groundwater contours in January 2017 (mid-wet season). During this sampling period, standing water levels (SWLs) were measured at 22 of the 12 m bores, providing an adequate overview of the hydraulic behaviours of the groundwater across the site, including its boundaries. Groundwater levels were highest at GW10-12 and GW6-12, with a groundwater level of 15.08 mAHD and 12.71 mAHD, respectively, and lowest at GW4-12, with a level of 4.33 mAHD. Groundwater levels across the site generally remained quite consistent when compared with the topographic conditions.

Figure 6-3 illustrates the groundwater contours in June 2017 (mid-dry season). During this sampling period, SWLs were measured at 15 of the 12 m bores. In comparison with the January 2017 samples, the reduced number of samples taken skews the map slightly, and are not considered representative of the entire site's groundwater behaviour during the dry season. However, similar trends are observed to that of the wet season. Groundwater levels were highest at GW6-12, with a groundwater level of 11.03 mAHD and lowest at GW4-12, with a level of -2.24 mAHD. The map illustrates a steep drop in groundwater levels during the dry season, from the centre of the site, towards the western, eastern and north-eastern boundaries.

Comparison between the levels of GW6-12 in both wet and dry seasons, indicate the potential for artificially elevated groundwater levels during the dry season (difference of almost 1.7 m), compared with a significant change in groundwater levels in GW4-12 between seasons of approximately 6.5m. Given the topographic positioning of GW10-12 (i.e. located on higher topography at the southern boundary of the site), the seasonal variation observed is to be expected.

It is likely that groundwater mounding is also present, which can be attributed to the shape of the landfill cells. The presence of a shallow groundwater table and overflowing of some bores is resulting in groundwater mixing with leachate at surface level in some areas of the site. Figures 3 to 6 in the *Shoal Bay Site Conceptual Site Model Report*, written by URS (2016), highlight certain areas where this could be occurring. The report also highlights areas where inferred leachate affected groundwater is present across the site, i.e. underneath Stages 1, 2 and 3 of the landfill.

Leachate migration from the site is possible, considering the topographic conditions of SBWMF and historic landfilling activities on the western boundary of the site. Where groundwater is flowing along the eastern and north-eastern boundaries, those areas would also be of interest in regards to leachate detection and monitoring. Given the sensitive receiving environments for stormwater runoff and groundwater flow, outside of the SBWMF's boundaries (i.e. bushland and Leanyer Swamp), the results of Section 7 are crucial in determining the extent of (if any) leachate migration.

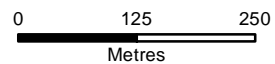


Red box indicates map extent

DARWIN

**Project data**

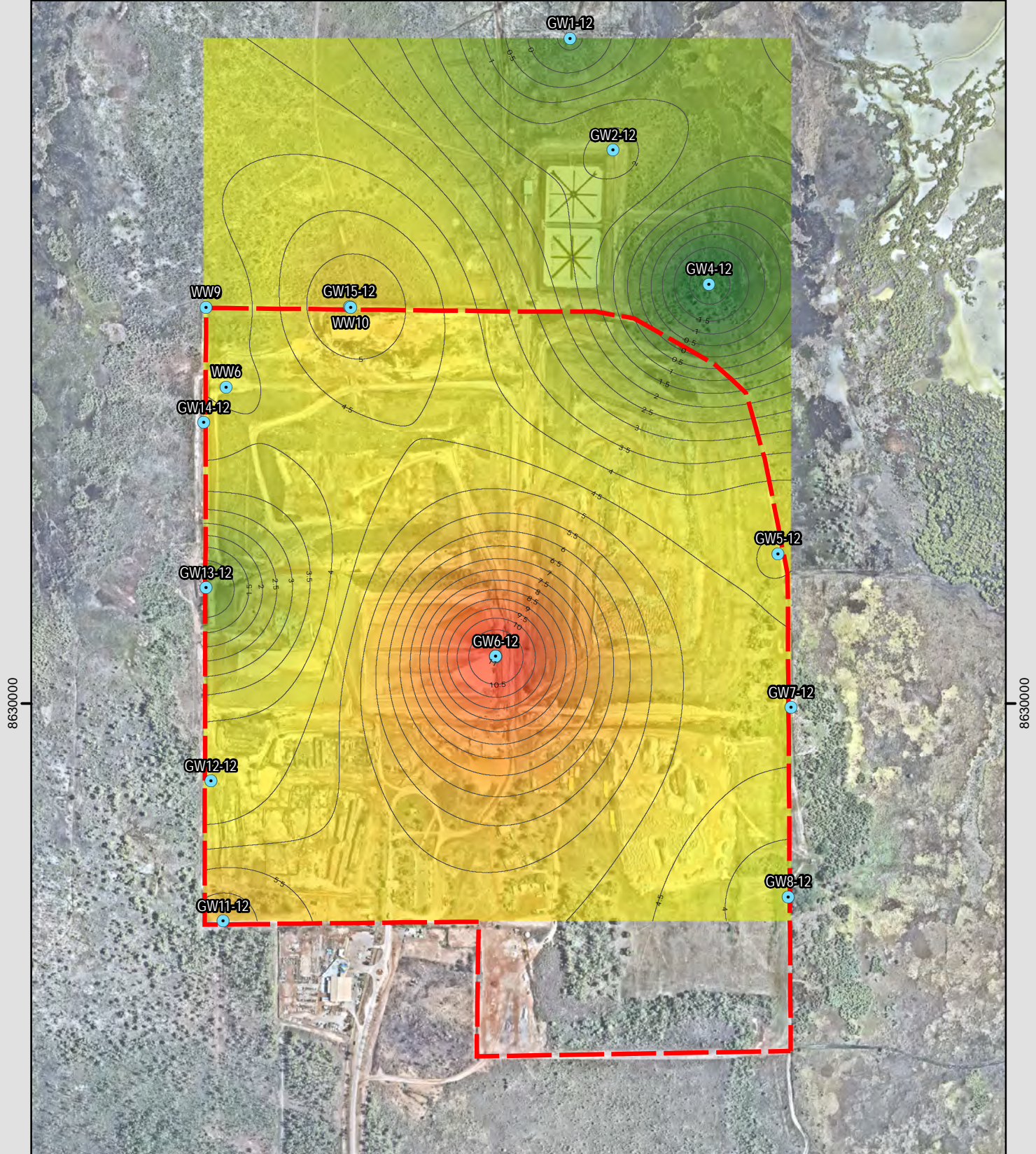
- 12m Bore
  - 50cm contours
  - Lot boundary
- Ground water level  
 High : 15.08  
 Low : 4.3301



**MAP INFORMATION**  
 Scale: 1:8,000 @ A4  
 Projection: GDA 1994 MGA Zone 52  
 Date Saved: 30/06/2020  
 Client: City of Darwin  
 Mapper: DC

**DATA SOURCE**  
 Topographic data: Geoscience Aust.  
 Project data: EcOz  
 Imagery: Shaded relief, Landsat

Figure 6-2. Map of groundwater level contours in mAHd for January 2017 (mid-wet season).



**Project data**

- 12m Bore
- 50cm contour
- Lot boundary

High : 11.0299  
Low : -2.23992

0      125      250

Metres

**MAP INFORMATION**  
 Scale: 1:8,000 @ A4  
 Projection: GDA 1994 MGA Zone 52  
 Date Saved: 30/06/2020  
 Client: City of Darwin  
 Mapper: DC

**DATA SOURCE**  
 Topographic data: Geoscience Aust.  
 Project data: EcOz  
 Imagery: Shaded relief, Landsat

Figure 6-3. Map of groundwater level contours in mAHd for June 2017 (mid-dry season).

## 7 DATA REVIEW

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The following data review is divided into leachate, surface water and groundwater. The leachate monitoring data is discussed first, in order to characterise leachate in the various landfills at the SBWMF so that this may then be used in identifying the presence of leachate in surface water and groundwater at the site. In particular, the leachate section identifies the key parameters that are elevated in, and unique to, the leachate as opposed to natural water sources (such as natural groundwater or seawater intrusion, which can also be elevated in an array of naturally-occurring dissolved constituents).

For each section (leachate, surface water, groundwater), each parameter is discussed sequentially, starting with physical parameters, then dissolved metals, nutrients, anions and cations, PFAS and hydrocarbons. The discussion of each parameter includes an outline of the relative concentrations measured at each site, comparisons to assessment criteria (where relevant), and any seasonal or long-term trends in concentrations. The results of this analysis are then summarised at the end of each of the leachate, surface water and groundwater sections. This includes highlighting any potential environmental concerns, recommended management actions or changes to the water quality monitoring program.

Median values are used when discussing each parameter in the sections below, due to the large volume of data collected over the July 2016 to March 2020 monitoring period and to screen-out outlier concentrations.

All graphs depicting the seasonal and long-term trends in water quality parameters discussed in the sections below are provided in Appendix B.

### 7.1 Leachate characterisation

Direct sampling of leachate is undertaken for the monitoring program at eight sites; as detailed in Table 4-2 and shown in Figure 2-1. The Stage 3/4 landfill is represented by the leachate dewatering points DW2, DW3 and TC Sump. The Stage 5 landfill is represented by the leachate dewatering points DW5 and DW6; although these two sites were only added to the monitoring program in June 2019 and November 2019 respectively, following establishment of the Stage 5 landfill. The two leachate storage ponds are represented by LP01 and LP02 respectively. The site LMP02, is the sump at the end of the drain that captures leachate seepage and surface water runoff from the Stage 1 and Stage 2 landfills.

Note that during the period September 2017 to June 2019, EcOz was advised not to sample the leachate sites DW2, DW3, TC Sump, LP01 and LP02, as these were being sampled by a different contractor as part of an investigation into leachate management options. EcOz has since been provided with data from September 2017 to March 2018, which has been included in this data review. EcOz has not been able to obtain data between April 2018 and June 2019 within this period for these five sites, and as such, there is a gap in the data shown in the graphs.

#### ***Parameters not discussed:***

The results for the parameters listed below are not presented or discussed further in the leachate section; to see the data for these parameters refer to the SBWMF water quality monitoring database, which contains all monitoring results for all groundwater, surface water and leachate sites since monitoring began in July 2016. All original field data and laboratory documentation (including chain of custody, sample receipt notification, certificate of analysis and quality control documentation) was emailed to CoD following each monitoring round.

**Polychlorinated biphenyls (PCBs)** were always below the laboratory limit of reporting (LOR) at all leachate sites during all sampling rounds.

**Nitrate (NO<sub>3</sub>)** concentrations were measured in leachate samples as per the URS (2016a) water monitoring plan requirements, but were extremely variable between sampling occasions, ranging from below detection, to several hundred mg/L at some sites. The laboratory also analysed and reported nitrite (NO<sub>2</sub>) concentrations along with NO<sub>3</sub> concentrations, however only NO<sub>3</sub> concentrations were transferred into the

SBWMF database given  $\text{NO}_3$  is used in the L/N ratio leachate indicator (see Section 4.6 above).  $\text{NO}_2$  is not listed as a parameter in the URS (2016a) water monitoring plan. This is unfortunate, as a review of a number of the raw laboratory reports reveals that  $\text{NO}_2$  often makes up a significant proportion of the oxidised nitrogen species in the leachate samples. Therefore, it would be misleading to make inferences regarding oxidised nitrogen species based only on the  $\text{NO}_3$  concentrations.

In order to derive meaningful conclusions regarding oxidised nitrogen, the nitrate+nitrite ( $\text{NO}_3+\text{NO}_2$ ; referred to as  $\text{NO}_x$ ) concentrations would be required. As such, the  $\text{NO}_3$  concentrations for the leachate sites are not included in the discussion below, apart from where it is used in the L/N ratio.

**Filterable reactive phosphorus (FRP)** was only measured at all leachate monitoring sites once during the monitoring period i.e. June 2019, and there is little value in using data from only one sampling round in this data review.

**Total organic nitrogen (TON)** and results are highly variable, and the high concentrations of the many different chemical constituents present in the leachate samples means the laboratory LOR is often raised significantly due to sample matrix interferences. It is not possible to derive meaningful conclusions from this data.

**Cyclotrimethyne trinitramine (RDX)** and **trinitrotoluene (TNT)** have only been analysed twice at all leachate sample sites since monitoring began in July 2016; i.e. January 2017 and February 2020. On both these occasions, all concentrations were below the respective LORs.

Chromium exists in two different forms: **trivalent (III) chromium** and **hexavalent (VI) chromium**, when dissolved in water. Chromium (VI) is more toxic than chromium (III) (see Section 8.3.7 of the ANZECC 2000 guidelines for more detail), and a lower ANZECC (2000) trigger value is specified for chromium (VI) compared to chromium (III) i.e. trigger values are 0.02 and 0.049 mg/L respectively. No trigger value is specified for the combined sum of both chromium species.

The quarterly and annual leachate sample analysis suite currently includes chromium (III) and chromium (VI) speciation. The combined sum of all dissolved chromium species present is also provided in all raw laboratory analysis reports; although only the speciated chromium (VI) and chromium (III) concentrations have to date been transferred into the SBWMF water quality monitoring database.

Unfortunately, the laboratory analytical method for chromium speciation is very sensitive to sample matrix interference. The high concentrations of the many different chemical constituents present in the leachate samples means the laboratory LOR is always raised. For both chromium (VI) and chromium (III), the LOR was raised to between 0.1 and 1.0 mg/L for all samples collected from all leachate sites between July 2016 and March 2020 (data not reproduced in this report – see the SBWMF water quality monitoring database). This was except for LMP02, where the LOR was often the standard 0.01 mg/L.

All chromium (VI) results for all leachate sites during the monitoring period were below the various LOR's. However, given these LOR's were higher than the ANZECC (2000) trigger value of 0.02 mg/L, it cannot be determined if chromium (VI) concentrations at the leachate sites are above the trigger value. This was except for LMP02, where the LOR was mostly 0.01 mg/L (but sometimes up to 0.1 mg/L). Therefore, for the times where the LOR was 0.01 mg/L at this site, it can be confirmed the concentration was below the ANZECC (2000) trigger value.

Similarly, for chromium (III), most concentrations were below the LOR's and it cannot be determined if these chromium (III) concentrations are above the ANZECC (2000) trigger value of 0.049 mg/L. Chromium (III) concentrations however, were at times high enough to be above the LOR's and therefore, confirmed as being above the trigger value.

In contrast to chromium speciation analysis, the analysis of all dissolved chromium (combined sum of both species) is less affected by matrix interferences. All combined chromium concentrations measured during the monitoring period at all leachate sites were above the LOR, which remained at the standard 0.001 mg/L. For samples where the chromium (III) concentration was above the LOR, comparison with the combined sum of both chromium species concentrations for this sample indicates the majority of chromium present is chromium (III). Given the combined sum of chromium data has a low enough LOR for all samples to record

a concentration, these concentrations were extracted from the original laboratory records (given they were not available in the SBWMF database) and are now discussed below in lieu of any useful chromium (III) and chromium (VI) data.

### 7.1.1 Physical parameters

#### **pH:**

Median pH's for the five leachate sites (see Table 7-1) range from neutral at LMP02 (7.00), to slightly alkaline at LP01 and LP02 (8.13 and 8.20 respectively).

Over the July 2016 to March 2020 monitoring period, all leachate site pH's predominantly remained within the Darwin Harbour water quality objective range of 6.0 to 8.5, with no sites showing evidence of an increasing or decreasing trend.

LMP02 is the only site with a seasonal pattern in pH concentrations. The pH at this site gradually rises (becomes more alkaline) during the dry season, with the highest concentrations typically occurring during the late dry season (September), and lowest during the wet season (December to March). This is likely reflecting the changing relative proportions of surface water runoff to groundwater seepage reporting to this site, where:

- Fresh rainwater and runoff, which has had little contact time with the buried Stage 1 and Stage 2 landfill materials is slightly acidic
- Infiltrated surface water and groundwater seepage that has had more contact with buried landfill materials is slightly alkaline.

#### **Electrical conductivity (EC):**

The Stage 3/4 landfill leachate site DW3 records the highest median EC i.e. 25,076  $\mu\text{S}/\text{cm}$  (see Table 7-1). This is followed by the other Stage 3/4 landfill leachate sites (DW2 and TC Sump) and Stage 5 landfill leachate sites (DW5 and DW6), with median ECs ranging between 18,491 and 22,361  $\mu\text{S}/\text{cm}$ . The leachate pond sites LP01 and LP02 are comparatively lower (13,401 and 15,733  $\mu\text{S}/\text{cm}$  respectively), and LMP02 has the lowest median EC (3,890  $\mu\text{S}/\text{cm}$ ).

Over the July 2016 to March 2020 monitoring period, EC concentrations measured at each leachate site were variable from month to month, and none of the sites showed clear evidence of a long-term increasing or decreasing trend.

LMP02 is the only site with a seasonal pattern in EC concentrations. Similarly, to pH, the EC at this site gradually increases during the dry season, with the highest concentrations typically occurring during the late dry season (September), and lowest during the wet season (December to March). Also, as for pH, this is likely reflecting the changing relative proportions of surface water runoff (with lower EC) to groundwater seepage (with higher EC due to contact time with landfill material) reporting to this site.

#### **Dissolved oxygen (DO):**

DO concentrations are almost always less than 50% saturation at all eight leachate monitoring sites. Median DO concentrations range between 7 and 28% saturation (Table 7-1).

DO is low in leachate because of the high oxygen demand of the landfill material it is in contact with i.e. from the breakdown of organic matter and oxidation of wastes. Also, the leachate, whilst within the landfill, has been out of contact with oxygen in the atmosphere.

Over the July 2016 to March 2020 monitoring period, DO concentrations measured at each leachate site were highly variable from month to month, and none of the sites showed clear evidence of a long-term increasing or decreasing trend, or seasonal pattern.

#### **Temperature:**

Temperatures measured in leachate at each site, over each year, follow the expected seasonal pattern of lowest during the dry season (May to August) and highest during the early to mid-wet season (November to

February). During any one monitoring round however, DW3 usually records the highest temperature (median temperature 36.5°C) compared to the other sites (Table 7-1). This is followed by the other Stage 3/4 landfill leachate sites (DW2 and TC Sump) and Stage 5 landfill leachate sites (DW5 and DW6), with median temperatures ranging from 32.2 to 35.7°C. The leachate pond sites LP01, LP02, and sump site LMP02 usually record the lowest temperature of all the sites, with median temperatures between 28.9 to 29.6°C.

These results are indicating the Stage 3/4 and Stage 5 landfill cells are more readily heated by the sun and/or from the breakdown of waste materials compared to the leachate ponds and the water reporting to LMP02.

**Table 7-1. Leachate site median physical parameter concentrations calculated for all data collected July 2016 – March 2019.**

Parameter	Units	LMP02	DW3	DW2	TC Sump	DW5	DW6	LP01	LP02
pH	pH units	7.00	7.76	7.87	7.76	7.97	7.93	8.13	8.20
EC	µS/cm	3,890	25,076	20,902	18,145	18,491	22,361	15,530	16,350
DO	%sat	12	7	18	9	25	28	10	17
Temp	°C	29.6	36.5	34.1	32.2	35.7	35.4	28.9	29.3

### 7.1.2 Dissolved metals

#### **Cadmium:**

Dissolved cadmium concentrations are almost always below the LOR (i.e. <0.001), and always below the ANZECC (2000) trigger value of 0.014 mg/L at all leachate sites during all sampling rounds for the July 2016 to March 2020 monitoring period. This is likely not a true reflection of cadmium concentrations in the leachate given very high dissolved cadmium concentrations are observed in some groundwater bores; see Section 7.6 below. Possibly in the leachate, given the pH and high amounts of organic and suspended material, cadmium is bound to this material, and is not in the dissolved phase. Therefore, the cadmium would be filtered-out during sample preparation prior to analysis. Measuring total (unfiltered) cadmium in the samples in future may reveal very high cadmium levels in the leachate.

#### **Chromium:**

DW3 records the highest median chromium concentration (0.739 mg/L), with the next highest median recorded at LP02 (0.493 mg/L). The other leachate sites record medians ranging between 0.215 and 0.394 mg/L (Table 7-2), except for LMP02, which records lower chromium concentrations and a median of 0.007 mg/L.

Based on the available July 2016 to March 2020 monitoring data, all chromium concentrations measured at all sites, were above the chromium (III) ANZECC (2000) trigger value. This is except for LMP02, which always recorded concentrations below the trigger value.

The chromium data for LMP02 indicates a seasonal trend, where the highest concentrations generally occur during the mid to late dry season (June – September) and the lowest concentrations during the mid-wet season (January – March). The other sites do not show clear evidence of a seasonal trend, although concentrations at DW3 tend to be higher during the dry season and lower during the wet season, whereas the leachate pond sites LP01 and LP02 tend to be highest during the wet season and lowest during the dry season.

Chromium concentrations do not appear to be increasing or decreasing over the long-term, at any of the leachate sites, based on the available data.

#### **Copper:**

Copper concentrations in samples from the Stage 3/4 landfill leachate sites DW3 and DW2 are typically

several times higher than the other sites (Table 7-2). The median copper concentration for DW3 and DW2 is 0.147 and 0.208 mg/L respectively, compared to the next highest median concentration of 0.049 mg/L for the southern leachate pond LP02.

Copper concentrations are lower in the northern leachate pond LP01 (median concentration 0.020 mg/L), compared to the southern leachate pond LP02. Copper concentrations in the Stage 3/4 landfill leachate site TC Sump (median concentration 0.033 mg/L) are also lower compared to the other Stage 3/4 landfill sites DW3 and DW2.

The Stage 5 landfill leachate sites DW5 and DW6, have only been tested for dissolved metals up to three times since these sites were added to the monitoring program in late 2019. Based on this limited data, DW5 records higher concentrations compared to DW6, with median concentrations of 0.042 and 0.017 mg/L respectively.

LMP02 records low copper concentrations compared to the other leachate sites, with a median of 0.001 mg/L. Concentrations at this site are often below the LOR i.e. <0.001 mg/L.

Based on the available July 2016 to March 2020 monitoring data, all copper concentrations measured at all leachate sites were above the ANZECC (2000) trigger value of 0.003 mg/L. This was except for LMP02, where only 25% of concentrations measured were above the trigger value; all of these occurring during the early to mid-wet season (October – January).

Copper concentrations do not appear to be increasing or decreasing over the long-term, at any of the leachate sites, based on the available data. Seasonal trends are also not evident at any of the sites, apart from the higher concentrations at LMP02 during the early to mid-wet season.

### **Iron:**

Iron is commonly present in natural waters and is an essential trace element for plants and animals. The ANZECC (2000) guidelines do not specify trigger values for iron due to the lack of data, although it is noted that adverse biological effects may occur at high concentrations above natural background levels.

Leachate samples are analysed for two different forms of iron: ferrous iron ( $Fe^{2+}$ ) and ferric iron ( $Fe^{3+}$ ). These are the two most common oxidation states of iron in water, although other forms may be present in organic and inorganic wastewater streams. In oxidised waters, iron is generally present in the ferric iron (III) state, whereas in reducing waters, the ferrous iron (II) form persists. Ferrous iron (II) is more soluble compared to ferric iron (III), which will often precipitate as a ferric hydroxide floc unless the water is very acidic (<pH 3.5).

LMP02 records the highest iron (II) concentrations, with a median of 10.6 mg/L (Table 7-2). This is followed by the Stage 3/4 landfill leachate sites TC Sump, with a median of 8.6 mg/L, and DW3, with a median of 7.5 mg/L. Almost all the iron present at LMP02 is ferrous iron (II); given the median ferric iron (III) concentration is only 0.05 mg/L. Similarly, the majority of iron at the DW3 and TC Sump sites is ferrous iron (II), with a median ferric iron (III) concentration of 1.71 and 3.27 mg/L respectively, i.e. ferrous iron (II) comprises 81% of iron at DW3, and 72% of iron at TC Sump. These results are indicating that the water at these sites is iron-rich, and has come from a reducing/anaerobic environment.

The leachate pond sites LP01 and LP02 record comparatively lower iron concentrations, with median ferrous (II) iron concentrations of 3.0 and 4.2 mg/L respectively. Ferric iron (III) comprises a greater proportion of iron at these sites, with medians of 3.90 and 3.8 mg/L respectively, i.e. ferrous iron (II) comprises only 43% of iron at LP01 and 53% at LP02. These results are indicating the leachate ponds are a comparatively more oxidised environment compared to the source of water to LMP02, DW3 and TC Sump.

DW2 records the lowest iron concentrations of all the sites, with a median iron (II) concentration of 1.76 mg/L and median iron (III) concentration of 0.86 mg/L.

Conclusions cannot be drawn from the iron concentrations so far measured at the Stage 5 landfill leachate sites DW5 and DW6. Only three concentrations have so far been measured at DW5 (June 2019, January 2020 and February 2020) and two at DW6 (January and February 2020). Iron (II) and iron (III) concentrations were highly variable between these sampling occasions and the calculated median may not

be representative.

The ferrous iron (II) data for LMP02 indicates a seasonal trend, where the highest concentrations generally occur during the wet season (January – April) and lowest at the end of the dry season (September - December). This trend is inverse to the seasonal trend of other dissolved metals at this site. Ferrous iron (II) is also higher at this site compared to the landfill leachate sites. This is indicating that this parameter is not directly related to leachate inputs and is possibly affected by surface water inputs and interactions in the environment.

The other leachate sites do not show clear evidence of a seasonal trend in ferrous iron (II).

It is difficult to discern any clear seasonal trends in ferric iron (III) concentrations at any of the sites including LMP02.

Iron concentrations do not appear to be increasing or decreasing over the long-term, at any of the leachate sites, based on the available data.

#### **Manganese:**

Manganese concentrations are relatively similar across the leachate sites, with median concentrations ranging from 0.072 mg/L at LMP02 to 0.172 mg/L at LP02 (Table 7-2). This is except for the Stage 5 landfill sites DW5 and DW6, which record concentrations higher than this, with medians of 0.200 and 0.367 mg/L respectively; although this is calculated using only the few measurements available for these two sites.

Based on the available July 2016 to March 2020 monitoring data, almost all manganese concentrations measured at all leachate sites were above the ANZECC (2000) trigger value of 0.08 mg/L. This was except for LMP02, where only 42% of concentrations measured were above the trigger value; all of these occurring during the early to mid-wet season (December to February).

Manganese concentrations do not appear to be increasing or decreasing over the long-term at any of the leachate sites, based on the available data. Seasonal trends are also not evident at any of the sites, apart from the higher concentrations at LMP02 during the early to mid-wet season.

#### **Nickel:**

Nickel concentrations are highest at the Stage 3/4 landfill sites (DW3, DW2 and TC Sump) and at LP02, with median concentrations ranging between 0.199 and 0.291 mg/L (Table 7-2). LP01 concentrations are lower, with a median of 0.166 mg/L. The Stage 5 landfill sites DW5 and DW6 also record lower concentrations, with medians of 0.120 and 0.075 mg/L respectively; although this is calculated using only the few measurements available for these two sites. LMP02 records the lowest median nickel concentration of all the leachate sites (0.023 mg/L).

Based on the available July 2016 to March 2020 monitoring data, the majority of nickel concentrations measured at DW3, DW2, TC Sump and LP02 were above the ANZECC (2000) trigger value of 0.2 mg/L. Whereas the majority of nickel concentrations at LP01 were below the trigger value, and all concentrations at LMP02 were below the trigger value.

A seasonal trend is evident at all sites, where nickel concentrations increase over the dry season and are highest at the end of the dry season (September – October), and lowest during the mid-wet season (January – February). Nickel concentrations do not appear to be increasing or decreasing over the long-term at any of the leachate sites, based on the available data.

#### **Lead:**

Lead concentrations are highest at the Stage 3/4 landfill sites (DW3 and TC Sump) and at LP02, with median concentrations of 0.044, 0.034 and 0.032 mg/L respectively (Table 7-2). LP01 and DW2 concentrations are lower, with a median of 0.018 mg/L. The Stage 5 landfill sites DW5 and DW6 also record low concentrations, with medians of 0.005 and 0.003 mg/L respectively; although this is calculated using only the few measurements available for these two sites. LMP02 has always recorded lead concentrations below the LOR (<0.001 mg/L) since monitoring began in July 2016.

Based on the available July 2016 to March 2020 monitoring data, all lead concentrations measured at DW3 were well above the ANZECC (2000) trigger value of 0.0066 mg/L. All concentrations were also above the trigger value at TC Sump and LP02, except for one isolated occurrence each, where it was below the trigger value. At DW2, LP01 and LP02, all lead concentrations were above the trigger value in 2016 and 2017; however, concentrations at these sites were lower in 2019 and 2020, and mostly below the trigger value.

Distinctive seasonal trends are not evident in the available data of any sites. There is however a general trend (not associated with seasons) of increasing concentrations at DW3, DW2, TC Sump, LP01 and LP02 between September 2016 and September 2017. Then, concentrations at these sites are generally lower during 2019 and 2020.

### **Zinc:**

Zinc concentrations are highest at DW3, with a median of 0.851 mg/L. This is followed by LP02, with a median of 0.675 mg/L. DW2, TC Sump and DW5 have similar concentrations, with medians ranging between 0.449 and 0.495 mg/L. LP01 and DW6 have lower concentrations (medians of 0.312 and 0.231 mg/L respectively), and LMP02 has the lowest concentrations, with a median 0.016 mg/L.

Based on the available July 2016 to March 2020 monitoring data, all zinc concentrations measured at all sites (except LMP02) were above the ANZECC (2000) trigger value of 0.023 mg/L. At LMP02, only 32% of zinc concentrations were above the trigger value; all these occurred during the early wet season, with the highest concentrations in December.

Distinctive seasonal trends are not evident in the available data of any sites, apart from that mentioned above for LMP02, where the concentrations at this site are higher during the early wet season. Concentrations at DW3, DW2, TC Sump, LP01 and LP02 do however, appear to decrease over the long-term, with concentrations measured during 2019 and 2020 being generally lower than between September 2016 and August 2017.

**Table 7-2. Leachate site median dissolved metal concentrations calculated for all data collected July 2016 – March 2019**

Parameter	Units	Trigger value	LMP02	DW3	DW2	TC Sump	DW5	DW6	LP01	LP02
<b>Cadmium</b>	mg/L	0.014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Chromium</b>	mg/L	0.049	0.007	0.739	0.363	0.285	0.394	0.215	0.297	0.493
<b>Copper</b>	mg/L	0.003	0.001	0.147	0.208	0.033	0.042	0.017	0.020	0.049
<b>Iron (II)</b>	mg/L	-	10.60	7.47	1.76	8.58	5.50	5.58	3.00	4.20
<b>Iron (III)</b>	mg/L	-	0.05	1.71	0.86	3.27	1.15	6.18	3.90	3.78
<b>Manganese</b>	mg/L	0.08	0.072	0.116	0.100	0.180	0.200	0.367	0.133	0.172
<b>Nickel</b>	mg/L	0.2	0.023	0.291	0.199	0.254	0.120	0.075	0.166	0.250
<b>Lead</b>	mg/L	0.0066	<0.001	0.044	0.018	0.034	0.005	0.003	0.018	0.032
<b>Zinc</b>	mg/L	0.023	0.016	0.851	0.466	0.449	0.495	0.231	0.312	0.675

*Median concentrations above the ANZECC (2000) trigger value for 90% species protection in marine water shaded in red.*

### **7.1.3 Nutrients, organic content and oxygen demand**

#### **Ammonia (NH<sub>3</sub>):**

Leachate samples are analysed for total ammonia as nitrogen (denoted as NH<sub>3</sub>-N). The term 'ammonia' refers to two chemical species of ammonia that are in equilibrium in water: the un-ionised ammonia, NH<sub>3</sub>, and ionised ammonium ion, (NH<sub>4</sub><sup>+</sup>) according to the equation NH<sub>3</sub> + H<sub>2</sub>O ⇌ NH<sub>4</sub><sup>+</sup> + OH<sup>-</sup>. The proportion of the two chemical forms NH<sub>3</sub> and NH<sub>4</sub><sup>+</sup> varies with the physico-chemical properties of the water, particularly pH and temperature. In alkaline (high pH) solutions, the predominant species is ammonia (NH<sub>3</sub>), while ammonium (NH<sub>4</sub><sup>+</sup>) predominates at lower pH.

The L/N ratio indicator (see Section 4.6 above), requires the concentration of ammonium ions ( $\text{NH}_4^+$ ). As such, the laboratory is requested to report the proportion of  $\text{NH}_3\text{-N}$  occurring as  $\text{NH}_4^+$ . In order to calculate this, the laboratory is provided with the field-measured pH and temperature of the sample point, at the time of sampling. Given  $\text{NH}_4^+$  is a calculated concentration based on the laboratory-analysed  $\text{NH}_3\text{-N}$ , only  $\text{NH}_3\text{-N}$  is discussed here. The L/N ratio results are discussed in Section 7.1.4 below.

Ammonia concentrations are high in leachate at all sites (Table 7-3). Median concentrations for the Stage 3/4 landfill leachate sites range from highest at DW3 with 2125 mg/L down to 1305 mg/L at TC Sump. This is between 1000 and 1800x higher than the ANZECC (2000) trigger value applying to the SBWMF site i.e. 1.2 mg/L. The leachate pond medians at LP01 and LP02 are lower (714 and 1020 mg/L respectively) compared to the Stage 3/4 landfill sites; equating to greater than 600x the trigger value. LMP02 records the lowest ammonia concentrations of all the leachate sites; although the median is 196 mg/L, which is still 163x above the trigger value. The Stage 5 landfill sites DW5 and DW6, record medians in the same range as the Stage 3/4 landfill i.e. 1860 and 1415 mg/L respectively; although this is based on the very few measurements available for these two sites.

Based on the available July 2016 to March 2020 monitoring data, LMP02 is the only site showing a distinct seasonal trend in ammonia concentrations. The ammonia at this site gradually increases over the dry season, with the highest concentrations typically occurring during the late dry season (September), and lowest during the wet season (December to March). This is likely reflecting the changing relative proportions of surface water runoff (which is lower in ammonia) to groundwater seepage (which is higher in ammonia due to contact with landfill material) reporting to this site, as explained above for pH and EC.

Ammonia concentrations do not appear to be increasing or decreasing over the long-term at any of the leachate sites, based on the available data.

#### **Total organic carbon (TOC):**

Total organic carbon (TOC) is the amount of carbon existing in organic compounds in the water, including in both dissolved and particulate forms, and from either natural or synthetic sources. ANZECC (2000) does not specify guideline values for TOC given this is not strictly a toxicant, although high concentrations can indicate highly polluted water and high inputs of organic matter to waterways can lead to eutrophication.

DW3 records the highest median TOC concentration (2050 mg/L), followed by the other Stage 3/4 landfill sites DW2 and TC Sump with medians of 1240 and 1090 mg/L respectively (Table 7-3). The Stage 5 landfill sites DW5 and DW6 also record medians similar to the Stage 3/4 landfill sites (medians 1500 and 1030 mg/L respectively); although these medians are based on the limited data available for these two sites. The leachate ponds LP01 and LP02 have lower TOC concentrations (medians of 854 and 1025 mg/L respectively). LMP02 has the lowest TOC concentrations with a significantly lower median of 97 mg/L.

Based on the available July 2016 to March 2020 monitoring data, LMP02 is the only site showing a distinct seasonal trend in TOC concentrations. The TOC at this site gradually increases during the dry season, with the highest concentrations typically occurring during the late dry season (August to September), and lowest during the early wet season (December to January). This is likely reflecting the changing relative proportions of surface water runoff (which has lower TOC concentrations) to groundwater seepage (which is higher in TOC due to contact with landfill material) reporting to this site, as explained above for pH and EC.

TOC concentrations do not appear to be increasing or decreasing over the long-term at any of the leachate sites, based on the available data.

#### **Chemical oxygen demand (COD) and biochemical oxygen demand (BOD):**

Chemical oxygen demand (COD) is an indicative measure of oxidisable pollutants in water; including organic matter and inorganic chemicals such as ammonia and nitrite. Biochemical oxygen demand (BOD) is also an indicative measure of oxidisable components in water, but only that which is oxidised by bacteria and other microorganisms whilst they decompose organic matter under aerobic conditions. Both COD and BOD indicate the potential reduction in dissolved oxygen caused by wastewater if it was to enter a natural waterway.

DW3 records by far the highest COD concentrations with a median of 6250 mg/L (Table 7-3). DW2, TC Sump, DW5, DW6 and LP02 record concentrations within a similar range, with medians for these sites ranging between 3460 and 4140 mg/L. LP01 records relatively lower concentrations (median of 2650 mg/L) and LMP02 records significantly lower concentrations (median of 298 mg/L).

BOD concentrations are similarly highest at DW3 (median of 275 mg/L) compared to the other sites, although not to the same degree as COD (Table 7-3). Median concentrations of the sites with the next highest concentrations, DW2 and TC Sump, are 215 and 149 mg/L respectively. The leachate pond sites LP01 and LP02 are relatively lower (64 and 107 mg/L respectively) and LMP02 is the lowest (20 mg/L). The Stage 5 landfill sites DW5 and DW6 only have one BOD concentration recorded during the monitoring period, which is insufficient to include in this site comparison.

Based on the available July 2016 to March 2020 monitoring data, LMP02 shows a distinct seasonal trend in COD and BOD concentrations. The COD and BOD at this site is generally highest during the mid to late dry season (July to October) and lowest during the early wet season (December-January). This is likely reflecting the changing relative proportions of surface water runoff (which has lower COD and BOD) to groundwater seepage (which has a higher COD and BOD due to contact with landfill material) reporting to this site, as explained above for pH and EC.

The Stage 3/4 landfill sites DW3, DW2 and TC Sump show evidence of a seasonal trend of generally higher concentrations during the dry season and lower concentrations during the wet season. The leachate pond sites LP01 and LP02 do not appear to have a seasonal pattern based on the available data; although LP01 shows an increasing trend between July 2016 and August 2017 unrelated to the seasons. None of the other sites appear to be increasing or decreasing over the long-term, based on the available data.

**Table 7-3. Leachate site median nutrient, organic content and oxygen demand concentrations calculated for all data collected July 2016 – March 2019.**

Parameter	Units	Trigger value	LMP02	DW3	DW2	TC Sump	DW5	DW6	LP01	LP02
Ammonia	mg/L	1.2	196	2125	1680	1305	1860	1415	714	1020
TOC	mg/L	-	97	2050	1240	1090	1500	1030	854	1025
BOD	mg/L	-	20	275	215.5	149	276	216	64	107
COD	mg/L	-	298	6250	3875	3460	4140	3930	2650	3860

*Median concentrations above the ANZECC (2000) trigger value for 90% species protection in marine water shaded in red – where a trigger value is available.*

#### 7.1.4 Anions, cations and L/N ratio

##### **Major anion and cation concentrations:**

Major anion (sulfate, chloride, alkalinity) and major cation (calcium, magnesium, potassium and sodium) concentrations recorded in the leachate monitoring sites are summarised as median concentrations in Table 7-4. DW3 records the highest chloride, alkalinity, potassium and sodium concentrations. The other sites DW2, TC Sump, DW5, DW6, LP01 and LP02 record concentrations of these anions and cations within a similar range. LMP02 records significantly lower concentrations for these anions and cations.

The anions and cations not listed above i.e. sulfate, calcium and magnesium, the newer Stage 5 landfill sites DW5 and DW6 record the highest concentrations.

Based on the available July 2016 to March 2020 monitoring data, LMP02 shows a distinct seasonal trend in chloride, alkalinity, potassium and sodium concentrations. These anions and cations at this site are generally highest during the dry season and lowest during the wet season. Similarly, for most other contaminants, this is likely reflecting the changing relative proportions of surface water runoff (which has lower contaminants) to groundwater seepage (which has higher contaminants due to contact with landfill material) reporting to this site, as explained above for pH and EC.

The Stage 3/4 landfill sites DW3, DW2 and TC Sump show evidence of a seasonal trend of generally higher chloride, alkalinity, potassium and sodium concentrations during the dry season, and lower concentrations during the wet season. These sites do not show a seasonal trend for sulfate, calcium and magnesium.

The leachate pond sites LP01 and LP02 do not appear to have a seasonal pattern based on the available data, and DW5 and DW6 do not have enough data to indicate any seasonal patterns.

None of the sites appear to be increasing or decreasing over the long-term, based on the available data.

**L/N ratios:**

All six ions required to calculate the L/N ratio (see Section 4.6 above) are analysed on a quarterly basis. The L/N ratio values calculated for each of these quarterly rounds, for each site, have been relatively consistent throughout the July 2016 to March 2020 monitoring period, with limited variation between monitoring rounds.

