Appendix C3 Annual Monitoring Report 2021

Annual Monitoring Review

Shoal bay Waste Management Facility Soil and Water Monitoring Program

CW1121900

Prepared for
City of Darwin

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Our report is based on information made available by the client. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Cardno is both complete and accurate. Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, changes may occur to the site conditions, the site context or the applicable planning framework. This report should not be used after any such changes without consulting the provider of the report or a suitably qualified person.

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1 Introduction

Cardno has been commissioned by the City of Darwin (CoD) to undertake groundwater, surface water, leachate, soil and dust deposition monitoring at the Shoal Bay Waste Management Facility (SBWMF) operated by City of Darwin (COD) in accordance with the site's environmental protection license (EPL) EPL 188 – 03. Assured Environmental (AE) has been commissioned separately to conduct emissions testing associated with the evapoconcentrator, BeneVap (BV300) operating at SBWMF as a part of the leachate treatment.

SBWMF is operated by COD in accordance with the environmental protection licence (EPL) EPL188 issued by the Northern Territory Environmental Protection Agency (NT EPA) pursuant to the *NT Waste Management and Pollution Control Act* (WMPC Act).

The EPL188 was updated and reissued by the Northern Territory Environmental Protection Agency (NT EPA) in December 2020 identifying further water monitoring requirements for those previous laid out in the *URS Shoal Bay Disposal Site Water Monitoring Plan* developed in 2016.

This annual monitoring period has occurred over the transition from the URS management plan to methodologies laid out in the Soil and Water Monitoring Plan (SWMP) (EcOz, 2021) to comply with the updated EPL188-03.

Figure 1-1 Shoal Bay Waste Management Facility

1.2 Site Location

The SBWMF (Figure 1-2) is located at Lot 03952 Town of Sanderson Plan S 79/149a, Vanderlin Drive, Holmes, Northern Territory (NT) (herein referred to as 'the Site').

Figure 1-2 Site Location (Source CoD 2016)

1.3 Purpose and Objectives

The purpose of this Annual Review is to provide a summary of the soil, dust, groundwater, surface water, leachate monitoring for the period 1 July 2020 to 30 June 2021, including analytical results and assessment against adopted criteria in accordance with the site's Licence conditions. This review has been prepared in accordance with the requirements of the NT EPA *Guideline for Reporting on Environmental Monitoring* and SWMP to include the following:

- Summary of all surface water, groundwater, leachate, air emissions, depositional and soil monitoring undertaken during the monitoring review period.
- Graphical and tabulated interpretation of all monitoring data for the monitoring period;
- Comparison of results with respect to the adopted quality criteria and/or action levels;
- Discussion of results with respect to long term monitoring data over a three-year period (where the data is available) and temporal and spatial trends; and
- Assess compliance with regulatory guidelines and standards including notifying the regulator;
- Provide recommendations for remediation where impacts are identified during monitoring and reporting activities.

Noting historical analytical data has also been provided separately in Microsoft Excel format.

2 Site Identification

2.1 Site Use

The SBWMF lies within Lot 3952, Town of Sanderson (see Figure 1-1) described in EPL 188-03 as a municipal waste resource recovery and disposal site operated by the CoD which services both domestic and commercial customers in the Darwin area. 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 the following scheduled activities:

- Operating premises for the disposal of waste by burial that service, or are designed to service, the waste disposal requirements of more than 1,000 persons;
- Collecting, transporting, storing, re-cycling, treating or disposing of a listed waste (see Table 3-1) on a commercial or fee for service basis, other than in or for the purpose of a sewage treatment plant; and
- Operating premises, other than a sewage treatment plant, associated with collecting, transporting, storing, re-cycling, treating or disposing of a listed waste (see Table 2-1) on a commercial or fee for service basis.

Table 2-1 Listed Wastes Authorised to be Handled

Listed Waste	Collection	Transport	Storage	Treatment	Recycling	Disposal
Acidic solutions or acids in solid form	✗	✗	✓	✗	✗	✗
Animal effluent and residues	✗	✗	✗	✗	✗	✓
Asbestos	✗	✗	✗	✗	✗	✓
Clinical and related wastes	✗	✗	✗	✗	✗	✓
Lead, lead compounds	✗	✗	✓	✗	✗	✗
Sewerage sludge and residues including nightsoil and septic tank sludge	✗	✗	✗	✗	✗	✓
Soils contaminated with a listed waste	✗	✗	✗	✗	✗	✓
Tyres	✗	✗	✗	✗	✗	✓
Waste from the production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish	✗	✗	✓	✗	✗	✗
Waste mineral oils unfit for their original intended use	✗	✗	✓	✗	✗	✗

✓ Activity authorised by EPL 188 ✗ Activity not authorised by EPL188

2.2 Site Layout

At the end of this monitoring period the Site included 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 Stage 3 and 4 putrescible waste landfill cells reached capacity and were capped during 2016 and 2017, with the waste accepted by the Stage 5 cell currently approaching capacity, where waste has started diverting to the Stage 6 landfill cell recently constructed.
- 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;
- The Stage 2 landfill cell, located in the north eastern portion of the Site is unlined and accepts inert waste (construction and demolition including asbestos). The Stage 1 landfill cell, located in the southeast is an historic unlined landfill, which is capped and not in use. Leachate from the unlined Stage 1 and 2 landfill cells is collected 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 is undertaken on a pad south of Stage 5;
- A facility for the short-term storage of chemicals is located in the southern portion of the Site; and
- 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 details 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 details on landfill leachate management and gas management, refer to the SBWMF *Environmental Management Plan* (CoD, 2016), Section 5.6 *Water Quality Management*.

2.3 Environmental Setting

2.3.1 Climate

The regional climate is tropical monsoonal with a distinct wet season (November to April) and dry season (May to October). Average yearly rainfall is 1,723.3 mm, 80% of which occurs between December and March (Darwin Airport, BoM Station Site Number 014015).

2.3.2 Hydrology

Surface water from the eastern portions of the SBWMF flows towards the Meckitt Creek floodplain. 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.

2.3.3 Hydrogeology

Geology and groundwater aquifers beneath the Site are described in detail in the *Shoal Bay Waste Disposal Site, Hydrogeological Investigation* (URS 2015).

The lithology encountered during groundwater bore drilling for the investigation comprised top soils (silts and clays), generally underlain by weathered (lateralised) siltstone over most of the site, and claystone east of Stage 1. Beneath this, sandstone was encountered at depths of 9.0 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 5.0 L/sec. Seasonal groundwater levels measured as part of the SBWMF water monitoring plan are greater than 12 meters below ground level (m bgl) at the end of the dry season and usually within 2.0 m of the ground surface during the peak of the wet season.

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 uses down-gradient of SBWMF other than that potentially associated with environmental supply of groundwater seepage into wetlands and tidal inlets.

Higher yielding weathered and fractured carbonate rock aquifers occur in the wider region, with yields commonly greater than 5.0 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 southeast 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 upgradient of the SBWMF. No significant areas of carbonate rock aquifer are located down-gradient of the SBWMF and no carbonate rocks were encountered during the installation of the 32 groundwater bores, to depths of up to 30 mbgl, across the Site for the hydrogeological investigation (URS 2016).

For detailed analysis of potential contamination pathways for leachate and other pollutants from the SBWMF towards potential human health and environmental receptors, refer to the *Shoal Bay Waste Disposal Site Conceptual Site Model* (URS 2016).

2.3.4 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 immediate surrounds:

- *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)*

The SBWMF also 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-datamaps/importantbiodiversityconservationsites/conservation/significance-list

3 Monitoring

Groundwater, surface water and leachate water quality monitoring have been undertaken at the SBWMF as per the monitoring plan since July 2016, when EPL188 was issued. Throughout this time, CoD initially commissioned EcOz Environmental Consultants (EcOz), assisted by Larrakia Nation Rangers, to carry out the monitoring, prior to engaging Cardno to undertake the monitoring activities.

Cardno has developed a specific safe work method statement (SWMS) and standard operating procedures (SOP) for groundwater and surface water (applicable to leachate), which are always adhered to.