The median L/N ratio calculated for each site is provided in Table 7-4. The ratio values are highest at DW5, DW6, DW3, DW2 and TC Sump sites in that order ranging from 164 down to 100. The LP01, LP02 and LMP02 sites record similar L/N ratios with medians of 88. Significantly, the LMP02 site, has a relatively high L/N ratio despite having lower contaminant concentrations compared to the other leachate sites (see sections above). This is showing that the contaminants that are present, are derived from landfill leachate, most likely from the seepage of groundwater from the Stage 1 and Stage 2 landfills into the drain that reports to this site.

**Table 7-4. Leachate site median anion and cation concentrations and L/N ratios calculated for all data collected July 2016 – March 2019.**

Parameter	Units	LMP02	DW3	DW2	TC Sump	DW5	DW6	LP01	LP02
Sulfate as SO <sub>4</sub>	mg/L	5	10	11	11	25	38	10	14
Chloride	mg/L	444	3090	2180	2340	2050	2300	1870	2180
Alkalinity as CaCO <sub>3</sub>	mg/L	1190	9570	7206	6113	5400	4645	3335	4900
Calcium	mg/L	48	36	40	50	71	154	34	50
Magnesium	mg/L	19	40	53	47	59	130	40	48
Potassium	mg/L	117	934	678	681	732	800	600	760
Sodium	mg/L	294	2300	1930	1850	1290	1148	1460	1850
L/N ratio	mg/L	85	125	111	100	164	149	88	88

*There are no ANZECC (2000) trigger values relating to anions and cations.*

**7.1.5 PFAS**

**PFAS:**

PFAS concentrations have only been analysed in samples from the leachate sample sites on three occasions for this monitoring program: June 2019, October 2019 and January 2020. Based on this data (see SBWMF database) the following is concluded for the direct leachate sampling sites DW3, DW2, TC Sump, DW5 and DW6:

- PFAS concentrations are high. The sum of all 28 species analysed is on average 20 µg/L.
- The PFAS species PFBS comprises 58% of this, followed by PFHxA (15%), PFPeA (7.5%) and PFOA (6.4%). Twelve other PFAS species comprise the remaining 13%, and 12 are usually below the LOR.
- Significantly, the three PFAS species with guidance values in the PFAS NEMP (i.e. PFHxS, PFOS and PFOA) only comprise 11% of the total PFAS concentration. The average PFOS+PFHxS concentration (1.15 µg/L) is above the PFAS NEMP recreational water guidance

value (0.7 µg/L), but below the 90% species protection aquatic ecosystem value (2 µg/L). The average PFOA concentration (1.83 µg/L) is below the recreational water guidance value (5.6 µg/L).

The leachate pond sites (LP01 and LP02) also record high PFAS concentrations, with the sum of all 28 species analysed on average 10 µg/L at LP01 and 25 µg/L at LP02. Again, the most prevalent PFAS species is PFBS (average for both sites combined 9.1 µg/L), followed by PFHxA (average 2.05 µg/L) and PFOA (average 1.84 µg/L).

LMP02 records the lowest concentrations of the leachate sampling sites with an average sum of all 28 species of 2.8 µg/L. Of note is that the most prevalent PFAS species at this site is PFOS (average 0.85 µg/L), followed by PFHxS (average 0.51 µg/L) and PFOA (average 0.33 µg/L). This is likely reflecting the older landfill signatures i.e. seepage from the Stage 1 and Stage 2 landfills, which pre-date the phasing out of these PFAS species for use in products. Whereas the Stage 3/4 and Stage 5 landfills contain relatively less of these PFAS species, which are now being replaced by alternative chemicals in products that previously would have contained PFOS, PFOA and PFHxS. The average PFOS+PFHxS concentration at LMP02 (1.36 µg/L) is well above the PFAS NEMP recreational guideline, but remains below the applicable aquatic ecosystem guideline value.

There is not yet enough data to determine any seasonal or long-term trends in PFAS concentrations at any of the leachate sites.

## 7.1.6 Hydrocarbons

### **Total recoverable hydrocarbons (TRH):**

All total petroleum (TPH) and total recoverable hydrocarbon (TRH) fractions are analysed in leachate samples, however only the TRH >C10—C40 fraction (sum) is transferred from laboratory reports and recorded in the SBWMF water quality monitoring database. As such, only this combined fraction concentration is discussed below. Note that no TPH or TRH data yet exists for the DW5 and DW6 sites and therefore, these are also not included in the discussion below.

DW3 records by far the highest TRH (sum) concentrations, with a median of 22,200 µg/L (Table 7-5). This is followed by DW2, TC Sump, LP02 and LP01, in that order. LMP02 records the lowest TRH concentrations, but these are still relatively high, with a median of 950 µg/L.

Based on the available July 2016 to March 2020 monitoring data, LMP02 is the only site showing a distinct seasonal trend in TRH concentrations. The TRH at this site gradually increases over the dry season and is lowest during the early to mid-wet season (November to February). This is likely reflecting the changing relative proportions of surface water runoff (which is lower in TRH) to groundwater seepage (which is higher in TRH due to contact with landfill material) reporting to this site, as explained above for pH and EC.

TRH concentrations do not appear to be increasing or decreasing over the long-term at any of the leachate sites, based on the available data.

### **Polycyclic aromatic hydrocarbons (PAHs):**

A suite of 16 different PAHs are analysed in leachate samples, however only the sum concentration of all of them is transferred from laboratory reports and recorded in the SBWMF water quality monitoring database. As such, only the PAH sum is discussed below.

All PAH sum concentrations measured to date at DW5, DW6 and LP01 are below the LOR (i.e. <0.5 µg/L), and all concentrations, except one, are below the LOR at LP02. Similarly, most concentrations recorded at DW2 and TC Sump are below the LOR, with some occasional concentrations of up to 1.9 and 2.4 µg/L respectively.

Concentrations at DW3 are up to 4.8 µg/L with all of this comprising the PAH naphthalene. This is relatively low given the ANZECC (2000) trigger value for naphthalene is 90 µg/L.

Conversely to other contaminants, LMP02 records the highest PAH (sum) concentrations, with a median of 2.7 µg/L and highest concentration of 10.1 µg/L. All of this also comprising naphthalene and therefore still well below the ANZECC (2000) trigger value. The cause of these incongruously high naphthalene concentrations at LMP02, compared to the pattern in other contaminants at this site, are not known, but may be unique to the Stage 1 and 2 landfill sources of leachate to this site or the type of environment of this site, being a catchment drain leading to a sump (as opposed to a leachate dewatering well).

Based on the available July 2016 to March 2020 monitoring data, there is no clear evidence of any seasonal trends or long-term trends at any of the sites.

**Benzene, toluene, ethylbenzene, xylene (BTEX):**

Benzene, toluene, ethylbenzene and xylene (BTEX) are volatile aromatic hydrocarbons (i.e. TPH fraction C6-C9). All these hydrocarbon compounds are analysed in leachate samples, however only the sum concentration of benzene, toluene, ethylbenzene and xylene has been transferred from laboratory reports and recorded in the SBWMF database. This is unfortunate given the ANZECC (2000) guidelines include trigger values for benzene, toluene, ethylbenzene and xylene but not the sum of these. A brief review of the historic raw laboratory reports reveals that all these compounds are present in varying concentrations at varying times to make up the sum total BTEX concentration. Without spending time entering all this data, only the BTEX (sum) can be discussed below without comparison to any ANZECC (2000) trigger values.

DW3 and DW2 record by far the highest BTEX concentrations (medians of 247 and 178 µg/l respectively) followed by TC Sump, DW5 and DW6 with median concentrations between 28 and 86 µg/L. LP01, LP02 and LMP02 record negligible BTEX concentrations, with medians all less than 5 µg/L.

Based on the available July 2016 to March 2020 monitoring data, there is no clear evidence of any seasonal trends or long-term trends at any of the sites.

**Phenols (total):**

Phenols (total) are highest at DW3, TC Sump and DW5; all have medians above 0.96 µg/L. Whereas phenol concentrations at TC Sump, DW6, LP01 and LP02 are relatively low; medians all below 0.32 µg/L. LMP02 has always recorded phenols below the LOR i.e. <0.05 µg/L.

Based on the available July 2016 to March 2020 monitoring data, there is no clear evidence of any seasonal trends or long-term trends at any of the sites.

**Table 7-5. Leachate site median hydrocarbon concentrations calculated for all data collected July 2016 – March 2019.**

Parameter	Units	LMP02	DW3	DW2	TC Sump	DW5	DW6	LP01	LP02
TRH >C10-C40 (sum)	µg/L	950	22,200	16,400	6,900	-	-	4,890	7,520
PAH (sum)	µg/L	2.7	1.0	0.3	0.4	<0.5	<0.5	<0.5	<0.5
BTEX (sum)	µg/L	4	247	178	37	28	86	5	5
Phenols (total)	µg/L	<0.05	1.19	0.96	0.15	1.02	0.32	0.50	0.50

*ANZECC (2000) trigger values are available for individual PAH, phenol and BTEX compounds but not for the combined sums of these compounds.*

**7.2 Summary of leachate characterisation**

Contaminant concentrations are generally always highest at the Stage 3/4 landfill site DW3, followed by the other Stage 3/4 landfill sites DW2 and TC Sump. The leachate pond sites LP02 and LP01 have the next highest concentrations. The leachate drain from the Stage 1 and 2 landfills (LMP02) generally has the lowest contaminant concentrations given this site also receives surface water runoff that has not been in

contact with landfill wastes (see discussion below). There is not yet enough data to include the Stage 5 landfill leachate sites DW5 and DW6 in this comparison.

The following dot points summarise the typical water quality of leachate:

- pH ranges from neutral (7.00) to slightly alkaline (8.20).
- EC is very high, ranging between 18,000 and 25,000  $\mu\text{S}/\text{cm}$  in leachate direct from the landfills, and between 13,400 and 16,000  $\mu\text{S}/\text{cm}$  in the leachate ponds. The leachate collection drain LMP02 has a seasonal pattern in EC concentrations (high during dry season and low during wet season), with a median concentration of 4,000  $\mu\text{S}/\text{cm}$ .
- DO concentrations are almost always less than 50% saturation at all eight leachate monitoring sites. Median DO concentrations range between 7 and 28% saturation.
- Temperatures follow the expected seasonal pattern of lowest during the dry season (May to August) and highest during the early to mid-wet season (November to February). At any one time, DW3 usually records the highest temperature (median temperature 36.5°C), followed by the other Stage 3/4 landfill leachate sites (DW2 and TC Sump) and Stage 5 landfill leachate sites (DW5 and DW6), with median temperatures ranging from 32.2 to 35.7°C. The leachate pond sites LP01, LP02, and sump site LMP02 usually record the lowest temperature of all the sites, with median temperatures between 28.9 to 29.6°C.
- Dissolved metal (chromium, copper, manganese, nickel, lead and zinc) concentrations are usually highest at DW3. This is followed by DW2, TC Sump, DW5 and DW6. The leachate ponds are comparatively lower, with the southern leachate pond (LP02) usually always recording higher concentrations than the northern leachate pond (LP01). All leachate sites (except LMP02) record dissolved metals concentrations well above the relevant ANZECC (2000) trigger value most of the time, and the median concentrations calculated for all these sites are all above the respective trigger values. Dissolved metal concentrations recorded at LMP02 are usually below the relevant ANZECC (2000) trigger values, with all medians below the respective trigger values.

Seasonal trends in dissolved metal concentrations are evident at LMP02, with the highest concentrations generally occurring during the end of the dry season/early wet season. None of the other sites show clear evidence of seasonal trends in the available data, except for nickel, which is highest during the dry season and lowest during the wet season. Significant long-term increasing or decreasing concentration trends over the July 2016 to March 2020 monitoring period are not evident at any of the sites.

- Cadmium concentrations are almost always below the LOR (i.e. <0.001 mg/L) at all leachate sites during all monitoring rounds. This is likely not a true reflection of cadmium in the leachate. It may be that all the cadmium exists in the solid phase and/or sorbed onto the high amounts of suspended and organic material in the leachate. Given the samples are analysed for 'dissolved' metals, they are filtered prior to analysis. Potentially the cadmium is removed through the filtering process.
- Ferrous (II) and ferric (III) iron concentrations differ to those metals listed above, in that iron (II) concentrations were generally highest at LMP02 and iron (III) concentrations highest at DW6, LP01, LP02, and TC Sump. The seasonal trend in iron (II) concentrations at LMP02 is also counter to that of other contaminants, in that concentrations are highest during the wet season and lowest during the dry season.
- Ammonia concentrations are extremely high at all leachate sites. Concentrations are generally between 1,000 and 1,800 times the applicable ANZECC (2000) trigger value at the Stage 3/4 and Stage 5 landfill sites (DW3, DW2, TC Sump, DW5 and DW6). Concentrations are lower in the leachate ponds (LP01 and LP02); although still more than 600 times the trigger value. LMP02 records the lowest concentrations, but these are also still generally more than 163 times the trigger value.

LMP02 is the only site showing seasonal variation in concentrations, with highest concentrations during the late dry season and lowest during the wet season. None of the leachate sites show evidence of an increasing or decreasing trend in concentrations based on the available data for the monitoring period.

- TOC, COD and BOD concentrations are highest at DW3. TOC and BOD concentrations are comparatively lower (but still very high), at the other Stage 3/4 landfill sites (DW2, TC Sump) and Stage 5 landfill sites (DW5 and DW6). The concentrations of TOC and BOD at these four sites are within a similar range. TOC and BOD are comparatively lower at LP01 and LP02, followed by LMP02, with the lowest concentrations.

COD is relatively lower than at DW3 (but still very high), and within a similar range at DW2, TC Sump, DW5, DW6, LP01 and LP02. Again, LMP02 records the lowest COD concentrations compared to the other leachate sites. LMP02 shows a seasonal trend of highest TOC, COD and BOD concentrations during the late dry season and lowest during the wet season. The only other seasonal trend identified in the TOC, COD and BOD data is higher COD and BOD concentrations during the dry season, and lower concentrations during the wet season at the Stage 3/4 landfill sites (DW3, DW2, TC Sump). The only long-term trend in concentrations (unrelated to seasons) was an increasing trend in COD and BOD at LP01 between July 2016 and August 2017.

- Major anion (sulfate, chloride, alkalinity) and major cation (calcium, magnesium, potassium and sodium) concentrations are highest at DW3. The other sites DW2, TC Sump, DW5, DW6, LP01 and LP02 record concentrations within a similar range. LMP02 records significantly lower concentrations.

LMP02 shows a distinct seasonal trend in chloride, alkalinity, potassium and sodium concentrations with highest concentrations during the dry season and lowest during the wet season. The Stage 3/4 landfill sites DW3, DW2 and TC Sump also show evidence of a seasonal trend of generally higher chloride, alkalinity, potassium and sodium concentrations during the dry season, and lower concentrations during the wet season. These sites do not show a seasonal trend for sulfate, calcium and magnesium. None of the sites appear to be increasing or decreasing over the long-term, based on the available data.

- The L/N ratio values calculated for each site have been relatively consistent throughout the monitoring period, with limited variation between monitoring rounds. The L/N ratio values are highest at DW5, DW6, DW3, DW2 and TC Sump in that order, ranging from 164 down to 100. The LP01, LP02 and LMP02 sites record similar L/N ratios, with medians between 85 and 88. The LMP02 site has a relatively high L/N ratio despite having lower contaminant concentrations compared to the other leachate sites. This is showing that the contaminants that are present, are derived from landfill leachate, most likely from the seepage of groundwater from the Stage 1 and Stage 2 landfills into the drain that reports to this site.
- PFAS concentrations are high at all leachate sampling sites. At all sites except LMP02, the most prevalent PFAS species are PFBS, PFHxA, PFPeA and PFOA, in that order. Of these, only PFOA has a guidance value in the PFAS NEMP (i.e. only PFHxS, PFOS and PFOA have guidance values). Despite this, even though PFOS+PFHxS is not the most prevalent PFAS species, these sites still record concentrations of PFOS+PFHxS above the PFAS NEMP recreational water guidance value (but still remains below the 90% species protection for aquatic ecosystems guideline value).

LMP02 records the lowest PFAS concentrations of the leachate sampling sites but of note is that the most prevalent PFAS species at this site are PFOS, PFHxS and PFOA, in that order. The average PFOS+PFHxS concentration is well above the PFAS NEMP recreational guideline. This is likely reflecting the older landfill signatures i.e. seepage from the Stage 1 and Stage 2 landfills, which pre-date the phasing out of these PFAS species for use in products. Whereas the Stage

3/4 and Stage 5 landfills contain relatively less of these PFAS species, which are now being replaced by alternative chemicals in products that previously would have contained PFOS, PFOA and PFHxS.

- In regards to hydrocarbons, TRH (sum) concentrations are the highest at DW3 (22,200 µg/L), followed by DW2, TC Sump, LP02 and LP01, in that order. LMP02 records the lowest TRH concentrations, but these are still relatively high, with a median of 950 µg/L. LMP02 is the only site showing evidence of a seasonal trend, with higher concentrations during the dry season and lower concentrations during the wet season.

For BTEX (sum), DW3 and DW2 record the highest concentrations (medians of 247 and 178 µg/L respectively) followed by TC Sump, DW5 and DW6, with median concentrations between 37 and 86 µg/L. LP01, LP02 and LMP02 record negligible BTEX concentrations, with medians all less than 5 µg/L.

Phenols (total) are highest at DW3, TC Sump and DW5; all have medians above 0.96 µg/L. Whereas phenol concentrations at TC Sump, DW6, LP01 and LP02 are relatively low; medians all below 0.32 µg/L. LMP02 has always recorded phenols below the LOR i.e. <0.05 µg/L.

Contrary to TRH, BTEX and phenols, LMP02 records the highest PAH concentrations (up to 10.1 µg/L) followed by DW3 (up to 4.8 µg/L). All of this comprises the PAH compound naphthalene at both of these sites and therefore concentrations are all below the ANZECC (2000) trigger value for naphthalene of 90 µg/L. All the other sites record concentrations predominantly below the LOR. The cause of these incongruously high naphthalene concentrations at LMP02, compared to the pattern in other contaminants at this site, are not known, but may be unique to the Stage 1 and 2 landfill sources of leachate to this site, or the type of environment of this site, being a catchment drain leading to a sump (as opposed to a leachate dewatering well).

Apart from the seasonal trend in TRH at LMP02, there are no seasonal trends or long-term trends evident in the data for TRH, PAH, BTEX or phenols at any of the sites.

In summary, the Stage 3/4 landfill leachate sites record the highest contaminant concentrations (i.e. DW3, DW2 and TC Sump), in particular, DW3, which often records concentrations well above that of all the other sites. The preliminary data available for the Stage 5 landfill sites DW5 and DW6 indicate leachate here is of a similar quality to that of the Stage 3/4 landfill sites. The leachate pond sites LP01 and LP02 usually record contaminant concentrations lower than the Stage 3/4 and Stage 5 landfill sites, with LP02 recording higher concentrations than LP01. Where ANZECC (2000) trigger values are available usually record concentrations well above the trigger value. This is except for LMP02, which records dissolved metal concentrations below the respective trigger values. Contaminant concentrations at LMP02 are usually well below that of the other sites, although ammonia concentrations still remain well above the trigger value, and COD concentrations and the L/N ratio indicates this still is heavily impacted by leachate from the Stage 1 and 2 landfills.

As seen in the summary above, LMP02 has a strong seasonal pattern in contaminant concentrations, where concentrations typically increase over the course of the dry season, with the highest concentrations during the late dry season (September-December). Concentrations are usually lowest during the wet season (December to March). This is likely reflecting the changing relative proportions of surface water runoff to groundwater seepage reporting to this site, where:

- Fresh rainwater and runoff, which has had little contact time with the buried Stage 1 and Stage 2 landfill materials is lower in contaminants
- Infiltrated surface water and groundwater seepage that has had more contact with buried landfill materials has higher contaminant concentrations.

This was except for ferrous iron (II), which shows a seasonal pattern counter to this, indicating this parameter may be associated with surface water inputs and/or environmental conditions in the drain (i.e. the drain is excavated along the edge of the floodplain environment), and not reflective of leachate inputs.

### ***Limitations***

Of note in regard to the above summary, is that data for all leachate sites (except LMP02) is skewed towards the 2016/2017 monitoring period, given there is monthly data between July 2016 and April 2018, then no data until June 2019, then monthly data until March 2020. This is especially pronounced for the parameters that are only measured quarterly e.g. dissolved metals, nutrients, cations and anions, as these were only measured four times after sampling at these sites recommenced in June 2019. As such, the conclusions for these quarterly parameters could be said to represent mainly what was occurring at the site between July 2016 and April 2018. This includes any influences from how the landfills and the leachate were being managed at this time.

The above point is particularly important when considering the leachate pond (LP01 and LP02) data, where the southern leachate pond (LP02) generally has recorded higher concentrations compared to the northern leachate pond (LP01). LP01 also shows an increasing trend in contaminant concentrations (unrelated to seasons) between July 2016 and April 2018. This pattern is likely reflecting the specific operation of these ponds during the 2016/2017 period e.g. which pond was being filled, which was being drained, and which was being left un-used at the time.

Also, of note is that the data available for the Stage 5 landfill leachate sites DW5 and DW6 is very limited, with only a few sampling occasions since monitoring of these sites commenced in late 2019. As such, the characterisation of leachate directly sampled from the landfill dewatering points is skewed towards the Stage 3/4 landfill sites DW3, DW2 and TC Sump.

## 7.3 Surface water results

Direct sampling of surface water is undertaken for the monitoring program at five sites; as detailed above in Table 4-2 and shown in Figure 2-1  
Figure 2-1. In summary, the sites comprise:

- ‘GW Sump’ representing surface runoff from the green waste processing and storage area. This site also likely receives surface runoff from the Stage 3 and Stage 5 landfills. Water overflows from this sump into the nearby bushland offsite.
- Site ‘SW12’ is a catchment dam at the base of the north-west corner of the Stage 3/4 landfill, and represents surface runoff from the northern and western sides of this part of the landfill, and also possibly seepage from the within the Stage 3/4 landfill. Water from this catchment dam overflows into the offsite downstream environment following heavy rainfall, or is also often pumped out into the leachate reticulation system.
- Wash-down water from large commercial waste transport vehicles on exiting the SBWMF is represented by the site ‘Wheel Wash’. Water sampled from the wheel wash sump has prior passed through an oily water separator. Water from this sump is irrigated over the Stage 1 landfill area.
- Site ‘STG1&2’ represents surface runoff from central SBWMF areas, however it has only been possible to sample this site on two occasions, as it only flows during heavy rainfall. Water from this stormwater drain flows east offsite into the downstream wetland/floodplain environments.
- Monitoring of ‘SW2’ was initiated in 2015 in response to a seepage issue from the Stage 3/4 landfill. This issue has since been addressed and seepage at this location is no longer observed. Sampling of surface water site SW2 has only been possible once (i.e. November 2016) during the July 2016 to March 2020 monitoring period due to lack of water flow.

Given It has only been possible to sample site STG1&2 twice and SW2 once during the monitoring period, these sites have been excluded from the discussion below due to the small dataset and the inability to determine either seasonal or long-term trends through analysis. The following section concentrates on the SW12, Wheel Wash and GW Sump sites. In addition, a number of parameters (i.e. the majority of dissolved metals, nutrients, major cations and major anions) were only included in annual sampling of all the surface water sites and therefore have small datasets. Seasonal and long-term trend analysis has not been attempted for these annual parameters.

As per Section 4.6 above, assessment criteria for physical parameters and nutrients e.g. pH, total nitrogen (TN), nitrate+nitrite (NOx), total phosphorus (TP) and filterable reactive phosphorus (FRP), are taken from the *Water Quality Objectives (WQOs) for the Darwin Harbour Region – Background Document* (NRETAS 2010) for the ‘Upper Estuary’. ANZECC (2000) trigger values for 90% species protection in aquatic ecosystem (marine) have been used for toxicant parameters (i.e. dissolved metals, ammonia, PAHs etc.).

### 7.3.1 Physical parameters

Table 7-6 below provides the median physical parameter concentrations calculated for each site, based on all available data collected from July 2016 to March 2020. Individual parameters are further discussed below.

#### **pH:**

Median pH values for the three surface water sites are close to neutral and range from pH 6.67 at Wheel Wash to pH 7.47 at SW12.

Over the July 2016 to March 2020 monitoring period, surface water pH's predominantly remained within the WQO range of 6.0 to 8.5, with all three sites showing evidence of an increasing pH trend (i.e. more alkaline).

Increasing seasonal trends were identified at all three sites. The pH at all sites gradually rising during the

dry season, with the highest concentrations typically occurring during the late dry season (September), and lowest during the wet season (December to March). This trend is not at evident during the 2018/19 wet season, due to a drier than average wet season.

**EC:**

The Stage 3/4 catchment dam site, SW12, recorded the highest median EC of 2,284 µS/cm, followed by GW Sump with an EC of 839 µS/cm, and then Wheel Wash with an EC of 512 µS/cm. There is no WQO for EC, therefore results have not been assessed against a trigger value.

Over the July 2016 to March 2020 monitoring period, EC concentrations measured at each surface water site were variable from month to month, and none of the sites showed clear evidence of a long-term increasing or decreasing trend.

Wheel Wash is the only site with a clear seasonal trend in EC concentrations. Similarly, to pH, the EC at this site gradually increases during the dry season, with the highest concentrations typically occurring during the late dry season (September), and lowest during the wet season (December to March). This is likely due to the evapo-concentration of chemical constituents in the sump due to the increased rate of evaporation during the dry season and decreased requirement to pump-out the sump and irrigate over the Stage 1 landfill area.

**DO:**

Median DO concentrations for the surface water sites range between 9 and 55% saturation. This is relatively low for surface water bodies and is indicating a high oxygen demand possibly due to contaminants in the surface water and/or reflecting the fact that these are not flowing surface water bodies but are usually stagnating water contained within a pit/sump or dam.

**Table 7-6. Surface water site median physical parameter concentrations calculated for all data collected July 2016 – March 2019.**

Parameter	Units	SW12	Wheel Wash	GW Sump
pH	pH units	7.47	6.67	7.33
EC	µS/cm	2,284	512	839
DO	%sat	55	9	28
Temp	°C	29.0	30.3	30.2

**7.3.2 Dissolved metals**

Sampling of dissolved metals for the surface water sites occurred as part of the annual sample analysis suite, therefore seasonal trend analysis is not possible. The following discussion outlines the range of the results for the dissolved metals and comparison to the ANZECC (2000) trigger values. Iron (II) and (III), cadmium and nickel have been excluded from the discussion due to concentrations being below the LOR, or due to a lack of trigger values for comparison.

**Chromium:**

Chromium (VI) concentrations for all sites (where the LOR was 0.01 mg/L) were below the ANZECC (2000) trigger value, whereas chromium (III) concentration were at times, above the LOR and therefore above the trigger value of 0.049 mg/L.

Chromium concentrations do not appear to be increasing or decreasing over the long-term, at any of the surface water sites, based on the available data.

**Copper:**

Prior to February 2020, annual copper concentrations ranged from 0.001 to 0.005 mg/L, with no particular increasing or decreasing trend. Site SW12 was the only site to exceed the ANZECC (2000) trigger value of

0.003 mg/L, with a concentration of 0.005 mg/L on one occasion.

During the February 2020 annual sampling, all three sites were above the ANZECC (2000) trigger value. Sites SW12 and Wheel Wash were seven and nine times higher than the trigger value respectively. Wheel Wash water has variable water quality, which is likely due to the variance of vehicles and equipment being cleaned at the site.

SW12 is located at the north-west of Stage 3/4, and the elevated copper concentrations, are potentially indicating leachate impacts; either from the seepage of leachate from the landfill, or from surface water runoff flowing off the landfill that has picked up residues from the irrigation of leachate back onto the landfill.

**Manganese:**

Median manganese concentrations range from 0.07 mg/L at site GW Sump to 0.30 mg/L at site Wheel Wash. Manganese concentrations at the Wheel Wash site consistently exceed the ANZECC (2000) trigger value of 0.08 mg/L.

Similarly, to the copper concentrations, all three sites saw an increase in concentrations during the February 2020 annual monitoring event. Sites SW12 and Wheel Wash were 1.3 times and 5 times higher than the trigger value, respectively.

**Lead:**

Median lead concentrations ranged from below the LOR (<0.001 mg/L) to 0.003 mg/L between 2017 and 2019, with no particular increasing or decreasing trends across sites and no exceedances of the ANZECC (2000) trigger value of 0.0066 mg/L.

During the annual sampling event for 2020, sites SW12 and Wheel Wash recorded the highest lead concentrations since sampling began in 2016. Whilst site SW12 was under the ANZECC (2000) trigger value, the Wheel Wash site recorded a concentration almost four times higher than the trigger value. The GW Sump site recorded the lowest concentrations since sampling began (i.e. below the LOR). The monitoring results appear to be spikes in the data and no long-term increasing or decreasing trends in lead concentrations can be determined.

**Zinc:**

Median zinc concentrations ranged from below the LOR (<0.05 mg/L) to 0.087 mg/L between 2017 and 2019, with the Wheel Wash site recording an exceedance of the ANZECC (2000) trigger value of 0.023 mg/L on one occasion.

Similarly, to the other dissolved metals discussed above, the 2020 annual sampling event recorded exceedances of the trigger value at SW12 and Wheel Wash. There have been no exceedances of the zinc trigger value for the GW Sump site.

**7.3.3 Nutrients, organic content and oxygen demand**

Table 7-7 provides the median nutrient and organic content concentrations calculated for each site, based on all available data collected between July 2016 and March 2020. Individual parameters are further discussed below.

**Ammonium (NH<sub>4</sub>):**

The surface water samples are analysed for total ammonia as nitrogen (denoted as NH<sub>3</sub>-N) annually, and ammonium (NH<sub>4</sub><sup>+</sup> as N), monthly. See Section 7.1.3 of this report for an explanation as to the relationship of ammonia and its chemical species. Given the larger range of data available, NH<sub>4</sub> is discussed with a comparison to the annual ammonia concentrations to determine the approximate percentage of NH<sub>4</sub><sup>+</sup> within NH<sub>3</sub>-N.

Analysis of the NH<sub>4</sub><sup>+</sup> ion, identified that it was present in 95%, 98% and 97% of the ammonia concentrations at sites SW12, Wheel Wash and GW Sump, respectively. Therefore, the ANZECC (2000) trigger value

concentration of 1.2 mg/L can be applied to the NH<sub>4</sub> results.

The Wheel Wash site recorded NH<sub>4</sub> concentrations above the trigger value for 97% of the sampling events, with the highest concentration observed being 37.1 mg/L. SW12 recorded concentrations about the trigger value for 55% of the sampling events, and GW Sump site recorded concentrations above the trigger value for 30% of the sampling events.

Ammonium concentrations do not appear to be increasing or decreasing over the long-term.

**Total organic carbon (TOC):**

Wheel Wash recorded the highest median TOC concentration of 55.0 mg/L, followed by GW Sump with a concentration of 45.5 mg/L and then SW12 with a concentration of 37.0 mg/L. The quality of water within the Wheel Wash site is directly related to the variability of vehicles and machine that use the facility. The Wheel Wash site was the only site to have a general seasonal trend, with the highest TOC concentrations occurring towards the start of the dry season and the lowest in the wet season. Similarly, to EC, this is likely due to the evapo-concentration of chemical constituents in the sump due to the increased rate of evaporation during the dry season and decreased requirement to pump-out the sump and irrigate over the Stage 1 landfill area.

TOC concentrations do not appear to be increasing or decreasing over the long-term.

**Chemical oxygen demand (COD):**

ANZECC (2000) does not specify guideline values for COD given this is not strictly a toxicant, although high concentrations can indicate high inputs of organic matter to waterways, and can lead to eutrophication.

COD is consistently highest at the Wheel Wash site, recording a median concentration of 253 mg/L, compared to GW Sump with a median concentration of 228 mg/L, and SW12 with a median concentration of 110 mg/L.

COD concentrations do not appear to be increasing or decreasing over the long-term at any of the surface water sites.

**Alkalinity:**

ANZECC (2000) does not specify guideline values for alkalinity given this is not strictly a toxicant, rather a parameter which aids in the determination of acid-neutralising capacity of the water system.

Alkalinity is consistently highest at the GW Sump site, recording a median concentration of 173 mg/L, compared to Wheel Wash, which has a median concentration of 143.5 mg/L, and SW12 which has a median concentration of 130.5 mg/L.

Alkalinity concentrations do not appear to be increasing or decreasing over the long-term at any of the surface water sites.

**Table 7-7. Surface water site median nutrients, organic content and oxygen demand concentrations calculated for all data collected July 2016 – March 2019.**

Parameter	Units	SW12	Wheel Wash	GW Sump
Ammonium	mg/L	1.70	7.21	2.03
TOC	mg/L	37	55	45.50
COD	mg/L	110	235	228
Alkalinity	mg/L	130.50	143.50	173

**7.3.4 Hydrocarbons and other miscellaneous parameters**

Hydrocarbon concentrations (i.e. total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and total phenolics) and other parameters such as RDX and TNT, for all sites had concentrations below the LOR.

Refer to the SBWMF water monitoring database for further information regarding the LOR limits and concentration results.

## 7.4 Summary of surface water results

There are elevated concentrations of surface water parameters across the SBWMF, which appear to be influenced by their location at the site and their proximity to specific operational areas of the landfill.

There do not appear to be any long-term increasing or decreasing trends in surface water quality parameters for the 2016 – 2020 dataset. However, a spike in surface water data was observed in February 2020 with several metals exceeding the ANZECC (2000) trigger values at the SW12 and Wheel Wash sites, in concentrations higher than during previous annual monitoring events. This was particularly the case for copper, lead and zinc concentrations. The cause of this spike cannot be determined based on the scant data i.e. only annual. If metals were analysed monthly at these sites during the wet season, it may be evident that concentrations similar to those measured during February 2020 occur more frequently and have also occurred in the past, however no seasonal trends can be determined from the dataset.

Some seasonal trends were observed for surface water parameters, which are expected given the nature of wet season dilution/mobilisation of certain parameters, and dry season concentration of certain parameters.

A summary of key findings identified in the above analysis for the three surface water sites is provided in Table 7-8.

**Table 7-8. Summary of key findings for surface water sites.**

Monitoring sites	Summary of observations	Justification/Inference
SW12	Surface waters tend to have high EC in comparison to WQOs and in comparison, to other sites. Copper, zinc and NH <sub>4</sub> concentrations have exceeded their respective ANZECC (2000) trigger values.	When a seasonal trend was identified, concentrations of contaminants were higher during the wet season, when runoff was occurring from Stages 3/4. SW12 is known to overflow during the wet season to the receiving environment (bushland located to the west and north-west of the site).
Wheel Wash	EC concentrates during the dry season and displays a seasonal trend. The copper concentration recorded during the 2020 monitoring event was higher than previous recorded concentrations and was nine times the ANZECC (2000) trigger value. Manganese, lead, zinc, NH <sub>4</sub> and concentrations have exceeded their respective trigger values. TOC and COD concentrations are higher at Wheel Wash compared to other surface water sites. Spikes in data have been observed, however no consistent seasonal trends have been observed with the exception of EV values.	The variability of vehicles and equipment cleaned at the site is introducing a number of physical and chemical compounds to the water. Seasonal trend in increased EC during the dry season is a result of concentration as evaporation rates are higher. Water from the Wheel Wash is irrigated across Stage 1.
GW Sump	NH <sub>4</sub> concentrations exceeded the ANZECC (2000) trigger values on 30% of monitoring events, which is less than SW12 and Wheel Wash sites. TOC and COD were similar to Wheel	The site is close to the green waste section of SBWMF, which account for the high TOC and COD concentrations in comparison to SW12. GW Sump is known to overflow during the wet season to the receiving environment (i.e. bushland to the west of site).

	<p>Wash, and therefore higher than SW12.</p> <p>Seasonal trends were easily attainable for this site. There was no indication of long-term increasing or decreasing concentrations.</p>	
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## 7.5 Groundwater results

Groundwater monitoring during the July 2016 to March 2020 monitoring period involved the sampling of over 40 bores on a predominantly monthly basis. This network of groundwater monitoring bores installed across the SBWMF is described in detail in Section 4.3.1 above and locations shown in Figure 2-1. Even taking out bores which were dry periodically, this has equated to more than 730 samples, with each of these samples analysed for more than 30 parameters. As such, presenting and describing this dataset in a succinct way that highlights the key issues and trends is difficult. Given this, only the key median concentrations are included in the discussion below and key trends presented in the graphs in Appendix B. For further detail regarding the data used to derive the interpretations below, please refer to the SBWMF water quality monitoring database.

### 7.5.1 Physical parameters

#### **pH:**

pH in groundwater across the site predominantly remains within the range of 4 to 7 i.e. acidic to neutral. This pH range is typical of the lateritic surface groundwater aquifers in the Darwin region. Three bores however, consistently record extremely alkaline pH's well above this range: GW1-12, (median pH of 11.86), GW4-12 (median pH of 11.12) and GW15-12 (median pH of 9.01). These alkaline pH values cannot be explained by any natural aquifer features or even the ingress of leachate. It is suspected that these bores are contaminated with the cement grout used to seal the annulus of the bores (between the screened interval and surface) after they were installed.

In regards to the other non-cement impacted bores, with median pHs between 4 and 7, two of these bores record relatively acidic median pH values: GW3-3 located to the east of the leachate storage ponds, and WW1 located on the eastern edge of Stage 3/4, which recorded a pH median value of less than 4. This is likely reflecting the pH of the surface water runoff directly infiltrating into the groundwater at these locations, with the acidity derived from the acidic nature of rainwater in the Darwin region.

A further 29 bores record mildly acidic median pH values (between 4 and 6). These are located across the entire site and include all three deep bores drilled to 30 m, as well as shallow (3 m) and mid-depth (12 m) bores.

The remaining six bores record close to neutral median pH's i.e. between 6 and 7: GW3-12, GW5-3, GW5-12, GW7-12, GW8-3 and GW12-3. All these bores are located on the eastern boundary of the site, with the exception of GW12-3, which is located on the western boundary.

#### **EC:**

The range in EC concentrations measured in bores across the site is extreme; with median concentrations ranging from very fresh (31.1  $\mu\text{S}/\text{cm}$ ) to hypersaline (78,024  $\mu\text{S}/\text{cm}$ , which is higher than the salinity of seawater). Two sites with the highest EC values are GW8-12 (median 78,024  $\mu\text{S}/\text{cm}$ ) located to the south-east of the site adjacent to the Principal Depot, and WW6 (median 68,246  $\mu\text{S}/\text{cm}$ ), located at the north-west corner of the Stage 3/4 landfill, i.e. on opposing sides of the site. These EC's are extremely high considering the highest median EC for leachate is 25,051  $\mu\text{S}/\text{cm}$ . Potentially the cause of these extreme EC's is a combination of seawater intrusion and leachate impacts.

Bores recording median EC values above 10,000  $\mu\text{S}/\text{cm}$  comprise GW1-12 and GW7-12, located on the eastern boundary, GW14-12 located on the north-western boundary and to the west of Stage 4, and WW13 located on the northern boundary and adjacent to the leachate storage ponds. Saltwater intrusion from tidal influence to the north of the site may be influencing some of these bores.

GW6-30, located within the middle of the site, and screened within the deeper sandstone aquifer below 20 m, recorded the lowest median EC value of 31.1  $\mu\text{S}/\text{cm}$ . Bores towards the southern boundary of the site GW9-12, GW10-3 and GW10-12, GW11-3 and GW11-12, were also relatively fresh; all recording median EC

values below 140  $\mu\text{S}/\text{cm}$ .

**DO:**

DO median concentrations were almost always less than 50% saturation, with the median ranging between 6.8 and 66.7% saturation. Low DO is expected in groundwater given it has been out of contact with oxygen in the atmosphere for a period of time.

## 7.5.2 Dissolved metals

Sampling of dissolved metals for the groundwater sites occurred as part of the quarterly and annual monitoring rounds. The following discussion outlines the range of results and comparison to the ANZECC (2000) guidelines. Median values that predominantly record concentrations below the limit of reporting (i.e. iron (Fe(II) and Fe(III) chromium (Cr(III) and Cr(VI)) are not discussed in further detail. In general, seasonal trends were not able to be determined, with the exception of WW6 and GW8-12.

**Cadmium:**

Cadmium median concentrations ranged between 0.0001 mg/L and 0.0157 mg/L. Most of the bores record median cadmium concentrations below the LOR (i.e. <0.001 mg/L). Three bores however, record elevated dissolved cadmium. WW6 recorded the highest median concentration of 0.0157 mg/L, which is above the ANZECC (2000) trigger value of 0.014 mg/L. This was followed by GW8-12 and WW13, with median concentrations of 0.0044 mg/L and 0.0016 mg/L respectively. Significantly, these concentrations are higher than those recorded in the leachate (see Section 7.1.2 above). The leachate recorded dissolved cadmium concentrations mainly below the LOR (<0.001 mg/L), however it is suspected that cadmium is in fact present in the leachate, it is just bound to the suspended and organic material and not in the dissolved form. When leachate enters the more acidic groundwater environment, with lower TOC concentrations, potentially the cadmium becomes more soluble.

Clear seasonal trends were evident at both sites WW6 and GW8-12, with increased cadmium concentrations observed mid-wet season and decreased concentrations around the mid-dry season. No evidence of long-term increasing or decreasing trends were evident.

**Manganese:**

Manganese median concentrations ranged between 0.001 mg/L and 53.9 mg/L. The site with the highest median manganese concentration, above the ANZECC (2000) trigger value of 0.08 mg/L, was WW6, with a concentration of 53.90 mg/L. The historic manganese concentrations for WW6 range from 49.9 mg/L to 61.4 mg/L, which is significantly higher than all other monitoring sites. Similarly, to cadmium, these manganese concentrations are several times higher than what is recorded in the leachate. Potentially, insoluble manganese contained within the leachate also becomes more soluble in the acidic, lower TOC groundwater environment.

GW14-12 recorded the next highest median manganese concentration of 3.44 mg/L. Other sites that recorded results above the trigger value were GW7-3, GW7-12, WW7 and WW9.

A clear seasonal trend was observed at WW6, with increased manganese concentrations observed mid-wet season and decreased concentrations around the mid-dry season. No long-term increasing or decreasing trends were observed.

**Copper:**

Median copper concentrations ranged between 0.001 mg/L and 0.061 mg/L. WW6 and GW8-12 recorded the highest median concentrations across groundwater bores of 0.061 mg/L and 0.045 mg/L respectively. These results were above the ANZECC (2000) trigger value concentration of 0.003 mg/L. The highest copper concentrations at these bores were observed during the January 2020 monitoring round.

Copper concentrations were recorded above the LOR at the majority of bores during the July 2016 to March 2020 monitoring period, with 60% of the 40 bores recording median values above the trigger value, with the

exception of GW4-30 and GW5-12, which consistently record copper concentrations below the LOR.

Clear seasonal trends were not observed at any of the groundwater bores, nor were any long-term increasing or decreasing trends.

#### **Nickel:**

Median nickel concentrations ranged between 0.001 mg/L and 1.25 mg/L. The site with the highest median nickel concentration, above the ANZECC (2000) trigger value of 0.2 mg/L was WW6, with a concentration of 1.25 mg/L. Nickel concentrations at WW6 are consistently above the trigger value, with concentrations increasing during the wet season and decreasing during the dry. Median nickel concentrations for all other bores were below the trigger value, however concentrations are predominantly above the LOR.

Seasonal or long-term increasing or decreasing trends were not observed for any other monitoring bores.

#### **Lead**

Median lead concentrations ranged between 0.001 mg/L to 0.013 mg/L. WW6 has recorded the highest median lead concentration, which exceeds the trigger value of 0.0066 mg/L. The median lead concentration for WW13 (0.008 mg/L) also exceeds the trigger value.

Most of the remaining bores reported concentrations consistently below the LOR. Seasonal trends were not identified, nor were any long-term increasing or decreasing trends.

#### **Zinc**

Median zinc concentrations ranged between 0.005 mg/L to 2.64 mg/L. The site with the highest median nickel concentration was WW6, with a concentration of 2.64 mg/L, almost 115 times above the ANZECC (2000) trigger value of 0.023 mg/L.

The majority (i.e. 80%) of groundwater bores recorded median zinc concentrations that exceeded the trigger value. Bores that did not exceed the trigger value include GW1-12, GW3-3, GW4-12, GW10-12, GW11-3, GW12-3, GW12-12 and GW15-3.

Seasonal or long-term increasing or decreasing trends were not observed for any monitoring bores.

### **7.5.3 Nutrients, organic content and oxygen demand**

#### **Ammonia (NH<sub>3</sub>) and Ammonium (NH<sub>4</sub>):**

The un-ionised species of ammonia can be harmful to aquatic organisms whilst the ionised ammonium is relatively harmless. As NH<sub>3</sub> is considered a toxicant, the ANZECC (2000) guidelines have adopted a trigger value 1.2 mg/L, whereas there is no guideline value for NH<sub>4</sub>.

NH<sub>3</sub> is frequently detected in all of the groundwater bores on-site, however over the review period it has only been detected at concentrations above the guideline value in GW7-3, GW8-3, GW8-12, GW13-12 and WW6. Within these bores, NH<sub>3</sub> was detected at median concentrations ranging from 1.37 mg/L (WW6) to 3.70 mg/L (GW7-3).

As previously discussed, there is a relationship between the proportion of NH<sub>3</sub> and NH<sub>4</sub> in any given sample, which is driven by pH and temperature. However, the database does not always include NH<sub>3</sub> concentrations for the same monitoring rounds as NH<sub>4</sub> concentrations, making it difficult to infer any relationship. Overall, the bores impacted by NH<sub>3</sub> concentrations above the trigger value were also found to have similar median concentrations of NH<sub>4</sub>, with the exception of GW8-3. The median concentration of NH<sub>3</sub> detected in GW8-3 was 3.66 mg/L, whilst NH<sub>4</sub> was 7.56 mg/L.

#### **Nitrate (NO<sub>3</sub>):**

There is no trigger value for nitrate. Nitrate was detected frequently in all of the groundwater bores however in the majority of bores it was at median concentrations of less than 1 mg/L. Bores GW2-3, GW5-3, GW6-12, GW7-3, GW8-3, GW14-3, WW1, WW3, WW5, WW7 and WW10 all have median nitrate concentrations

above 1 mg/L, with concentrations ranging from 1.05 mg/L (WW10) to 14.5 mg/L (WW1).

**Total organic nitrogen (TON):**

There is no guideline value for TON. TON was detected frequently in all of the groundwater bores however in the majority of bores it was at median concentrations of less than 1 mg/L. Bores GW7-3, GW8-3, GW12-3, WW1, and WW7 all have median TON concentrations ranging from 1.3 mg/L (WW7) to 2.6 mg/L (WW1).

**Filterable reactive phosphorus (FRP):**

Results for FRP have only been provided from December 2017 to March 2019. Based on this dataset, FRP was only frequently detected above the LOR in GW2-12, GW4-30, GW5-12, GW7-12, GW12-3, WW1, WW6 and WW7. Where concentrations of FRP were detected, the median concentration was found to be above the trigger value of 0.05 mg/L in GW5-12 (0.05 mg/L), GW12-3 (0.09 mg/L), WW1 (0.17 mg/L) and WW6 (0.12 mg/L).

**Total organic carbon (TOC):**

There is no trigger value for TOC. TOC was detected at concentrations above the LOR in approximately 50% of the groundwater bores. Where TOC concentrations were recorded, it was at concentrations of less than 2 mg/L in all bores with exception to GW6-3, GW7-3, GW8-3, GW12-3, GW13-12, GW14-3 and WW7. Within these bores, the concentration of TOC ranged from 4 mg/L (GW6-3 & GW13-12) to 23 mg/L (GW12-3).

**Chemical oxygen demand (COD):**

The median concentrations of COD recorded were variable across all bores ranging from 5 mg/L to over 200 mg/L, with the highest concentration recorded at WW6 (206.5 mg/L). WW6 recorded the highest COD concentration observed throughout the monitoring program of 7,000 mg/L in July 2016.

## 7.5.4 Anions, cations and L/N ratio

**Sodium:**

There is no trigger value for sodium. Median sodium concentrations ranged between 2 mg/L and 16,500 mg/L, with the highest median concentrations recorded at GW8-12 (16,500 mg/L) and WW6 (13,600 mg/L).

Sodium was observed to be consistently high at GW2-12, GW7-12, GW14-12, WW5 and WW13, ranging from 1,410 mg/L at WW5 to 3,570 mg/L at GW2-12.

**Potassium:**

There is no trigger value for potassium. Median potassium concentrations ranged between 1 mg/L and 377 mg/L, with the highest median concentrations recorded at GW8-12 (377 mg/L), and WW6 (233 mg/L).

Potassium was observed to be consistently high at GW2-12, 4-12, 7-3, 7-12, 8-3, 8-12, 12-3, 14-12 and WW6, ranging from 32 mg/L at GW2-12 to 377 mg/L at GW8-12.

**Calcium:**

There is no trigger value for calcium. Median calcium concentrations ranged between 1 mg/L and 1,460 mg/L, with the highest median concentrations recorded at WW6, and GW8-12 (1,060 mg/L).

Calcium was observed to be consistently high at GW2-12, GW4-12, GW7-3, GW7-12, GW8-3, GW8-12, GW12-3, GW14-12 and WW6.

**Magnesium:**

There is no guideline value for magnesium. Median magnesium concentrations ranged between 0.6 mg/L and 2080 mg/L, with the highest median concentrations recorded at GW8-12 (2,080 mg/L), and WW6 (1,840 mg/L).

Magnesium was observed to be consistently high at GW2-12, 7-12, 8-12, 14-12 WW5, WW6 and WW13, ranging from 124 mg/L at GW7-12 to 2,080 mg/L at GW8-12.

**Sulfate:**

There is no trigger value for sulfate. Median sulfate concentrations ranged between 1 mg/L and 3625 mg/L, with the highest median concentrations recorded at GW8-12 (3,625 mg/L), and WW6 (3,025 mg/L).

Sulfate was observed to be consistently high at GW2-12, GW7-12, GW8-12, GW14-12 WW5, WW6, WW7 and WW13, ranging from 222 mg/L at WW7 to 3,625 mg/L at GW8-12.

**Alkalinity:**

There is no trigger value for alkalinity. Median alkalinity concentrations ranged between 1 mg/L and 909 mg/L, with the highest median concentrations recorded at GW1-12 (909 mg/L), and GW8-3 and GW8-12 with median alkalinity concentrations of 276 mg/L and 273 mg/L, respectively.

Alkalinity was observed to be consistently high at GW1-12, GW7-12, GW8-3, GW8-12, GW12-3, GW14-12, WW5, WW6, WW7 and WW13, ranging from 124 mg/L at GW7-12 to 909 mg/L GW1-12.

**Chloride:**

There is no trigger value for chloride. Median chloride concentrations ranged between 4 mg/L and 29,550 mg/L, with the highest median concentrations recorded at GW8-12, and WW6 with a median concentration of (25,900 mg/L), in comparison the next highest median concentration was at GW2-12 (6,980 mg/L).

Chloride was observed to be consistently high at GW2-12, GW7-12, GW8-12, GW14-12, WW5, WW6 and WW13.

**L/N ratios:**

L/N ratios, calculated within the SBWMF database identified that the following bores, consistently exceeded the L/N ration of 10:

- GW6, GW12 and GW13, nested bores at all depths.
- GW7, GW8, GW10 and GW11 in the shallow bores (3 m)
- GW9-12 (singular bore).

Given Bores GW9-12, GW10-3 and GW11-3 are up-gradient of the site and not subject to any leachate impacts, the validity of this L/N ratio is questionable.

## 7.5.5 PFAS

Several PFAS substances were detected above limits of reporting, predominantly at GW8-3 and GW13-12.

PFOS was detected above the LOR at sites GW7-12, GW8-3, GW11-12, GW12-12 and GW13-12. GW8-3 recorded PFOS above the PFAS NEMP recreational water guidance value (0.07 µg/L) during both instances where it was sampled (i.e. concentrations of 0.32 µg/L and 0.47 µg/L).

## 7.5.6 Hydrocarbons

Hydrocarbon concentrations (i.e. total petroleum hydrocarbons, polycyclic aromatic hydrocarbons) for all sites had concentrations below the LOR. Refer to the SBWMF water monitoring database for further information regarding the LOR limits and concentration results.

## 7.6 Summary of groundwater results

There are elevated concentrations of groundwater parameters across the SBWMF, which appear to be influenced by their location at the site and their proximity to specific operational areas of the landfill, as well as the specific aquifer depth.

In particular, six out of the 40 existing groundwater monitoring bores have recorded consistently high levels of various parameters. These are GW2-12, located to the north-east of the leachate ponds, G8-12 located to

the east of the Stage 1 landfill, GW14-3, GW14-12, WW6 and WW7 located to the north-west of the Stage 3/4 landfill, and WW13 located on the northern site bound and to the south-west of the leachate ponds. A summary of key findings identified in the above analysis for these six groundwater bores is provided in Table 7-9.

Bores WW6 and GW8-12 recorded consistently elevated concentrations of various parameters in comparison to other monitoring bores, with several exceedances of guideline trigger values. These bores are located at different area within SBWMF, however they are both in close proximity to landfills, i.e. WW6 located to the north-west of the Stage 3/4 landfill and GW8-12 located on the eastern site boundary adjacent to the Stage 1 landfill.

Bore WW6 is a deep bore at 20.4 m and is in close proximity to WW7 and the nested GW14, which are 12 m or less in depth. Both WW7 and GW14 recorded several elevated parameter concentrations in comparison to other bores located across SBWMF, however not to the extent of WW6.

There were some observable seasonal trends for EC and certain metals at WW6 and GW8-12 with concentrations increasing in the mid-wet season and reducing in the dry season. There do not appear to be any long-term increasing or decreasing trends in groundwater quality parameters for the 2016 – 2020 dataset.

There is currently no offsite upstream groundwater quality data available for use as a comparison of background water quality, however bores GW10 (3 and 12 m), GW11 (3 and 12 m) and GW9-12 are located on the southern boundary of SBWMF and correlate with the high groundwater levels identified in Figure 6-2.

Groundwater in these bores is of consistently good quality compared to the majority of bores within SBWMF, with low EC and below trigger value zinc concentrations. However, GW9-12, GW10-3 and GW11-3 consistently exceed the L/N ratio of 10, which is recommended for removal from the future monitoring program (see Section 9.1). Additionally, GW11-3 was one of five bores to record PFOS concentrations above the limit of detection.

**Table 7-9. Summary of key groundwater sites**

Monitoring sites	Summary of observations	Justification/Inference
GW2	GW2-12 recorded high levels of some dissolved metals, in particular zinc. High levels of anion and cation concentrations were also observed; however, L/N ratios are below 10.	The higher concentrations of anions and cations indicate that there is likely saline intrusion, due to GW2-12 position, north of the SBWMF. The GW2 bores are located on the boundary of SBWMF with bushland to the north and east.
GW8	GW8-12 recorded high levels of some dissolved metals i.e. cadmium, copper (above ANZECC (2000) trigger value) and zinc. EC values are highly saline and ammonia concentrations are above trigger values. High levels of anions and cations were common. L/N ratios commonly exceed 10.	Leachate ingress is likely in this area of SBWMF, due to GW8's positioning, east of the unlined Stage 1 landfill and south of leachate site LMP02. The GW8 bores are located on the boundary of SBWMF with bushland to the east.
WW6, WW7, GW14	WW6 recorded several exceedances of trigger values for cadmium, nickel, lead, zinc and ammonia. WW6 also had higher COD than all other bores and highly saline EC values. WW7 and GW14 had high EC and anion and cations including sodium, manganese, calcium, sulfate and alkalinity.	This cluster of monitoring bores is located on the north-western boundary of SBWMF and the Stage 3/4 landfill. Leachate activity and ingress is likely in this particular area due to the exceedance in ANZECC (2000) guidelines, high COD and ammonia. As surface and groundwater flows during the wet season flow towards the north-west (see Figure 6-2), the receiving environment (undisturbed bushland located to the west and north-west of the site) is of importance.

<p>WW13</p>	<p>WW13 recorded high EC, cadmium and lead, as well as some cations and anions (sodium, magnesium, sulfate, alkalinity and chloride).</p>	<p>WW13 is located on the northern boundary of the site and to the immediate south-west of the lined leachate treatment ponds. It is unlikely that the leachate treatment ponds are influencing WW13. Groundwater contours identified in Figure 6-2 indicate WW13 may be influenced by the Stage 3 landfill. The receiving environment to the north is undisturbed bushland.</p>
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## 8 GROUNDWATER AND SURFACE WATER IMPACTS

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Leachate is generated throughout the SBWMF and is of a quality that is indicative of an active landfill site. This leachate has the potential to impact on surface and groundwater quality within the SBWMF and in the receiving environment.

The SBWMF is located on a low-lying peninsula with tributaries from the Leanyer Swamp located on the western and eastern boundaries of the site. Hydrogeological modelling detailed in Section 6 indicates that groundwater's flow in an eastern and north-eastern, and western direction across the site and towards the Leanyer Swamp tributaries and surrounding bushland i.e. the receiving environment (see Figure 6-2). Surface water mimics this general flow direction, from the southern extent of the site to the north-east and north-west towards Leanyer Swamp, as well as being directed across the site to its boundaries through drainage resulting from site infrastructure.

The high ammonia, TOC, COD and BOD found in the leachate have the potential to lead to eutrophication of waterways downstream. Additionally, the high metals, ammonia, hydrocarbons and PFAS in leachate can be toxic to aquatic organisms downstream.

Leachate is produced through landfilling activities and the decomposition and degradation of waste. Leachate is captured in sumps across the site and then managed according to the specific area of the SBWMF including:

- Stage 1/2: Intercepted leachate is pumped to a surface irrigation system operated within the plateau area of Stage 1. This area is unlined.
- Stages 3 to 6: Leachate from each sump is pumped through a rising main to two 15 ML covered leachate storage ponds (Northern Pond and Southern Pond). These ponds are lined and contain a leachate detection system.
- Stage 3/4: Leachate from the storage ponds is pumped to a surface irrigation system operated within the plateau area of Stage 3/4, which is lined.

The location of these landfills correlates with the surface and groundwater flow directions (i.e. Stage 1 and 2 landfills correlate with the eastern and north-eastern flow direction, and Stage 3 and 4 landfills correlate with the western flow direction, see Figure 6-3). A number of surface and groundwater monitoring sites are located down gradient of these landfills to provide an indication of impacts to water quality as a result of leachate generation. These landfills, their corresponding flow directions and monitoring locations are discussed in the following sections.

### 8.1 Stage 1 and 2 landfills

Surface and groundwater flows along the eastern and north-eastern boundary of the site (see Figure 6-2). These offsite directional flows correlate with the location of the Stage 1/2 landfills, which are unlined. Leachate is intercepted through a sub-surface toe drain, collected in a sump and irrigated across the Stage 1 plateau. The nested groundwater bores GW4, GW5, GW7 and GW8 are considered down gradient of this area based on the hydrogeological modelling and are along the eastern boundary of the site. The leachate monitoring site LMP02 is to the east of the Stage 1 landfill and there are no surface water sites downstream of the Stage 1/2 landfills or along the eastern site boundary.

LMP02 is a leachate collection sump however it also receives surface water runoff that has not come in contact with landfill wastes, and therefore generally has the lowest contaminant concentrations off all the leachate monitoring sites. Water at LMP02 therefore has a seasonal pattern for several analytes, where concentrations are high during the dry season and lower during the wet season (i.e. EC, metals, TOC, COD, BOD, chloride, alkalinity, potassium, sodium and TRH).

Dissolved metal concentrations recorded at LMP02 are usually below the relevant ANZECC (2000) trigger values, however ammonia concentrations consistently exceed the trigger values. PFAS concentrations in the Stage 1/2 landfills reflect older landfill signatures with the average PFOS+PFHxS concentration well above the PFAS NEMP recreational guideline, which pre-date the phasing out of these PFAS species for use in products.

Based on the results for LMP02, there is a possibility that some contaminants would be entering the receiving environment surface waters above trigger values and therefore at concentrations that could cause environmental harm.

Nested groundwater bores GW4 and GW5, which are located to the east of Stage 2 and to the north-east of Stage 2, had relatively good water quality with no exceedances of trigger values. These results indicate that groundwater down gradient of the Stage 2 landfill is not reflecting influences of leachate water at the nested GW4 and GW5 monitoring bores, which monitor water at 3 m and 12 m depths. There is no deep (30 m) bore located on the site boundary adjacent to the Stage 2 landfill, therefore impacts to depth cannot be determined.

GW7 located on the eastern boundary between the Stage 1 and 2 landfills recorded elevated analyte concentrations at particular depths. The shallow 3 m bore recorded manganese concentrations above the trigger value and elevated nutrient concentrations (ammonia, nitrate and TON), while the 12 m bore recorded elevated EC, cations and anions. The groundwater quality at GW7 represents similar concentrations to the LMP02 leachate water.

The GW8 nested bore recorded some of the highest concentrations of analytes at SBWMF. GW8-12 in particular has very high EC (greater than seawater) and recorded dissolved metal (cadmium, copper and zinc) and ammonia concentrations above the trigger values, and consistently high anions and cations. While GW8-3 did not reflect these results, the concentrations at GW8-12 indicate seepage from the Stage 1 landfill which is unlined.

Whilst there are no surface water monitoring sites along the eastern site boundary, the Meckitt Creek floodplain is located to the east of SBWMF and surface and groundwater's will flow towards this system, however as no monitoring has occurred beyond the site boundary, it is not known if the receiving environments water quality is being effected.

## 8.2 Stage 3 and 4 landfills

Surface water and groundwater flows along the western site boundary, and are particularly isolated within the north-western corner of the site (see Figure 6-2). These offsite directional flows correlate with the location of the Stage 3/4 landfills, and positioning of groundwater monitoring sites WW6, WW7 and GW14. Leachate is monitored at DW2, DW3 and TC Sump for the Stage 3/4 landfills. Surface water is monitored at SW12 and SW2 which are both considered downstream of the Stage 3/4 landfills. Surface water from SW12 on the western site boundary of the Stage 3/4 landfills, is known to overflow during high rainfall events to bushland immediately west of the site.

Leachate contaminant concentrations are generally always highest at the Stage 3/4 landfill site DW3 for all leachate monitoring points. Groundwater bore WW5 and the surface water site SW2 are considered down gradient monitoring sites from DW3, however no data is available from SW2 due to sampling constraints and groundwater quality at WW5 is not reflective of the DW3 results.

Bores located down gradient of the Stage 3/4 landfills and adjacent to DW2 include WW6, WW7 and GW14, all of which indicate some water quality results influenced by leachate. WW7 and GW14 had high EC, manganese, nutrient, and anion and cation concentrations, with some analytes exceeding the trigger values. WW6 in particular recorded several exceedances of trigger values for cadmium, nickel, lead, zinc and ammonia. WW6 also had higher COD than all other bores across SBWMF and highly saline EC values (greater than seawater). WW6 is constructed to 20.4 m, which is deeper than the adjacent WW7 (5.8 m) and GW14 (3 m and 12 m) bores. Seepage from the Stage 3/4 landfills is entering this deeper aquifer and influencing water quality.

Despite the lining of the Stage 3/4 landfill, water quality data indicates that leachate migration is likely considering the topographic conditions, historic landfilling activities and location of the leachate collection points on the western boundary of the site. The Leanyer Swamp and Buffalo Creek are down gradient of flows from the western catchment of SBWMF, however as no monitoring has occurred beyond the site boundary, it is not known if the receiving environments water quality is being effected.

Improved leachate capture, particularly to control seepage to groundwater, as well as improved practices to reduce leachate runoff to surface waters is required to prevent impacts to the receiving environment.

# 9 MONITORING PROGRAM REVIEW

## 9.1 Review of parameters and analytes

Based on the above characterisation in Section 7, certain parameters and analytes are considered most useful in indicating impacts to water quality from SBWMF operations, whilst some analytes have been identified as unnecessary and therefore recommended for removal from the monitoring program. Table 9-1 provides a summary of the review of monitoring program parameters and analytes, and indicates those recommended for inclusion and removal in the program going forward.

It is proposed that the parameters listed in Table 9-1 for inclusion in future monitoring programs, be analysed consistently in all leachate, surface water and groundwater sampling for simplicity. The current arrangement of differing parameter suites that change depending on whether the site is leachate, surface water or groundwater, and also different between monthly, quarterly and annually is over complicated and leads to mistakes in sample preparation, sample submission to the laboratory and data entry. Having the same, consistent set of key parameters for all sampling at all times will also assist with streamlining data review and analysis.

**Table 9-1. Monitoring program parameters and analyte review summary**

Parameter / analyte	Review summary
<b>Parameters and analytes recommended for inclusion in future monitoring programs</b>	
Physical parameters (i.e. pH, temperature, EC and DO)	Very important for determining factors that can influence the behaviour of chemical constituents e.g. solubility.
Ammonia (NH <sub>3</sub> as N)	Concentrations are extremely elevated in landfill leachate, generally more than 1000x the ANZECC trigger value, and concentrations of this magnitude are unlikely to derive from natural sources.
Nitrate (NO <sub>3</sub> ), nitrite (NO <sub>2</sub> ) and nitrate+nitrite (NO <sub>x</sub> )	To date only NO <sub>3</sub> is included in the monitoring program, however review of the historic raw lab data, where both NO <sub>2</sub> and NO <sub>3</sub> are available shows NO <sub>2</sub> also makes up a significant proportion of the oxidised nitrogen in leachate. Only measuring and recording NO <sub>3</sub> in the database has meant a significant proportion of the oxidised nitrogen is not known. It is proposed that nitrite be added to the monitoring program.
COD	Concentrations are extremely high in the landfill leachate and concentrations of this magnitude are unlikely to derive from natural sources. BOD is generally correlated with COD, and it is not considered necessary to measure both.
Dissolved metals (chromium, copper, nickel, lead and zinc)	Concentrations are extremely high in the landfill leachate and concentrations of this magnitude are unlikely to derive from natural sources. Note that: cadmium (dissolved) is always very low in the leachate, but this is possibly because it is existing in the solid phase and/or sorbed to the suspended and organic matter. It is proposed that 'total' cadmium be measured as a trial in future monitoring rounds.
PFAS	Concentrations are high in the landfill leachate and it is only possible for PFAS to derive from un-natural sources. The particular PFAS species present can also be useful in determining the source of the contamination e.g. PFBS from Stage 3/4 landfill and PFOS from Stage 1 and 2 landfills.
TRH and BTEXN	Concentrations are relatively high in the landfill leachate, and it is unlikely these can derive from natural sources. Note that the individual TRH fractions and BTEXN compounds e.g. benzene, toluene etc need to be recorded in the database. The BTEX (sum) concentration has limited value and cannot be compared against the individual ANZECC (2000) guidelines for each of the individual BTEXN compounds. Note that naphthalene is included in the BTEXN suite. It was found that naphthalene was the only detectable PAH in

Parameter / analyte	Review summary
	the PAH suite, as such it is suggested that the PAH suite be taken out of the monitoring parameters provided naphthalene is still analysed.
Anions, cations and alkalinity	Important for determining factors that can influence the behaviour of contaminants.
Total phosphorus (TP)	Has not been included in the monitoring of leachate to date and very little filterable reactive phosphorus (FRP) data was collected during the monitoring period. It is proposed that TP be added to the leachate analysis suite, as this parameter is likely to be elevated and a potential contaminant of concern.
Analytes recommended for removal from future monitoring programs	
Chromium speciation analysis	Chromium (III) and chromium (VI) is of no value in leachate analysis as the matrix interferences mean that the laboratory LOR is raised well above the ANZECC (2000) trigger values. The sum chromium concentration is not affected by this and it is proposed this be analysed in future instead of chromium speciation.
Iron speciation analysis	The ferrous iron (II) and ferric iron (III) are of limited value in indicating leachate inputs to receiving waters.
RDX and TNT	Have always recorded levels below detection so are not useful as leachate impact indicators.
The L/N ratio	Is considered over-complicated, and also requires the derivation of extra parameters (e.g. NH <sub>4</sub> <sup>+</sup> ), when the above-listed parameters would be sufficient for identifying leachate impacts. Also, in the groundwater results analysis below (see Section 7.5.4), L/N ratios greater than 10 were often recorded in bores which are up-gradient of the site and definitely not subject to any leachate impacts.

## 9.2 Review of sampling frequency

The current monitoring program sampling frequency is provided in Table 4-3. As a result of this data review, a more targeted sampling frequency is proposed and presented in Table 9-2.

**Table 9-2. Monitoring program sampling frequency review summary**

Month	Groundwater		Surface Water	Leachate	Standard suite
	Levels	Chemical parameters			
January	X	X	X	X	<b>Field parameters:</b> SWL, pH, EC, DO, temperature <b>Lab parameters:</b> <ul style="list-style-type: none"> <li>• Major ions, NH<sub>4</sub>, TDS, COD, TOC</li> <li>• Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO<sub>4</sub>),</li> <li>• Nutrients (NH<sub>3</sub> as N, NO<sub>3</sub>, NO<sub>2</sub>, NO<sub>x</sub>)</li> <li>• Dissolved metals (chromium, copper, nickel, lead and zinc)</li> <li>• TRH and BTEXN</li> <li>• Total nitrogen (TN) and Total phosphorus (TP),</li> <li>• COD</li> <li>• PFAS</li> </ul>
February	X		X		
March	X		X		
April	X	X	X	X	
May	X				
June	X				
July	X	X	X	X	
August	X				
September	X				
October	X	X	X	X	
November	X				
December	X		X		

### 9.3 Review of monitoring sites

This data review has identified a number of monitoring sites that could be removed from the monitoring program, as summarised in Table 9-3.

**Table 9-3. Monitoring program sampling sites review summary**

Sampling site	Justification for removal
<b>Surface water</b>	
SW2	As stated in Section 7.3, sampling of surface water site SW2 has only been possible once during the July 2016 to March 2020 monitoring period due to lack of water flow. Monitoring of this site was initiated in 2015 to investigate a seepage issue from the Stage 3/4 landfill. This issue has since been addressed and seepage at this location is no longer observed. It is proposed that this site be removed from the water quality monitoring program.
Wheel Wash	Wheel Wash water is not indicative of water discharging from the site.
<b>Groundwater</b>	
WW3	Located in the centre of SBWMF and east of Stage 3/4 landfill. Monitoring bore WW1 is immediately north of WW3, and the new GW16 nested bores are immediately to the south, and monitoring of this area can be represented by these bores.
WW5	Located on the western boundary and to the west of Stage 3/4 landfill. The GW13 nested bores are immediately to the south of WW5 and can be used to represent groundwater at this location.
WW7	Located to the north-west of Stage 3/4 landfill, and adjacent to WW6. WW7 is a shallow bore (i.e. <10 m) and is capturing the impacts from leachate intrusion, however these are being observed at WW6, a deeper bore of ~ 20.4 m (see Section 7.5). Several bores are located along the site boundary in the down gradient groundwater direction, and can be used to determine off site impacts (i.e. GW14 (nested), WW9 and GW15 (nested)).
WW10	Located adjacent to the nested GW15 bores on the northern boundary, to the north of Stage 3/4 landfill. Monitoring of this area can be represented by these bores.

During preparation of this data review, the GW6 nested bores were decommissioned due to the construction of the new Stage 6 landfill. The GW6 bores were replaced by GW16 nested bores (3m, 12m and 30m) in a nearby location and should be added to the monitoring program.

The proposed leachate treatment system, which is to be constructed over a 2 ha area adjacent and to the west of the existing leachate storage ponds at the SBWMF, will require specific monitoring of groundwater bores during construction and operations. Existing groundwater bores relevant to the location of the leachate treatment system include the nested GW1, GW2, GW14 and GW15 bores, and WW9 and WW13. Two additional nested groundwater bores are proposed to be constructed and are detailed in Table 9-4.

It is proposed that these bores be monitored on a monthly basis for an initial period of 12 months from their construction. These bores should then be incorporated into the SBWMF monitoring program at the frequency specified in Table 9-2.

**Table 9-4. Proposed new groundwater bores for the leachate treatment system**

Groundwater bore ID	Bore type	Location	Purpose
GW17-3 GW17-12 GW17-30	<ul style="list-style-type: none"> <li>• 3 m (perched)</li> <li>• 12 m</li> <li>• 30 m</li> </ul>	Within the proposed treatment plant area	<p>Assess shallow and deep groundwater within the proposed plant area, and existing potential migration of impacted groundwater towards the site from leachate ponds.</p> <p>Additional deeper well to assess interconnectivity of sandstone and siltstone aquifers.</p>
GW18-3 GW18-12	<ul style="list-style-type: none"> <li>• 3 m (perched)</li> <li>• 12 m</li> </ul>	Within the proposed treatment plant area	Assess shallow and deep groundwater within the proposed plant area.

## 10 REFERENCES

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- ANZECC 2000, *Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines*, October 2000, National Water Quality Management Strategy, Paper No. 4, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- CoD 2016, *Shoal Bay Waste Management Facility Environmental Management Plan*, City of Darwin (CoD), June 2016.
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- NRETA 2008, *Groundwater Supply Prospects of the Cox Peninsula Region Map*, February 2008, Department of Natural Resources, Environment and the Arts (NRETA), Northern Territory Government, Palmerston, Northern Territory.
- URS 2015, *Shoal Bay Waste Disposal Site, Hydrogeological Investigation*, Report prepared by URS Australia Pty Ltd for John Holland Pty Ltd, November 2015.
- URS 2016a, *Shoal Bay Disposal Site Water Monitoring Plan*, Report prepared by URS Australia Pty Ltd for John Holland Pty Ltd, March 2016.
- URS 2016b, *Shoal Bay Waste Disposal Site, Conceptual Site Model*, Report prepared by URS Australia Pty Ltd for John Holland Pty Ltd, February 2016
- URS 2016c, *Shoal Bay Waste Disposal Site Ecological Risk Assessment*, Report prepared by URS Australia Pty Ltd for John Holland Pty Ltd, March 2016.

## APPENDIX A STANDARD OPERATING PROCEDURE, SHOAL BAY WASTE DISPOSAL SITE, WATER MONITORING

# Standard Operating Procedure: Shoal Bay Waste Disposal Site Water Monitoring *Prepared for City of Darwin*



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Appendix A – Surface Water / Leachate Field Data Sheet

Appendix B – Groundwater Field Data Sheet

Appendix C – Laboratory Chain of Custody Form

# 1 Introduction

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## 1.1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to ensure that all groundwater, surface water and leachate sampling specified in the *Shoal Bay Waste Disposal Site Water Monitoring Plan* (URS 2016) is undertaken in a consistent, quality controlled, and safe manner, and follows best-practice procedures in accordance with the relevant standards and guidelines.

The methodologies, timelines and contingencies outlined in this SOP also aim to ensure that the sampling schedule and reporting of analytical results meet the required monthly, quarterly and annual deadlines.

Water monitoring at the Shoal Bay Waste Disposal Site (the site) is required for compliance with the site's Environment Protection Licence (EPL12-09), issued by the Northern Territory (NT) Environment Protection Authority (EPA) under the NT *Waste Management and Pollution Control Act*.

## 1.2 Scope

This SOP applies to all groundwater, surface water, and leachate sampling undertaken by EcOz Environmental Consultants (EcOz) and Larrakia Rangers at the Shoal Bay Waste Disposal Site. Primarily, this SOP applies to all water sampling required for EPL compliance reporting, but also any ad hoc, incident, or special purpose water monitoring required at the site.

## 1.3 Legal requirements, standards and guidelines

This SOP has been developed in accordance with the following:

- URS 2016, *Shoal Bay Waste Disposal Site Water Monitoring Plan*, March 2016, Report prepared for John Holland Pty Ltd, URS Australia, Darwin, NT.
- Updated site information from City of Darwin (updated site map provided February 2020).
- NT EPA 2011, *Environment Protection Licence EPL12-09*, Issued 1 March 2011, Expires 1 July 2016, Northern Territory Environment Protection Authority (NT EPA), Darwin, NT.
- NT EPA 2013, *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory*, Northern Territory Environment Protection Authority (NT EPA), Darwin, NT.
- Australian/New Zealand Standard on Water Quality Sampling - Part 1: *Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998), Standards Australia, New South Wales.
- Australian Standard on Water Quality Sampling - Part 4: *Guidance on sampling from lakes, natural and man-made* (AS/NZS 5667.4:1998), Standards Australia, New South Wales.
- Australian/New Zealand Standard on Water Quality Sampling - Part 6: *Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998), Standards Australia, New South Wales.
- Australian Standard on Water Quality Sampling – Part 10: *Guidance on sampling of waste waters* (AN/NZS 5667.10:1998), Standards Australia, New South Wales.
- Australian/New Zealand Standard on Water Quality Sampling – Part 11: *Guidance on sampling of groundwater* (AS/NZS 5667.11:1998), Standards Australia, New South Wales.
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- *Work Health and Safety (National Uniform Legislation) Act*, and *Work Health and Safety (National Uniform Legislation) Regulations*, NT Government.

- ANZECC & AMRCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.
- ANZECC & AMRCANZ 2000, *Australian Guidelines for Water Quality Monitoring and Reporting*, National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

## 2 Methodology, Safety, Training and Quality Assurance

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### 2.1 Groundwater, surface water and leachate sampling methodology

All sampling will comply with the Australian/New Zealand Standard on Water Quality Sampling - Part 1: *Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998).

#### 2.1.1 Groundwater sampling

Groundwater sampling methods will comply with the Australian/New Zealand Standard on Water Quality Sampling – Part 11: *Guidance on sampling of groundwater* (AS/NZS 5667.11:1998).

Groundwater sampling involves:

1. The measurement of physical parameters (pH, temperature, EC, DO, turbidity) in groundwater using hand-held YSI field water quality meters calibrated immediately prior to mobilisation to site, and
2. The collection of groundwater into laboratory-supplied sample bottles for sending to the laboratory for analysis.

Samples will be collected from groundwater bores using a micropurge/low-flow bladder pump in the first instance, or manual bailers if groundwater yields are insufficient to allow pumping. The micropurge/low-flow sampling set up comprises a QED MP50 drawdown controller, 12V DC compressor and QED Sample Pro portable micropurge pump. This type of system is proven for minimal effect on water chemistry and obtaining representative samples (Sundaram 2009). If manual bailing is required, disposable Clear-View PVC bailers will be used; a new bailer for each bore.

Experience gained from groundwater sampling undertaken by EcOz at numerous sites in the Darwin region shows that shallow bores with depths up to 20 m can be easily sampled with a low-flow bladder pump in the mid to late wet season (January-April) but pumping can become difficult in the dry season and early wet season (May-December), and manual bailers are sometimes required. Often shallow bores less than 20 m deep can be dry in the mid to late dry season and cannot be sampled. Similarly, surface water bodies dry up during the dry season and cannot be sampled.

In order to gain a representative sample of the surrounding groundwater aquifer quality and not stagnant water contained within the bore, the pump is lowered to within the screened interval, and the rate of pumping matched to the groundwater recharge rate; confirmed by constant monitoring of the standing water level (SWL), which must remain stable. Water quality parameters (pH, temperature, EC, DO, ORP) are constantly monitored in the groundwater as it is pumped from the bore using YSI water quality meters that have been calibrated immediately prior to mobilisation to site. Pumping is continued until readings stabilise i.e. until three consecutive readings of all parameters measured at 5 minute intervals stabilise to within 5% of each other. This usually takes at least 30 minutes of pumping. Low dissolved oxygen (DO) and negative oxidation reduction potential (ORP) are also indicators of fresh groundwater, and not water from within the bore casing which is in contact with the air. Once stable readings are achieved, samples for laboratory analysis are collected directly into laboratory-supplied bottles.

When using manual bailers, a dedicated bailer is used for each bore, and the bore is purged until dry and then sampled once the bore has recharged and SWL has returned to its original level. If recharge in the bore means it doesn't completely empty, then three x volumes worth of standing water in the bore must be removed and the original standing water level allowed to return prior to sampling.

### 2.1.2 Surface water and leachate sampling

Surface water and leachate sampling methods will comply with the Australian/New Zealand Standard on Water Quality Sampling - Part 6: *Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998), Part 4: *Guidance on sampling from lakes, natural and man-made* (AS/NZS 5667.4:1998), and Part 10: *Guidance on sampling of waste waters* (AN/NZS 5667.10:1998).

Surface water and leachate sampling involves:

1. The measurement of physical parameters (pH, temperature, EC, DO, turbidity) using hand-held YSI field water quality meters calibrated immediately prior to mobilisation to site, and
2. The collection of water into laboratory-supplied sample bottles for sending to the laboratory for analysis.