3.1 Methodologies

Cardno’s suitably qualified scientist undertook groundwater, surface water, soil and dust deposition sampling detailed below, consistent with procedures laid out in the SWMP and in accordance with the following best practice industry standards and guidelines:

- NT EPA 'Guideline for Reporting on Environmental Monitoring'
- AS 4482.1-2005 “Guide to the investigation and sampling of sites with potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds”;
- AS 4482.2-1999 “Guide to the sampling and investigation of potentially contaminated soil, Part 2: Volatile substances”;
- AS 5667.1 “Water Quality-Sampling: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples”;
- AS 5667.11-1998 “Water Quality-Sampling: Guidance on sampling of groundwater”;
- Department of Environment and Regulation (DER), 2014, “Assessment and Management of Contaminated Sites”;
- AS/NZS 5667.4:1998 “Water Quality Sampling - Part 4: Guidance on sampling from lakes, natural and man-made”;
- AS/NZS 5667.6:1998 “Water Quality Sampling – Part 6: Guidance on sampling of rivers and streams”;
- AN/NZS 5667.10:1998 “Water Quality Sampling – Part 10: Guidance on sampling of waste waters”;
- DoH, 2014, Contaminated Sites Ground and Surface Water Chemical Screening Guidelines
- National Environment Protection Council (NEPC), 1999, *National Environmental Protection (Assessment of Site Contamination) Measure (as amended)*, registered May 2013;
- AS/NZS 3580.10.1-2016 Methods for sampling and analysis of ambient air - Determination of particulate matter – deposited matter – gravimetric method;
- AS/NZS 3580.1.1-2016 Methods for sampling and analysis of ambient air - Guide to Siting Air Monitoring Equipment;
- NEPC Schedule B (1): Guideline on the Investigation Levels for Soil and Groundwater.

3.1.1 General Monitoring Approach

During each monitoring round team of two of Cardno’s suitably qualified environmental scientists and hydrologists undertook groundwater, surface water, soil and dust deposition monitoring in line with the aforementioned standards and SWMP and WMP prior. On each monitoring event, surveys were undertaken for up to 3 consecutive days. The monitoring procedures for groundwater, surface water, soil and dust deposition monitoring were carried out concurrently and consisted of the following preliminaries:

- Prior to attendance to site preparation/update the Site Works Method Statement (SWMS) which include details of health and safety procedures, map showing location of sacred sites likely to have restrictions to access, and identification of required PPE for site conditions/requirements.
- At start of each field day and prior to each survey commencing, conduct a safety start meeting identifying potential hazards. Liaise with site manager to identify no-go zones regarding site’s operations and other relevant safety information.
- Scope specific sampling procedures, data collection, and analysis are discussed in their respective sections below.

3.1.2 Ground Water Monitoring

During this monitoring period the following groundwater monitoring procedures were carried out by Cardno's suitably qualified personnel at each ground water monitoring location where hydrasleeve was the predominant sampling technique prior to the new SWMP:

- HydraSleeve sampling
  - HydraSleeves are deployed with top weight for sample collection to begin at the lowest point. HydraSleeve sampling devices are left in wells for a minimum of 4 hours to allow restabilisation of the well following the slight disturbance caused by sampler deployment.
  - Samples are then collected via continuous pull method at a rate allowing the water to pass through the check value into the sample sleeve.
  - Samples are discharged immediately (minimise changes in chemistry) via discharge tube.
- Low Flow Purging and sampling
  - Groundwater is purged utilising the "continue flow" technique using a low flow bladder pump.
  - Purging of each monitoring bore continues until groundwater field parameters [including pH, electrical conductivity (EC), oxidation reduction potential (ORP), dissolved oxygen (DO) and temperature] stabilise (as indicated by at least three consecutive measurements falling within +/- 5% of each other) and a sustainable sampling flow rate (i.e. minimal draw down) has been established to confirm that a representative sample of the Superficial Aquifer is collected.
- In situ temperature, pH and redox (mV) is measured using a YSI Pro Plus Multiparameter Instrument
- Groundwater sampling can commence once the physiochemical parameters have stabilised, indicating that they represent natural groundwater in the aquifer.
- Samples collected for dissolved heavy metal analysis are filtered in the field using an in-line 0.45 micron (μm) filter to remove suspended solids and colloids
- Use of dedicated pump tubing at each groundwater well; and, thorough washing of all re-usable sampling equipment (i.e. pumps) and with detergent (Liquinox), then double rinsing with clean water and drying before the collection of each sample.
- Samples are collected directly in into appropriately labelled and preserved laboratory supplied bottles and packed in chilled containers for delivery to the laboratory under Chain of Custody documentation.
- Sample containers, preservation procedures, sample storage requirements and holding times are undertaken in accordance with those recommended by Standards Australia (AS/NZS 5667.1:1998 and AS 4482.1 as appropriate). All holding times comply with the requirements set out in "Australian Standard AS/NZS 5567.1:1998 and AS 4482.1".

3.1.3 Storm / Surface Water and Leachate Monitoring Procedures

The following surface water sampling procedures were carried out by Cardno's suitably qualified personnel at each surface and storm water sampling location:

- In situ temperature, pH and redox (mV) shall be measured using a YSI Pro Plus Multiparameter Instrument or equivalent
- The specific method of sampling adhered to those specified in WMP and SWMP;
- Samples are collected directly in into appropriately labelled and preserved laboratory supplied bottles and packed in chilled containers for delivery to the laboratory under Chain of Custody documentation.
- Surface water samples collected for dissolved heavy metal analysis are filtered in the field using an in-line 0.45 micron (μm) filter to remove suspended solids and colloids.
- Sample containers, preservation procedures, sample storage requirements and holding times are undertaken in accordance with those recommended by Standards Australia (AS/NZS 5667.1:1998 and AS 4482.1 as appropriate). All holding times comply with the requirements set out in "Australian Standard AS/NZS 5567.1:1998 and AS 4482.1".
- Use of dedicated disposable sampling equipment at each surface water location; and, thorough washing of all re-usable sampling equipment with detergent (Liquinox), then double rinsing with clean water and drying before the collection of each sample.

3.1.4 Soil Sampling Procedures

The following soil sampling procedures were carried out by Cardno's suitably qualified personnel at each soil sampling location:

- Two replicate surficial sediment samples (e.g. top 200 mm) are collected from each soil sampling location;
- Samples are collected directly in into appropriately labelled and preserved laboratory supplied bottles and packed in chilled containers for delivery to the laboratory under Chain of Custody documentation.
- Sample containers, preservation procedures, sample storage requirements and holding times will be undertaken in accordance with those recommended by Standards Australia (AS/NZS 5667.1:1998 and AS 4482.1 as appropriate). All holding times comply with the requirements set out in "Australian Standard AS/NZS 5567.1:1998 and AS 4482.1".

3.1.5 Dust Depositional Sampling Procedures

Dust depositional sampling will closely adhere to those specified in the SWMP in accordance with Australian Standards and include the following approach:

- Installation of laboratory supplied deposition dust stand, glass funnel and stopper and 4L sample bottle with copper sulphate preservative at a height of 2magl;
- All gauges are labelled with site name, date and time of installation to ensure correct timing of sample collection;
- After each biannual 30-day sample period all deposited matter on the glass funnel will be washed into the deposition bottle using a minimum amount of demineralised water.
- Samples are collected directly in into appropriately labelled and preserved laboratory supplied bottles and packed in chilled containers for delivery to the laboratory under Chain of Custody documentation.
- Sample containers, preservation procedures, sample storage requirements and holding times are undertaken in accordance with those recommended by Standards Australia (AS/NZS 3580.10.1and AS/NZS 3580.1.1). All holding times comply with the requirements set out in "Australian Standard AS/NZS 3580.10.1and AS/NZS 3580.1.1".

It is noted that the dust analysis method follows Australian Standard AS/NZ 3580.10.1:2003 - Determination of Particulate Matter - Deposited matter - Gravimetric and this requires the addition of a known volume of copper sulfate solution to prevent mould growth. Being analytical reagent grade CuSO4, Copper cannot be analysed as per the methods stipulated by the EPL and SWMP.

3.1.6 Emissions Monitoring

Emissions testing methodologies associated with the evapoconcentrator, BeneVap (BV300) are discussed in detail in the following reports, also provided in Appendix A:

- *Source Emissions Monitoring – Shoal Bay BenVap System 2021,* Report Ref: *13439_MON_R0-signed* (Assured Environmental, 2021)
- *Source Emissions Monitoring – Shoal Bay BenVap System 2021,* Report Ref: *13446_MON_R0-signed* (Assured Environmental, 2021)

3.1.7 Quality Assurance / Quality Control

QA/QC samples are collected at the frequency detailed in the SWMP and analysed for the same analytes as the primary samples:

3.1.7.1 Water sampling

- Field duplicate (intra-laboratory) at 1 per 10 primary water samples
- Field triplicate (inter-laboratory) at 1 per 10 primary water samples
- Field blank (one per event)

3.1.7.2 Soil Sampling

- Field duplicate (intra-laboratory) at 1 per 20 primary sediment samples and/or sampling event
- Field duplicate (inter-laboratory) at 1 per 20 primary sediment samples and/or sampling event

3.2 Monitoring Sites

The current network of monitoring sites includes 10 leachate sites, 43 groundwater sites, and 9 surface water and stormwater sampling sites. In addition to water monitoring networks there are 4 soil sampling locations and 4 dust depositional locations. Each monitoring network is described in detail in their respective sections below.

3.2.1 Leachate Monitoring Network

Leachate sampling sites allow for the characterisation of contaminant concentrations in landfill leachate to allow for comparison with groundwater and surface water samples. The leachate sampling locations are detailed in Table 3-1 and include:

- Deleaching Well (DW) DW2 - collects leachate from the south-west corner of the Stage 3/4 landfill;
- DW3 - collects leachate from the north-west corner of the Stage 3/4 landfill;
- Stage 3 leachate sump (TC Sump) - collects leachate from the eastern side of the Stage 3/4 landfill;
- LS5A - collects leachate from the western side of the Stage 5 landfill;
- LS5B - collects leachate from the south-west corner of the Stage 5 landfill;
- Leachate Pond (LP) LP01 - Northern leachate storage pond;
- LP02 - Southern leachate storage pond; and
- 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.

Table 3-1 Leachate Sampling Locations

Site ID	Easting (m)	Northing (m)	Location	Source
DW2	709029	8630459	Deleaching well on southwest corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells
DW3	709038	8630216	Deleaching well on northwest corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells
LS5A	709023	8630122	Deleaching well on west side of Stage 5 landfill	Represents leachate from Stage 5 landfill cell
LS5B	709041	8630039	Deleaching well on southwest corner of Stage 5 landfill	Represents leachate from Stage 5 landfill cell
TC Sump	709465	8630233	Sump on southeast corner of Stage 3/4 landfill	Represents leachate from Stage 3/4 landfill cells
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.
LP01	709534	8630726	Northern leachate storage pond	Represents leachate in northern storage pond
LP02	709531	8630713	Southern leachate storage pond	Represents leachate in southern storage pond

3.2.2 Groundwater Monitoring Network

Ground water monitoring bores provide an indication of landfill leachate and/or other contaminants associated with SBWMF operations migrating from site in groundwater down gradient. The 43 groundwater monitoring bores to be monitored under EPL188-03 and bores previously monitored in line with the URS WMP are detailed in Table 3-2 and comprise:

- A total 41 bores at 22 locations across the site, with up to 3 bores (nested) at some locations. Installation of this monitoring network began in 2015 to inform a hydrogeological investigation (URS 2015) and development of a CSM (URS 2016). Since then additional clustered have been installed in 2019 and 2021 to inform groundwater impacts from newly constructed Stage 6 landfill and future leachate treatment infrastructure. Generally, each of the 22 locations includes a shallow bore screened between 1.5 and 3 m below ground level (mbgl), and a deeper bore screened between 9 and 12 mBGL. Three of the locations have a third bore screened at 30 mBGL. The ID's for these bores are prefixed with a 'GW' and suffixed with a -3, -12 or -30 to indicate bore screening depth.

> Eight bores of the current monitoring network installed prior to the URS (2015) hydrogeological investigation prefixed with a 'WW' with varying screened intervals; all less than 10 m deep.

> The most recent installation includes GW19 and GW20 (renamed from GWI5 and GWI6) which represent water from underneath the two landfill stages (stage 5/6 ad stage 2). As they have not been installed with monument and complete monitoring well infrastructure, they do not have TOC and other bore related information.

Table 3-2 Monitoring Bore Locations and 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
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
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
GW16-3	709493	8630030	TBC	TBC	TBC	1.5-3	Sandy Claystone
GW16-12	709494	8630025	TBC	TBC	TBC	9-12	Siltstone
GW16-30	709495	8630021	TBC	TBC	TBC	30	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
GW17-3	709418	8630692	TBC	TBC	TBC	3	-
GW17-12	709418	8630691	TBC	TBC	TBC	12	-
GW17-30	709418	8630691	TBC	TBC	TBC	30	-
GW18-3	709464	8630729	TBC	TBC	TBC	3	-
GW18-12	709464	8630728	TBC	TBC	TBC		-
GW19	708952	8630107	-	-	-	-	-
GW20	709811	8629975	-	-	-	-	-
WW1	709471	8630255	-	16.60	15.90	0-6.3	-
WW3	709471	8630151	-	16.38	15.68	0-20.3	-
WW5	708980	8630234	-	8.34	7.64	0-6.0	-
WW6	709047	8630478	-	7.46	6.76	0-20.4	-
WW7	709045	8630483	-	7.45	6.75	0-5.8	-
WW9	709016	8630598	-	7.09	6.39	1-9.8	Siltstone
WW10	709235	8630598	-	10.92	10.21	1-9.7	Siltstone
WW13	709457	8630598	+0.8	+0.7	Not available	1-10	Siltstone

3.2.3 Stormwater and Surface Water Monitoring Network

Surface water sampling locations provide an indication of landfill leachate and/or other contaminants associated with SBWMF operations that have the potential flow downstream and offsite affecting surrounding receptors. The surface water monitoring sites are detailed in Table 3-3 and include:

- Wheel Wash Sump - collects the wash-down water from the bunded area used to wash commercial waste disposal vehicles;
- Water outfall from Stage 1 and Stage 2 landfills (STG1 & 2) - surface water drain along the western edge of the Stage 1 and Stage 2 landfills;
- Water outfall from Stage 3 and Stage 5 landfills (SWStg5) - surface water drain along the western edge of the Stage 3 and Stage 5 landfills
- Greenwaste (GW) Sump - collects surface water drainage from the green waste processing area; and
- SW12, SW13 and SW14 - receive surface water runoff (and potentially seepage) from the Stage 3 and 4 landfill cells.
- SW12, SW13 and SW14 - receive surface water runoff

It is noted that the SW2 site, reportedly included in the original water monitoring program to be a wet season seepage site, has only had enough surface water to be sampled twice since monitoring began (i.e. sampled in November 2016 and December 2020 and has been removed from the current monitoring network along with the Wheel Wash location.

Table 3-3 Storm water and Surface Water Monitoring Locations

Site ID	Easting (m)	Northing (m)	Location	Source
Wheel Wash	709479	8629775	Sump within vehicle wash-down bay	Receives wash-down water from large commercial waste transport vehicles
SWStg1&2 (formerly STG1&2)	709448	8629979	Surface drain between Stage 1 and Stage 2	Receives surface water runoff from central SBWMF areas
SWStg5	709003	8630206	Northwest of Stage 5	Receives surface water runoff from central Stage 3 and Stage 5 landfills.

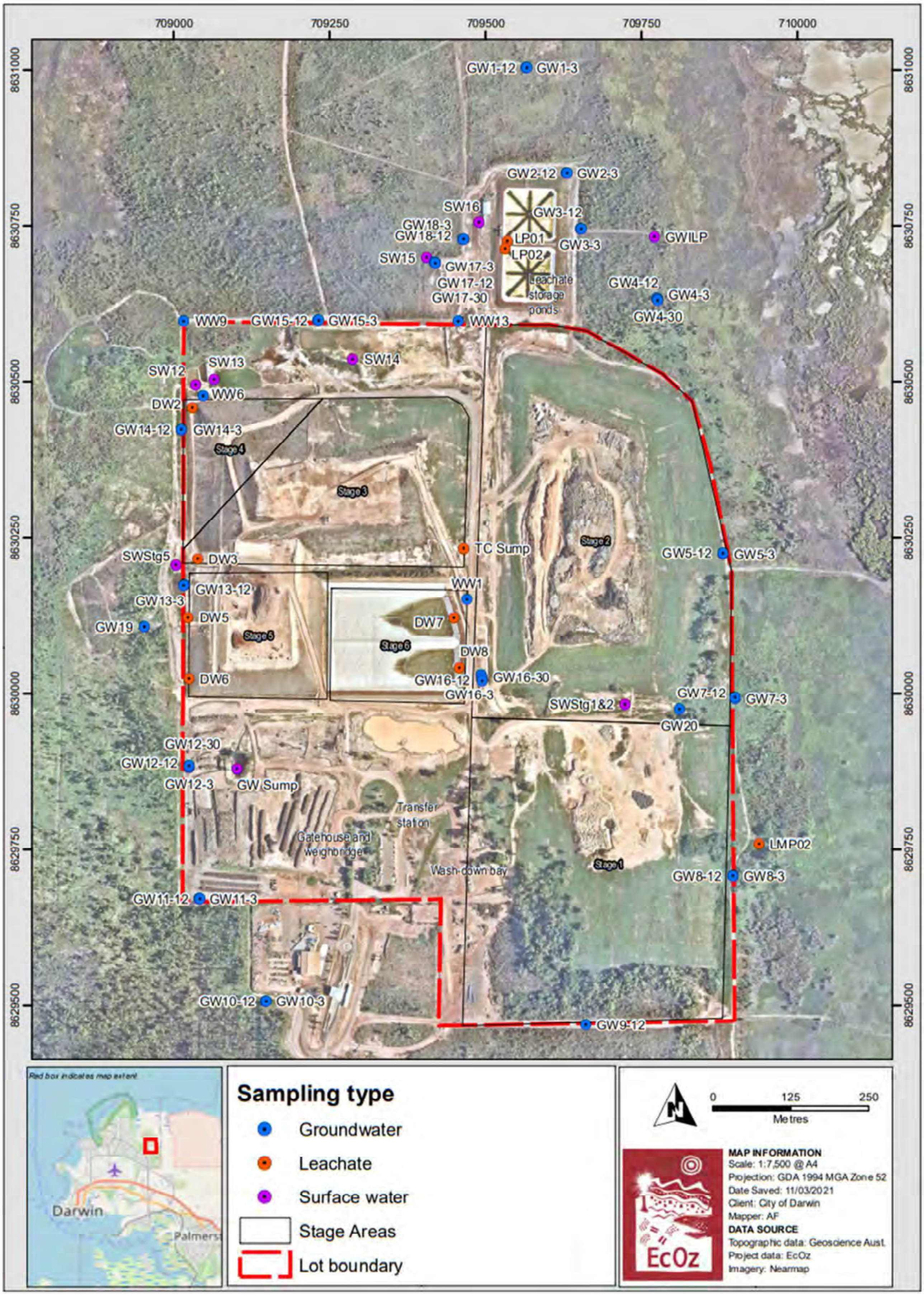
Site ID	Easting (m)	Northing (m)	Location	Source
GW Sump	709102	8629880	Sump within green waste processing and storage area	Receives surface water runoff from green waste processing and storage area. Possibly also surface runoff from the Stage 3 and 5 landfills.
GWILP	709771	8630733	East of the leachate ponds	Receives surface runoff from the existing leachate ponds.
SW2	708973	8630296	West of Stage 3/4 landfill	Receives seepage from Stage 3/4 landfill
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
SW13	709065	8630504	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
SW14	709287	8630536	Catchment dam north of Stage 3/4 landfill	Receives surface water runoff (and potentially seepage) from the western landfill cells
SW15	709405	8630699	North of leachate treatment	Receives runoff from the new leachate treatment plant
SW16	709490	8630756	West of leachate treatment plant	Receives runoff from the new leachate treatment plant