The specific method of sampling differs depending on the water source. The five different types of water sources and corresponding sampling methods are:

- Surface water bodies, ponds, and drains with safe direct access – will be sampled directly by placing field water quality meters into the water body for physical parameters, and collecting water samples for laboratory analysis directly into the laboratory-supplied sample bottles (note for bottles with preservative, sample will be decanted into the bottle from one of the unpreserved laboratory-supplied bottles to prevent loss of preservative).
- Surface water bodies, ponds, and drains without safe direct access – will be sampled using a clean, decontaminated jug on a pole, and the physical parameters measured immediately from within the jug. The jug on a pole will then be rinsed in the sample water several times prior to collecting sample for decanting into the laboratory-supplied sample containers for laboratory analysis.
- Sumps without a pump – will be sampled using a clean, decontaminated jug on a pole (as explained above) or a dedicated bailer. When using a bailer, the sample is decanted into a clean, decontaminated jug for measuring physical parameters and the sample poured directly into laboratory-supplied sample containers for laboratory analysis.
- Sumps with a pump – will be sampled by turning the tap on and the sample going into a clean, decontaminated jug for measuring physical parameters and then poured directly from the tap into laboratory-supplied sample containers for laboratory analysis.
- Leachate pond risers – will be sampled using a submersible pump lowered into the riser with the sample going from the hose into a clean, decontaminated jug for measuring physical parameters and then directly from the hose into laboratory-supplied sample containers for laboratory analysis.

For surface water bodies and sumps sampled either directly or using a sample pole or bailer, samples will be collected approximately 0.3 m below the water surface. When collecting samples from flowing water bodies, the sample must be collected a reasonable distance from the water's edge and facing into the flow direction, keeping hands and sampler equipment downstream to prevent contamination.

Samples for metals analysis (both groundwater and surface leachate water) will be field-filtered using a new disposable syringe and filter (0.45 µm) for each sample.

## 2.2 Responsibilities

EcOz Environmental Consulting is responsible for overall coordination of the monitoring program, including sub-contractor management, liaising with the site manager, the quality of sample collection and handling prior to delivery to the laboratories, and the delivery of laboratory results and field data to the Waste Services Manager. EcOz must ensure that suitably skilled and experienced staff are available to complete the monitoring within the required timeframes, and that sampling equipment is always maintained in good working order ready for both routine and any ad hoc sampling required.

EcOz staff and Larrakia Ranger staff are responsible for undertaking the sampling in accordance with this SOP.

EcOz / Larrakia Rangers shall not disclose to any person, any information or documentation relating to the Principal of the affairs of others which may have come to its or their knowledge as a result of the works and shall take all necessary precautions to prevent unauthorised access to such information or documentation. EcOz / Larrakia Rangers shall not divulge any information regarding the nature of the works or give any publicity concerning the works except with the written consent of the Principal.

ALS Laboratories are responsible for the quality of sample handling and analysis once samples are received from EcOz / Larrakia Rangers. ALS are also responsible for undertaking all required within-laboratory quality assurance / quality control (QA/QC) procedures in accordance with their NATA accreditations, and timely delivery of analytical results. Similarly, Eurofins mgt laboratories is responsible for spilt (triplicate) samples sent to them for QA/QC purposes (i.e. inter-laboratory variability).

The Waste Services Manager is responsible for communicating any changes to the water monitoring plan that need to be reflected in changes to the sampling program. For example, changes requested by the NT EPA for compliance purposes. The Waste Services Manager is also responsible for communicating any safety issues or access issues at the site relevant to the monitoring activities, over and above those normally expected for the site. Having said this, EcOz acknowledges that all EcOz staff will take the utmost care to make themselves informed of the status of operations during the days when monitoring is being conducted, and to maintain communications with heavy vehicle and plant operators to avoid any incidents.

## 2.3 Health, safety and site access requirements

A specific Job Hazard Analysis (JHA) for the Shoal Bay Waste Disposal Site has been developed based on the standard hazard management outlined in Table 1. The JHA also includes details of personal protective equipment (PPE), such as:

- Sturdy boots (steel cap and laces)
- Hat, safety/polaroid sunglasses, sunscreen etc for sun protection
- Hard hat
- Long pants and shirt (high-visibility)
- Gloves for handling heavy equipment

For safety reasons, field sampling will always be undertaken by at least two personnel. All personnel undertaking the sampling will have current first-aid training and have completed a 4WD course and have hands-on, regular experience driving off-road.

The JHA is stored in EcOz's Document Management System (Vantage folder B0304). Prior to each monthly monitoring round, this JHA must be reviewed in relation to that specific month, any updates/changes made, and then printed out. The printed copy must be read, understood, and signed by all field party members, and also signed off by the Fieldwork Leader/Project Manager, EcOz OH&S Officer, and EcOz Manager. Completed and signed JHA's are saved in the Vantage VBM project folder B0304. A copy of the JHA must be taken into the field for reference when undertaking the works.

EcOz is deemed the Principal Contractor and shall at all times comply with its obligations under the *Work Health and Safety National Uniform Legislation Act* (NT Government). All EcOz/Larrakia Rangers will hold a White Card or otherwise comply with the *Northern Territory Code of Practice for Induction for Construction Work*.

EcOz has nominated Senior Environmental Consultant Emma Smith as its representative for the site. Emma will prior to the commencement of works undergo a site induction together with the Superintendent's representative and representatives of Territoria Civil; the landfill operator. EcOz's site representative shall then ensure that all employees and subcontractors involved in the water monitoring sampling program are similarly inducted to the site prior to commencing work.

**Table 1. Standard hazard management for groundwater and surface water sampling**

Job Steps	Potential Hazards	Hazard Management
Driving to and around site	Heavy vehicles and plant	<ul style="list-style-type: none"> <li>Always maintain radio communications with heavy vehicle and plant operators, or if not possible maintain a safe distance</li> </ul>
	Site operations	<ul style="list-style-type: none"> <li>Discuss with site manager prior to each day's work site operational activities that may pose a hazard or restrict access to sampling locations</li> <li>Pre-inform the site manager of the monitoring activities for that day and the specific areas to be accessed for sampling</li> </ul>
	Animals on road	<ul style="list-style-type: none"> <li>Do not swerve to avoid hitting fauna on the road, slow down and maintain line</li> <li>Avoid travelling on roads early morning, late afternoon and night</li> </ul>
	Other vehicles	<ul style="list-style-type: none"> <li>Maintain good observation when driving</li> <li>Even on quiet roads, always assume the possibility of an oncoming vehicle</li> </ul>
	Road conditions	<ul style="list-style-type: none"> <li>Stay within speed limits and drive according to conditions</li> </ul>
	Driver fatigue	<ul style="list-style-type: none"> <li>Regularly swap drivers and take breaks</li> </ul>
	Flat tyres	<ul style="list-style-type: none"> <li>Carry spare tyres, jack and tools</li> <li>All party members must be proficient in changing a tyre on the type of vehicle being used</li> </ul>
	Getting lost	<ul style="list-style-type: none"> <li>Use GPS, maps and radio</li> <li>Always work in pairs</li> <li>Prepare scheduled call-in procedure prior to leaving office and abide by this procedure</li> <li>Agree on procedure in the event of a missed call-in i.e. time to wait before calling emergency services</li> </ul>
	Bogging	<ul style="list-style-type: none"> <li>Avoid driving in wet areas</li> <li>Carry vehicle recovery equipment</li> <li>At least one party member must be proficient safe use of recovery equipment</li> <li>Maintain communications (i.e. radio channel 40, satphone)</li> <li>Vehicle recovery only to be undertaken by personnel who have undertaken "4WD recovery training"</li> <li>In areas of high risk, vehicles to travel in pairs, with the second vehicle not proceeding into boggy areas until first vehicle has made it through</li> </ul>
Mechanical failure	<ul style="list-style-type: none"> <li>Pre-start vehicle checks</li> <li>Maintain communications (i.e. radio channel 40, satphone)</li> </ul>	
Groundwater and Surface water sampling	Unsafe worksite	<ul style="list-style-type: none"> <li>Upon arrival to each site, perform an assessment of potential risks/dangers unique to the area and mitigate accordingly (Take 5)</li> <li>Add any new hazards to JHA</li> </ul>
	Cuts/abrasions	<ul style="list-style-type: none"> <li>Wear full PPE when performing sampling</li> </ul>
	Manual handling	<ul style="list-style-type: none"> <li>Use appropriate lifting techniques, e.g. straight back, bent knees when lifting equipment</li> </ul>

Job Steps	Potential Hazards	Hazard Management
		<ul style="list-style-type: none"> <li>• Lift equipment using two persons when appropriate</li> </ul>
	Contaminated water	<ul style="list-style-type: none"> <li>• Do not contact any surface or groundwater when sampling, use powder-free gloves</li> </ul>
	Pump and compressor operation (12V micro purge system)	<ul style="list-style-type: none"> <li>• Personnel must be inducted in the use of the groundwater sampling equipment</li> <li>• Perform pre-start on groundwater equipment (particularly pressure fittings, controller)</li> <li>• Take care when connecting power leads to vehicle – ensure vehicle is off and all wires are free from moving engine parts when vehicle is started</li> <li>• Minimum 2 staff to ensure lifting and retrieving can be done in team</li> <li>• Avoid pinch points when retrieving hoses</li> <li>• Always lock hose reel and place pump in holder when moving between sites</li> </ul>
	Surface water site access	<ul style="list-style-type: none"> <li>• Surface water bodies only to be sampled directly if safe to do so i.e. no steep, slippery banks, no risk of crocodiles, no toxic fumes/confined space.</li> <li>• If not safe, samples to be collected using sampling pole or an alternative method.</li> </ul>
	Snakes	<ul style="list-style-type: none"> <li>• Correct PPE (i.e. sturdy boots, long pants/gators)</li> <li>• All personal have first aid training</li> <li>• Care taken when stepping over logs</li> <li>• Each person to carry snake bandage at all times</li> </ul>
	Feral animals (e.g. cattle, buffalo, pigs)	<ul style="list-style-type: none"> <li>• Assess each site for potential dangerous animals upon arrival (Take 5)</li> <li>• Maintain safe distance from any animals</li> <li>• Shelter in vehicle if required</li> </ul>
	Ticks	<ul style="list-style-type: none"> <li>• Check body and clothing for ticks at the end of each day</li> <li>• Shirts to remain tucked into the trousers</li> <li>• Advising other personnel of the locations where ticks have been seen/recorded</li> <li>• Ticks to be carefully removed to avoid squeezing the tick</li> <li>• Seek medical advice if a tick bite is found</li> </ul>
	Tripping / slipping / strains	<ul style="list-style-type: none"> <li>• Care taken walking in rough / overgrown terrain (or seek alternative route)</li> <li>• Use appropriate lifting techniques (i.e. bend knees), 2 person lifts and lift within capabilities</li> </ul>
	Dehydration / heat exhaustion	<ul style="list-style-type: none"> <li>• Adequate water and electrolyte replacement carried for all personnel and personnel to maintain their fluid levels</li> <li>• Competent first aid trained person within sampling group</li> <li>• Correct PPE</li> <li>• First aid is readily available</li> </ul>
	Burns (re-fuelling)	<ul style="list-style-type: none"> <li>• Ensure that re-fuelling takes place in an open area</li> <li>• Fire extinguisher fitted in each vehicle</li> <li>• Engine off</li> <li>• First aid kit carried</li> <li>• Competent first aid trained person within sampling group</li> <li>• Ensure no ignition sources are nearby (e.g. radios,</li> </ul>

Job Steps	Potential Hazards	Hazard Management
		monitoring equipment)
	Lightning	<ul style="list-style-type: none"> <li>Sampling must stop and the field party return to the site office if lightening within 10 km of the site i.e. less than 10 sec gap between lightning and thunder. Works not to recommence until lightning moves further than 10 km away.</li> </ul>
	Sunburn and biting insects	<ul style="list-style-type: none"> <li>Use sunscreen and insect repellent and wear correct PPE (i.e. hat, long sleeves, long pants)</li> </ul>

## 2.4 Personnel, training and competency

Two EcOz/Larrakia Ranger staff will be required to undertake the sampling for both safety and time efficiency reasons. All personnel conducting the sampling shall be familiar with this SOP, and be experienced in the sampling procedures and strict QA/QC requirements to prevent sample contamination and obtain representative samples. All personnel will also have prior experience in calibrating and operating the hand-held field water quality meters, groundwater sampling using the compressor and low-flow bladder pump set-up and manual bailers, and grab sample collection from surface water bodies.

## 2.5 Quality assurance summary

The quality, accuracy and representativeness of samples and analytical results is assured given the following:

- All sampling will be carried out by well-experienced local EcOz / Larrakia Ranger personnel who have undertaken both groundwater and surface water sampling at numerous commercial/industrial sites across the Darwin region and who have in-depth, hands-on knowledge of the nature of groundwater aquifers and surface water bodies and run-off, seasonal variations, and logistical and safety requirements.
- EcOz's groundwater sampling set up (micropurge/low flow pump) and groundwater sampling procedure is the most effective in obtaining representative samples in the type of bores and aquifer system at the Shoal Bay site. Also, stringent procedures are followed to ensure the actual groundwater aquifer is being sampled and not stagnant water within the bore casing; where groundwater pumping is matched to the recharge rate (i.e. no drawdown) and water quality parameters (pH, temperature, EC, DO, ORP) must stabilise to within 5% for three consecutive 5 minute readings before sample collection. If manual bailers are required due to poor recharge, the bore must be emptied, or three x bore volumes worth of water removed and allowed to recharge prior to sample collection.
- Field QA/QC samples will be collected as per Section 3.4 below, and also the laboratories ALS / Eurofins mgt have stringent internal QA/QC procedures in accordance with their NATA accreditation. Field QA/QC results and internal laboratory QA/QC results will be provided along with the sample results.
- To prevent contamination of samples during field collection;
  - sampling personnel will wear powder-free disposable gloves (a new pair for each sample),
  - disposable syringes and field filters will be used for filtering metals samples,
  - samples will be collected into laboratory-supplied, pre-preserved containers,
  - all equipment that is re-used (e.g. groundwater pump and hoses) will be rinsed with Decon 90 and deionised water between bores/sample sites,

- wherever possible, samples will be collected directly into sample containers negating the need to clean equipment between samples, e.g sample goes directly into bottles from groundwater pump hose, and samples are collected directly from surface water bodies,
  - when filling sample containers, whilst the lid is off, the lid will not be placed edge-down in contact with any surfaces, and nothing will be allowed to contact the opening of the bottle,
  - all sampling equipment and hands will be kept downstream of where samples are collected in surface water bodies.
- Once collected, samples will be kept cool in eskies with frozen ice-bricks until drop off at the laboratory shopfront, after which they will be kept refrigerated <math><4^{\circ}\text{C}</math> until analysed. Ice is not to be used in eskies as melted ice can contaminate the samples.
  - All samples will be delivered to the laboratories to allow for analysis to be undertaken within holding times (see Table 13 below). The shortest holding time is two days for BOD, nitrate, nitrite and phosphorus. In order to allow samples to be delivered to the interstate laboratories and meet this holding time, samples with these parameters (i.e. all quarterly and annual samples) will need to be delivered to the Darwin ALS / Eurofins mgt shopfront by 3 pm each day and not on a Friday, Saturday or Sunday. As such, sampling will need to start very early (7 am) and be completed in four days (Mon/Tues/Wed/Thurs). If sampling is not completed on Thursday, it will need to be finished the following Monday. The shortest holding time for monthly samples is 14 days, therefore sample delivery to the laboratories by 3 pm is not critical but this will be achieved if possible.
  - Strict chain of custody (COC) procedures and documentation will be maintained and provided along with results.

## 2.6 Contingencies

Achieving the required monthly/quarterly/annual monitoring rounds within the required timeframe i.e. sampling in the first week of the month and results delivered by the last week of the month, is assured by the large pool of EcOz/Larrakia Ranger staff available who are well-experienced in groundwater and surface water sampling. At least seven EcOz staff are available and five Larrakia Rangers. This large pool of staff also means that any emergency incident or extra ad hoc sampling can be undertaken at short notice when required. Similarly, all groundwater and surface water sampling equipment, laboratory bottles and documentation (COCs, JHAs, Field Data Sheets) are well maintained and ready for mobilisation at short notice. This includes having at least two groundwater pump set-ups, and sets of water quality meters so that if they are already in use for another job, there is still a set available.

It is not envisaged that weather presents a high risk to the undertaking of sampling, given that groundwater, surface water and leachate sampling can still occur if it is raining and all sampling is undertaken using a 4WD vehicle with recovery gear and staff who are well-experienced in challenging 4WDing conditions. EcOz also owns several All-Terrain Vehicles and side-by-side off-road vehicles, which can be used if required.

An extreme storm event, or cyclone may mean that sampling is postponed, but in this case EcOz would endeavour to still achieve results delivery by the last week of the month by commencing sampling as soon as it is safe to do so, even if working over a weekend is required. Similarly, if works or operations on site mean that groundwater bores and/or surface water / leachate sites are inaccessible, EcOz would sample any sites which are not affected by the works first in consultation with the site manager, and then sample the remaining sites as soon as they become accessible again.

EcOz has a long established and good working relationship with both ALS and Eurofins mgt Laboratories. This ensures quick follow-up in the case of any inquiries regarding sample results, and also a quick response to any requests for extra or unusual analysis etc. EcOz is a valued client of these laboratories; given the amount of work we bring them, and as such, we are given a discount on analytical costs.

## 3 Sampling Overview

### 3.1 Sampling schedule

Groundwater, surface water and leachate sampling is undertaken monthly, with differing parameters analysed on a monthly, quarterly and annual basis (see Tables 3 to 11). Sampling must be undertaken in the first week of each month, noting that this is taken to represent the previous month e.g. sampling undertaken in the first week of July is taken to represent June. Sampling in the first week of each month ensures that laboratory analytical results are completed and sent to the Waste Services Manager by the final week of each month. It is estimated that for each monthly monitoring round, all groundwater, surface water and leachate samples will take 4 to 5 days to collect; less depending on the number of dry bores and surface water sites.

Figure 1 shows the sampling schedule. The annual sampling round, comprising a larger suite of analysis, is timed to coincide with the time of maximum wet season rainfall; typically January in the Darwin region. Note this would be the sampling round undertaken in the first week of February. This is the time of maximum recharge to groundwater bores and is likely to reflect the cumulative effect of any contamination entrained in wet season rainfall, run-off and infiltration.

The shortest holding time for the suite of analytical parameters is two days for quarterly and annual sampling, and 14 days for monthly sampling. In order to allow samples to be delivered to the interstate laboratories and meet the two day holding time, samples will need to be delivered to the Darwin ALS / Eurofins mgt shopfront by 3 pm each day and not on a Friday, Saturday or Sunday. As such, sampling will need to start very early (7 am) and be completed in four days (Mon/Tues/Wed/Thurs). If sampling is not completed on Thursday, it will need to be finished the following Monday. For monthly sampling, a Monday to Friday sampling timeframe is acceptable, with sample delivery by COB each day.

	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
MONTHLY	■	■		■	■			■		■	■	
QUARTERLY			■			■			■			■
ANNUAL							■					

**Figure 1. Monthly/Quarterly/Annual sampling schedule**

## 3.2 Sampling sites

The water monitoring program includes the sampling of 37 groundwater bores, five surface water sites, and eight leachate sites. Site locations are shown in Figure 2, and coordinates listed in Table 2 and Table 3. Relevant bore construction details are also provided in Table 2.

The 37 groundwater monitoring bores are located at 21 different sites i.e. most sites have more than one bore (see Figure 2). For the 29 bores with the identifier "GW" the number of bores at each site is either two or three bores, with each bore being a different depth, i.e. 3 m, 12 m and up to 30 m deep. The 8 bores with the identifier "WW" exist as a single bore at each site with varying depths between 5.8 and 20.3 m.

As mentioned in Section 2.1.2 above, the specific method of sample collection for surface water / leachate sites differs depending on the site as outlined below:

- Surface water bodies, ponds, drains include the sites: SW2, SW12, STG1&2 and GW Sump
- Sumps without a pump: Wheel Wash, LMP02
- Sumps with a pump and tap: DW2, DW3, DW5, DW6 and TC Sump
- Leachate ponds with riser: LP01 and LP02
- Leachate seepage sites : LS5A and LS5B

Importantly to note in planning is that it is unlikely that during the dry season, all groundwater bores and surface water sites can be sampled, as once wet season rains cease in April/May, the groundwater table can lower further than the base of the bores and surface water bodies i.e. they are dry. Similarly, some surface water sites are dry during the dry season.

Also, during the wet season, access to some sites may become boggy and EcOz's All-Terrain Vehicles or side-by-side off-road vehicles may be required.



**Table 2. Sample location coordinates and bore construction details.  
(adapted from URS 2016)**

Bore	Easting (m)*	Northing (m)	Monument Elevation (m AHD)	PVC Elevation (m AHD)	Ground Elevation (m AHD)	Screened Interval (m bgl)	Screened Interval Lithology
GW1-3	709564	8631004	8.71	8.63	8.02	1.5 - 3	Siltstone
GW1-12	709566	8631004	8.71	8.59	8.00	9 - 12	Siltstone
GW2-3	709629	8630835	8.06	7.94	7.33	1.5 - 3	Siltstone
GW2-12	709631	8630835	8.08	7.94	7.28	9 - 12	Siltstone
GW3-3	709652	8630746	9.94	9.80	9.12	1.5 - 3	Siltstone
GW3-12	709654	8630746	9.87	9.82	9.10	9 - 12	Siltstone
GW4-3	709775	8630634	5.65	5.49	4.88	1.5 - 3	Siltstone
GW4-12	709776	8630633	5.61	5.44	5.36	9 - 12	Siltstone
GW4-30	709777	8630631	5.50	5.20	5.33	15 - 21	Gravelly Sand, Sandstone
GW5-3	709880	8630224	5.51	5.41	4.70	1.5 - 3	Siltstone
GW5-12	709880	8630226	5.48	5.33	4.70	9 - 12	Siltstone, Gravelly Clay
GW7-3	709900	8629992	5.18	5.03	4.33	1.5 - 3	Siltstone
GW7-12	709900	8629994	5.16	5.08	4.33	9 - 12	Siltstone, Sandy Silt
GW8-3	709896	8629708	5.42	5.28	4.65	1.5 - 3	Claystone
GW8-12	709896	8629708	5.37	5.22	4.62	9.1 - 12.1	Claystone, Sandstone
GW9-12	709660	8629469	16.18	15.93	15.44	9 - 12	Siltstone
GW10-3	709147	8629507	18.12	18.06	17.32	1.5 - 3	Siltstone
GW10-12	709149	8629507	18.13	17.98	17.37	9.1 - 12.1	Siltstone
GW11-3	709040	8629671	13.50	13.38	12.72	1.5 - 3	Siltstone
GW11-12	709042	8629671	13.52	13.38	12.84	9 - 12	Siltstone, Sandstone
GW12-3	709024	8629881	12.20	12.07	11.44	1.5 - 3	Siltstone
GW12-12	709024	8629883	12.22	12.04	11.50	9 - 12	Siltstone
GW12-30	709024	8629885	12.21	12.05	11.55	24 - 30	Sandstone
GW13-3	709017	8630175	12.93	12.88	12.32	3 - 4.5	Siltstone
GW13-12	709016	8630174	12.91	12.86	12.25	10 - 13.5	Siltstone
GW14-3	709013	8630423	6.78	6.73	6.09	1.5 - 3	Siltstone
GW14-12	709013	8630424	6.77	6.64	6.08	9 - 12	Siltstone

Bore	Easting (m)*	Northing (m)	Monument Elevation (m AHD)	PVC Elevation (m AHD)	Ground Elevation (m AHD)	Screened Interval (m bgl)	Screened Interval Lithology
GW15-3	709230	8630599	11.27	11.06	10.44	1.5 - 3	Siltstone
GW15-12	709233	8630599	11.20	11.04	10.44	9 - 12	Siltstone
WW1	709471	8630255	-	-	15.90	0 - 6.3	-
WW3	709471	8630151	-	-	15.68	0 - 20.3	-
WW5	708980	8630234	-	-	7.64	0 - 6.0	-
WW7	709045	8630483	-	-	6.75	0 - 5.8	-
WW9	709016	8630598	-	-	6.39	0 - 9.8	-
WW10	709235	8630598	-	-	10.21	0 - 9.7	-
WW13	709457	8630598	-	-	-	0 - 10 (Approx)	-

**Table 3: Updated site information for additional groundwater bores, and all surface water and groundwater sites (updated February 2020)**

Sample site	Easting (m)	Northing (m)	Comment
WW6	709085	8630448	Groundwater bore
SW2	708973	8630296	Surface water site West of Stage 4
SW12	709035	8630495	Surface water site Northwest of Stage 4
SW13	709065	8630504	Surface water (North Dam)
SW14	709287	8630536	Surface water (Borrow Pit)
SW Stg 1&2	709448	8629979	Surface water site Surface drain between Stage 1 and 2
GW Sump	709102	8629880	Surface water site Greenwaste area
Wheel wash	709479	8629755	Surface water site
LP01	709534	8630726	Leachate site
LP02	709531	8630713	Leachate site
LMP02	709938	8629759	Leachate site East of Stage 1
DW2	709029	8630459	Leachate site Deleaching well Stage 3.3
DW3	709038	8630216	Leachate site
DW5	709023	8630122	Leachate site
DW6	709041	8630039	Leachate site
TC SUMP	709465	8630233	Leachate site
LS5A	708994	8630070	Leachate site
LS5B	708950	8630108	Leachate site

### 3.3 Sampling equipment

- **Copy of this SOP**
- **Copy of the Job Hazard Analysis (JHA)** must be signed
- **Maps** (monitoring site locations see Figure 2)
- **Site Coordinates** (see Table 2 and Table 3)
- **GPS** (handheld); spare batteries
- **Any site access or permit requirements** such as keys, ID Cards, White Card, Contractor Induction Certificates
- **Folder/clipboard, Field Data Sheets** (see Appendix A and B), enough for all sites plus spares; all printed on waterproof paper
- **Chain of Custody (COC)** forms (See Appendix C)
- **Stationary:** Pens / pencils, **permanent markers** (xylene-free) for completing sample bottle labelling
- **Sample containers** obtained from ALS / Eurofins mgt as per Section 3.6. Enough for all sample sites, QA/QC samples and some spares
- **YSI field water quality meters** (pH, EC, temperature, DO, ORP, Turbidity) calibrated each day prior to mobilising to site
- **Plastic jugs**
- **Sample pole**
- **Syringes and Filters** (for sampling dissolved metals)
- **Eskies** with frozen ice bricks; enough for the entire days' worth of samples
- **Camera** fully charged
- **Decon 90** solution mixed with deionised water (1:20) and **Plastic tub** to clean equipment between samples
- **Disposable powder-free gloves**
- **PPE** see JHA
- **Garbage bag** for general waste generated during sampling
  - **Communications** equipment (e.g. mobile/satellite phone, radio, EPIRB)

#### ***Groundwater-specific sampling equipment:***

- **Pump, hose reel and compressor set-up**
- **Flow cell**
- **New disposable bailers – enough for one for each bore requiring bailing**
- **Bore construction reports for each bore**
- **Fox whistle or electronic dip meter for measuring standing water level (SWL)**
- **Bucket (20 L)**
- **Hand tools to open bore caps and keys if bores are locked**
- **Calculator and Watch/time keeper**

### 3.4 Quality Assurance / Quality Control Samples

QA/QC samples will comprise:

- a) Field duplicate samples at 1 per 10 water samples per monitoring event;
- b) Field triplicate samples 1 per 20 water samples per monitoring event; the split sample will be analysed by Eurofins mgt
- c) Field rinsate samples at 1 per day;
- d) Field blank samples at 1 per day; and
- e) Trip blanks 1 per esky containing samples scheduled for volatile analysis.

### 3.5 Sample nomenclature

Samples will be labelled on sample bottles, and in all laboratory documentation and results according to the site names listed in Table 2 and Table 3. Duplicates and triplicates will be labelled as "Duplicate 1", Duplicate 2", "Triplicate 1" etc, and the site where the duplicate/triplicate sample was taken identified on the Field Data Sheets. Trip blanks will be labelled "Trip Blank dd/mm/yyyy". The date is included to identify which batch of samples the trip blanks accompanied.

### 3.6 Analytical parameters, sample containers and holding times

Tables 4 to 14 provide details of the analytical parameters and limits of reporting (LOR) for monthly/quarterly/annual groundwater, surface water and leachate sampling. Table 13 outlines the required sample containers, and Table 14 the holding times for each parameter.

**Table 4. Monthly groundwater analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 5. Monthly surface water analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 6. Monthly leachate analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 7. Quarterly groundwater analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Nitrite as N	NT-4	APHA 4500 NO <sub>2</sub> <sup>-</sup> - I	0.01
Nitrate as N		APHA VCl3 reduction 4500 NO <sub>3</sub> <sup>-</sup> + NO <sub>2</sub> -B	0.01
Organic Nitrogen as N (calculation of TKN - Ammonia)	EK060	APHA 4500 Norg /NH <sub>3</sub>	0.1
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Phosphorus Reactive as P	EK071	APHA 4500 P - F	0.01
ICP/MS (dissolved): Cd, Cr, Cu, Pb, Fe, Mn, Ni, Zn	EG020F	USEPA 6020 ICP/MS	Cd: 0.0001 Zn: 0.005 Other: 0.001
Trivalent Chromium ( <i>must be requested with Hex<sup>+</sup> Cr and dissolved Cr</i> )	EG049	APHA 3500 Cr- A & B	0.01
Hexavalent Chromium - Dissolved	EG050	APHA 3500 Cr-B	0.01
Iron - Ferrous (dissolved)	EG051	APHA3500 Fe-B	0.05
Iron - Ferric (dissolved)	EG053	Calc from dissolved and ferrous.	0.05
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10
TPH (C6-C36) plus TRH (C6-C40)	EP080/071	USEPA 8260/8015 P&T-GC/MS/FID APHA 5520F	20-100 (µg/L)
PAH - Standard level ( <i>16 analytes</i> )	EP075B (SIM)	USEPA 3510/8270	0.5-1 (µg/L)
PFAS – 28 analytes	EP231X	In house LC/MS-MS	0.002-0.01 (µg/L)

**Table 8. Quarterly surface water analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 9. Quarterly leachate analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO <sub>4</sub> -E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Nitrite as N	NT-4	APHA 4500 NO <sub>2</sub> <sup>-</sup> - I	0.01
Nitrate as N		APHA VCl <sub>3</sub> reduction 4500 NO <sub>3</sub> <sup>-</sup> + NO <sub>2</sub> -B	0.01
Organic Nitrogen as N (calculation of TKN - Ammonia)	EK060	APHA 4500 Norg /NH <sub>3</sub>	0.1
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH <sub>4</sub>	Calculation	0.01
Phosphorus Reactive as P	EK071	APHA 4500 P - F	0.01
ICP/MS (dissolved): Cd, Cr, Cu, Pb, Fe, Mn, Ni, Zn	EG020F	USEPA 6020 ICP/MS	Cd: 0.0001 Zn: 0.005 Other: 0.001
Trivalent Chromium ( <i>must be requested with Hex' Cr and dissolved Cr</i> )	EG049	APHA 3500 Cr- A & B	0.01
Hexavalent Chromium - Dissolved	EG050	APHA 3500 Cr-B	0.01
Iron - Ferrous (dissolved)	EG051	APHA3500 Fe-B	0.05
Iron - Ferric (dissolved)	EG053	Calc from dissolved and ferrous.	0.05
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10
TRH (C6-C40)/BTEXN/PAH	W-7	GC/FID, P&T- or HS-GC/MS,GC/MS-SIM	TPH: 20-100µg/L BTEX:1-5µg/L PAH: 0.5-1µg/L
Phenolics - Total	EP035	APHA 5530 B&D	0.05
PFAS – 28 analytes	EP231X	In house LC/MS-MS	0.002-0.01 (µg/L)

**Table 10. Annual groundwater analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Nitrite as N	NT-4	APHA 4500 NO <sub>2</sub> <sup>-</sup> - I	0.01
Nitrate as N		APHA VCl3 reduction 4500 NO <sub>3</sub> <sup>-</sup> + NO <sub>2</sub> <sup>-</sup> -B	0.01
Organic Nitrogen as N (calculation of TKN - Ammonia)	EK060	APHA 4500 Norg /NH <sub>3</sub>	0.1
Ammonium ( <i>Calc: Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Phosphorus Reactive as P	EK071	APHA 4500 P - F	0.01
ICP/MS (dissolved): Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn	EG020F	USEPA 6020 ICP/MS	Cd: 0.0001 Zn: 0.005 Other: 0.001
Trivalent Chromium ( <i>must be requested with Hex' Cr and dissolved Cr</i> )	EG049	APHA 3500 Cr- A & B	0.01
Hexavalent Chromium - Dissolved	EG050	APHA 3500 Cr-B	0.01
Iron - Ferrous (dissolved)	EG051	APHA3500 Fe-B	0.05
Iron - Ferric (dissolved)	EG053	Calc from dissolved and ferrous.	0.05
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 11. Annual surface water analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO4-E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Nitrite as N	NT-4	APHA 4500 NO <sub>2</sub> <sup>-</sup> - I	0.01
Nitrate as N		APHA VCI3 reduction 4500 NO <sub>3</sub> <sup>-</sup> + NO <sub>2</sub> -B	0.01
Organic Nitrogen as N (calculation of TKN - Ammonia)	EK060	APHA 4500 Norg /NH <sub>3</sub>	0.1
Ammonium ( <i>Calc:Field pH &amp; temp provided by client</i> )	EK055G-NH4	Calculation	0.01
Phosphorus Reactive as P	EK071	APHA 4500 P - F	0.01
ICP/MS (dissolved): Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn	EG020F	USEPA 6020 ICP/MS	Cd: 0.0001 Zn: 0.005 Other: 0.001
Trivalent Chromium ( <i>must be requested with Hex' Cr and dissolved Cr</i> )	EG049	APHA 3500 Cr- A & B	0.01
Hexavalent Chromium - Dissolved	EG050	APHA 3500 Cr-B	0.01
Iron - Ferrous (dissolved)	EG051	APHA3500 Fe-B	0.05
Iron - Ferric (dissolved)	EG053	Calc from dissolved and ferrous.	0.05
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10

**Table 12. Annual leachate analytical parameters, method references and limits of reporting from ALS Laboratories.**

Parameter	ALS Code	Technique/ Method Reference	LOR (mg/L) (or as indicated)
Cations: Calcium, Magnesium, Sodium, Potassium	NT-1	APHA 3120B or 3125B	1
Sulfate - (Turbidimetric) as SO <sub>4</sub>	NT-2	APHA 4500 SO <sub>4</sub> -E	1
Chloride - standard		APHA 4500-Cl <sup>-</sup> -G	1
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>		APHA 2320 B	1
Nitrite as N	NT-4	APHA 4500 NO <sub>2</sub> <sup>-</sup> - I	0.01
Nitrate as N		APHA VCl <sub>3</sub> reduction 4500 NO <sub>3</sub> <sup>-</sup> + NO <sub>2</sub> <sup>-</sup> -B	0.01
Organic Nitrogen as N (calculation of TKN - Ammonia)	EK060	APHA 4500 Norg /NH <sub>3</sub>	0.1
Ammonium ( <i>Calc: Field pH &amp; temp provided by client</i> )	EK055G-NH <sub>4</sub>	Calculation	0.01
Phosphorus Reactive as P	EK071	APHA 4500 P - F	0.01
ICP/MS (dissolved): Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn	EG020F	USEPA 6020 ICP/MS	Cd: 0.0001 Zn: 0.005 Other: 0.001
Trivalent Chromium ( <i>must be requested with Hex<sup>3+</sup> Cr and dissolved Cr</i> )	EG049	APHA 3500 Cr- A & B	0.01
Hexavalent Chromium - Dissolved	EG050	APHA 3500 Cr-B	0.01
Iron - Ferrous (dissolved)	EG051	APHA3500 Fe-B	0.05
Iron - Ferric (dissolved)	EG053	Calc from dissolved and ferrous.	0.05
Organic Carbon Total (TOC)	EP005	APHA 5310 B	1
Chemical Oxygen Demand (COD)	EP026	APHA 5220 B	10
TRH (C6-C40)/BTEXN/PAH	W-7	GC/FID, P&T- or HS-GC/MS,GC/MS-SIM	TPH: 20-100µg/L BTEX:1-5µg/L PAH: 0.5-1µg/L
Phenolics - Total	EP035	APHA 5530 B&D	0.05
PCB Total - Standard level	EP066	USEPA 3510/8270 GC/ECD/ECD/ MS	1 (µg/L)
Explosives ( <i>18 analytes including TNT, RDX</i> ) - Standard level	EP203	USEPA 8330 LC/MS	20-200 (µg/L)
Volatile Acids as Acetic Acid (CH <sub>3</sub> COOH)	EP045	5560 C	5
BOD - Biochemical Oxygen Demand	EP030	APHA 5210 B	2

**Table 13. Sample container and volume requirements.**

<i>Volumes listed below are recommended based on "clean" waters. Please contact ALS for further advice on sample volumes.</i>			
<b>INORGANICS</b>			
No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Green	250mL plastic	Alkalinity, EC, pH, Cations, Cl, SO <sub>4</sub> , F, Nitrite, Nitrate, Reactive P
	Green	500mL plastic	As above plus std. level TDS, BOD
	Purple	60mL plastic (H <sub>2</sub> SO <sub>4</sub> acid)	NO <sub>x</sub> , Ammonia and Total Phenolics <u>or</u> TKN/TP, NO <sub>x</sub> , COD
	Purple	40mL Glass vial (H <sub>2</sub> SO <sub>4</sub> acid)	TOC
<b>METALS &amp; RADIONUCLIDES</b>			
No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Red	60mL plastic (HNO <sub>3</sub> acid)	Metals/Cations Dissolved(Field Filtered) <u>or</u> Total
	Red & Green	60mL plastic AIRFREIGHT OPTION	Metals/Cations Dissolved(Field Filtered) <u>or</u> Total
	Maroon	60mL plastic (HCl acid)	Ferrous Iron (Field Filtered)
	Blue	60mL plastic (NaOH)	Hexavalent Chromium (Field Filtered)
<b>MICRO &amp; ALGAE</b>			
No.	Label Colour	Container Type (Preservation)	Test Parameter(s)
	Grey	250mL Sterile plastic jar/lid (With Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> )	Multiple 'Micro' Tests.
<b>ORGANICS</b>			
No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Purple	Pairs of 40mL glass vials (Sulfuric Acid)	TPH/TRH(C6-C10), BTEXN, VOCs, Alcohols, Gases <u>or</u> Methane <u>or</u> CWG (VOC) speciation
	Orange	100mL glass bottle (primary test). Note: Additional 2 bottles required for QA/QC <sup>NOTE 1</sup>	Std TRH(C10-C40)/PCB/PAHs/Phenols
	Green & White Stripe	100mL glass bottle includes QA/QC <sup>NOTE 1</sup>	Standard Level LCMS testing including Explosives
	Grey	2 x 20mL plastic	PFAS or TOP Assay (standard level)

**Table 14. Sample holding times.**

Parameter	Holding Time
Total Dissolved Solids	7 Days
Ammonium ( <i>Calc"Field pH &amp; temp provided by client</i> )	28 Days
Cations: Calcium, Magnesium, Sodium, Potassium	28 Days
Sulfate – (Turbidimetric) as SO <sub>4</sub>	28 Days
Chloride – standard	28 Days
Alkalinity: including Bicarbonate, Carbonate, Hydroxide & Total as CaCO <sub>3</sub>	14 Days
Organic Carbon Total (TOC)	28 Days
Chemical Oxygen Demand (COD)	28 Days
Nitrate as N	2 Days
Organic Nitrogen as N	28 Days
Phosphorus Reactive as P	2 Days
Metals	180 Days
Trivalent Chromium	28 Days
Hexavalent Chromium	28 Days
Iron – Ferrous (dissolved)	7 Days
Iron – Ferric (dissolved)	7 Days
TPH (C6–C36) plus TRH (C6–C40)	7 Days
PAH – Standard level ( <i>16 analytes</i> )	7 Days
Phenolics – Total	28 Days
BOD – Biochemical Oxygen Demand	2 Days
PCB Total – Standard level	7 Days
Explosives ( <i>18 analytes including TNT, ROX</i> ) – Standard level	7 Days
Volatile Acids as Acetic Acid (CH <sub>3</sub> COOH)	14 Days
PFAS	180 days

### 3.7 Additional parameters

Additional parameters will need to be analysed in quarterly and annual groundwater and surface water samples if leachate impacts are observed. Leachate impacts are indicated where the L/N ratio is greater than 10. The L/N ratio is the ratio of leachate ions (L) such as  $K^+$ ,  $NH_4^+$  and  $NO_3^-$ , to natural groundwater ions (N) such as  $Ca^{2+}$ ,  $Na^+$  and  $Mg^{2+}$ .

$$L/N = (K^+ + NH_4^+ NO_3^-) / (Ca^{2+} + Na^+ + Mg^{2+}) * 100$$

If the L/N ratio is greater 10 the additional parameters BTEXN and total phenolics will need to be analysed in quarterly groundwater samples, and the following parameters in the annual groundwater and surface water samples: TRHs, PAHs, BTEXN, total phenolics, BOD, VFA, PCB, TNT, RDX.