3.2.4 Soil and Dust Depositional Monitoring Network

In line with the new EPL and monitoring plan, 4 soil and dust depositional monitoring sites have been added to the monitoring network. Both soil and dust monitoring sites coincide with the same locations and are detailed below in Table 3-4 and presented in Figure 3-2.

Table 3-4 Soil and dust monitoring locations details

Site ID	Easting	Northing	Location
SS01 / DS01	709187	8630904	North west of leachate pond and leachate treatment plant
SS02 / DS02	709580	8631014	North of leachate ponds
SS03 / DS03	709788	8630614	South east of leachate treatment ponds, north east of Stage 2 landfills
SS04/DS04	709252	8630601	North of Stage 3/4 cells, directly east of GW15-3



MAP INFORMATION
Scale: 1:7,500 @ A4
Projection: GDA 1994 MGA Zone 52
Date Saved: 11/03/2021
Client: City of Darwin
Mapper: AF
DATA SOURCE
Topographic data: Geoscience Aust.
Project data: EcOz
Imagery: Nearmap

Figure 3-1 Water Monitoring Locations (Source: EcOz 2021)

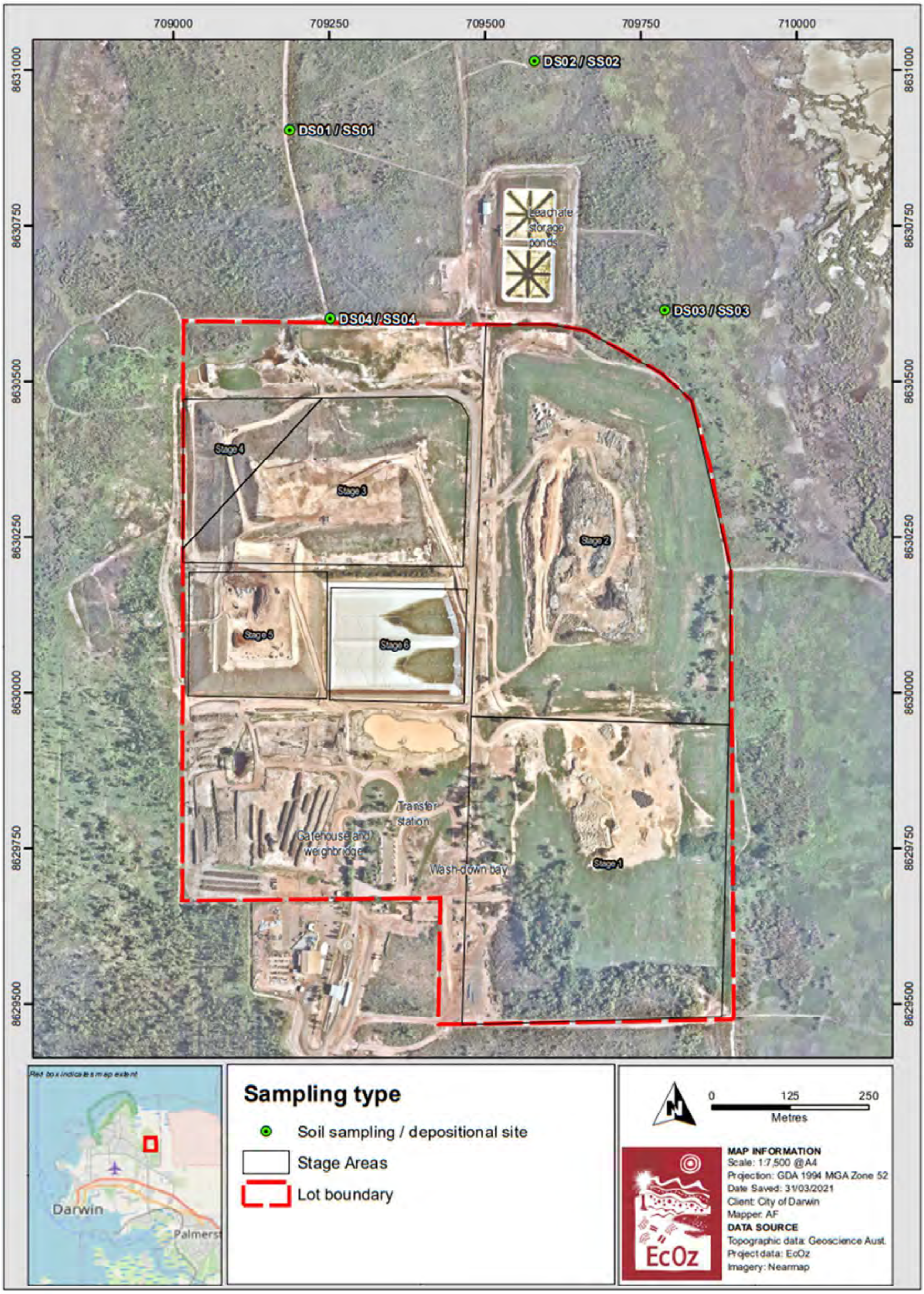


Figure 3-2 Soil and Dust Depositional Monitoring Locations (Source: EcOz 2021)

3.3 Additional Bore Installation

CoD has commissioned the installation of two new monitoring well clusters directly west of the leachate treatment ponds (GW17-3, GW17-12, GW17-30, GW18-3, GW18-12) to be included in the updated monitoring schedule. CoD has also since decommissioned WW5 and will resume sampling WW1 in line with the updated EPL188-03 in future monitoring events.

3.4 Sampling Frequency

The URS monitoring plan, adhered to for the majority of this review period, requires monthly sampling of all monitoring sites (Appendix B) while the updated EPL188-03 has stipulated new sampling frequencies and analysis for each sampling location provided in Appendix B. The specific sites actually sampled each month vary concurrent with seasonal changes in rainfall, surface water flows and groundwater levels. The availability of sites for sampling throughout the year (i.e. availability of water to sample) has been described in previous annual reviews (EcOz, 2019, Cardno, 2020) and is summarised as follows:

- All leachate sites (DW2, DW3 and LMP02) and the wheel wash sump can be sampled throughout the year;
- The GW Sump can usually be sampled throughout the wet season, between the months of September and May;
- The surface water site SW12 is a sediment dam that holds water throughout the wet season and well into the dry season i.e. is usually only dry from June to September;
- The surface water sites STG1&2 only have water and can be sampled immediately after heavy rainfall at the peak of the wet season i.e. January and February;
- During the dry season, most of the shallow 3.0 m deep bores, and a large number of the 12 m deep bores are dry i.e. groundwater levels drop below the bottom of the bore;
- The established deep bores GW4-30, GW16-30 and GW12-30 are known to contain water throughout the year, with standing water levels (SWLs) of up to 12 m bgl at the end of the dry season (at GW12-30) and within 6.0 m of the ground surface during the wet season. GW4-30, located close to the swamp northeast of the SBWMF, is often artesian throughout the wet season and only drops to a maximum 3.0 m bgl during the dry season.
- In addition to the three deep bores mentioned above, the following bores also contain groundwater throughout the dry season and can be sampled:
  - GW-5-12;
  - GW6-12;
  - GW7-12;
  - GW8-12; and
  - GW16-12.
- Newly installed wells west of the leachate treatment ponds have yet to be sampled through a full dry season.