### 3.8 Reporting

Sampling will be undertaken during the first week of each month and sample analysis will be completed and results emailed to the Waste Services Manager by the last week of the month at the latest.

Samples will be submitted to the laboratories with a "standard" turn-around-time, which is estimated at 10 business days for the particular suite of analysis requested. Sample batches will be submitted to the laboratory shopfront on a daily basis during the sampling campaign, therefore results from the first day of sampling will be received first etc. Laboratory results and documentation will be emailed to the Waste Services Manager immediately upon receipt. In addition, if particular parameters are completed before others, these preliminary results will be sent to the Waste Services Manager as they are received.

All raw laboratory results and laboratory documentation will be forwarded including excel spreadsheets, chain of custody (COC) forms, certificate of analysis (COA), sample receipt notifications (SRN) and QA/QC documentation.

All Field Data Sheets will be scanned and sent to the Waste Services Manager upon completion of the last day of sampling for each monthly round i.e. at the end of the first week of the month. All site photos and other relevant photos will also be sent.

Following each monthly round, an email report will be submitted to the Waste Services Manager which will include a summary of sampling undertaken and a brief summary of results, with any exceedances of applicable trigger values noted.

Following each quarterly round, a formal report will be developed which will include:

- Summary of sampling undertaken (e.g. number of sites sampled, dates of sampling)
- Tabulation of results, and graphical representation if appropriate
- Comparison of results with applicable trigger values, highlighting any exceedances
- Trend analysis and comparison of results to historical data
- Interpretation of results, overall conclusions and recommendations

An annual report may be undertaken based on request from City of Darwin.

## 4 Step-by-step Procedure

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### 4.1 Preparation prior to commencement

- 4.1.1 Confirm with Waste Services Manager the dates for sampling and discuss any potential site access issues.
- 4.1.2 Look at weather forecast in relation to sampling safety and the ability to obtain samples.
- 4.1.3 Ensure that JHA has been completed and that all staff involved have read, understood and signed the printed JHA.
- 4.1.4 Get together all the equipment listed in Section 3.3 (and any additional monitoring round-specific equipment) ready to go, ideally packing most of the gear together into a large plastic crate.
- 4.1.5 Bottles may need to be ordered from the laboratory (i.e. ALS and Eurofins mgt) if not already in stock in EcOz storeroom.
- 4.1.6 Put together a package of sample bottles for each site (i.e. in a large snap-lock bag), including bottles for duplicates, split/triplicate samples and blanks.
- 4.1.7 Calibrate the field test meters (e.g. pH, EC, Turbidity, DO, ORP) according to the laminated instruction card provided in the Calibration Folder and/or manufacturer's instructions. Fill out the *EcOz Calibration Record Sheet* and file in the Calibration Record Sheet Folder.
- 4.1.8 Ensure camera and GPS are fully charged and have a cleared memory.
- 4.1.9 Prepare a sufficient volume of Decon 90 solution (i.e. 1:20 Decon:de-ionised water) to use for cleaning sampling equipment in the field.
- 4.1.10 Print out required number of blank Field Data Sheets (Appendix A and B), COC forms (Appendix C), maps and bore reports.
- 4.1.11 Ensure that ice bricks have been put in the freezer for transfer to eskies on the morning of each sampling day.
- 4.1.12 Test run the groundwater pump at the EcOz shed to ensure everything is working properly.
- 4.1.13 Complete pre-start checks using the *EcOz Vehicle Pre-Start Checklist* on all vehicles being used i.e. 4WD vehicle and if required ATV or side-by-side.

### 4.2 Surface water / leachate sampling

- 4.2.1 Proceed to sample site using map (Figure 2), coordinates (Table 2 and Table 3) and GPS.
- 4.2.2 Record on field sheets the date, time, site name/number, sampler's name, and field observations such as weather conditions, water colour, clarity, water depth, flow rate, any obvious pollution (e.g. rubbish, odours, surface films etc.), flora/fauna, and any other issues that may affect the samples.
- 4.2.3 Put on disposable powder-free gloves.
- 4.2.4 Ideally, in-situ readings (e.g. pH, Temperature, DO, Turbidity, and EC) are collected directly from the water body being sampled by immersing the meters in the area to be sampled. However, if safety

and/or logistical issues preclude this, field readings may need to be taken from the sampling jug.

- 4.2.5 Record the in-situ parameters just below the water surface (between 0.2 and 0.5 m depth), depending on water depth. Alternatively, if collecting samples from various depths (e.g. depth profiling), ensure the field meter is lowered to the desired depth.
- 4.2.6 If collecting field readings from the sampling jug, collect a representative water sample using the jug mounted on a sampling pole. Ensure that the jug/sampler is fully immersed and rinsed at least 3 times, tipping the rinse water away from where the sample is to be collected (e.g. on the bank).
- 4.2.7 If sampling flowing waters, ensure that you are standing downstream of where you are sampling so as not to contaminate the sample.
- 4.2.8 Record all the readings on the Field Data Sheet (Appendix A).
- 4.2.9 Note that the procedure above is for the surface water bodies, ponds, and drains with direct access. Please refer to Sections 2.1.2 and 3.2 above for the slightly differing methods for the sumps without a pump, sumps with a pump, and the leachate ponds.

### 4.3 Sample collection

- 4.3.1 Ensure gloves are on.
- 4.3.2 Take out the snap-lock bag full of sample bottles for the site and fill in the required information on the labels with the permanent marker (e.g. site name, time, name of sampler etc.)
- 4.3.3 For metals, tick the box on the bottle label for either *filtered* or *total*, depending on whether samples for metals analysis will be filtered in the field.
- 4.3.4 Unscrew the cap, making sure not to touch the opening of the bottle with your fingers to avoid contaminating the sample. Put the cap upside-down on a clean surface where it won't pick up any contaminants.
- 4.3.5 If safe to do so (i.e. no crocodiles, steep banks, or fast water flow), fill the bottles directly from the water body being sampled; otherwise use the jug on the end of the pole to collect a water sample representative of the site.
- 4.3.6 Fully immerse the sample bottle or jug in the water and rinse at least 3 times before filling. For sample bottles containing preservatives (e.g. nutrients, VOC hydrocarbons), do not rinse before filling, use the jug to fill these sample bottles.
- 4.3.7 Make sure that you are standing downstream of where you are sampling so as not to contaminate the sample.
- 4.3.8 If using the jug, pour the water into each sample bottle.
- 4.3.9 Fill each bottle to the top leaving no headspace and screw on the cap.
- 4.3.10 For samples requiring field filtering (e.g. dissolved metals), draw some water (as per 3.4.4 above) into a syringe, put a filter on the end of the syringe, rinse the filter by pushing a few drops of the sample through onto the ground, then fill the bottle leaving no headspace. Depending on the size of the syringe, it may be necessary to draw several syringes-full of water to fill the sample bottle.

- 4.3.11 Put all the sample bottles back in the snap-lock bag and immediately place them in the esky with frozen ice-bricks.
- 4.3.12 Note that the procedure above is for the surface water bodies, ponds, and drains with direct access. Please refer to Sections 2.1.2 and 3.2 above for the slightly differing methods for the sumps without a pump, sumps with a pump, and the leachate ponds.

## 4.4 Groundwater sampling

- 4.4.1 Proceed to bore using map (Figure 2), coordinates (Table 2 and Table 3) and GPS.
- 4.4.2 Record on field sheets the date, time, site name/number, sampler's name, and field observations
- 4.4.3 Open bore cap using hand tools.
- 4.4.4 Lower the fox whistle or electronic dip meter and measure SWL.
- 4.4.5 Record the SWL and the Time on the Field Data Sheet.

### **If using Bailers:**

- 4.4.6 Based on the SWL, calculate the volume of water in the bore requiring removal using this calculation:

$$\pi r^2 (D-SWL) \times 1000$$

Where: r = the radius of the inner bore cap (in meters)

$\pi$  = pi (3.14)

D = the total depth of the bore (in meters) taken from the bore reports

SWL = the Standing Water Level (distance from ground to water level – in meters)

- 4.4.7 Make sure bailer cord is securely attached to the bailer (each bore should have a separate bailer and cord).
- 4.4.8 Start bailing. Each bailer is just over 1 L when full, therefore assume each time you bail you are removing 1 L of water from the bore.
- 4.4.9 Lower the bailer inside the borehole slowly and gently until it is submerged.
- 4.4.10 Once the bailer fills, retrieve the bailer from the well slowly, in a steady, smooth motion and empty the bailer into the 20 L bucket.
- 4.4.11 Once the required amount of water is removed from the bore for purging, empty the 20 L bucket at least 5 m away from the bore to avoid contamination of the bore.
- 4.4.12 Collect water samples for laboratory analysis direct from bailer into sample bottle
- 4.4.13 Fill jug with sample water and in-situ readings (e.g. pH, Temperature, DO, Turbidity, and EC).

### **If using Low-Flow Pump:**

- 4.4.14 Set up the pump, hose and compressor and attach power leads to car battery.

- 4.4.15 Lower pump into bore to the level where the bore casing is slotted (known from the bore report).
- 4.4.16 Lower dip meter back into bore so that SWL can be continuously measured during pumping – the pumping rate must be adjusted so that change in SWL is minimal i.e pumping rate = recharge rate.
- 4.4.17 Begin pumping and record the time pumping began on the Data Sheet.
- 4.4.18 Continue to pump and observe any reduction in SWL to match pumping rate with recharge rate.
- 4.4.19 After about 5 minutes of pumping take a photo of the water colour and make any observations such as colour, sediment, odour or contamination etc
- 4.4.20 Set up flow-through cell and insert water quality meters (pH, EC, ORP, DO).
- 4.4.21 Every 5 min record the time, SWL, Temperature, flow rate, pH, EC, ORP, DO, Turbidity and any water colour, odour, signs of hydrocarbon sheen or other contamination.
- 4.4.22 Continue pumping until three consecutive readings stabilise within 5% of each other. Record all readings on the Field Data Sheet.
- 4.4.23 Once a stable chemistry is reached (usually after about 30 min of pumping depending on the bore), record the final time, SWL and water quality parameters and collect water samples for laboratory analysis direct into sample bottles from the hose.

## 4.1 Cleaning of field equipment

- 4.1.1 After sampling each surface water / leachate site or groundwater bore, rinse all sampling equipment (e.g. jugs, groundwater pump hoses) with the pre-mixed Decon 90 solution, followed by deionised water.
- 4.1.2 For the groundwater pump hose this means placing pump into the 20 L bucket with decon and then deionised water to flush the hose. Also, the external surface of the hose must be rinsed with decon and deionised water.
- 4.1.3 Dispose of used filters, syringes, and gloves in the garbage bag.

## 4.1 Collection of field blanks, split samples and duplicates

- 4.1.1 The QA/QC samples required are listed in Section 3.4 above.
- 4.1.2 To collect a field blank, simply follow the steps outlined above using de-ionised water instead of water from the site / bore being sampled.
- 4.1.3 For split / triplicate samples and duplicates, collect extra bottle sets using the same surface water / groundwater sampling methods as per above steps.
- 4.1.4 Ensure to note collection of these samples on the Field Data Sheet for that site / bore as the site location mustn't be recorded on the sample bottles.

## 4.2 Sample dispatch

- 4.2.1 Fill out the COC.
- 4.2.2 Prepare a small esky containing the split samples for dropping to separate laboratory.
- 4.2.3 Deliver samples direct to laboratory shop fronts.
- 4.2.4 Note that all samples must be delivered to the laboratories to allow for analysis to be undertaken within holding times (see Table 13). The shortest holding time is two days for BOD, nitrate, nitrite and phosphorus. In order to allow samples to be delivered to the interstate laboratories and meet this holding time, samples with these parameters (i.e. all quarterly and annual samples) will need to be delivered to the Darwin ALS / Eurofins mgt shopfront by 3 pm each day and not on a Friday, Saturday or Sunday. As such, sampling will need to start very early (7 am) and be completed in four days (Mon/Tues/Wed/Thurs). If sampling is not completed on Thursday, it will need to be finished the following Monday. The shortest holding time for monthly samples is 14 days, therefore sample delivery to the laboratories by 3 pm is not critical but this will be achieved if possible.

## 4.3 Data management

- 4.3.1 At the end of each day, all Field Data Sheets must be scanned and saved, and all photographs downloaded, saved, and labelled according to the relevant site name.
- 4.3.2 Once the Sample Receipt Notification (SRN) is received from the Labs, notify the Waste Services Manager of the expected due date for sample analysis results. Also check the SRN for any mistakes, missing analysis etc and inform labs immediately of any issues.
- 4.3.3 Send all scanned Field Data Sheets and photographs to the Waste Services Manager on completion of the monthly sampling round.
- 4.3.4 Send all lab results to Waste Services Manager immediately upon receipt.

## 5 Acronyms

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ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BTEXN	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene
COA	Certificate of Analysis
COC	Chain of Custody form
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EC	Electrical Conductivity
EPL	Environment Protection Licence
LOR	Limit of Reporting
N.A.T.A	National Association of Testing Authorities
NT EPA	Northern Territory Environment Protection Authority
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PPE	Personal Protective Equipment
QA / QC	Quality Assurance / Quality Control
RDX	Cyclotrimethyne trinitramine
SOP	Standard Operating Procedure
SRN	Sample Receipt Notification
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
VFA	Volatile acids as acetic acid

## 6 References

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- URS 2016, *Shoal Bay Waste Disposal Site Water Monitoring Plan*, March 2016, Report prepared for John Holland Pty Ltd, URS Australia, Darwin, NT.
- NT EPA 2011, *Environment Protection Licence EPL12-09*, Issued 1 March 2011, Expires 1 July 2016, Northern Territory Environment Protection Authority (NT EPA), Darwin, NT.
- NT EPA 2013, *Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory*, Northern Territory Environment Protection Authority (NT EPA), Darwin, NT.
- Australian/New Zealand Standard on Water Quality Sampling - Part 1: *Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998), Standards Australia, New South Wales.
- Australian/New Zealand Standard on Water Quality Sampling - Part 6: *Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998), Standards Australia, New South Wales.
- Australian/New Zealand Standard on Water Quality Sampling – Part 11: *Guidance on sampling of groundwater* (AS/NZS 5667.11:1998), Standards Australia, New South Wales.
- Sundaram, B., Feitz, A., Caritat, P. de, Plazinska, A., Brodie, R., Coram, J. and Ransley, T., 2009. *Groundwater Sampling and Analysis – A Field Guide*. Geoscience Australia, Record 2009/27, Commonwealth Government, Canberra.
- ANZECC & AMRCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.
- ANZECC & AMRCANZ 2000, *Australian Guidelines for Water Quality Monitoring and Reporting*, National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

## Appendix A – Surface Water / Leachate Field Data Sheet

# Surface Water Field Data Sheet

PROJECT:		DATE and TIME:		
SITE NUMBER / NAME:				
SAMPLERS NAME:		PHOTO NOS:		
EASTING:		NORTHING:		
<b>GENERAL OBSERVATIONS</b>				
WATER COLOUR		PRESENCE OF AQUATIC FAUNA		
ODOUR		AQUATIC PLANTS		
SURFACE SCUM/ALGAE		EROSION		
RIPARIAN CONDITION		GROSS POLLUTANTS		
<b>WATER CONDITIONS</b>				
APPROX DEPTH OF WATER (m)		WATER FLOW (m/sec)		
<b>WEATHER CONDITIONS</b>				
Cloud cover/ precipitation/ wind conditions:				
<b>FIELD SAMPLES</b>				
Parameter	Unit	Result	Meter Used	Date of calibration
pH				
Temperature				
E.C				
TDS				
Salinity				
D.O				
ORP				
Turbidity				
<b>LABORATORY SAMPLES</b>				
Analytes Requested		Containers Used		QA/QC Samples Collected (circle)
				Duplicate Split Blank

Any other comments or special procedures (see over):

## Appendix B – Groundwater Field Data Sheet

# Groundwater Sampling Data Sheet

<b>Site/Project:</b>	
Sample Date:	
Bore Name:	
Sampled By:	
Bore Head Condition:	
Total Depth (mbgl):	
Screen Intervals (mbgl):	
Pump Depth:	

SWL Initial (m below top of casing):				
Casing Height (m above ground):				
SWL Initial (m below ground level):				
<b>Casing:</b>	<b>Colour at Start:</b>	<b>Odour:</b>	<b>Equip?</b>	
PVC		Nil	Y	N
Steel	<b>Colour at End:</b>	H <sub>2</sub> S	psi	
Other		Other:	L/s	
Comments:				

Time started Pumping/Purging:										
Time										24hr
EC										µs/cm
pH										
Temp										°C
Turbidity										NTU
Salinity										ppt
TDS										g/L
ORP										mV
D.O.										%sat
SWL										mbtoc
Flow Rate										L/min

Time										24hr
EC										µs/cm
pH										
Temp										°C
Turbidity										NTU
Salinity										ppt
TDS										g/L
ORP										mV
D.O.										%sat
SWL										mtoc
Flow Rate										L/min

<b>Time Lab Samples Collected:</b>
------------------------------------

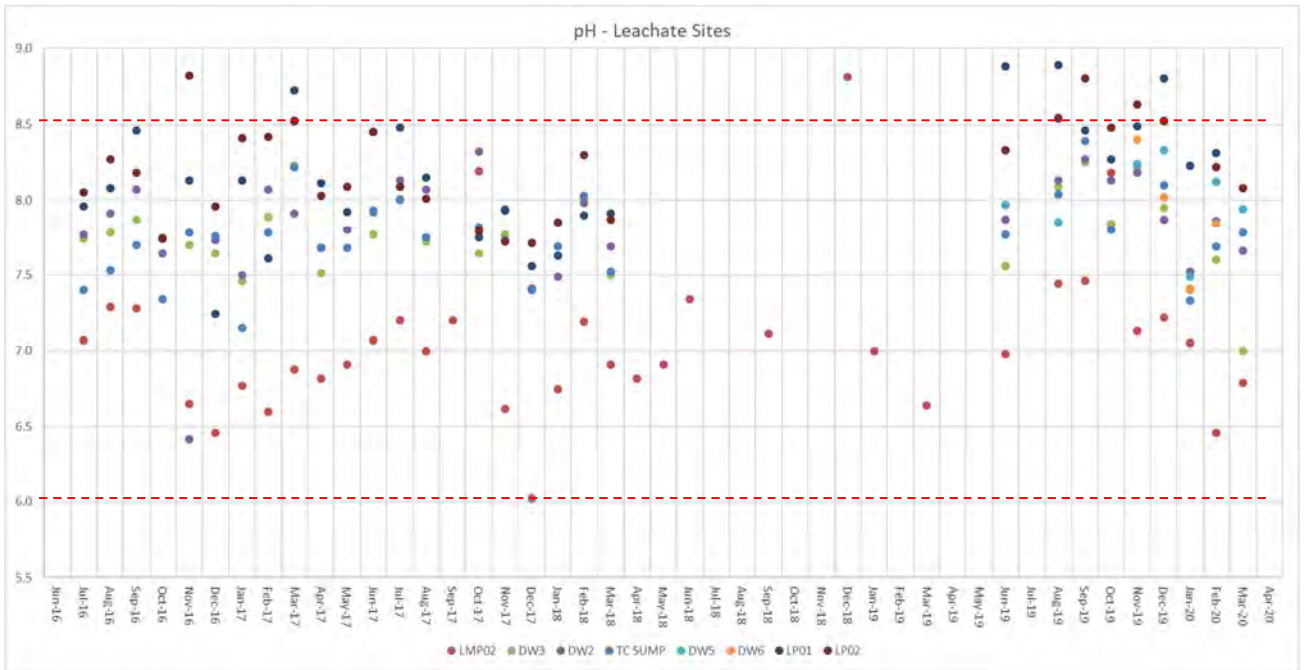
<b>Comments:</b>

## Appendix C – Laboratory Chain of Custody Form

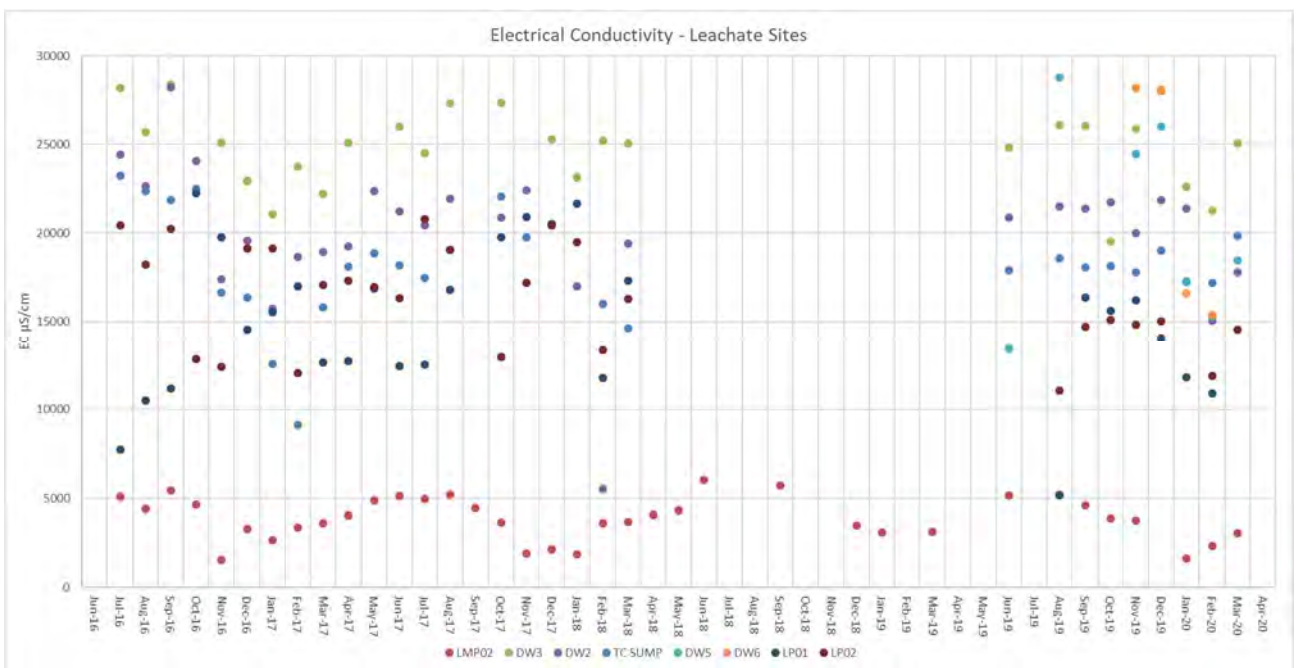


## APPENDIX B WATER QUALITY TREND ANALYSIS GRAPHS

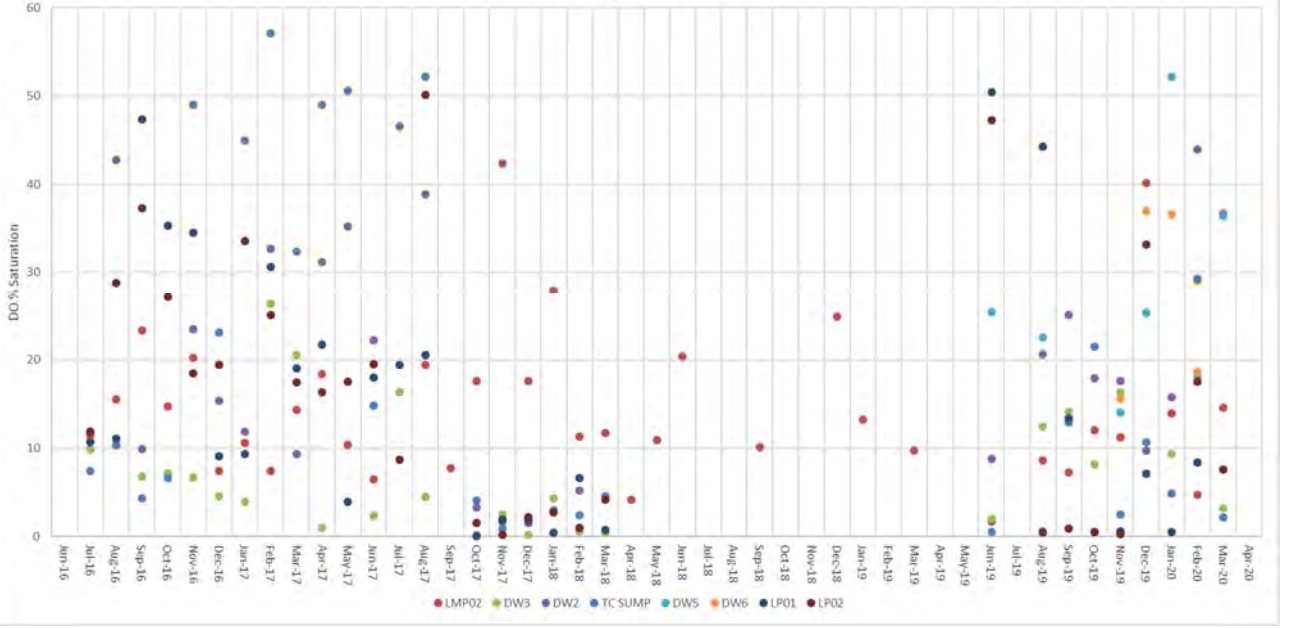
**Graphs of leachate sites measurements between July 2016 and March 2020.**



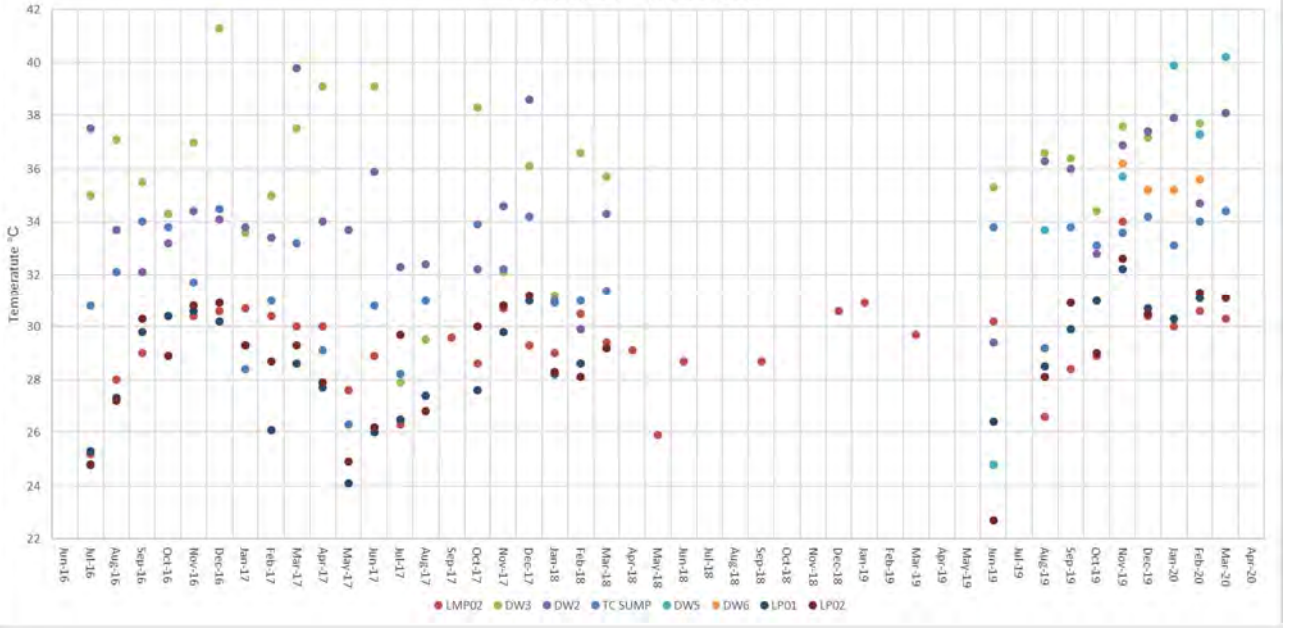
*Darwin Harbour water quality objective upper and lower limits shown by red dashed lines.*

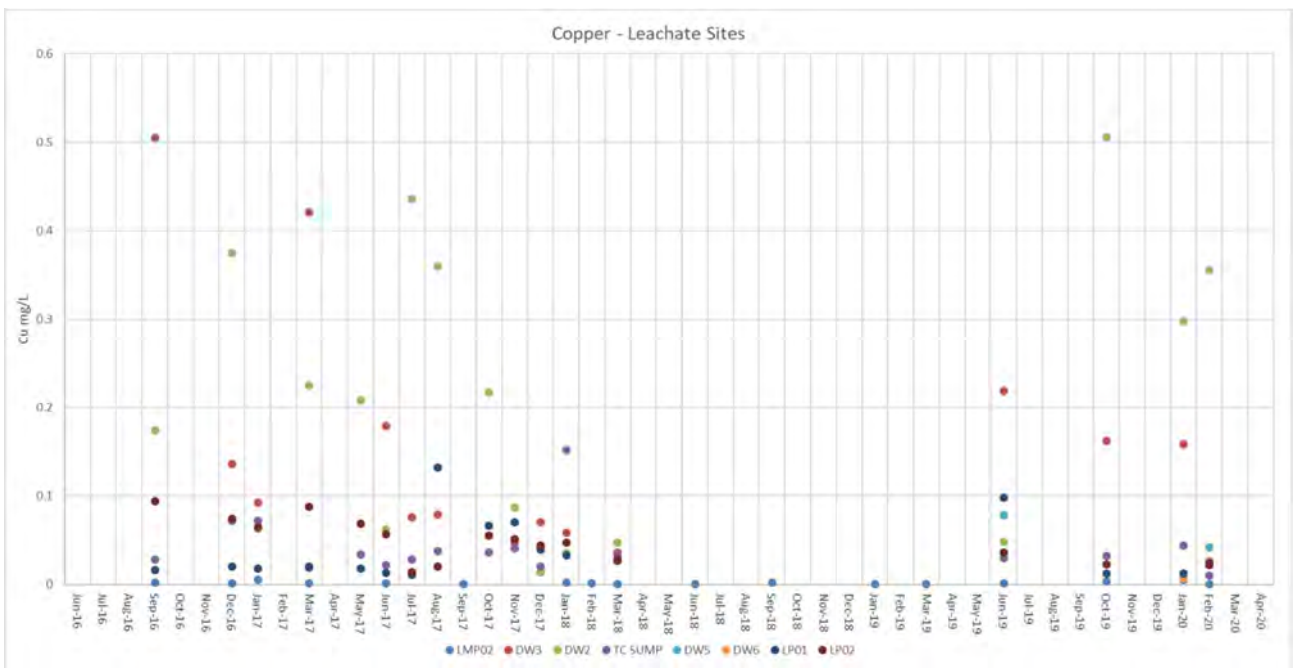
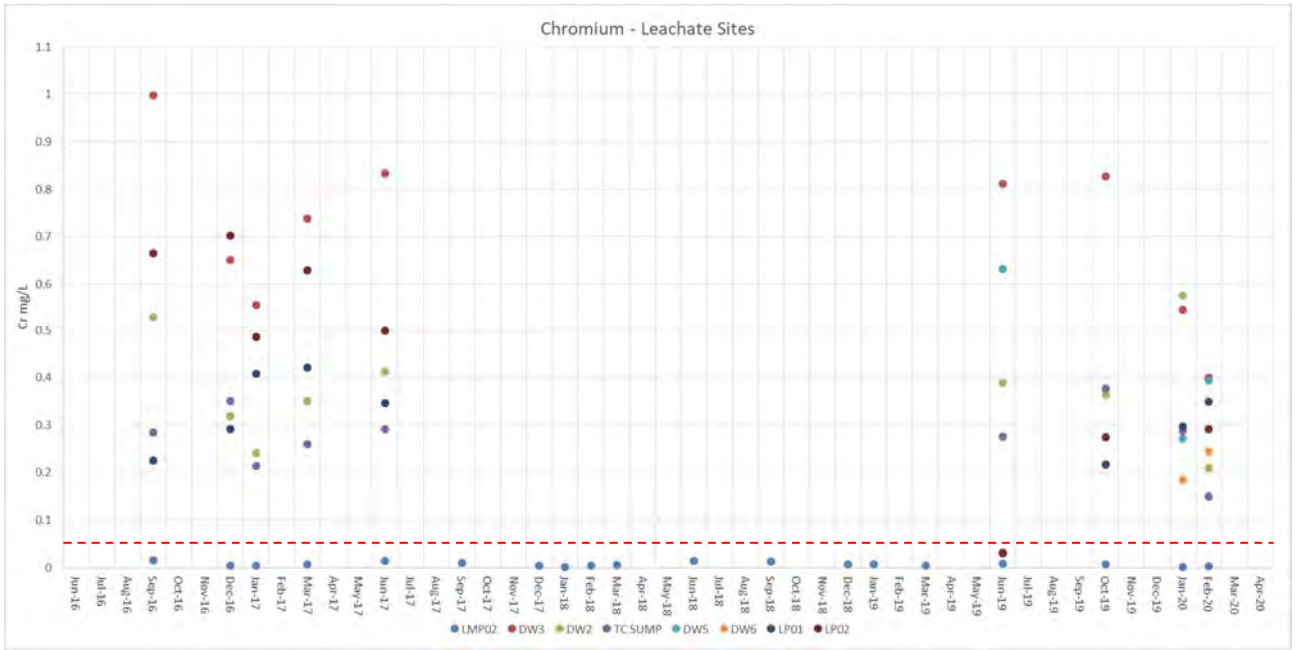


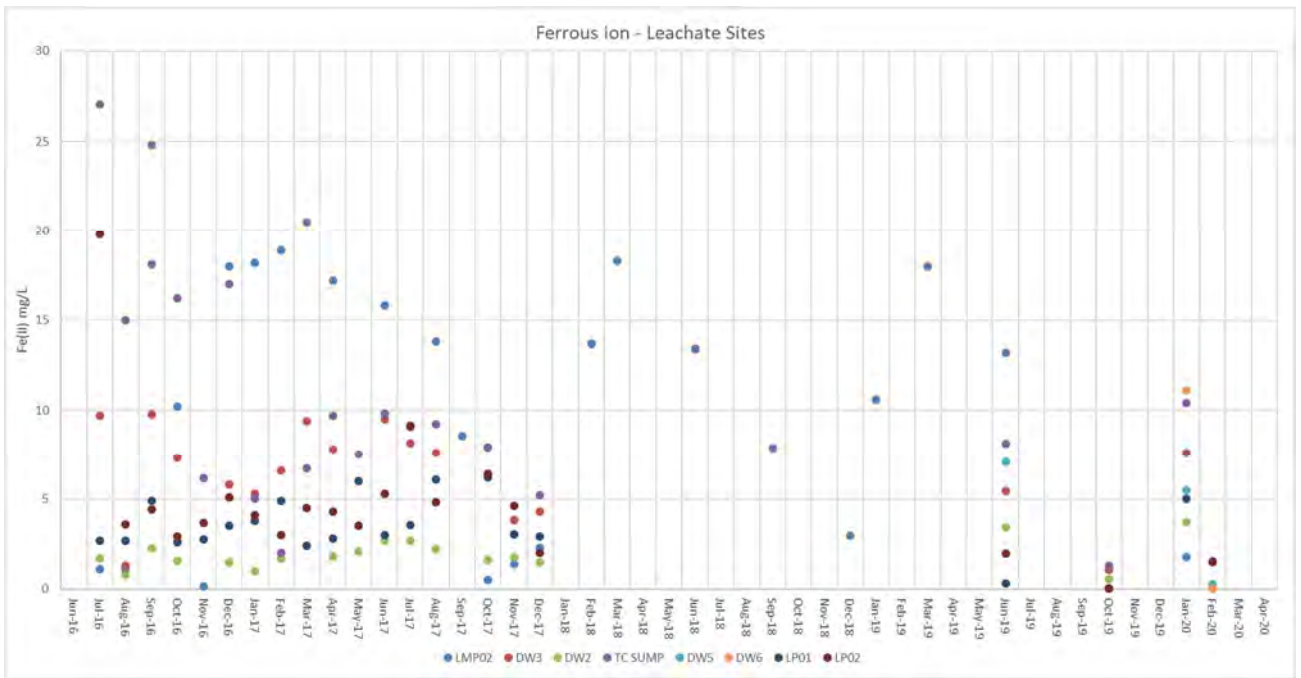
Dissolved Oxygen - Leachate Sites



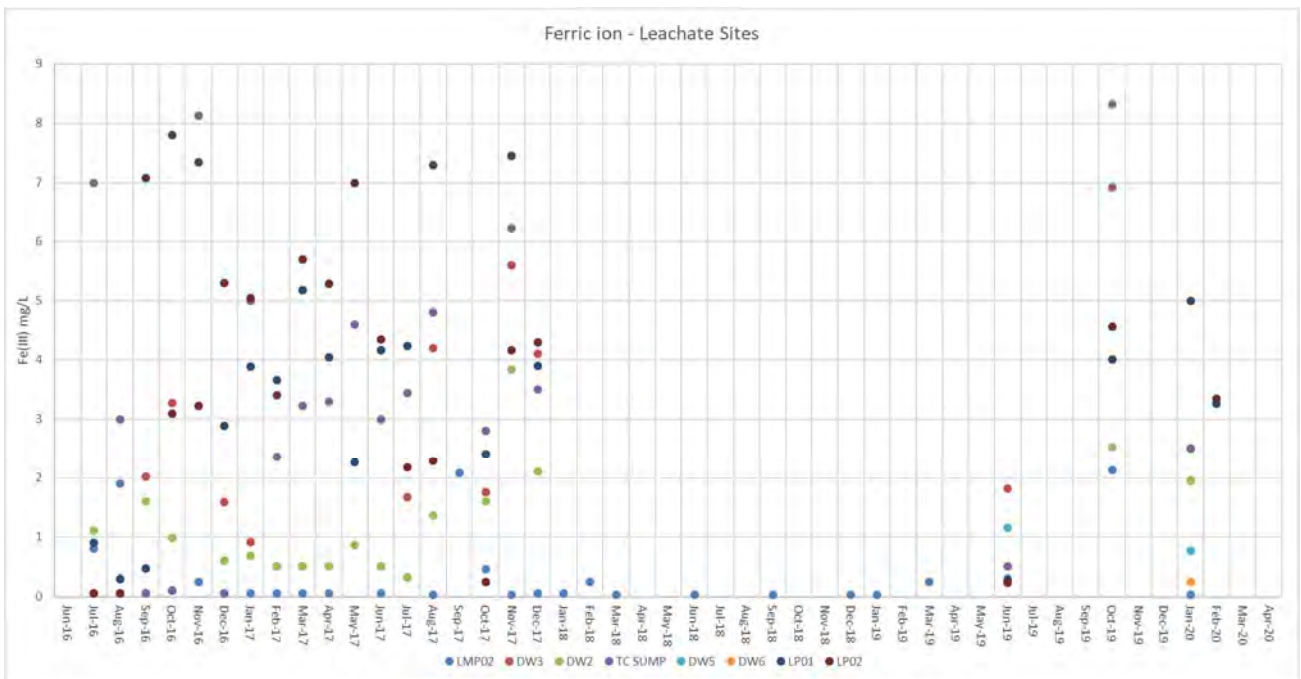
Temperature - Leachate Sites



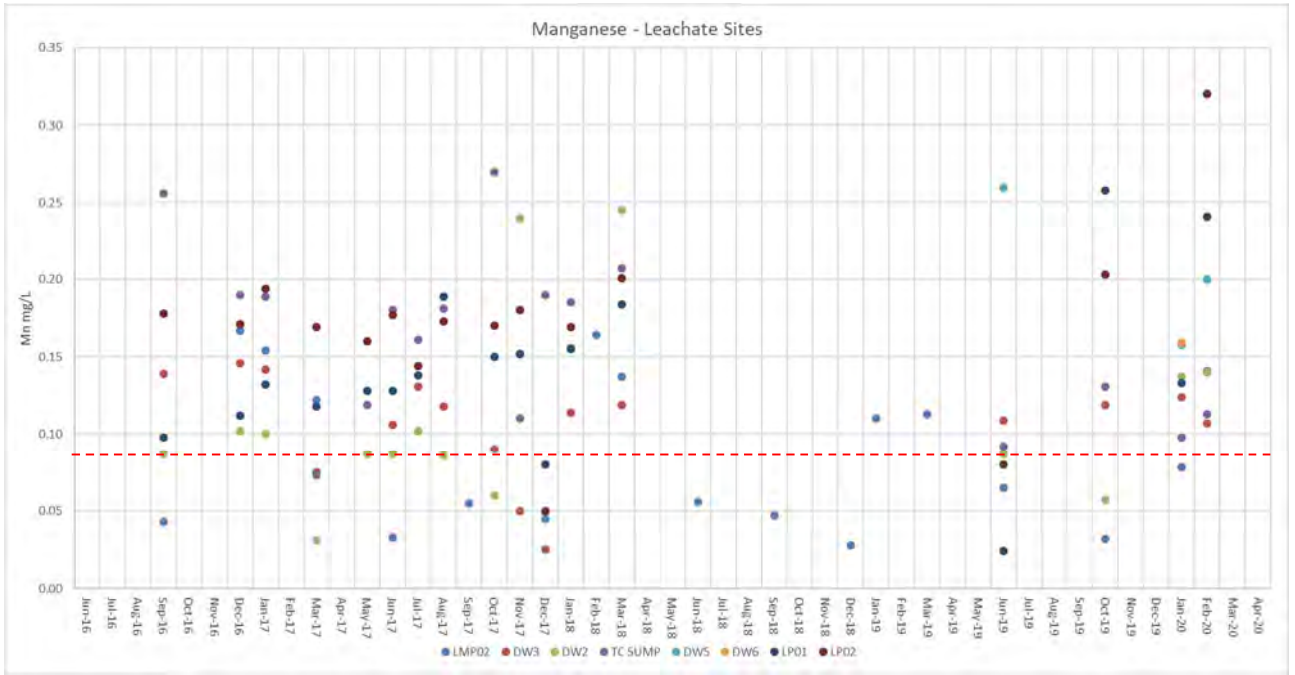




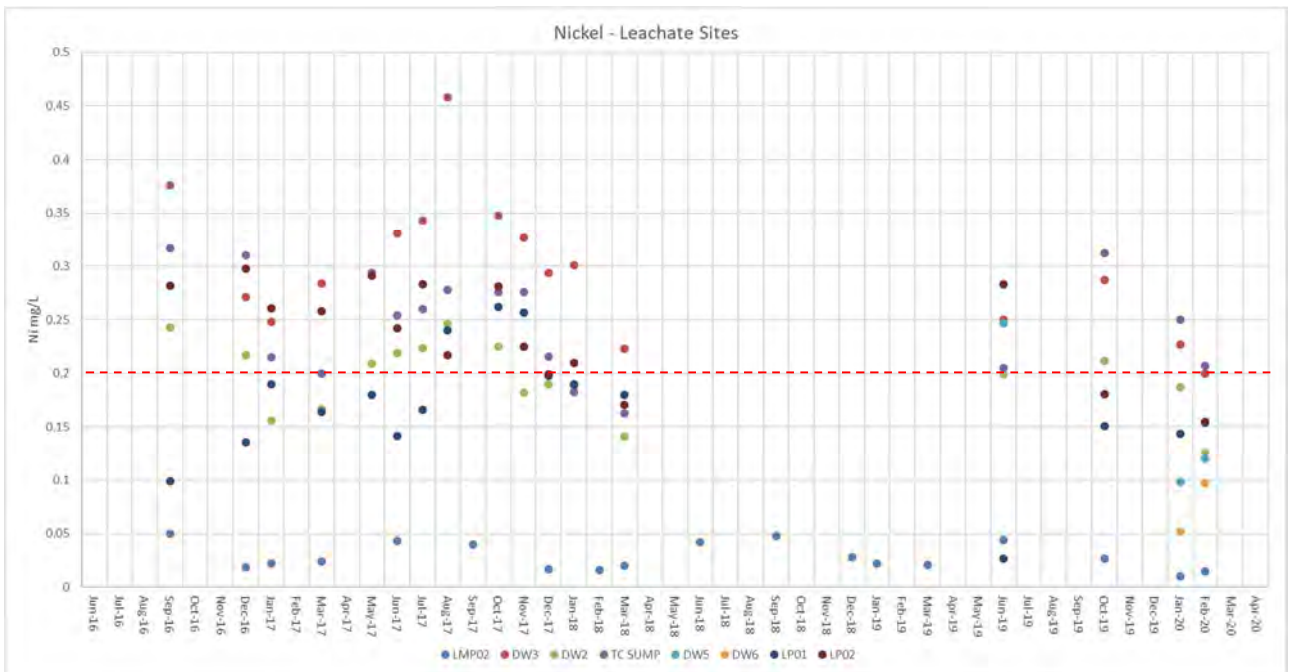
*There is no ANZECC (2000) trigger value for iron.*



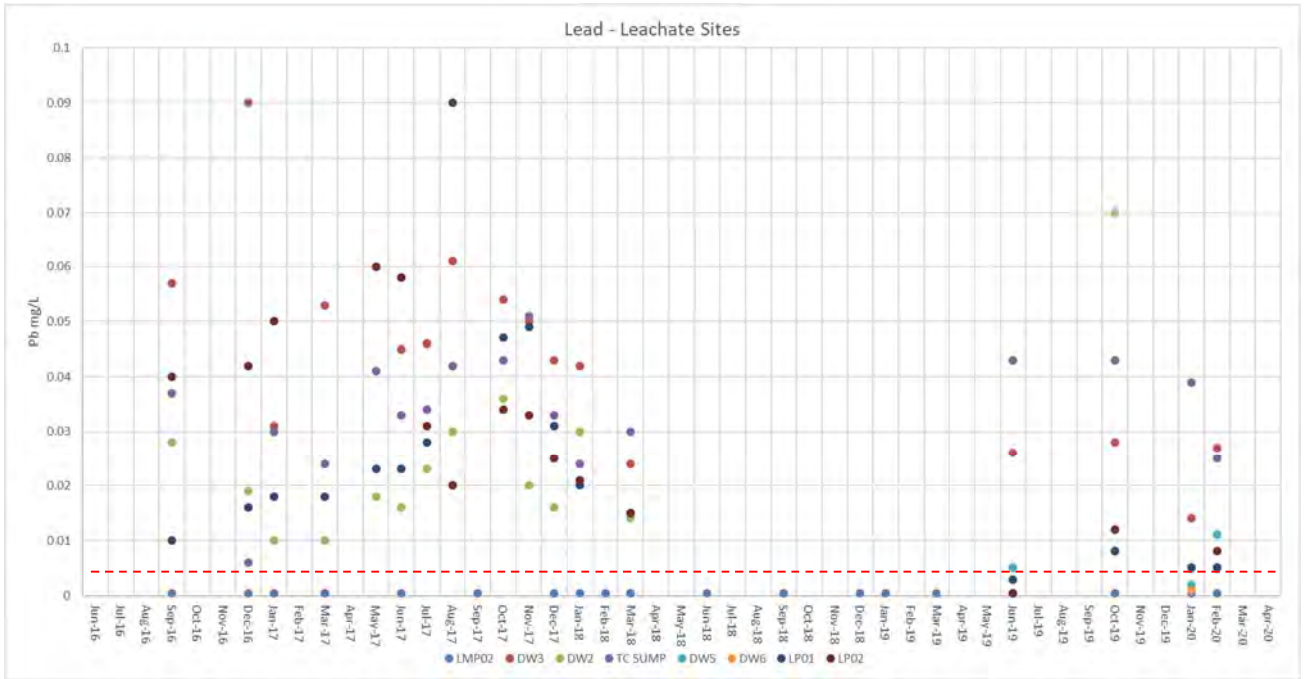
*There is no ANZECC (2000) trigger value for iron.*



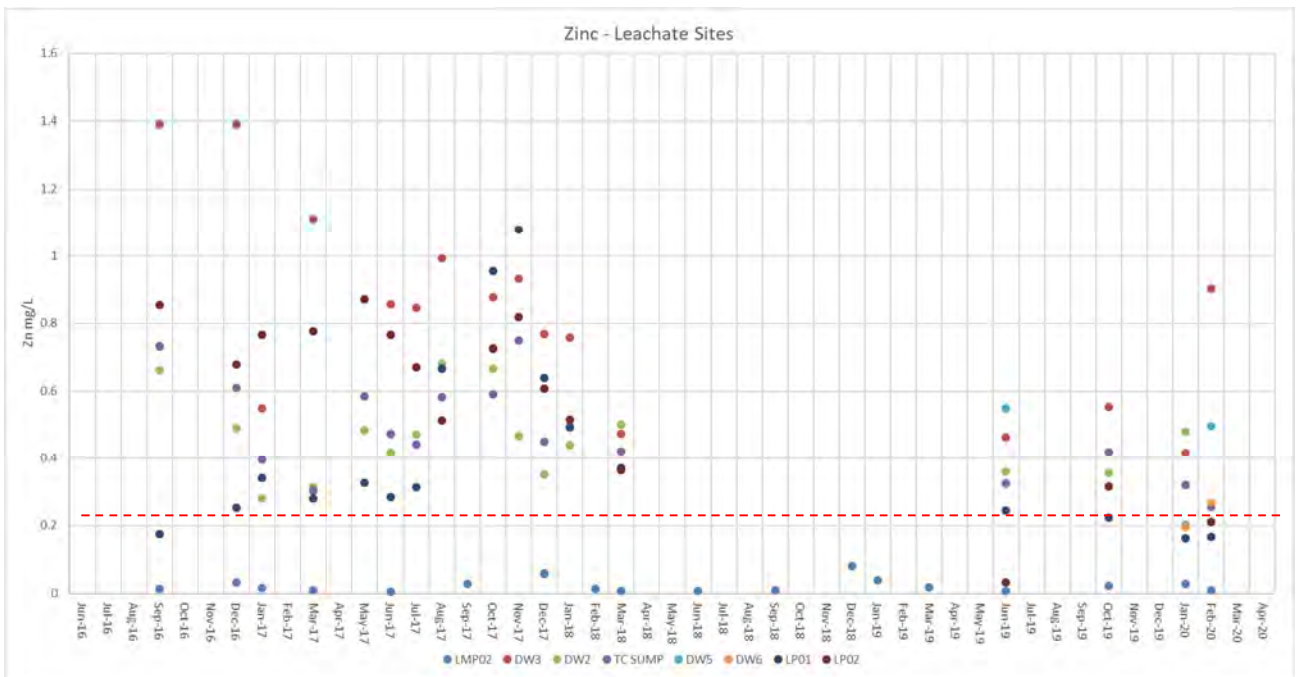
ANZECC (2000) 'low reliability' trigger value in marine water shown by red dashed line i.e. 0.08 mg/L. This value is based on limited data and should be considered as indicative only. No species protection level is indicated.



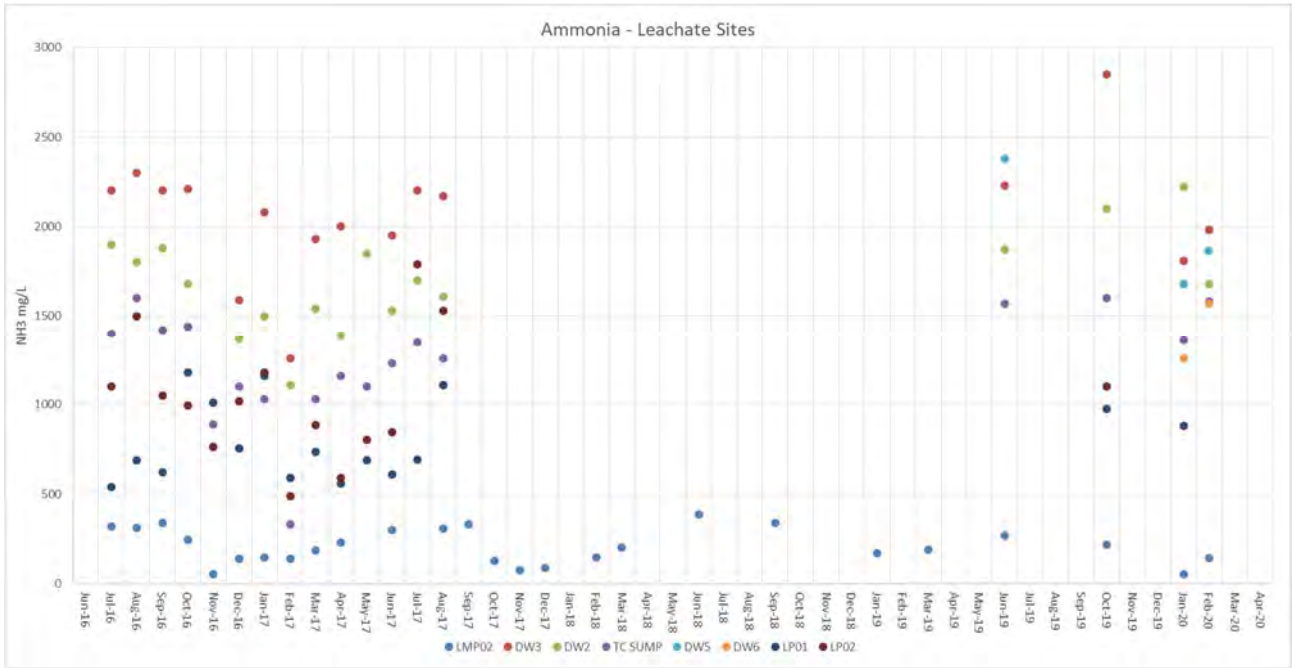
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.2 mg/L.



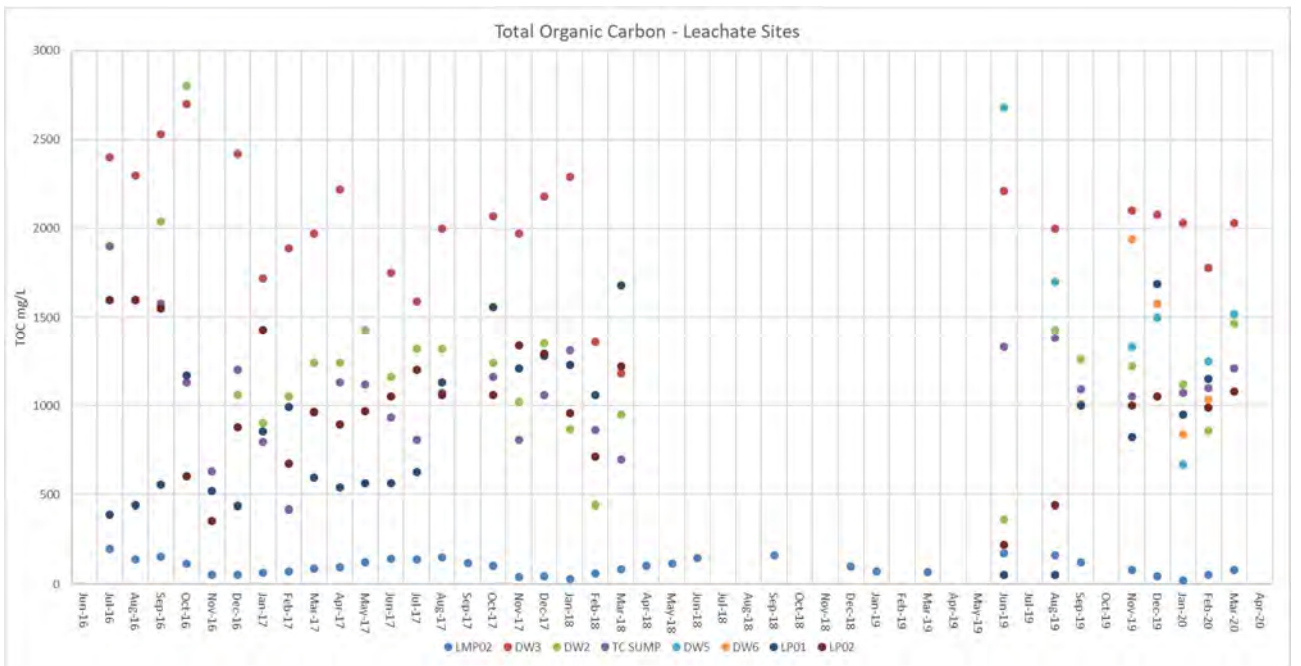
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.0066 mg/L.



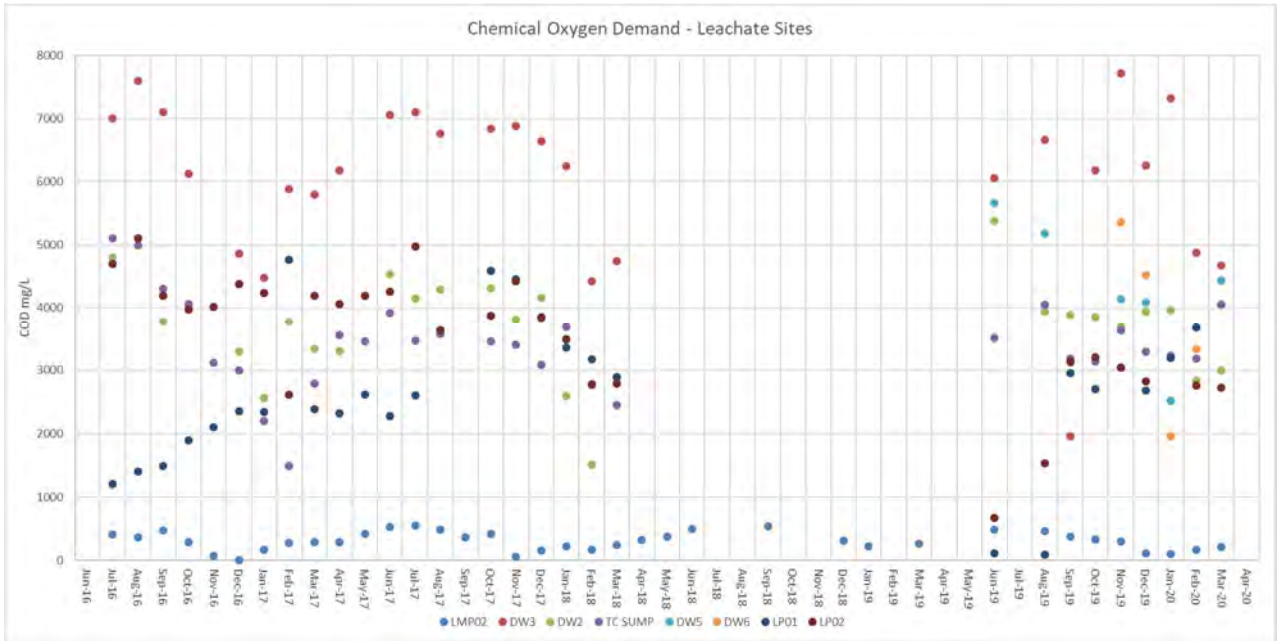
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.023 mg/L.



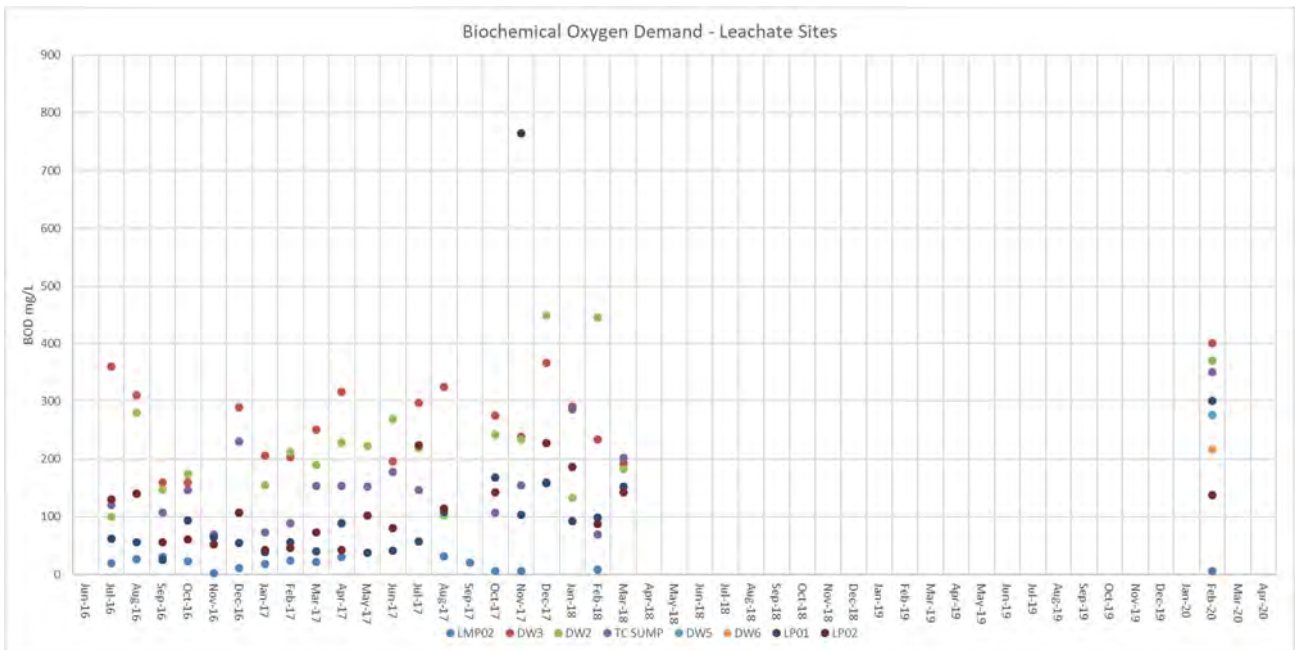
*ANZECC (2000) trigger value for 90% species protection in marine water is 1.2 mg/L and too low to be shown on the graph; all concentrations are above the trigger value.*



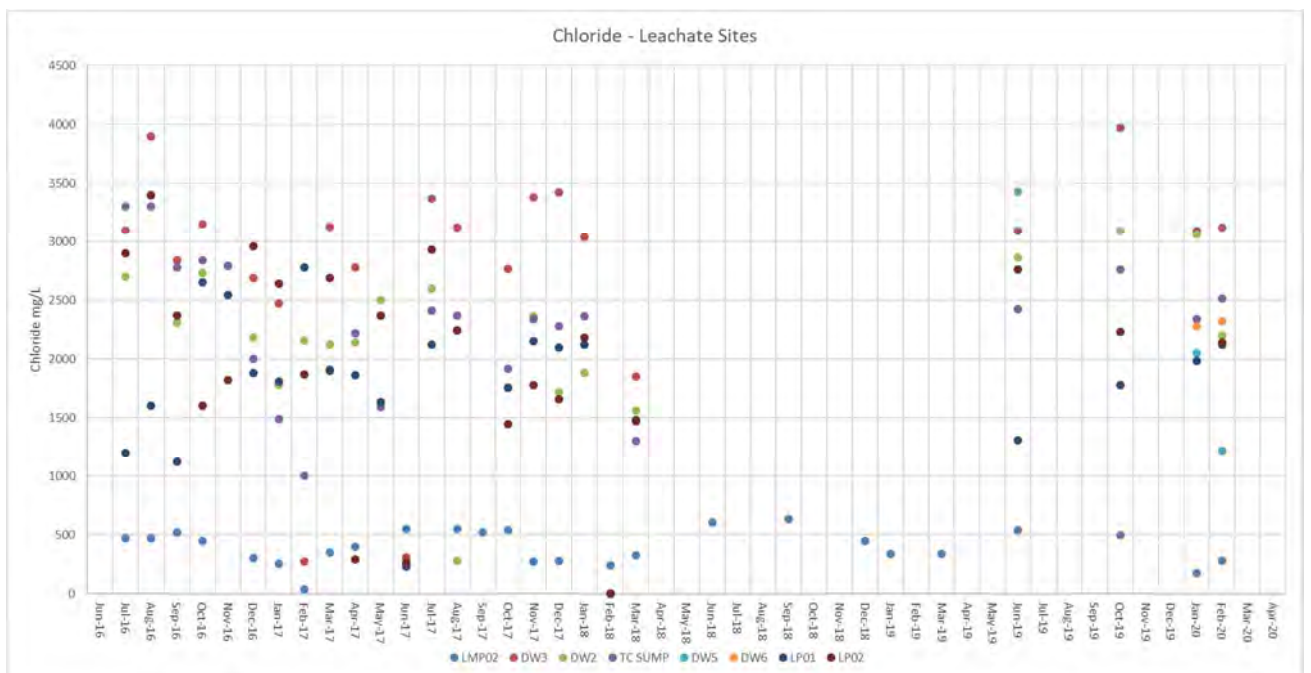
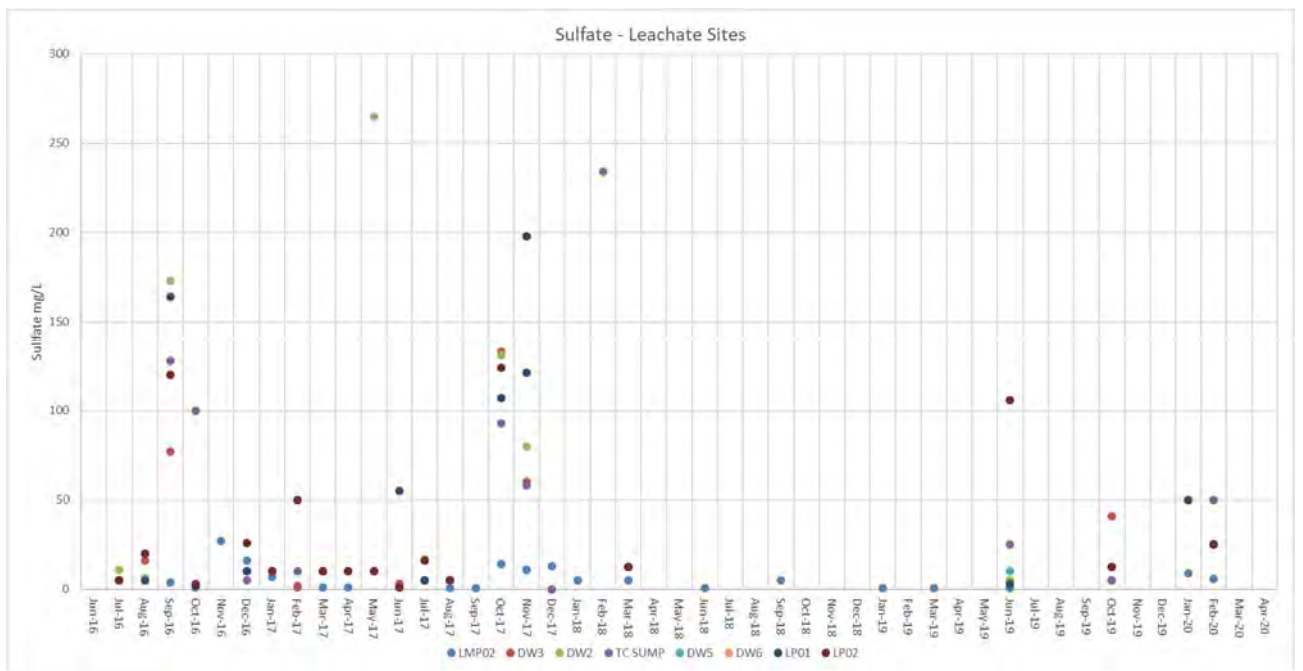
*There is no ANZECC (2000) guideline value for TOC.*

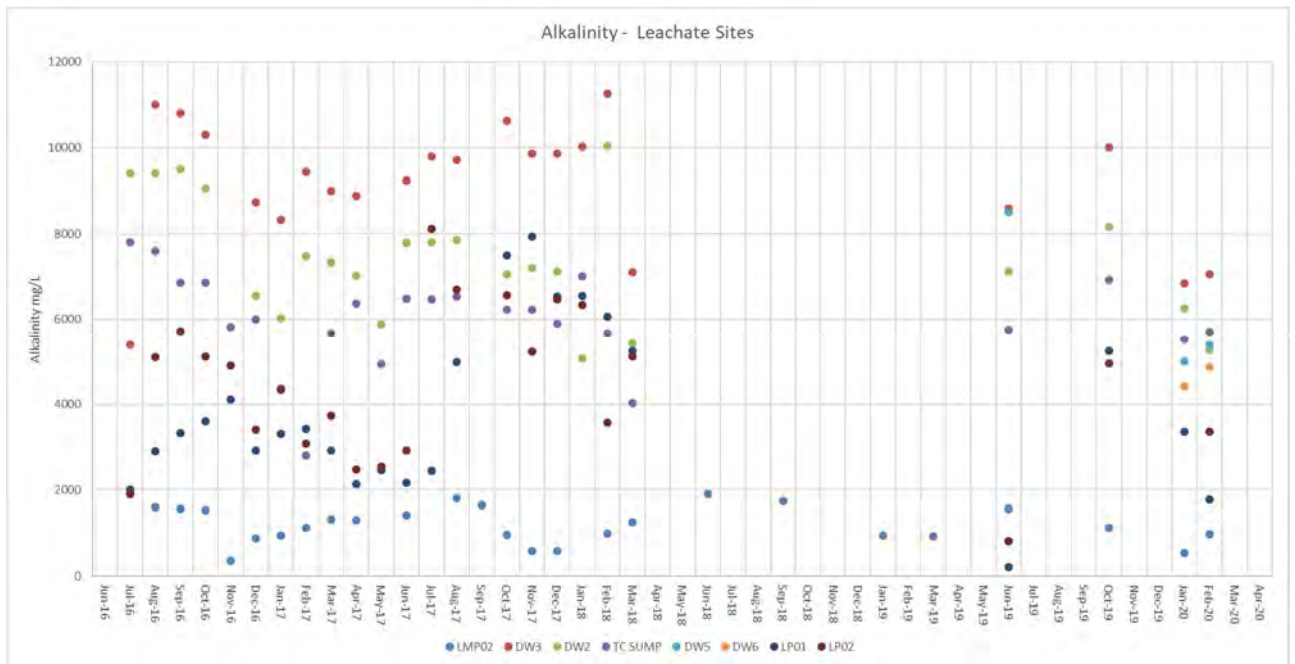


*There is no ANZECC (2000) guideline value for COD.*

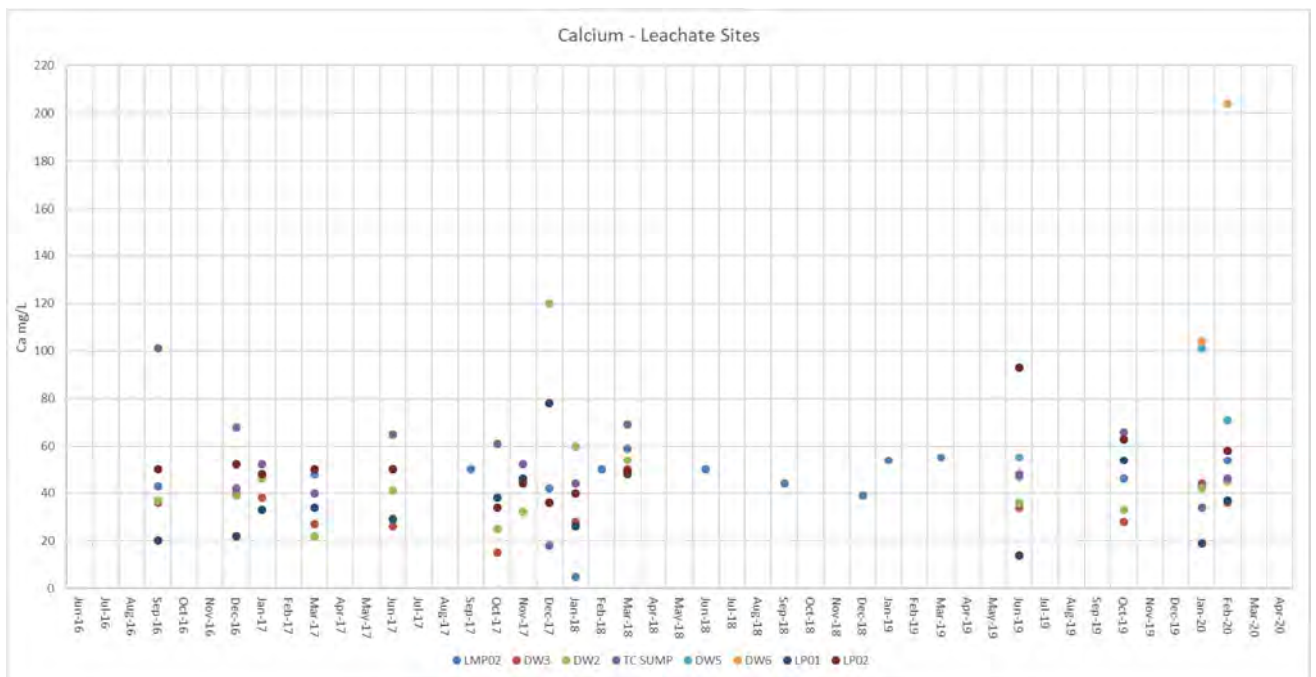


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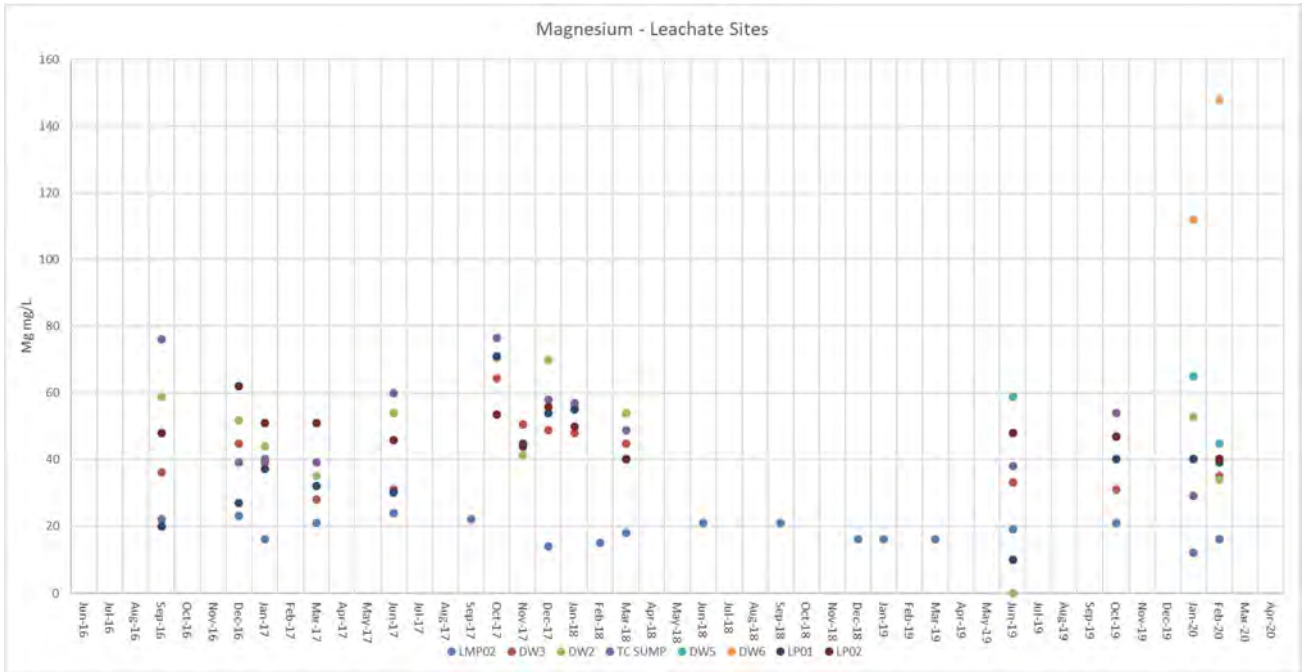




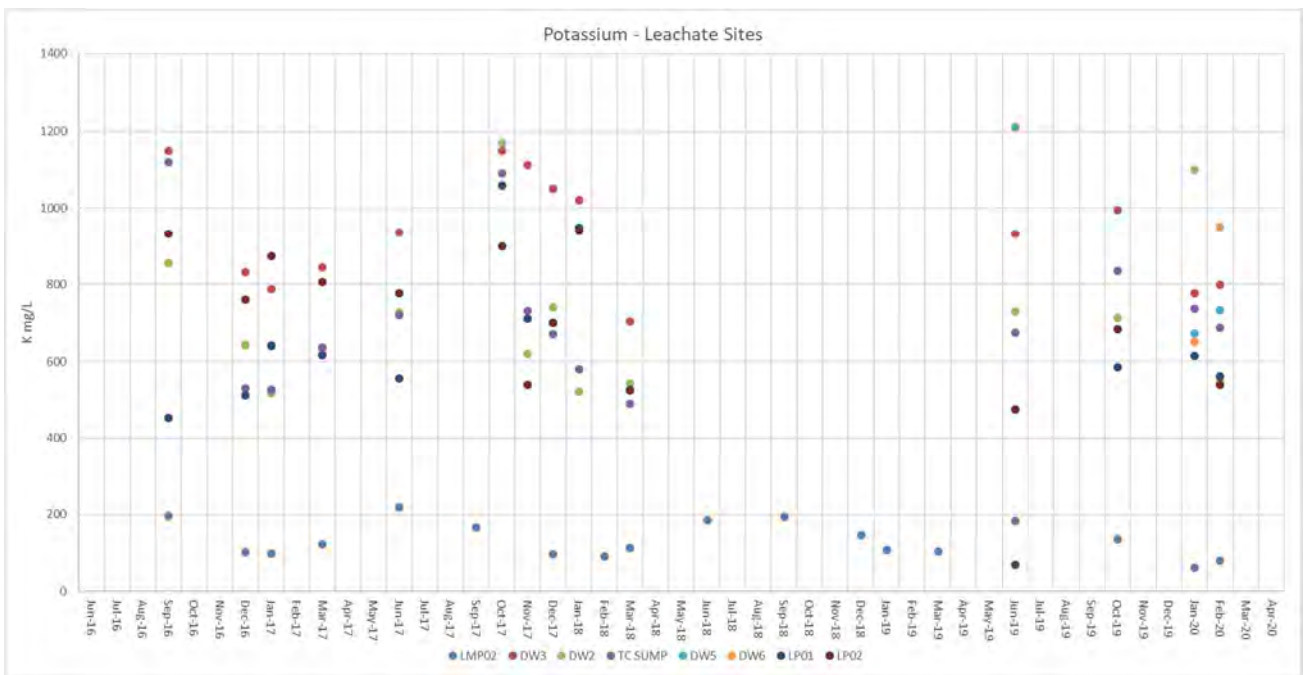
*There are no ANZECC (2000) guideline values for anions and cations.*



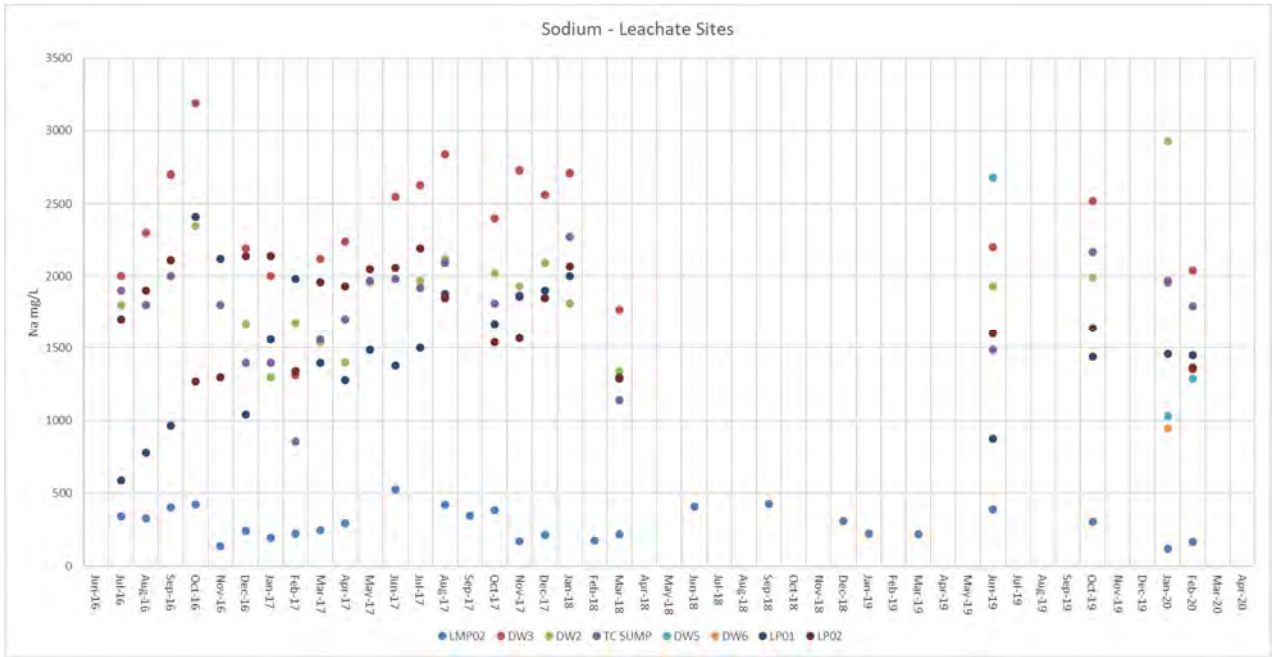
*There are no ANZECC (2000) guideline values for anions and cations.*



There are no ANZECC (2000) guideline values for anions and cations.