Sampling is undertaken during the first week of every month, representative of water quality for the previous month, i.e. sampling during the first week of July represents June.

3.5 Parameters measured

As monitoring activities have transitioned to methodologies laid out in the SWMP (EcOz, 2021) to comply with the updated EPL188-03, analysis suites have not been consistent across all twelve months of this monitoring period.

As per the URS monitoring plan a differing suite of laboratory parameters is analysed on a monthly, quarterly and annual basis detailed in Appendix X. Updated EPL-188-03 analysis suites are provided in Appendix X. In addition to the aforementioned sampling suites, monthly sampling of groundwater and surface water sites as per EPA304-01 for initial 12 months (April 2021 to March 2022) detailed in Table 3-1 below. Table 3-2 provides which parameter suite was analysed during each monitoring round from July 2020 to June 2021.

Table 3-1 EPA304-01 Monthly Sampling Analysis

New Monitoring Locations	Analysis Details
GW16-3 GW16-12 GW16-30 GW17-3 GW17-12 SW15 SW16	The following parameters are assessed in new groundwater and surface water sampling locations: *In situ field parameters* ▪ Temperature ▪ Dissolved oxygen (DO) ▪ Electrical conductivity (EC) ▪ Total dissolved solids (TDS) ▪ Salinity ▪ pH ▪ Oxidation-reduction potential (ORP) ▪ Turbidity *Laboratory Testing* ▪ Ammonium of nitrogen (NH_4) ▪ Chemical oxygen demand (COD) ▪ Total dissolved solids (TDS) ▪ Total organic carbon (TOC) ▪ Major Ions (Sodium, Potassium, Magnesium, alkalinity, chloride, sulfate) ▪ Explosives - TNT and RDX ▪ PFAS ▪ Glyphosate ▪ Nutrients (nitrogen compounds) ▪ Dissolved heavy metals (NEPM suite 15 metals plus Fe, CrVI) ▪ Faecal coliforms and E. coli ▪ Polychlorinated biphenyls (PCBs) ▪ Organochlorine pesticides (OCP) ▪ Organophosphate pesticides (OPP) ▪ Volatile organic compounds (VOCs) ▪ Total recoverable hydrocarbons (TRH) ▪ Benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN) ▪ Polycyclic aromatic hydrocarbons (PAHs) ▪ Phenolic compounds ▪ Volatile fatty acids (VFAs) ▪ Absorbable organic halide (AOX)

Table 3-2 Water Quality Analysis Schedule July 2020 – June 2021

Monitoring Event	Monitoring Schedule	Analysis Suite
July 2020	URS WMP	Monthly
August 2020	URS WMP	Monthly
September 2020	URS WMP	Quarterly
October 2020	URS WMP	Monthly
November 2020	URS WMP	Monthly
December 2020	URS WMP	Quarterly
January 2021	URS WMP	Monthly
February 2021	URS WMP	Monthly
March 2021	URS WMP	Monthly, Biannual (soil sampled on request)

Monitoring Event	Monitoring Schedule	Analysis Suite
April 2021	URS WMP, EPA304-01	Monthly
May 2021	EPA304-01	Monthly
June 2021	EPA304-01	Monthly, Biannual (dust sampled on request, awaiting results)

3.6 Assessment Criteria

Assessment Criteria have remained consistent with the below details during this monitoring review period with the exception of “Leachate Impact Indicator” being omitted following the implementation of EPA304-01 sampling.

3.6.1 Water Quality

The *Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality* (2018) trigger values for protection of 90% of marine ecosystems have been adopted to inform the assessment of analytical results. These criteria aim to better assess the potential risk to surrounding environmental receptors.

Pursuant to EPL 188, if at the time of review, groundwater, surface water and/or leachate quality issues have been identified (i.e. trigger levels are reached) then these issues will be raised formally with the CEO and NT EPA, provided that:

> Trigger levels have been exceeded over three consecutive monitoring events;

> A trigger level is exceeded greater than or equal to two times the trigger value; or

> A trigger level is exceeded at a median value over six consecutive monitoring events.

Following this review period, reporting will also adopt *Darwin Harbour Water Objectives (Shoal Bay upper area marine ambient water quality)* in accordance the update EPL188-03.

3.6.2 Leachate Impact Indicator

As per the URS monitoring plan a leachate impact indicator is used to determine the ration of leachate (L) to natural groundwater (N) by comparing ion concentrations indicative of leachate, to the ion concentrations associated with groundwater

Leachate Impact Indicator is therefore determined as follows:

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

Groundwater monitoring bores recording a ratio of L/N greater than 10 will require additional monitoring (Ad Hoc) where a larger suite of parameters is analysed for these bores in the next monitoring round.

3.6.3 PFAS Assessment

Each assessment of this monitoring review period has adopted the ecological water quality guideline values for PFAS as per the *PFAS National Environmental Management Plan v2.0* (HEPA, 2020), for the following exposure scenarios:

> The 95% species protection – slightly to moderately disturbed systems in interim marine water (Perfluorooctane sulfonic acid (PFOS) – 0.13 µg/L and Perfluorooctanoate acid (PFOA) – 220 µg/L).

> The 90% species protection – highly disturbed systems (PFOS – 2 µg/L and PFOA – 632 µg/L).

The aforementioned guidelines currently reference freshwater values in lieu of interim marine guidelines, using the nationally agreed process under the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* where PFOS and PFOA are the only PFAS species with guidelines values for aquatic ecosystems.

3.6.4 Soil Leachability

Soil was analysed for the leachability of contaminants to provide for comparison with groundwater monitoring data against the same adopted guidelines: *(ANZG) for Fresh and Marine Water Quality* (2018) *DGVs* and *PFAS National EMP (2020) Interim marine water 90%/95%*

3.6.5 Emissions

Emission values have been compared against the emission limits stipulated in Attachment 7 of EPL188-03.

3.7 Rainfall and Site Conditions

The availability of water for sampling at a number of groundwater and surface water sites is dependent on rainfall described in Section 2.3 Surface only water flows in stormwater drains across the site during and immediately after rainfall although surface water catchments such as ‘SW12,13,14’ and ‘GW Sump’ hold water for long periods. The ‘wheel wash’ site receives vehicle wash-down water sourced from the Darwin reticulated water supply and is not dependent on rainfall.

Figure 3-1 illustrates monthly rainfalls from July 2020 to June 2021, collected from the nearest BoM station with consistent, reliable rainfall data (Darwin Airport Station No. 014015). The average annual rainfall for this station is 1,723.1 mm.

Based on historical data and *SBWMF Annual Monitoring Review, 1 July 2019 – 30 June 2020* (Cardno 2020) it is evident that after the below average wet season in 2019 resulting in lower groundwater levels and bores become dry earlier in the year, this monitoring period has experienced more typical water levels compared to the previous monitoring period.

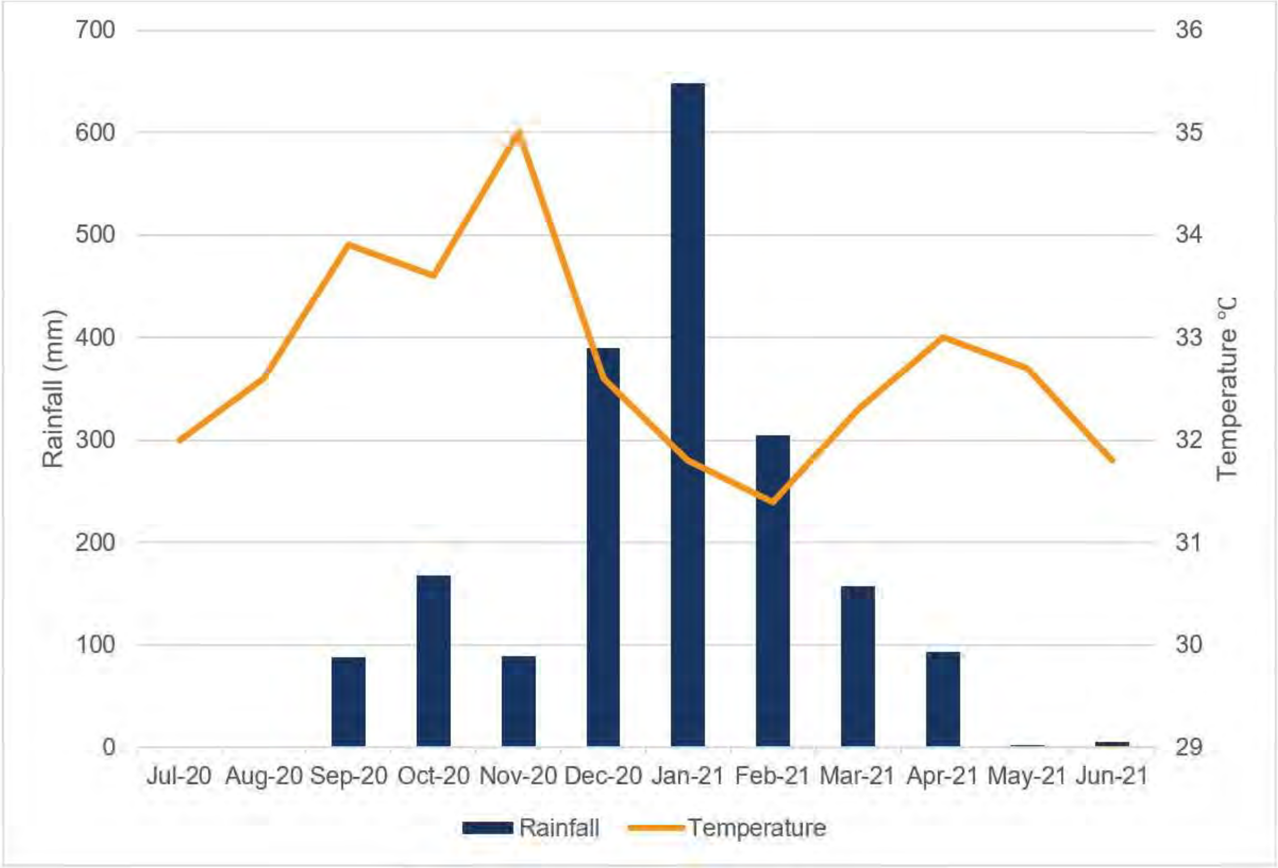


Figure 3-1 Average Monthly Rainfall, July 2020 – June 2021 (Source: Darwin Airport BoM Station, Site Number 014015)

4 Results

All raw soil, dust and water quality results (groundwater, surface water and leachate) obtained during the reporting period July 2020 – June 2021 are provided in Appendix C. Laboratory analysis reports produced during Cardno's June sampling activities are provided in Appendix D, all other laboratory analysis reports have been provided to CoD during respective monthly reporting.

4.1 Field Observations

4.1.1 Groundwater

Groundwater at SBWMF is recharged via direct infiltration of rainfall and/or runoff making groundwater levels in the shallow aquifer highly reactive to rainfall totals.

SWLs of groundwater bores sampled during each monitoring event of this reporting period are provided below in Table 4-1.

Table 4-1 Standing Water Levels for Bores Sampled

Monitoring Event	Sampled Groundwater Bore	Standing Water Levels (mbgl)
July 2020	GW1-12, GW12-12, GW12-30, GW13-12, GW14-12, GW15-12, GW15-3, GW2-12, GW3-12, GW4-12, GW4-30, GW7-12, GW7-3, GW8-12, GW8-3, WW6, WW7, WW9	Min: 0.75 at GW7-12 Max: 11.13 at GW12-12
August 2020	GW2-12, GW4-12, GW5-12, GW7-12, GW8-3, GW8-12, GW12-30, GW13-12, GW14-12, GW4-30, WW6	Min: 1.37 at GW7-12 Max: 11.66 at GW12-30
September 2020	GW12-30, GW13-12, GW14-12, GW2-12, GW2-3, GW4-30, GW5-12, GW7-12, GW8-12, GW8-3, WW6	Min: 0.59 at GW2-3 Max: 12.71 at GW13-12
October 2020	GW12-12, GW12-30, GW13-12, GW14-12, GW15-12, GW2-12, GW4-30, GW5-12, GW5-3, GW7-12, GW8-12, GW8-3 WW6, WW7, WW9	Min: 0.62 at GW7-12 Max: 12.03 at GW13-12
November 2020	GW12-12, GW12-30, GW13-12, GW14-12, GW15-12, GW2-12, GW2-3, GW3-12, GW4-30, GW5-12, GW7-12, GW7-3, GW8-12, GW8-3, GW9-12, WW5, WW6, WW7, WW9	Min: 0.03 at GW7-12 Max: 11.23 at GW13-12
December 2020	GW10-12, GW10-3, GW11-12, GW1-12, GW11-3, GW12-12, GW12-3, GW12-30, GW1-3, GW13-12, GW15-12, GW15-3, GW16-12, GW16-3, GW16-30, GW2-12, GW2-3, GW3-12, GW3-3, GW4-12, GW4-3, GW4-30, GW5-12, GW5-3, GW7-12, GW7-3, GW8-12, GW8-3, GW9-12, WW5, WW6, WW7, WW9	Min: - 0.28 at GW4-30 (overflowing) Max: 11.29 at WW9
January 2021	DW2, DW3, GW10-12, GW10-3, GW11-12, GW1-12, GW11-3, GW12-12, GW12-3, GW12-30, GW1-3, GW13-12, GW15-12, GW15-3, GW16-12, GW16-3, GW16-30, GW2-12, GW2-3, GW3-12, GW3-3, GW5-12, GW5-3, GW8-12, GW8-3, GW9-12, GWSUMP, LMP02, LP01, LP02, STG1&2, SW12, TCSUMP, WHEELWASH, WW13, WW5, WW6, WW7, WW9	Min: -0.55 at GW8-12 Max: 5.80 at WW13
February 2021	DW2, DW3, GW SUMP, GW10-12, GW11-12, GW1-12, GW12-12, GW12-30, GW1-3, GW13-12, GW15-12, GW15-3, GW16-12, GW16-3, GW16-30, GW2-12, GW2-3, GW3-12, GW5-12, GW5-3, GW8-12, GW8-3, GW9-12, LMP02, LP01, LP02, STG1&2, SW12, TC SUMP, WHEELWASH, WW13, WW5, WW6, WW7, WW9	Min: -0.39 at GW8-12 Max: 6.98 at GW13-12

Monitoring Event	Sampled Groundwater Bore	Standing Water Levels (mbgl)
March 2021	DW2, GW SUMP, GW10-12, GW1-12, GW12-12, GW12-3, GW12-30, GW1-3, GW13-12, GW14-12, GW14-3, GW15-12, GW15-3, GW16-3, GW16-30, GW2-12, GW2-3, GW5-3, GW9-12, LS5A, LMP02, LP01, LP02, STG1&2, SW12, TC SUMP, WHEELWASH, WW13, WW5, WW6, WW7	Min: 0.54 at GW14-12 Max: 6.70 at GW13-12
April 2021	GW17-12, GW17-30, GW17-3, GW18-12, GW18-3, GW10-12, GW11-12, GW1-12, GW12-12, GW12-3, GW12-30, GW1-3, GW13-12, GW14-12, GW14-3, GW15-12, GW15-3, GW16-12, GW16-3, GW16-30, GW2-12, GW2-3, GW3-12, GW4-12, GW4-3, GW4-30, GW5-12, GW5-3, GW7-12, GW7-3, GW8-12, GW8-3, GW9-12, WW13, WW5, WW6, WW7, WW9	Min: overflowing at GW4-30, GW5-12, GW7-12 Max: 11.86 at GW11-12
May 2021	GW17-12, GW17-30, GW18-12	Min: 5.45 mbtoc at GW18-12 Max: 6.08 mbtoc at GW17-30
June 2021	GW17-12, GW17-30, GW18-12	Min: 5.19 mbtoc at GW18-12 Max: 7.73 mbtoc at GW17-30

4.1.2 Surface Water and Leachate

Surface only water flows in stormwater drains across the site during and immediately after rainfall although surface water catchments such as ‘SW12,13,14’ and ‘GW Sump’ hold water for long periods. The ‘wheel wash’ site receives vehicle wash-down water sourced from the Darwin reticulated water supply and is not dependent on rainfall.

Surface water and leachate sites sampled during this reporting are provided below in Table 4-2.