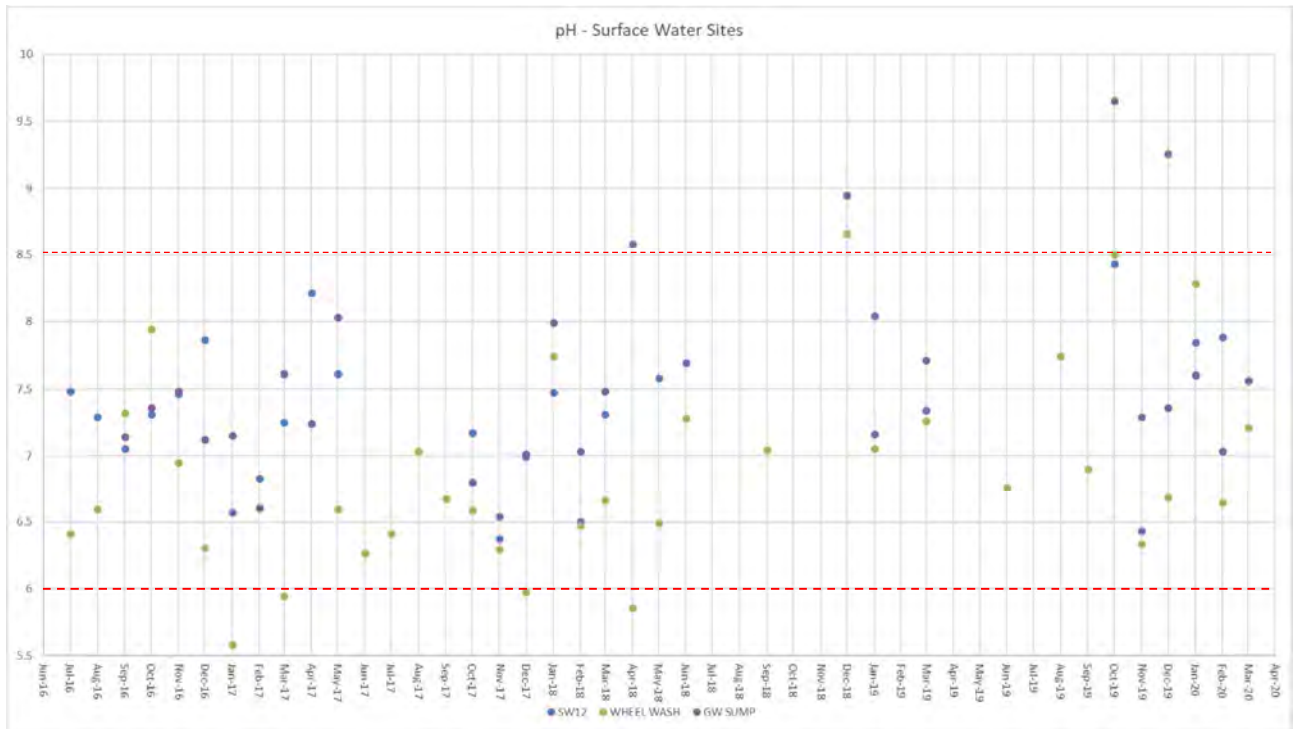


There are no ANZECC (2000) guideline values for anions and cations.

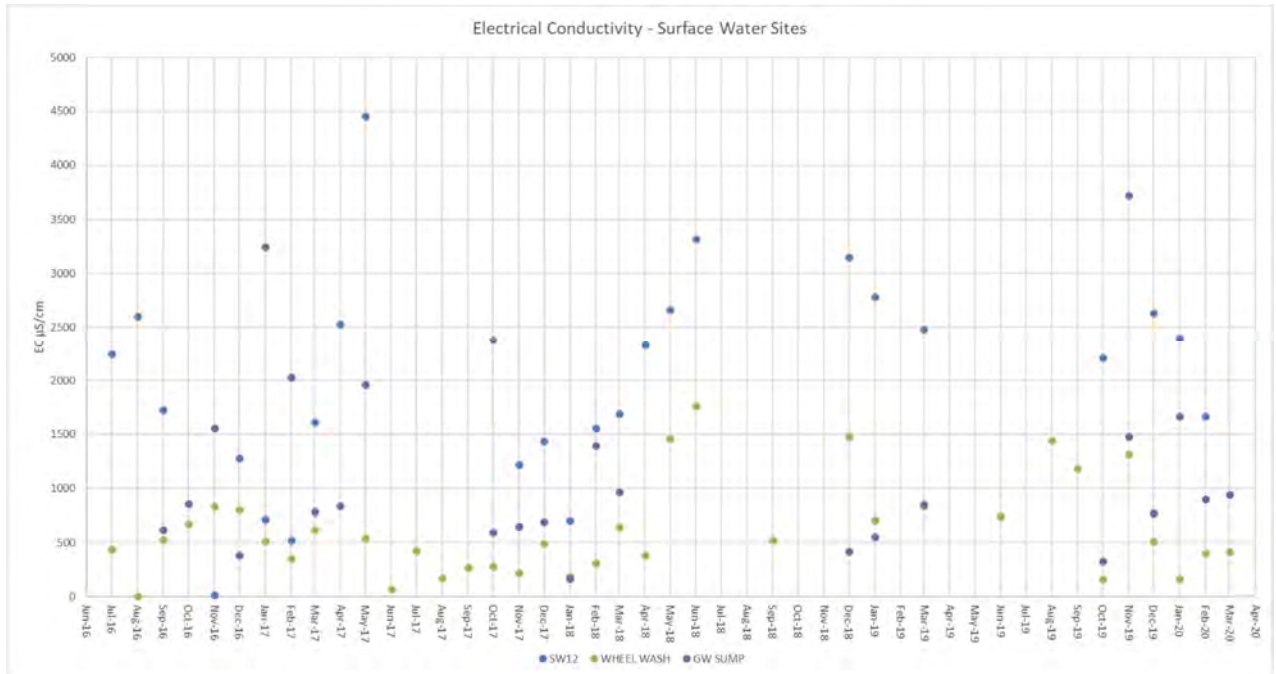


*There are no ANZECC (2000) guideline values for anions and cations.*

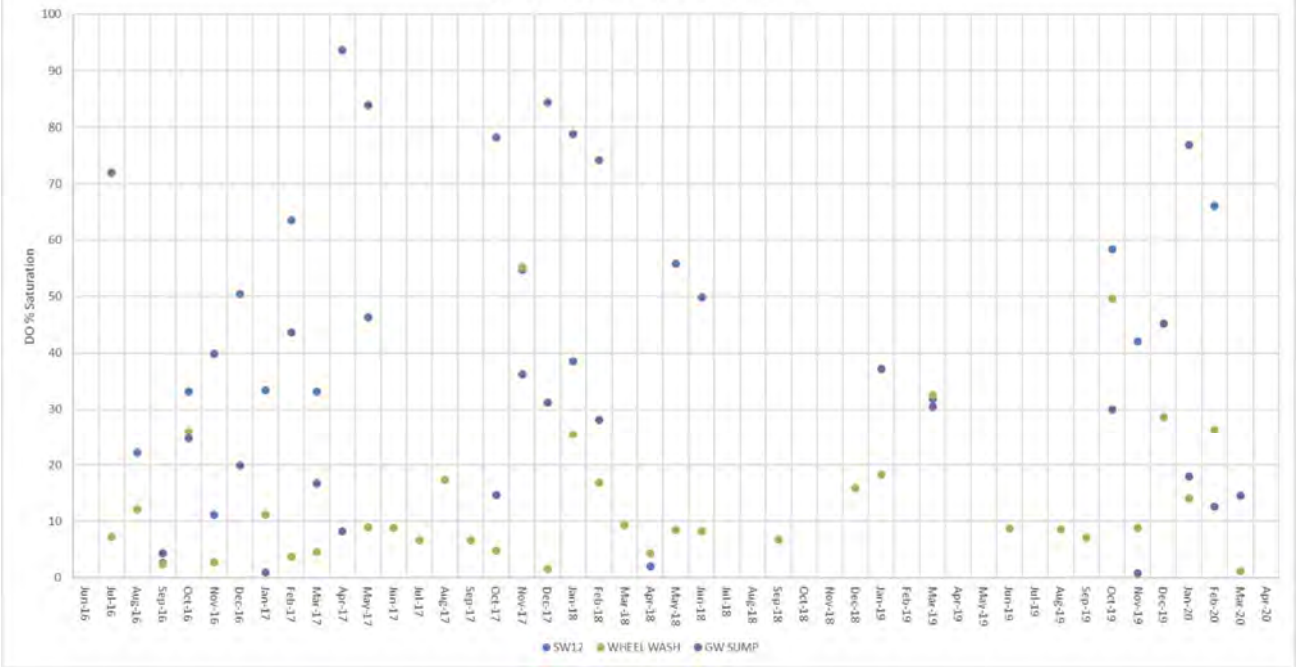
**Graphs of surface water site measurements between July 2016 and March 2020.**



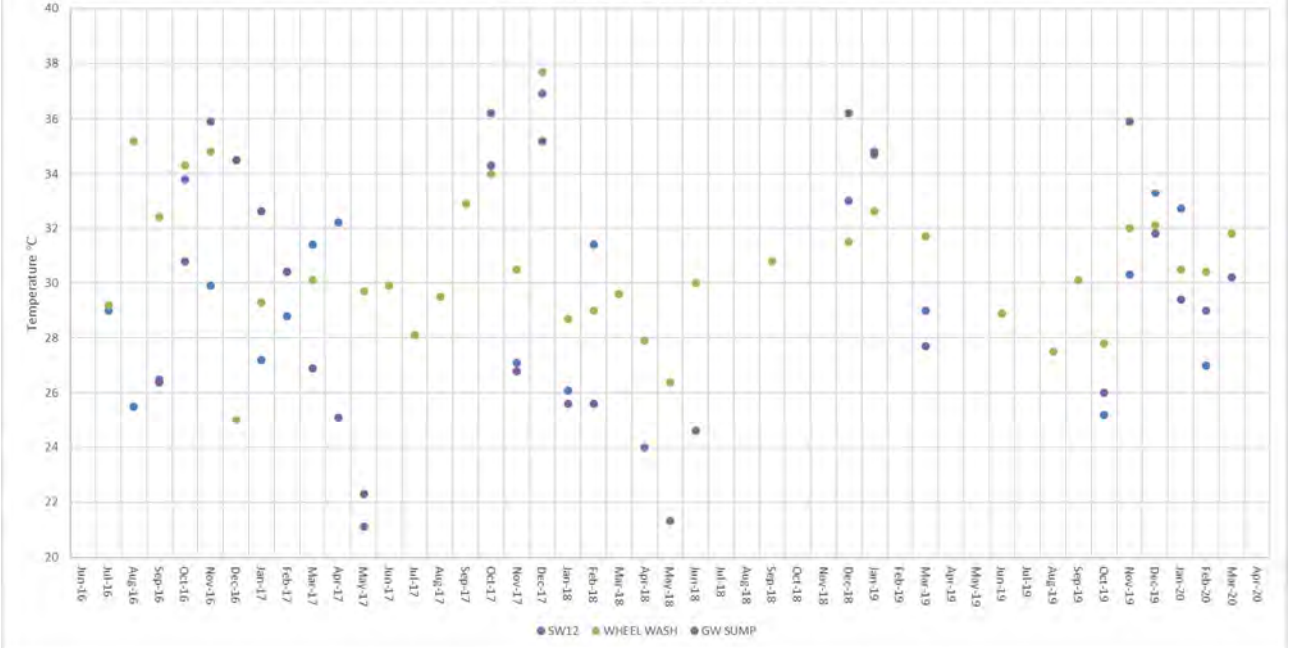
*Darwin Harbour water quality objective upper and lower limits shown by red dashed lines.*

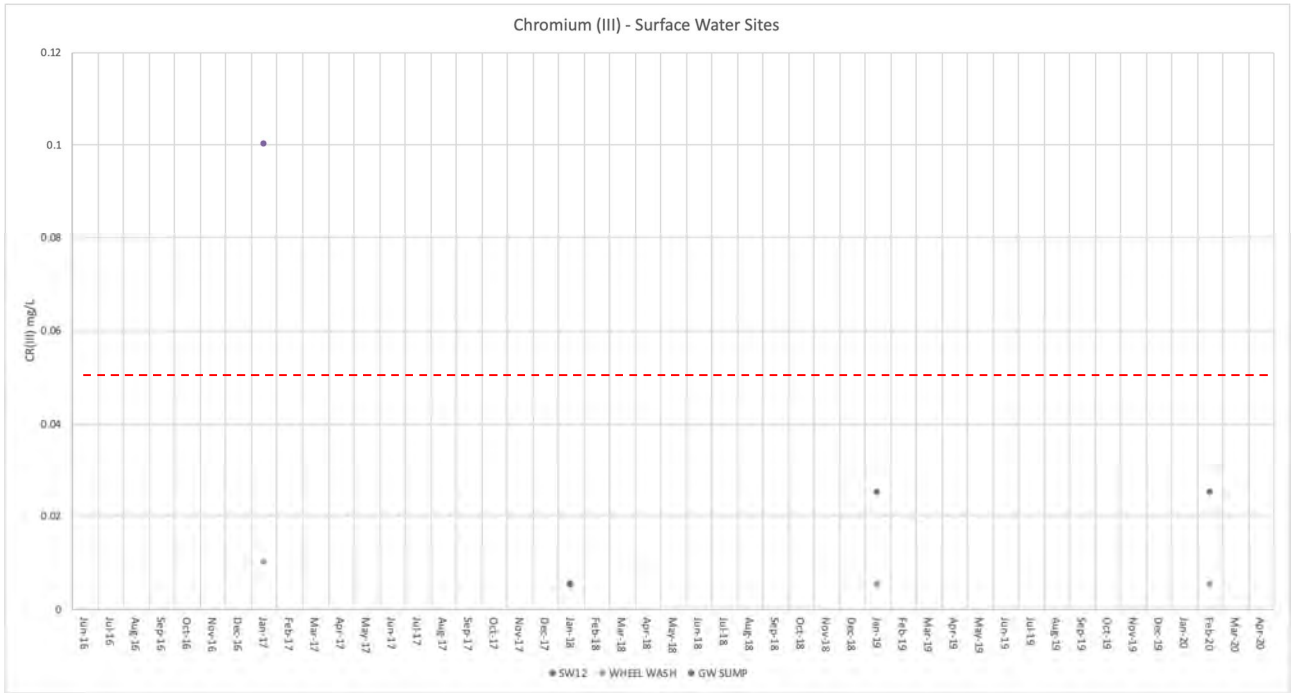


Dissolved Oxygen - Surface Water Sites

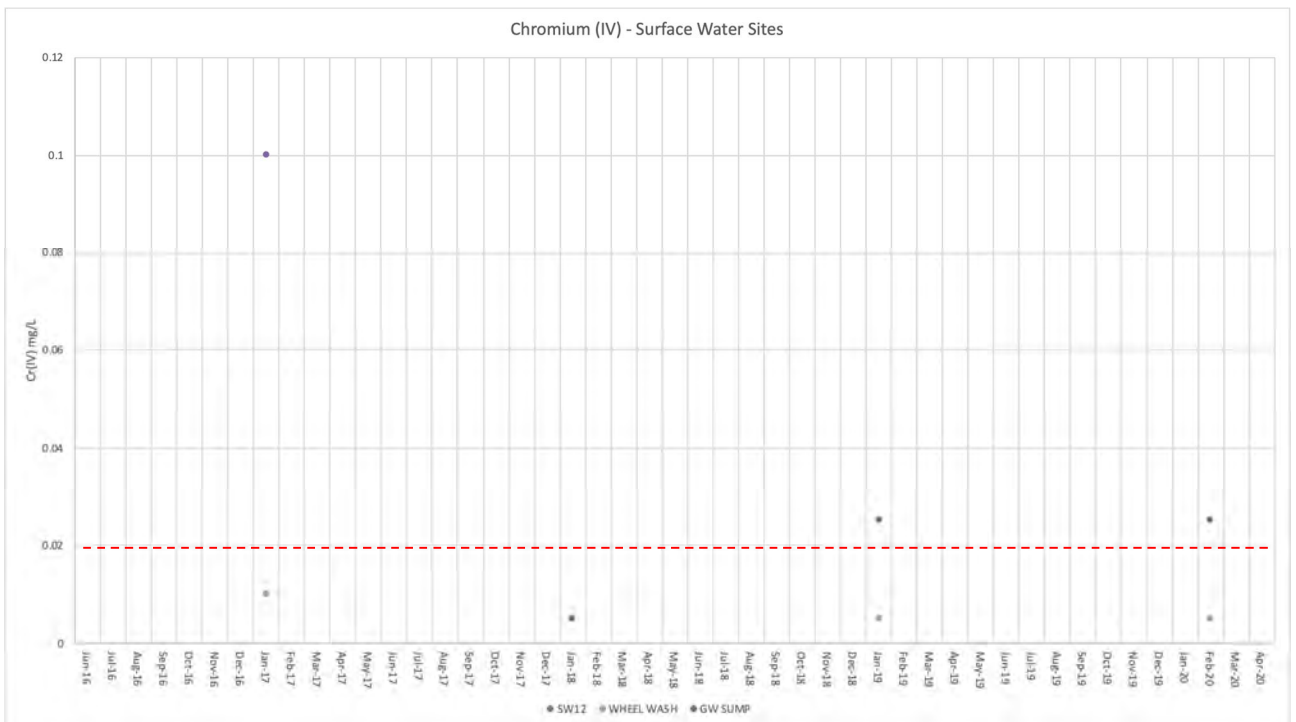


Temperature - Surface Water Sites

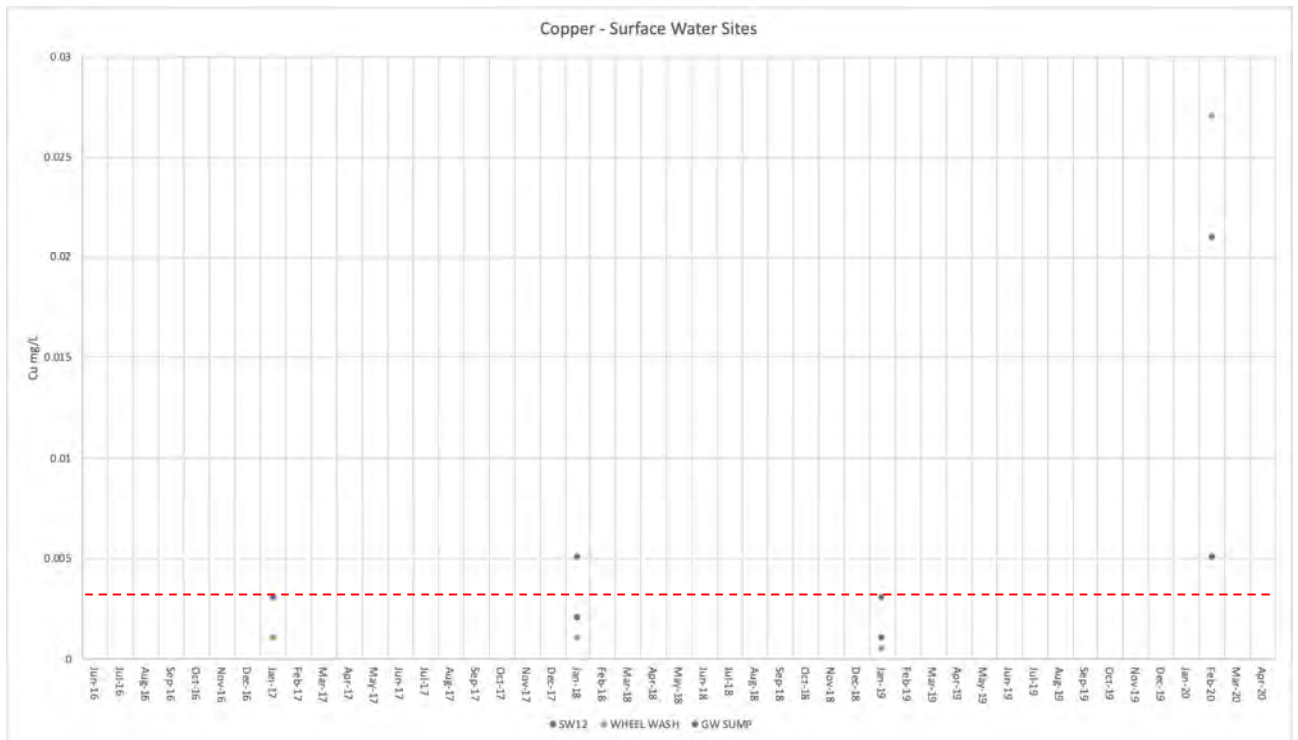




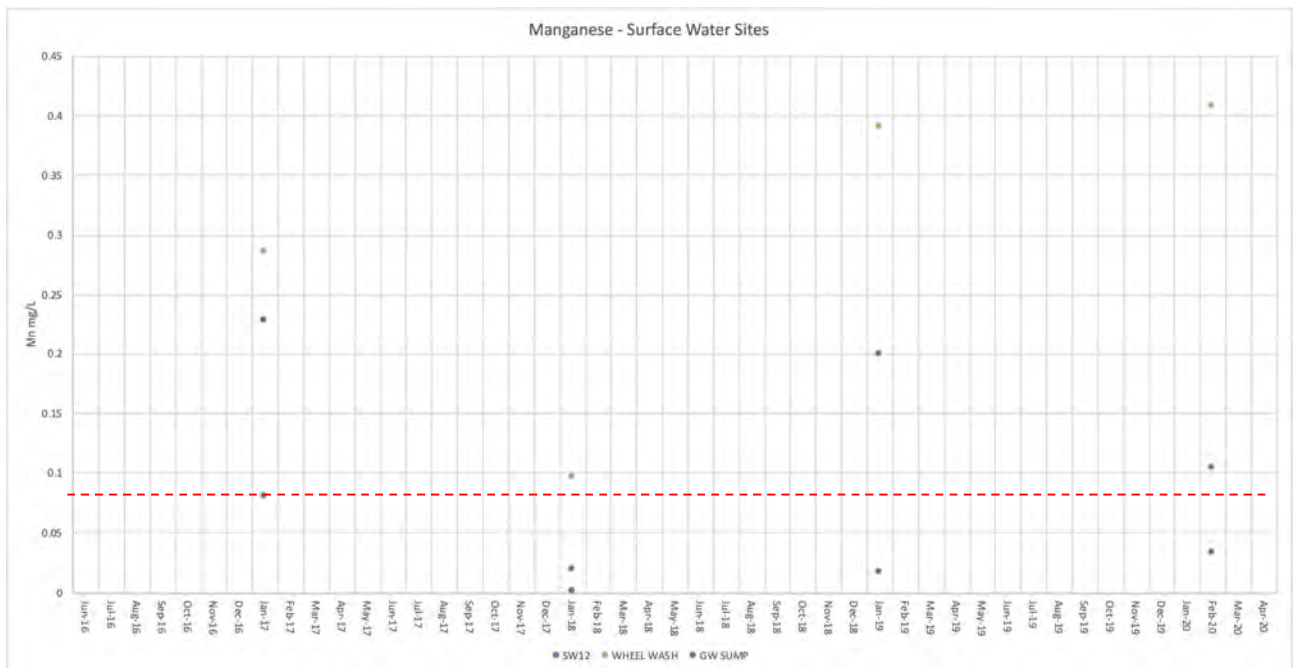
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.049 mg/L.



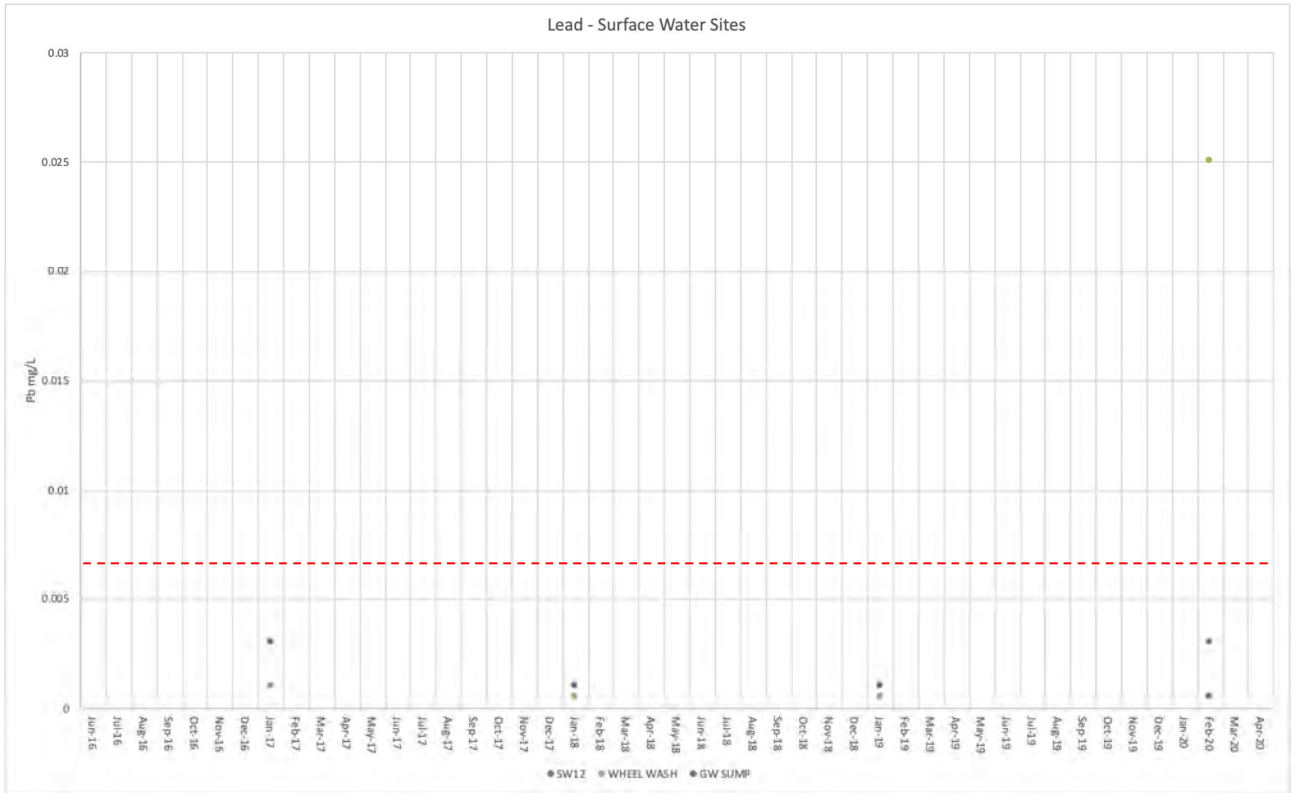
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.02 mg/L.



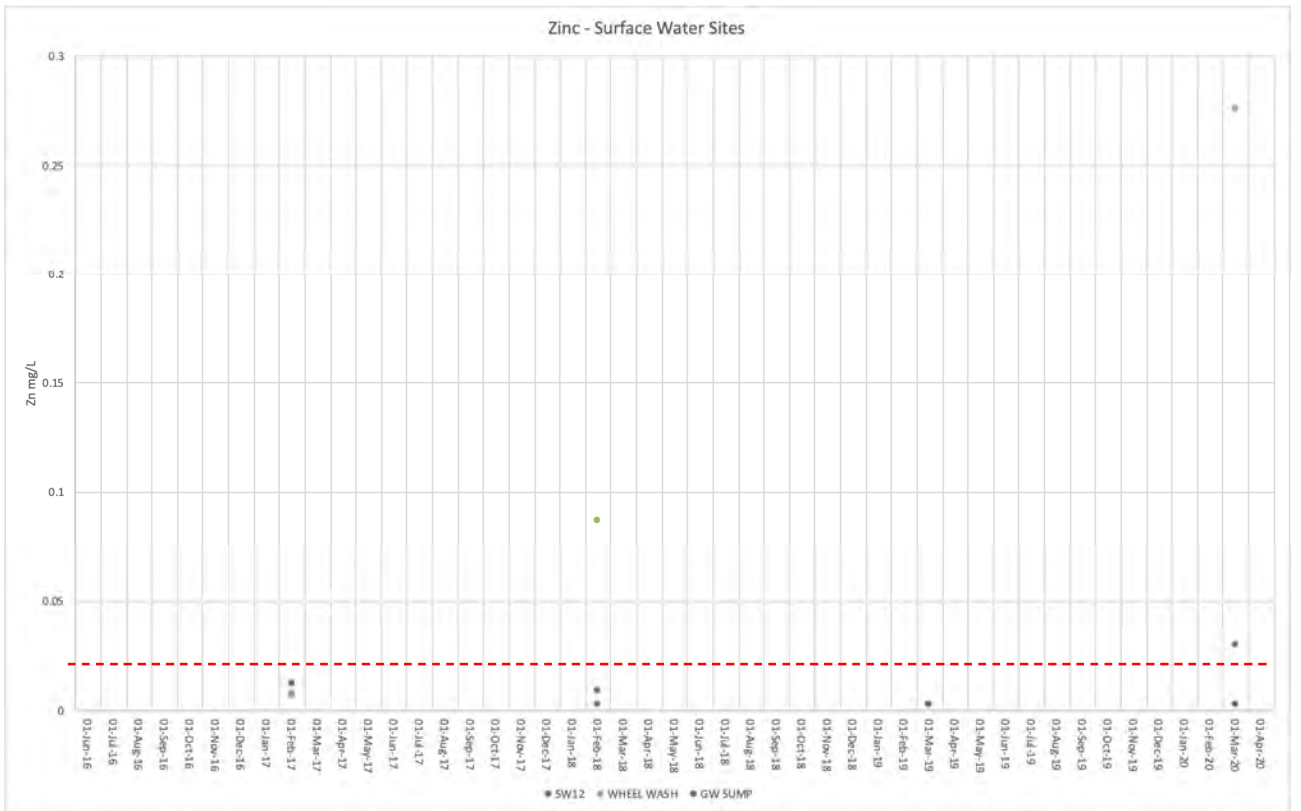
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.003 mg/L.



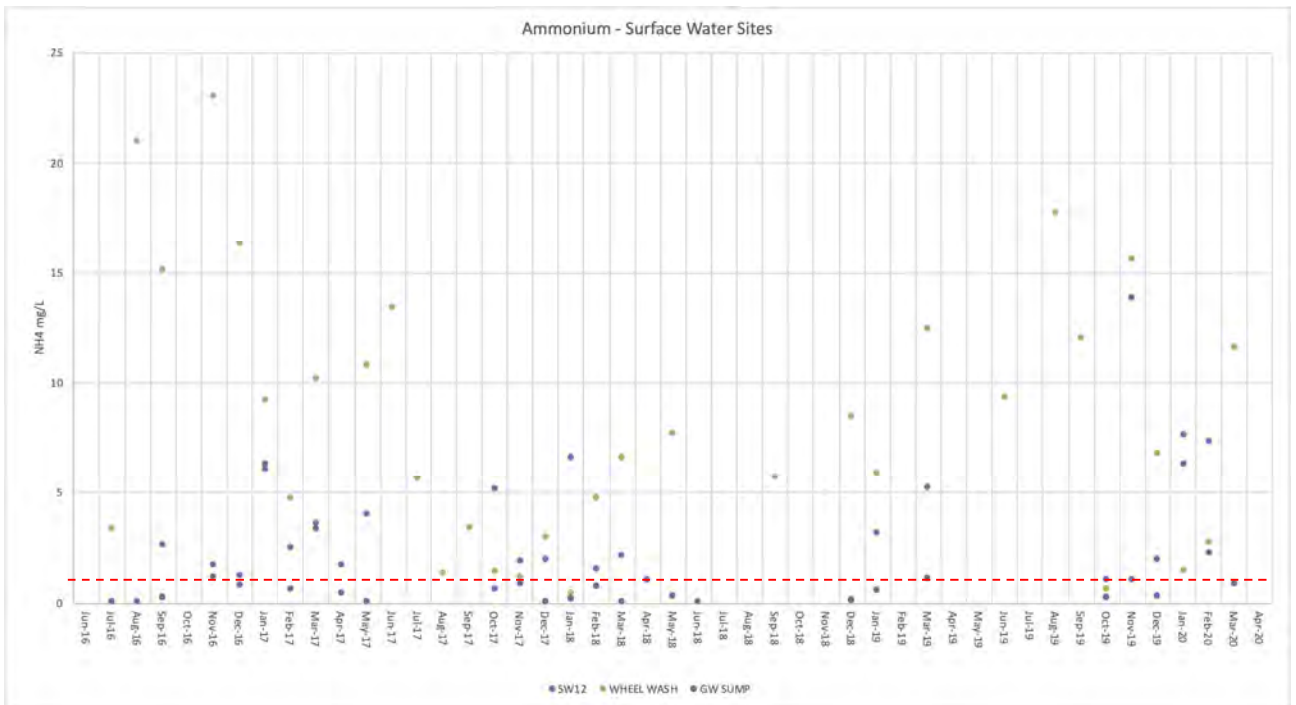
ANZECC (2000) 'low reliability' trigger value in marine water shown by red dashed line i.e. 0.08 mg/L. This value is based on limited data and should be considered as indicative only. No species protection level is indicated.



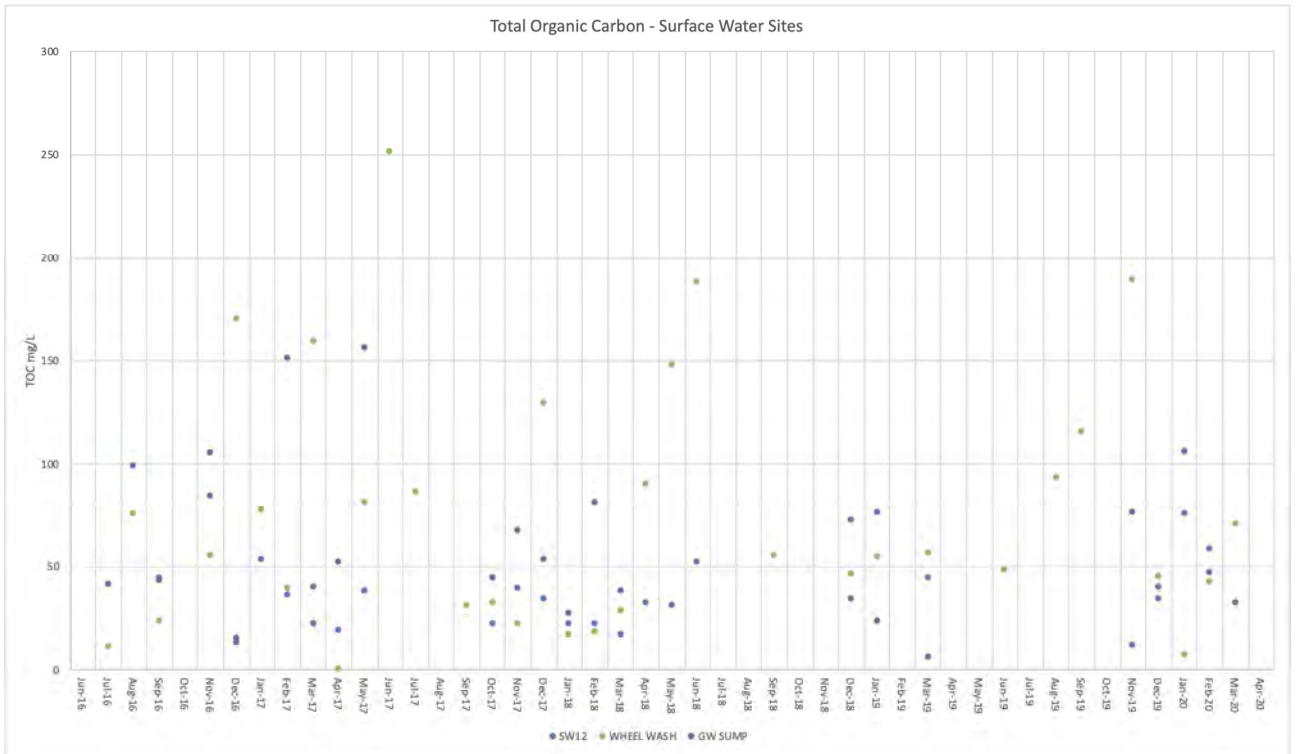
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.0066 mg/L.



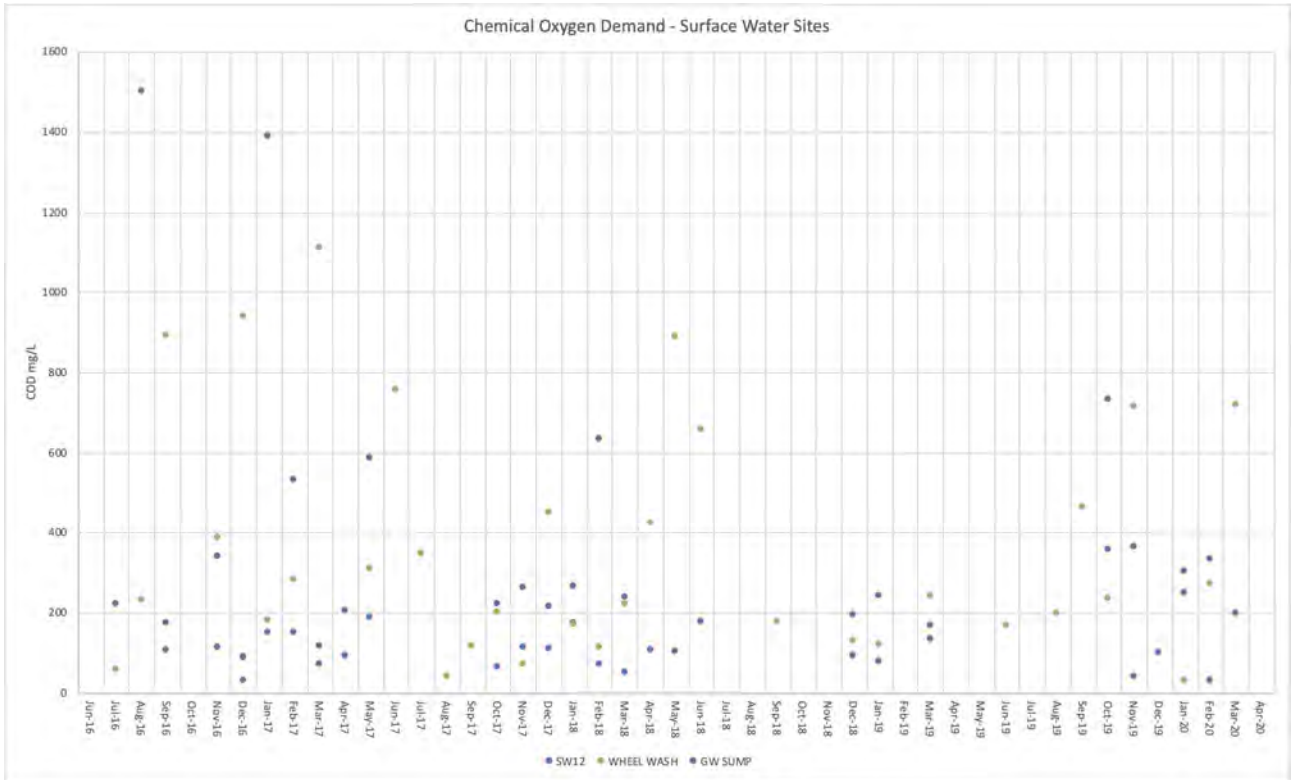
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.023 mg/L.