Table 4-2 Water and Leachate Locations Sampled

Monitoring Event	Surface Water Sites Sampled	Leachate Sites Sampled
July 2020	SW12, TC SUMP, WHEELWASH	DW2, LP01, LP02, LS5A, LS5B
August 2020	SW12, TC SUMP, WHEELWASH	DW2, LP01, LP02, LS5A, LS5B
September 2020	SW12, TC SUMP, WHEELWASH	DW2, DW3, LP01, LP02
October 2020	SW12, TC SUMP, WHEELWASH	DW2, DW3, LP01, LP02, LS5A, LS5B, LMP02
November 2020	SW12, TC SUMP, WHEELWASH	DW2, DW3, LP01, LP02, LS5B, LMP02
December 2020	SW12, TC SUMP, WHEELWASH	DW2, LP02, LMP02
January 2021	GW SUMP, STG1&2, SW12, WHEELWASH	DW2, DW3, LP01, LP02, LMP02, TC SUMP
February 2021	GW SUMP, STG1&2, SW12, WHEELWASH	DW2, DW3, LP01, LP02, LMP02, TC SUMP
March 2021	GW SUMP, STG1&2, SW12, WHEELWASH	DW2, LS5A, LP01, LP02, LMP02, TC SUMP
April 2021	GW SUMP, SW12, WHEELWASH	DW2, DW3, LMP02, LP01, LP02, LS5B, TC SUMP
May 2021	SW12, SW13, SW14	Nil
June 2021	SW12, SW13, SW14	Nil

4.2 Emissions Monitoring

As per the Environmental Protection License 188-01 condition 48, BeneVap emission monitoring, as detailed in the Attachment 7 of the license, was conducted during the commissioning phase of the BV300 between 15 & 17 December 2020, and again between 3 & 5 March 2021 at SBWMF.

Detailed emission results and comparison of these results with the prescribed emission limits is provided Appendix A

Both monitoring events concluded that all measured parameters were within the emissions limits outlined in Attachment 7 of EPL188-01 (Assured Environmental, 2021)

4.3 Laboratory Results

4.3.1 Surface, Groundwater and Leachate Trigger Level Exceedances

Table 5-3 to Table 5-8 below present all ANZG 2018 trigger value exceedances for the 90% species protection level in fresh and marine water. The results highlighted in yellow indicate when the surface water trigger value was exceeded on three or more consecutive occasions as per EPL188-01 Condition 60. Results with an asterisk (*) indicate when the results are greater than or equal to two times the trigger value as per Condition 62.2. Trigger level exceedances of the newly adopted *Darwin Harbour Water Objectives (Shoal Bay upper area marine ambient water quality)* are provided in Appendix C highlighted in orange.

Note that only trigger value exceedances are listed in the tables below. Where a concentration is not listed for a site or month and does not appear in the table, either the concentration was below the trigger value, the site was not sampled because it was dry or limited suites of analytes were assessed during that month. Refer to Section 4.1 above for the sites that were sampled during the reporting period.

It should also be noted only newly installed wells and limited surface were sampled during May and June monitoring events as the sampling schedule transitioned to the updated EPL.

4.3.1.1 Ammonia

Ammonia concentrations above adopted assessment criteria (1,200 µg/L) were observed at several sampling locations provided in Table 4-3. Findings are summarised as follows:

- Exceedances of ammonia occurred in the sediment dams receiving runoff from the Stage 3, 4, 5 and 6 landfills (SW12, GW SUMP) and the sump collecting water from the washdown area (WHEELWASH).
- Groundwater impacts from leachate are indicated by consistently elevated ammonia concentrations more than 2 times the trigger value at the bore cluster located east of the Stage 1 landfill (GW8-3 and GW8-12). Bores at the north west corner of Stage 4 landfill continue to show leachate impact exceeding the trigger value for ammonia (WW6 and WW7).
- Leachate sampling locations exceeded the ammonia trigger value by over 1,300 times during the March monitoring event.
- No exceedances in ammonia were recorded during the May and June sampling events.

It has not been confirmed if the groundwater is to a degree possibly elevated in copper. Leachate however, is also potentially further increasing copper concentrations in ground water monitoring bores across the site.

Table 4-3 Exceedances of Ammonia above 1200 µg/L

Location	Ammonia concentration (µg/L)								
	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr
DW2					1,100,000*			1,300,000*	
GW SUMP			6000*	3500*	1400	2800*	3600*		
GW1-12						1500			1400
GW12-3						1500			
GW13-12	2600*	2500*	2700*	3000*	3200*	3200*	3200*	2700*	2500*
GW3-12									
GW4-30			2100	2000	2400*				2500*
GW8-12	3300*	1300		1600	2500*	3600*	3500*		3300*
GW8-3	22,000*	16,000*	10,000*	9100*	5600*	18,000*	16,000*		17,000*
LMP02					98,000*			220,000*	
LS5A								1,600,000*	

Location	Ammonia concentration (µg/L)								
	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr
LP01								32,000*	
LP02					810,000*			650,000*	
SW12		11,000*			1400	8800*			22,000*
TC SUMP					940,000*			1,200,000*	
WHEEL WASH	16,000*	3800*	52,000*	3800*	9800*	8000*	39,000*		
WW6	1200		1500	1200	1700	1400	1300	2700*	4500*
WW7	5000*		14,000*	80,000*	1200	3900*	16,000*	7500*	13,000*

Notes

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.2 Copper

Recorded Copper concentrations exceeding the trigger value (0.003mg/L) for 90% species protection are provided in Table 4-4 below and summarised as follows:

> Copper concentrations have been recorded up to 93 times the trigger value over three consecutive events during the wet season in the leachate from the Stage 3, 4 and 5 landfills (DW2 and TC Sump)

> No surface water sampling locations recorded copper exceedances during this annual review period.

> In groundwater, copper often exceeds the trigger value in bores across the site with the greatest number of affected bores occurring during March. The highest concentrations occurring on the western side of Stage 4 landfill as well as at GW18-12 on the western side of the leachate treatment ponds and GW8-12 east of Stage 1 landfill.

Table 4-4 Exceedances of copper above the relevant trigger value of 0.003mg/L

Location	Copper concentration (mg/L)					
	Sep	Dec	Mar	Apr	May	Jun
DW2	0.16*	0.28*	0.17*			
DW3	0.072*					
GW18-12				0.008*	0.005	0.004
GW1-12			0.003			
GW14-12	0.004	0.005	0.003			
GW15-12			0.008*			
GW17-12				0.004		
GW7-3		0.003				
GW8-12		0.003				
GW8-3	0.008*	0.005				
LS5A			0.016*			
LP01	0.018*		0.008*			
LP02	0.014*		0.011*			
TC SUMP	0.058*	0.013*	0.022*			
WW7			0.006*			

Notes

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.3 Nickel

Seen in , Nickel only exceeded the trigger value of 0.2mg/L during September in the leachate from DW3 (0.32 mg/L), LP01 (0.2 mg/L) and in TC Sump (0.31mg/L). Nickel was consistently elevated by more than twice the trigger value following each monitoring event, up until March after which I was no longer sampled on a monthly basis as per EPL188-01.

Table 4-5 Exceedances of Nickel above the relevant trigger value of 0.2mg/L

Location	Nickel concentration (mg/L)		
	Sep	Dec	Mar
DW3	0.32		
LP01	0.2		
TC SUMP	0.31		
WW6	1.2*	0.84*	0.65*

Notes

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.4 Lead

Recorded copper concentrations exceeding the trigger value (0.003mg/L) for 90% species protection are provided in Table 4-6 below and summarised as follows:

- Lead concentrations in leachate from the Stage 3 (DW2 and TC Sump) was elevated up to 2.7 times the trigger value during the wet season monitoring events.
- No surface water sampling locations produced elevated copper concentrations exceeding the trigger value of 0.003mg/L.
- Newly installed monitoring bores GW17-3, GW17-30 and GW18-3 found west of the leachate treatment facility exceeded the trigger value for lead with GW17-30 exceeding the trigger level over three consecutive monitoring events between April and June.
- No exceedances were recorded during the march monitoring event.

Table 4-6 Exceedances of Lead above the relevant trigger value of 0.0066mg/L

Location	Lead concentration (mg/L)				
	Sep	Dec	Apr	May	Jun
DW2	0.018*	0.012			
DW3	0.035*				
GW18-3			0.02*		
GW17-3			0.11*		
GW17-30			0.18*	0.13*	0.11*
LP01	0.013				
TC SUMP	0.1	0.014*			

Notes

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.5 Zinc

Zinc concentrations recorded above adopted assessment criteria of 0.0023mg/L were observed at a number of locations across the Site provided in Table 4-7 below. Findings are summarised as follows:

- Zinc concentrations consistently exceeded the relevant trigger value in the leachate from the Stage 3 and 4 landfills (DW2 and TC SUMP), occurring on 3 consecutive monitoring events between September and March. Exceedances were also recorded in in the southern leachate treatment pond over three consecutive monitoring events.
- No surface water sampling locations produced elevated Zinc concentrations exceeding the trigger value of 0.023 mg/L.