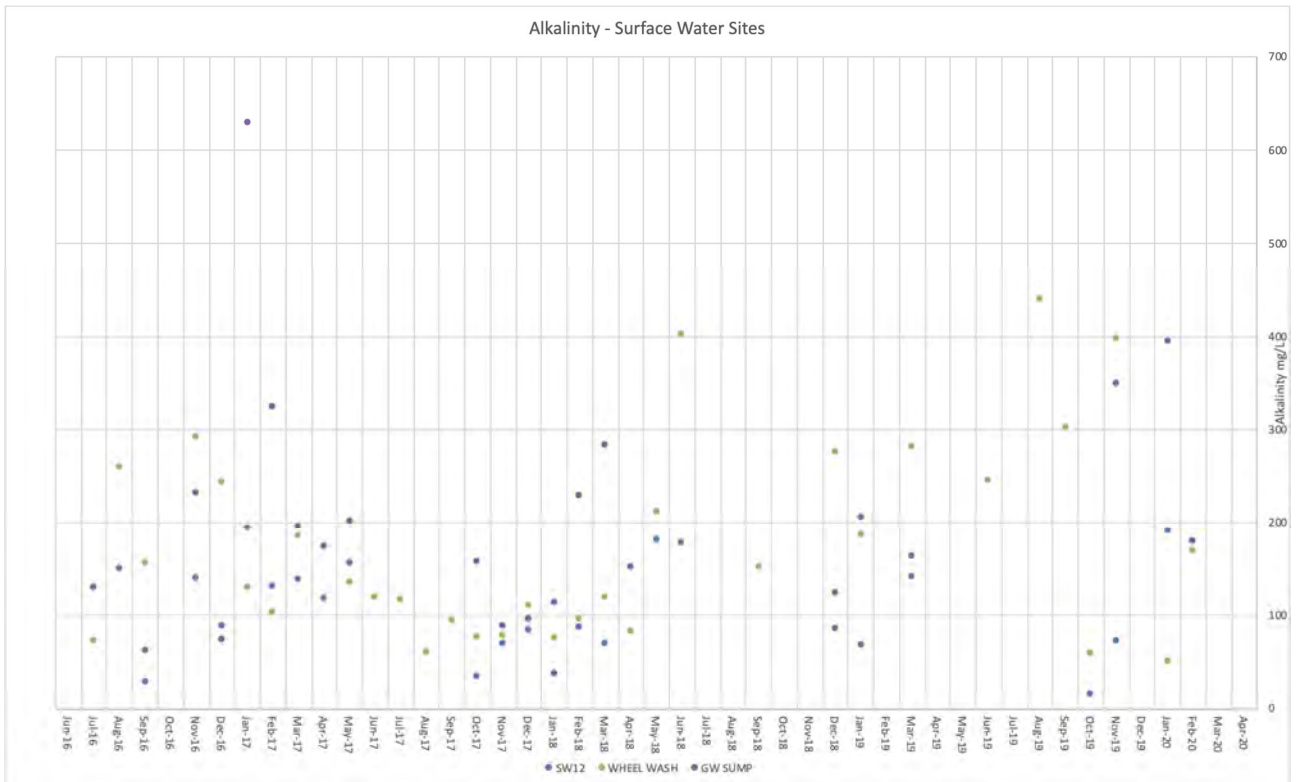
ANZECC (2000) trigger value for 90% species protection in marine water for  $\text{NH}_3\text{-N}$  is 1.2 mg/L. This is applied here (i.e. red line) as only  $\text{NH}_4^+$  as N data is available monthly for surface water sites and comparison of  $\text{NH}_4^+$  as N results to  $\text{NH}_3\text{-N}$  (where available) shows that  $\text{NH}_3\text{-N}$  is usually only slightly higher than  $\text{NH}_4^+$  as N.



There is no ANZECC (2000) guideline value for TOC.

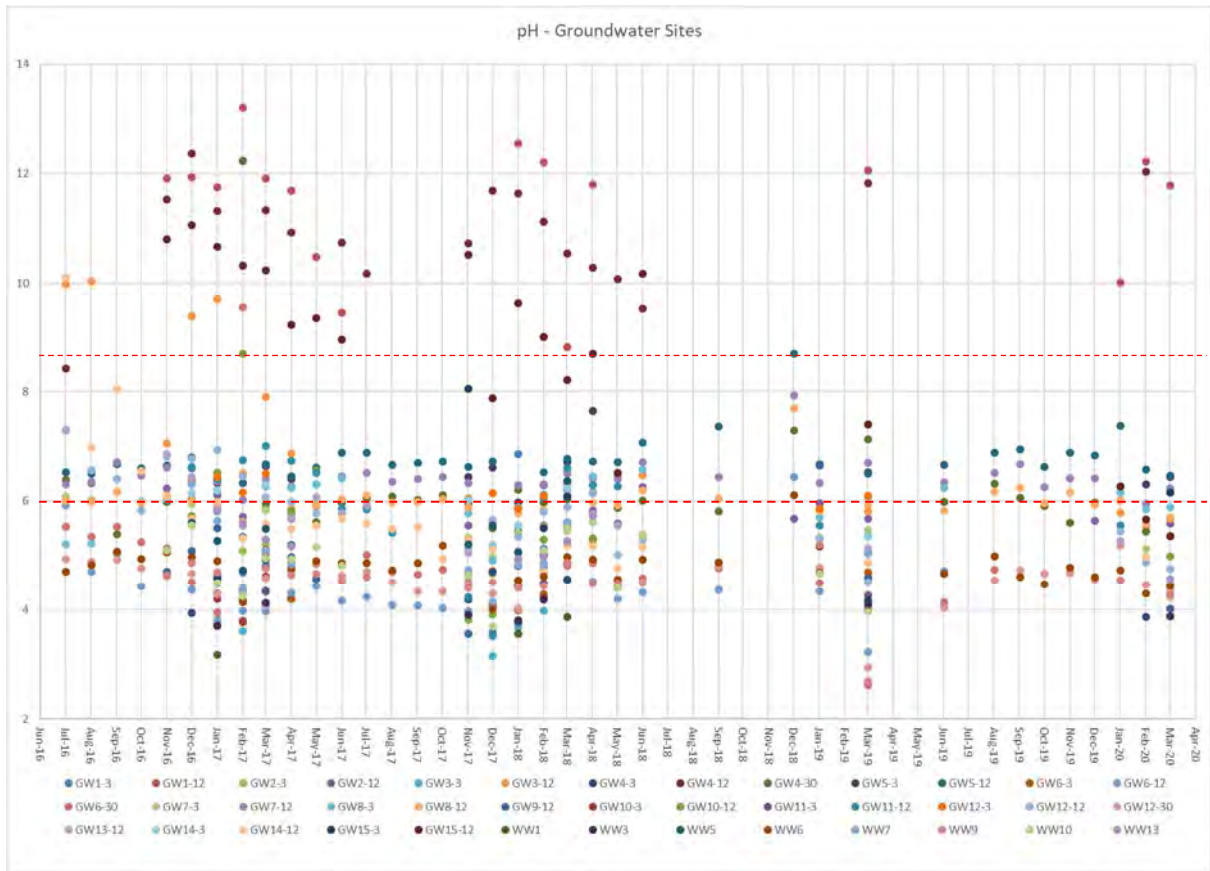


*There is no ANZECC (2000) guideline value for COD.*

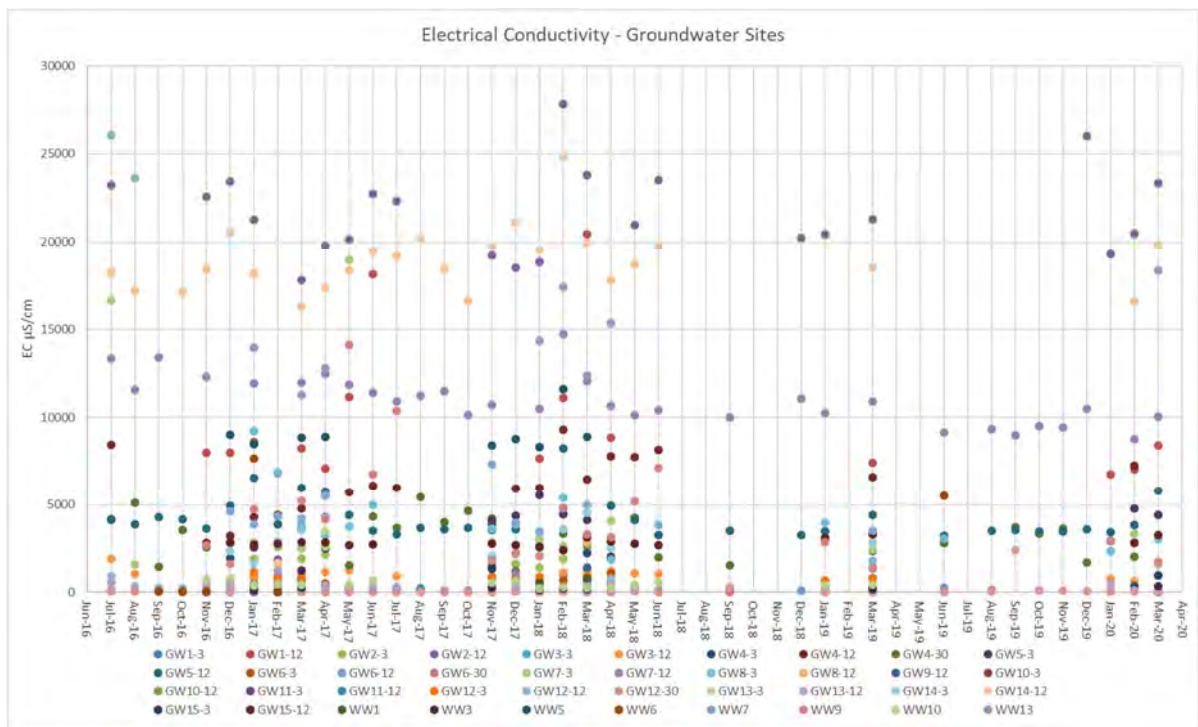


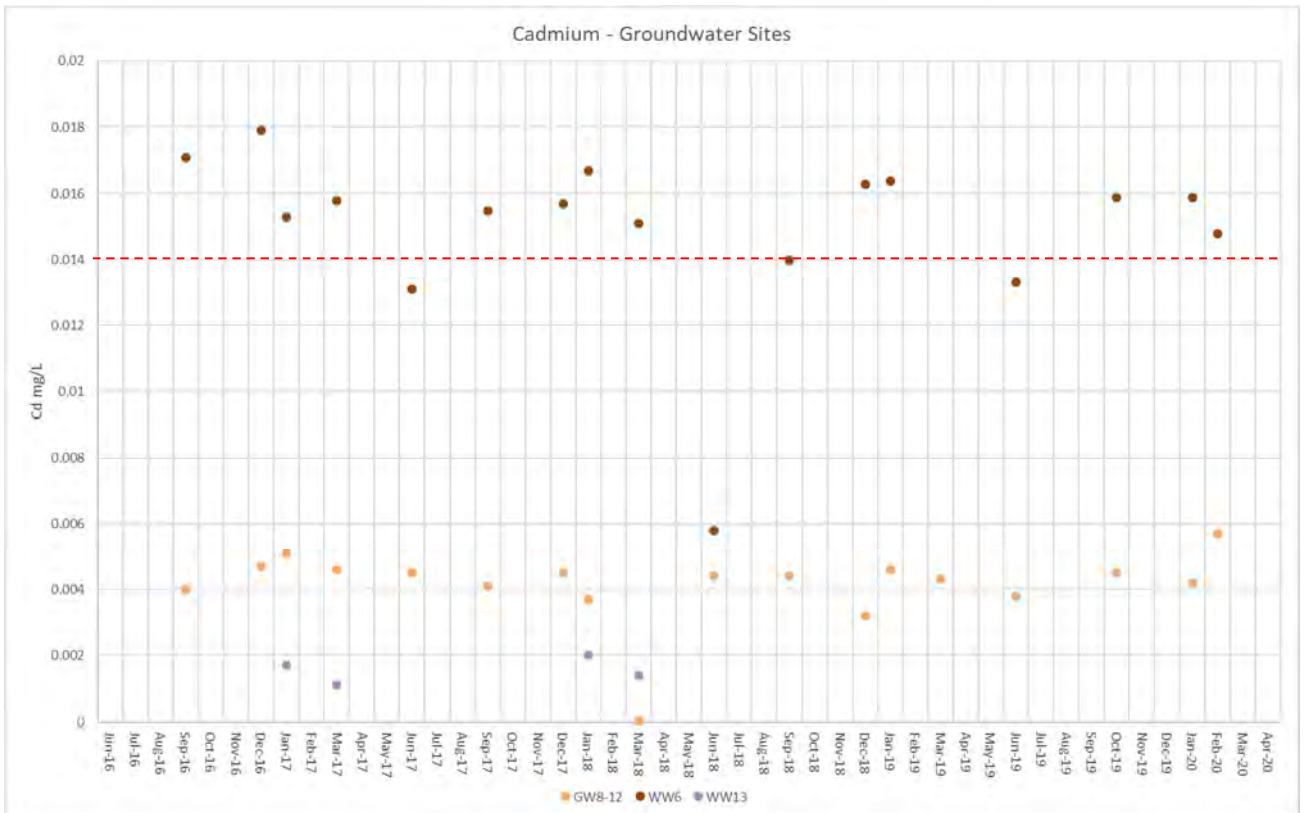
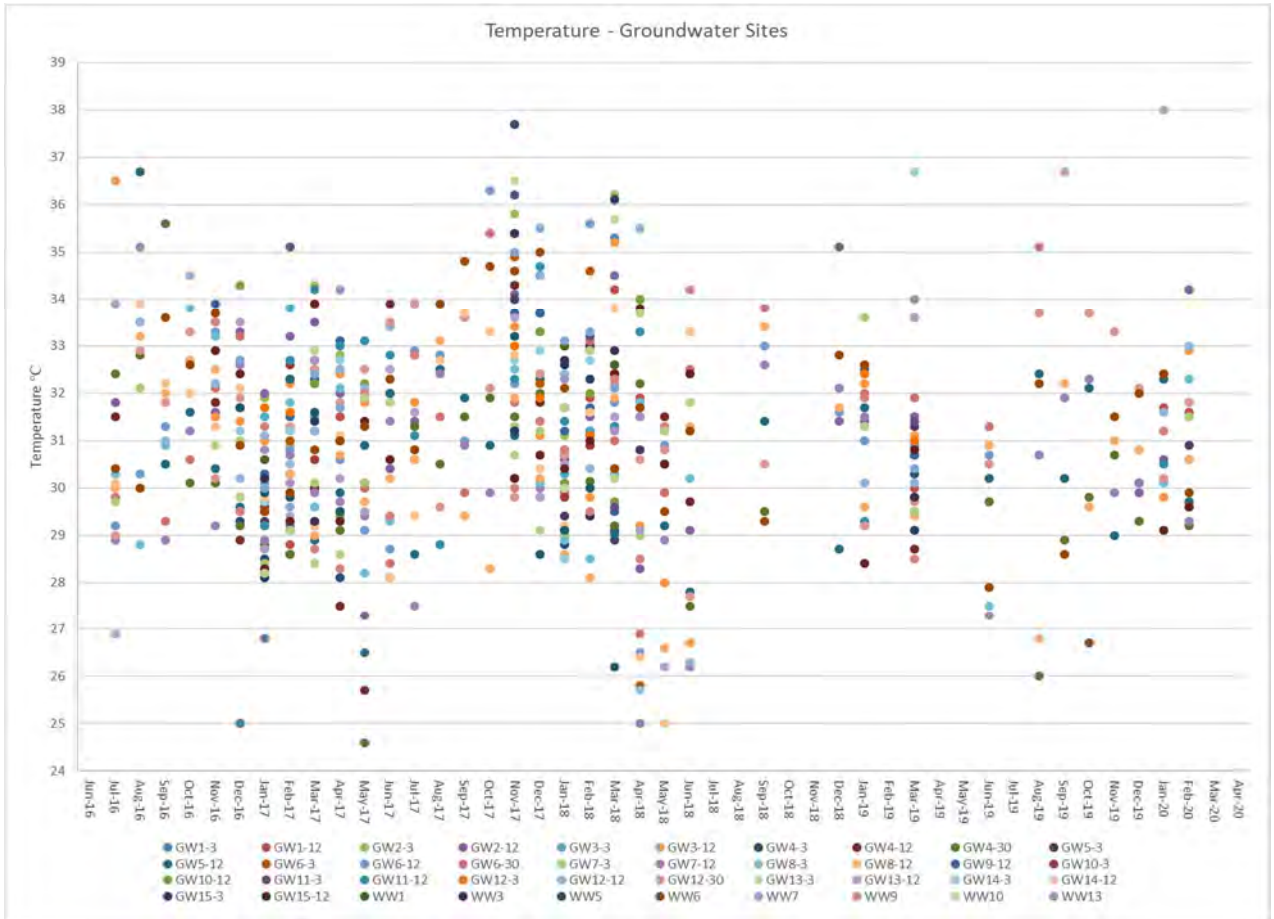
*There are no ANZECC (2000) guideline values for alkalinity.*

**Graphs of groundwater bore measurements between July 2016 and March 2020.**

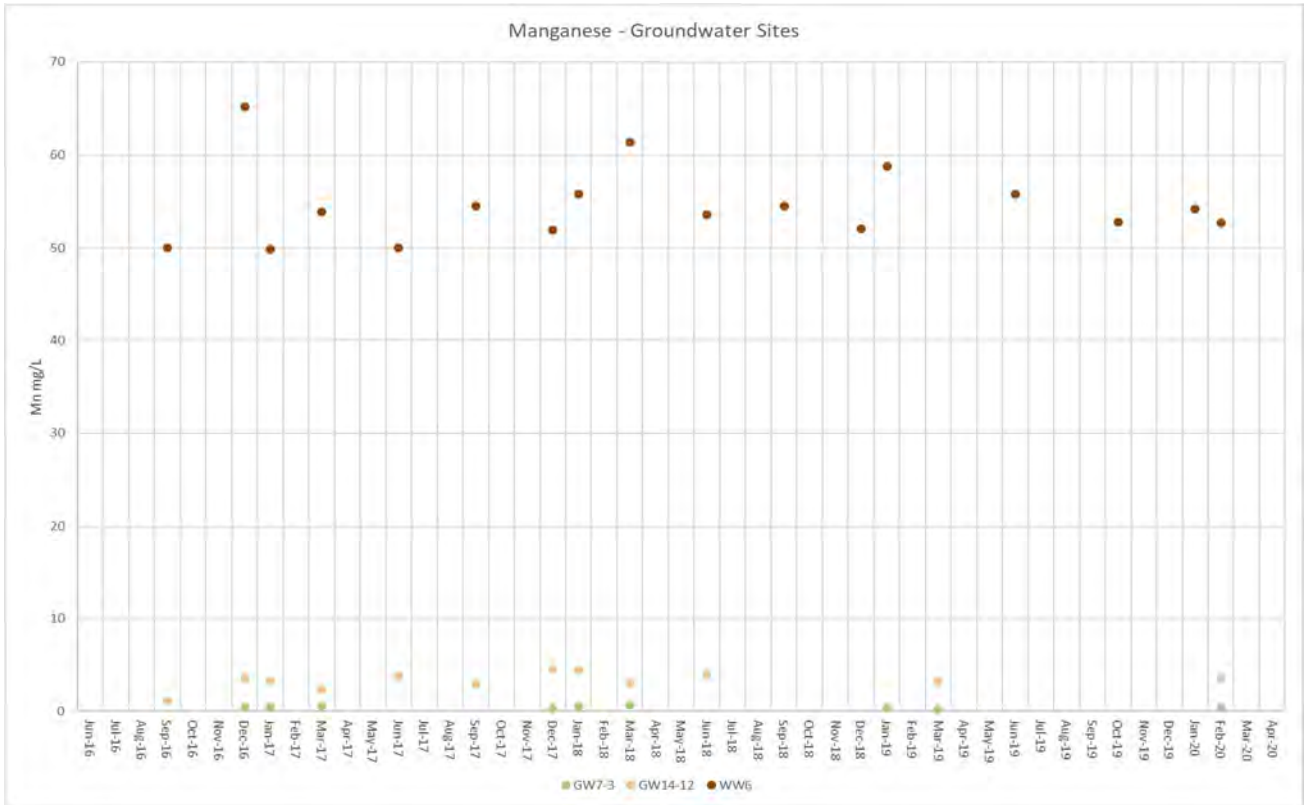


*Darwin Harbour water quality objective upper and lower limits shown by red dashed lines.*

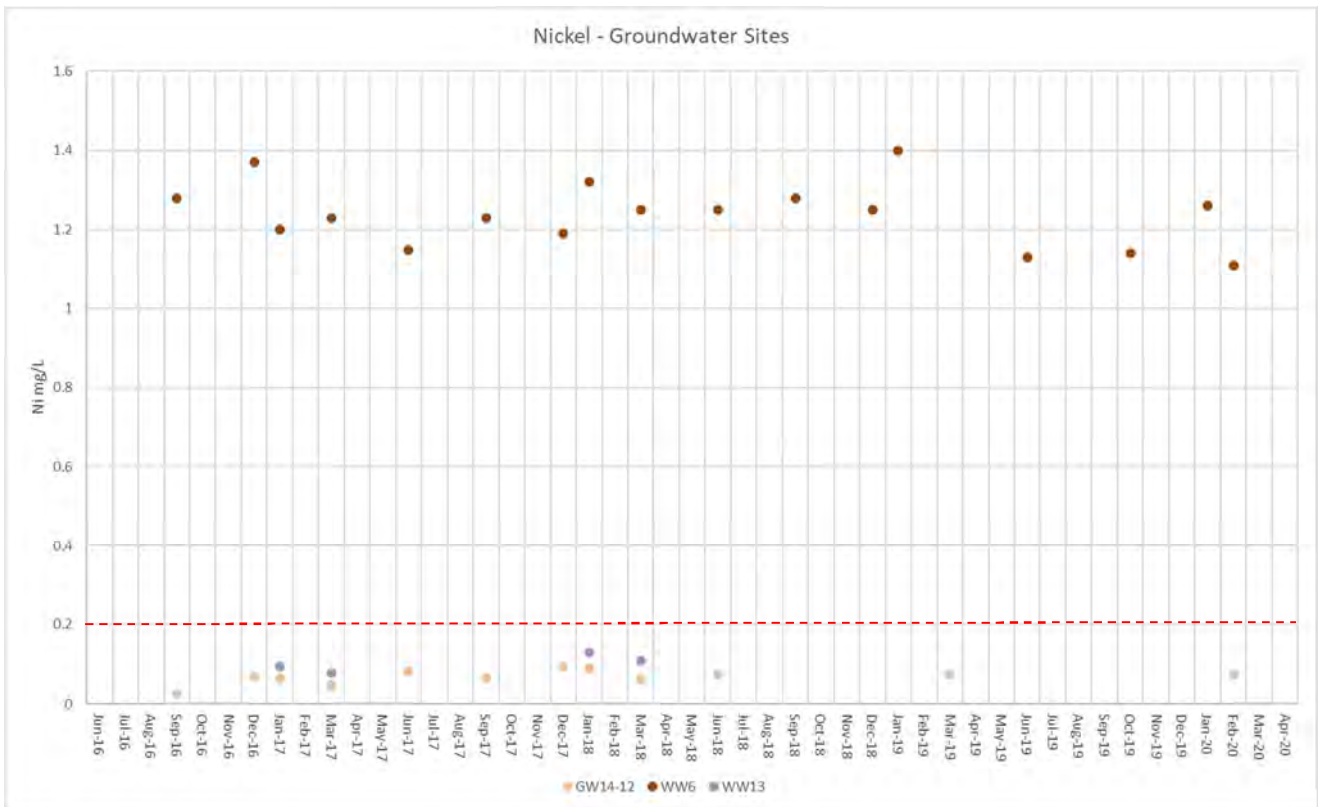




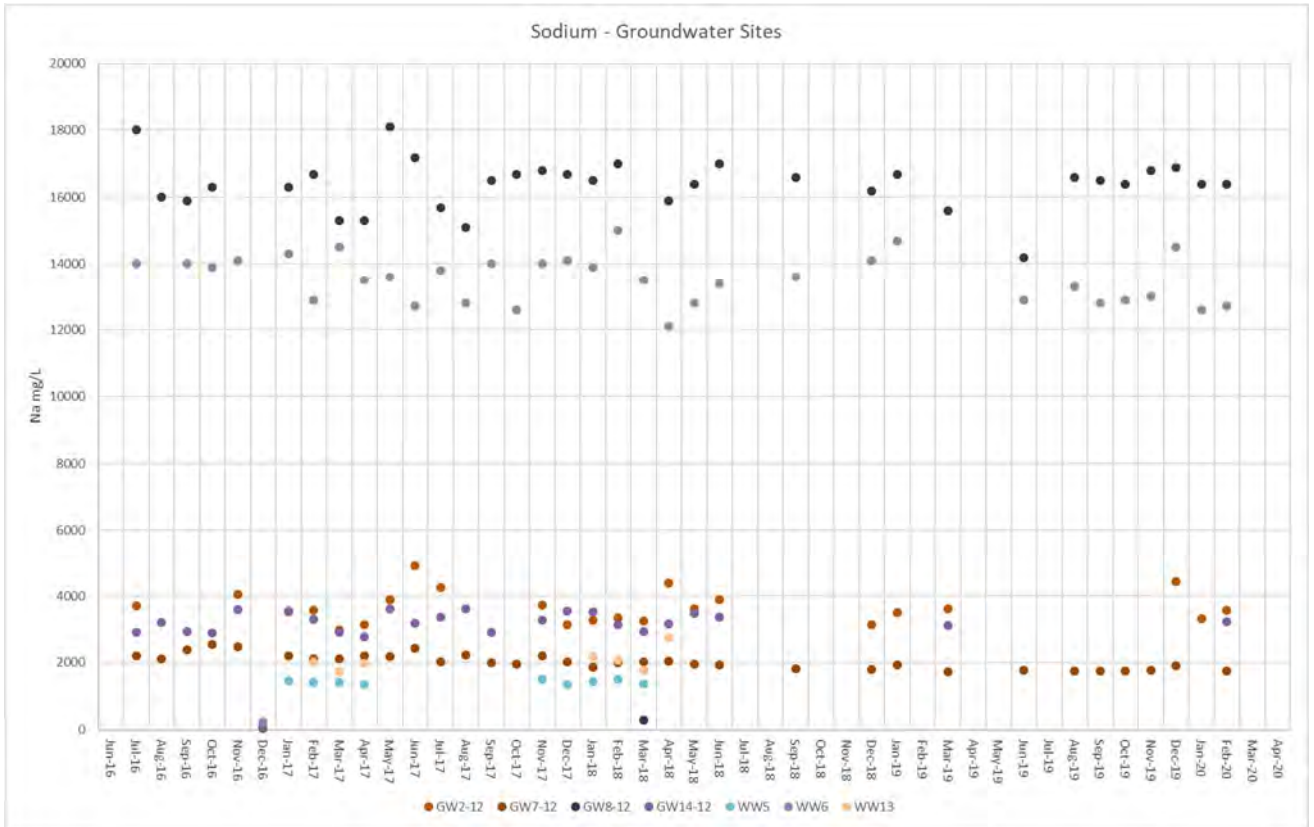
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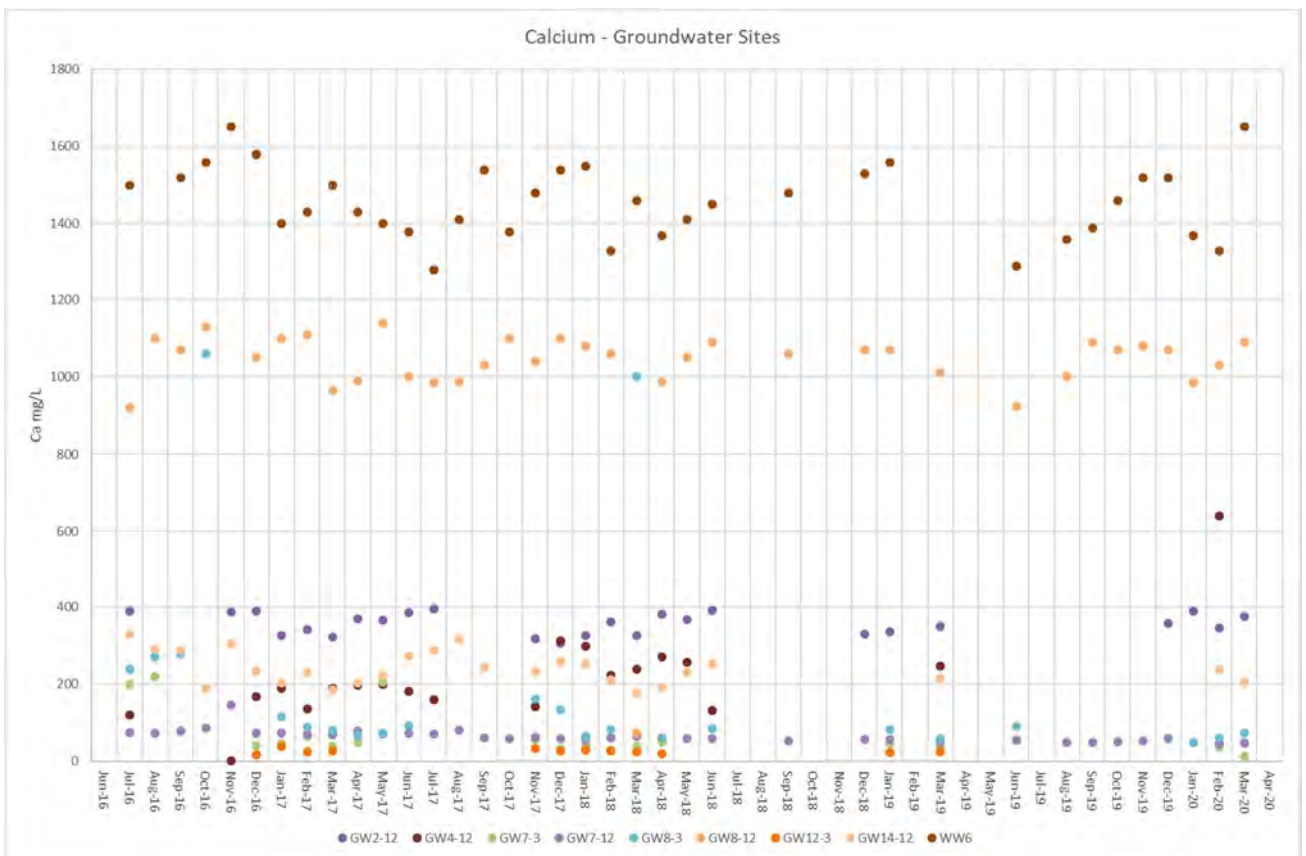
ANZECC (2000) 'low reliability' trigger value in marine water is 0.08 mg/L, which is too small to be shown on this graph. This trigger value is based on limited data and should be considered as indicative only. No species protection level is indicated.



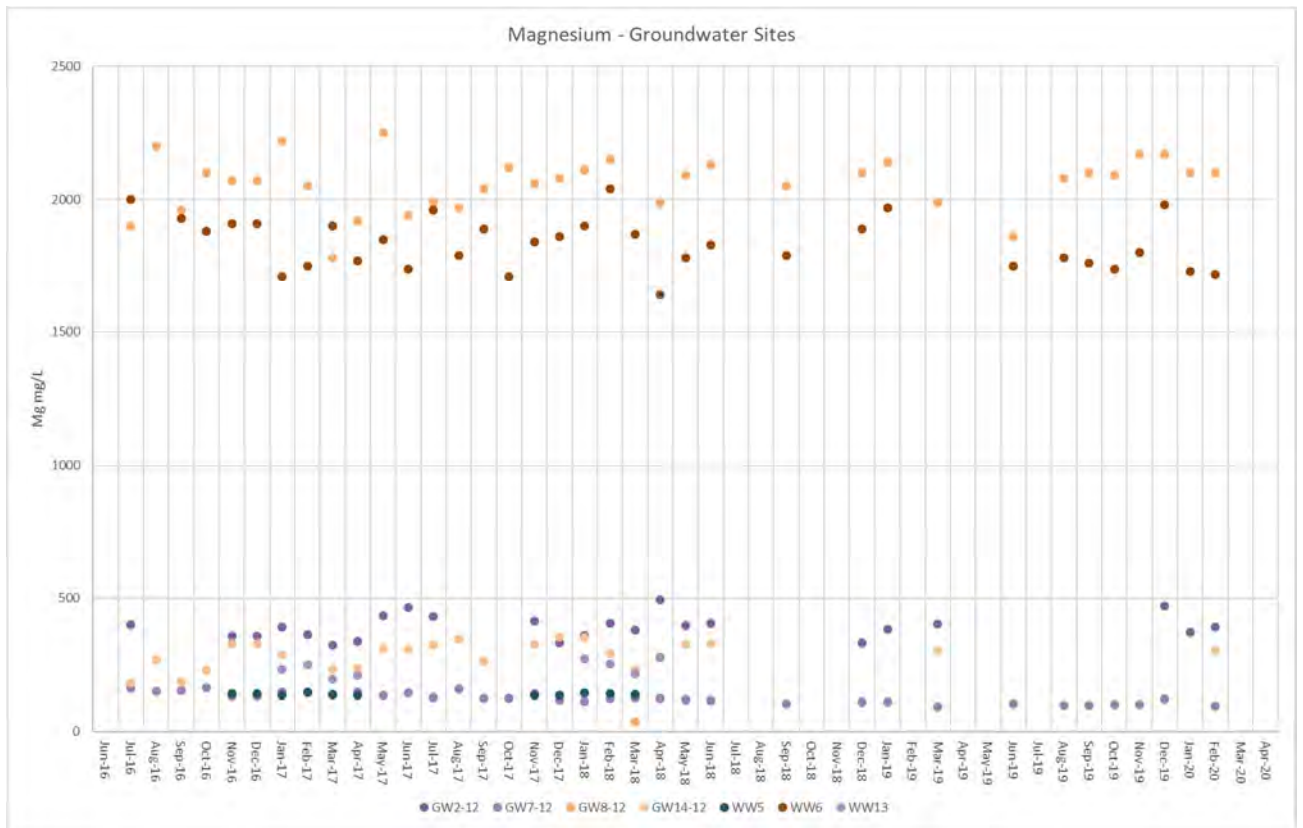
ANZECC (2000) 90% species protection in marine waters is shown by red dashed line i.e. 0.2 mg/L.



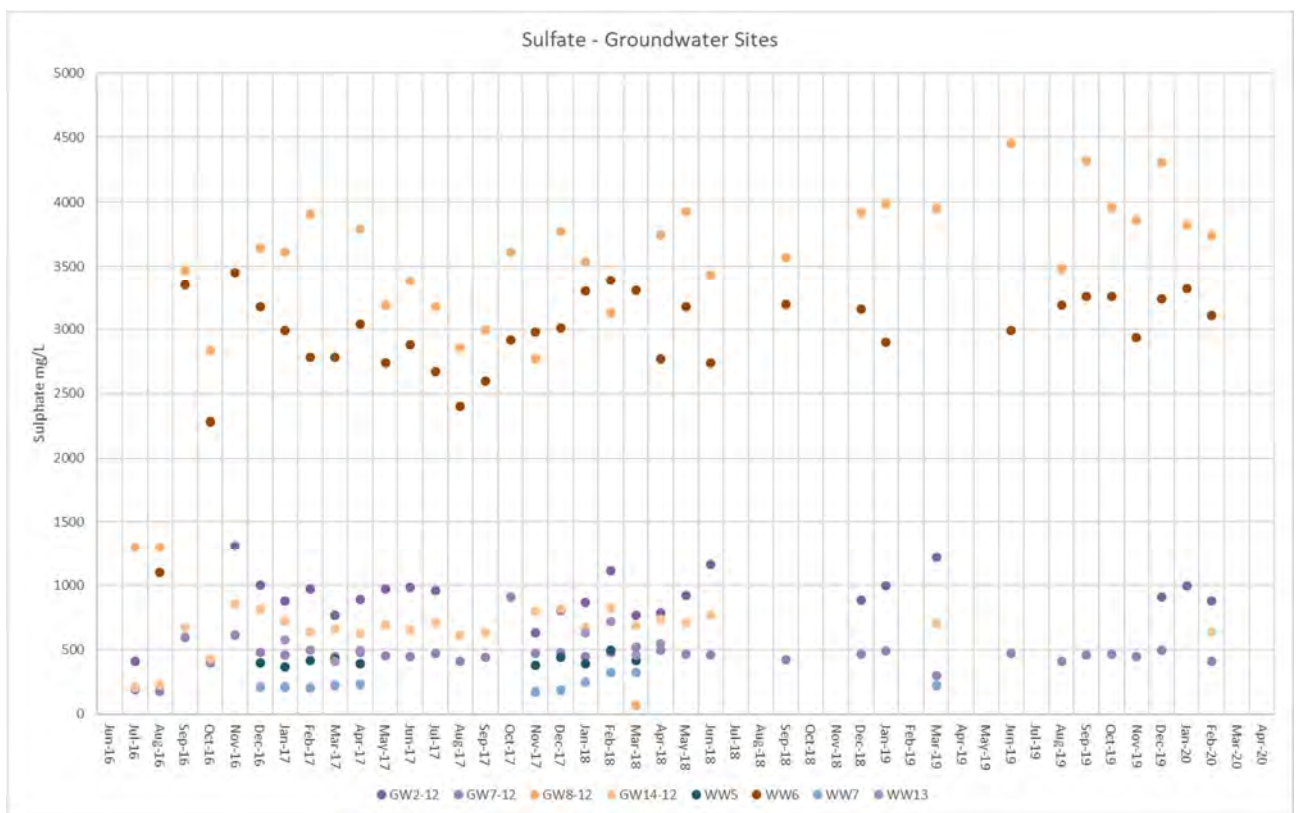
*There are no ANZECC (2000) guideline values for anions and cations.*



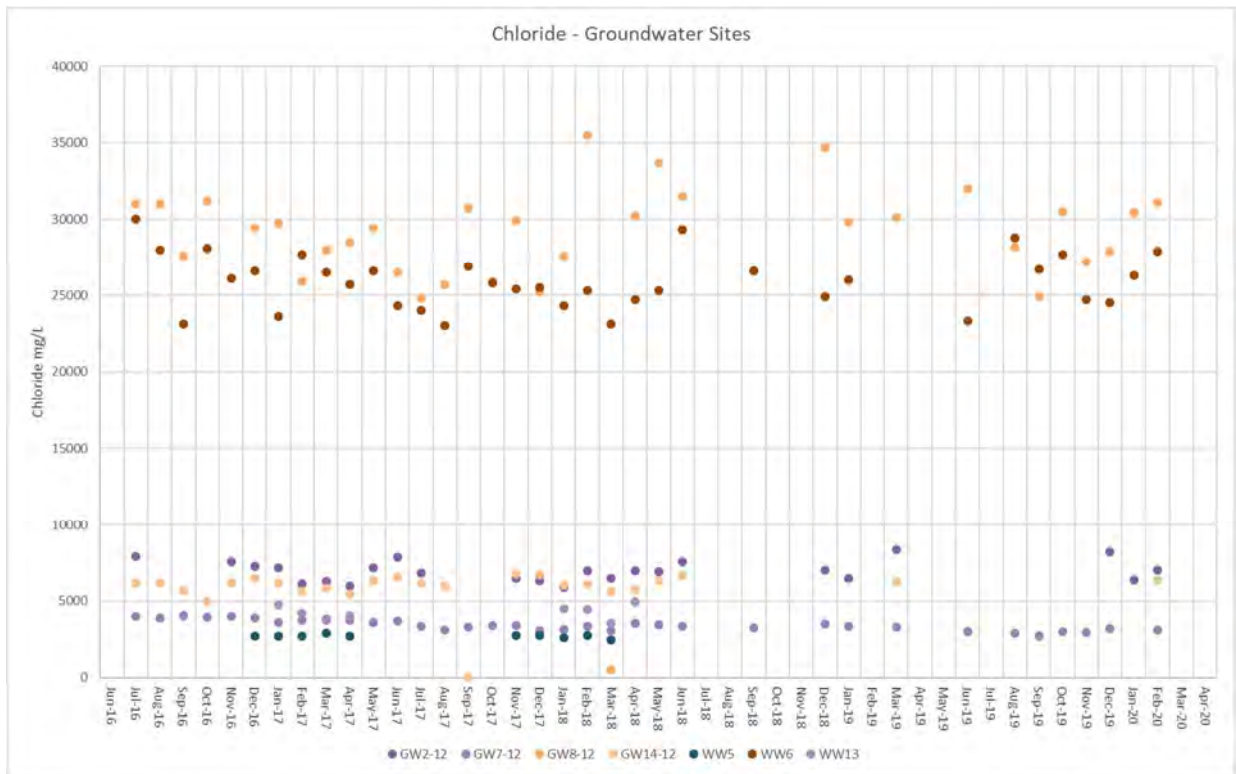
*There are no ANZECC (2000) guideline values for anions and cations.*



*There are no ANZECC (2000) guideline values for anions and cations.*



*There are no ANZECC (2000) guideline values for anions and cations.*



*There are no ANZECC (2000) guideline values for anions and cations.*



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