- Zinc often exceeded the trigger value in ground water monitoring bores across the site with the greatest number of affected bores occurring during December. High concentrations occurred most often on the western side of Stage 4 and 5 landfills and east of Stage 1 landfill.
- Newly installed monitoring bores GW17-3 GW17-30 found west of the leachate treatment facility exceeded the trigger value for Zinc over three consecutive monitoring events between April and June.

Given the widespread nature of zinc exceedances, the groundwater is to a degree possibly naturally elevated in zinc. Leachate however, is also potentially further increasing zinc concentrations in some bores.

Table 4-7 Exceedances of Zinc above the relevant trigger value of 0.023 mg/L

Location	Zinc concentration (mg/L)					
	Sep	Dec	Mar	Apr	May	Jun
DW2	0.57*	0.34*	0.31			
DW3	0.77*					
GW10-12			0.023			
GW11-12		0.023				
GW1-3			0.048*			
GW13-12	0.0768					
GW14-12	0.098*		0.14*			
GW15-12		0.03	0.039			
GW17-12				0.015	0.18*	0.2*
GW17-3				0.54*		
GW17-30				0.25*	0.19*	0.19*
GW18-3				0.045		
GW2-12	0.49*	0.33*	0.33*			
GW3-12		0.041				
GW4-3		0.028				
GW7-12	0.039	0.042				
GW7-3		0.057*				
GW8-12	0.14*	0.067*				
GW8-3	0.031	0.051*				
LMP02		0.037				
LP01	0.31*					
LP02	0.039	0.27	0.28			
LS5A	0.42*		0.95*			
TC SUMP	0.78*	0.24	0.34			
WW13			0.58*			
WW5		0.045	0.069*			
WW6	0.14*	0.075*				
WW7		0.091*	0.13*			
WW9		0.064*				

Notes

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.6 Chromium

Chromium (trivalent) exceeded the trigger value of 0.0486mg/L during the December monitoring event in leachate from the Stage 3 landfill (TC Sump) and west of the Stage 1 landfill (LMP02). During the March monitoring event chromium (trivalent) exceeded the trigger value in leachate from the Stage 3 and 5 landfills (DW2 and LS5A) and in the leachate treatment ponds (LP02). Chromium (trivalent) only exceeded the trigger value in ground water west of the Stage 4 landfill during the March monitoring event at GW14-12)

Chromium (hexavalent) only exceeded the trigger value of 0.02mg/L in leachate during December. Exceedances were recorded in groundwater monitoring wells GW14-12 found west of the Stage 4 landfill and on three consecutive monitoring events in GW18-12 found west of the leachate treatment ponds.

Table 4-8 Exceedances of Chromium (hexavalent) above the relevant trigger value of 0.02mg/L

Location	Chromium (hexavalent) concentration (mg/L)					
	Sep	Dec	Mar	Apr	May	Jun
DW2		0.15*				
GW14-12	0.037		0.084*			
GW18-12				0.5*	0.67*	0.23*
LP02		0.061*				
TC SUMP		0.11*				

Notes:

- The results highlighted in yellow indicate when the trigger value was exceeded on three or more consecutive occasions as per the URS monitoring plan.
- Results with an asterisk (*) indicate when the surface water results are greater than or equal to two times the trigger value as per Condition 60 of EPL188-01.

4.3.1.7 PFAS Assessment

The below table provides the sampling locations that exceeded the HEPA (2020) guideline value for 95% species protection (0.13 µg/L) for PFOS. There were no exceedances of the guideline value for 95% species protection or PFOA guideline values.

Table 4-9 Exceedances of PFOS above the relevant trigger value of 0.13 µg/L

Location	PFOS concentration (mg/L)		
	Sep	Dec	Mar
DW2			0.39
DW3	0.98		
GW10-12		0.15	
GW11-3		0.23	
GW13-12	0.14		
GW8-3	0.35	0.86	
LP01	1.7		0.27
LP02	0.67	5.5	1.9
LMP02		0.61	0.89
LS5A			0.17
TC SUMP	0.5	0.45	0.59

This is consistent with EcOz (2020) observations of higher PFOS concentrations compared to PFOA at SBWMF, in addition to more conservative PFOA guideline values.

4.3.2 Leachate Impact Indicator

Seen below in Table 4-10, the L/N ratio discussed in Section 3.6.2 exceeded the adopted assessment criteria of 10 during several monitoring events in this annual review period.

Groundwater monitoring bores presented leachate impact during July, August, November, December, January, February and June following high rainfall seen in Figure 3-1, noting that L/N were not calculated for September as Ammonia was not analysed and the L/N ratio was not assessed in May and June as per the SWMP.

L/N ratios for this review period indicate leachate migration west and south west of the Stage 3, 4 and 5 landfills as well as south, between the Stage 2 and 6 landfills (GW16).

Table 4-10 Groundwater L/N ratios exceeding 10

Location	L/N ratio							
	July	Aug	Nov	Dec	Jan	Feb	Mar	Apr
GW15-3						11.3		
GW13-12	22	22.8		28.2		13.8	25.3	24.9
GW16-3				13.9	11.3	11.15	12.7	13
GW16-30				15.5			11.3	12.2
GW12-3				76.8	75		79.5	77.2
GW12-30	21		17.6	19.4				19.1
WW7					11.9	14.6	11.7	11.1

4.3.3 Soil Chemistry

Exceedances for *ANZG (2018) Marine water 90% toxicant DGVs* and *PFAS National EMP (2020) Interim marine water 90%/95%* in soil leachability are highlighted in the sediment chemistry table (Appendix C). Results are summarised below:

- pH levels marginally exceeded the ANZG (2018) assessment criteria (6-8) at sampling locations DS02 (5.8 pH), DS04 (5.8 pH) and SS04 (5.9).
- No detectable levels of PFOS or PFOA were reported in any samples.
- Elevated levels of Zinc were reported in all samples, which exceeded the ANZG (2018) assessment criteria (0.023 mg/L) seen in the attached table.
- Aluminium also reported detectable concentrations however the assessment criteria does not provide for aluminium.
- Nickel was the only other metal to report a leachable concentration of 0.01mg/L at DS04, falling well below the ANZG (2018) assessment criteria of 0.2mg/L.

4.3.4 Dust Depositional Monitoring

Rates of dust deposition and chemistry are provided in Appendix C and summarised as follows:

- Dust deposition rates were highest at DS03 (330g/m^2/mth) and lowest at DS01 (36g/m^2/mth) with an average rate of 157g/m^2/mth for the whole site.
- There were no detectable levels of metals or PFAS substances in any samples for all sampling locations.

4.4 Quality Assurance / Quality Control

All quality control/quality assurance procedures outlined in Section 3 and respective SOP's (Appendix E) were followed during field sampling as part of each monitoring event while all analysis was completed within holding times.

At each monitoring event relative percent difference (RPD) was calculated for primary, duplicate and triplicate samples where 30% RPD values infer precise data. Where the RPD was above 30%, the primary result was only used in further assessment if RPD was within 5 times the LOR and therefore remained acceptable. RPD tables are provided to CoD following each monthly and quarterly monitoring event.

The QA/QC review concluded that there are no significant systematic errors in the data collection process and therefore, the dataset used for the assessment is considered valid and complete.

5 Discussion of Results

Based on the results of contaminants measured in leachate, surface water and groundwater during the reporting period (in particular ammonia, metals and L/N), impacts from the migration of leachate in groundwater and/or surface water flowing from the Site are occurring to the southwest, west and northwest of the Stage 3, 4 and 5 landfills and in the centre of the west of Stage 1 (GW16).

Exceedances recorded in the newly installed monitoring wells west of the leachate treatment ponds may be in accurate as sufficient recharge over the next wet season may further stabilise the bore chemistry.

As with previous reporting (Cardno, 2020) copper and zinc are the most prevalent metals often and significantly elevated in groundwater across the site. This appears to be attributed to a degree of natural background levels, with some impacts from the landfills increasing concentrations in locations east of the site adjacent to the Stage 1 landfill, and west of the site adjacent to the Stage 3, 4 and 5 landfills.

AE found that no compounds including PFAS found in air emissions from the BV300 exceeded the regulatory limits prescribed in the EPL188 and further more pose no risk (AE, 2021).

Soil chemistry was consistent with potentially naturally elevated levels of metals found in the ground water, however further soil chemistry trends will be better understood following future sampling events for the Site.

As dust sampling recorded very low levels of deposition discussed in Section 4.3.4 these results may not be definitive as they rely on very small volumes of material for chemistry analysis. However, sampling location DS03 being the exception did provide a high deposition rate and did not reach detection limits for any metals or PFAS compounds.

6 Historic Water Quality Trends

Key exceedances reported during this reporting period discussed above in Section 4 are overall consistent with previous data sets and historical water quality trends. The long-term trends of contaminants are briefly summarised, and illustrated in the charts below. It is noted that no long-term increase in contaminants is evident.

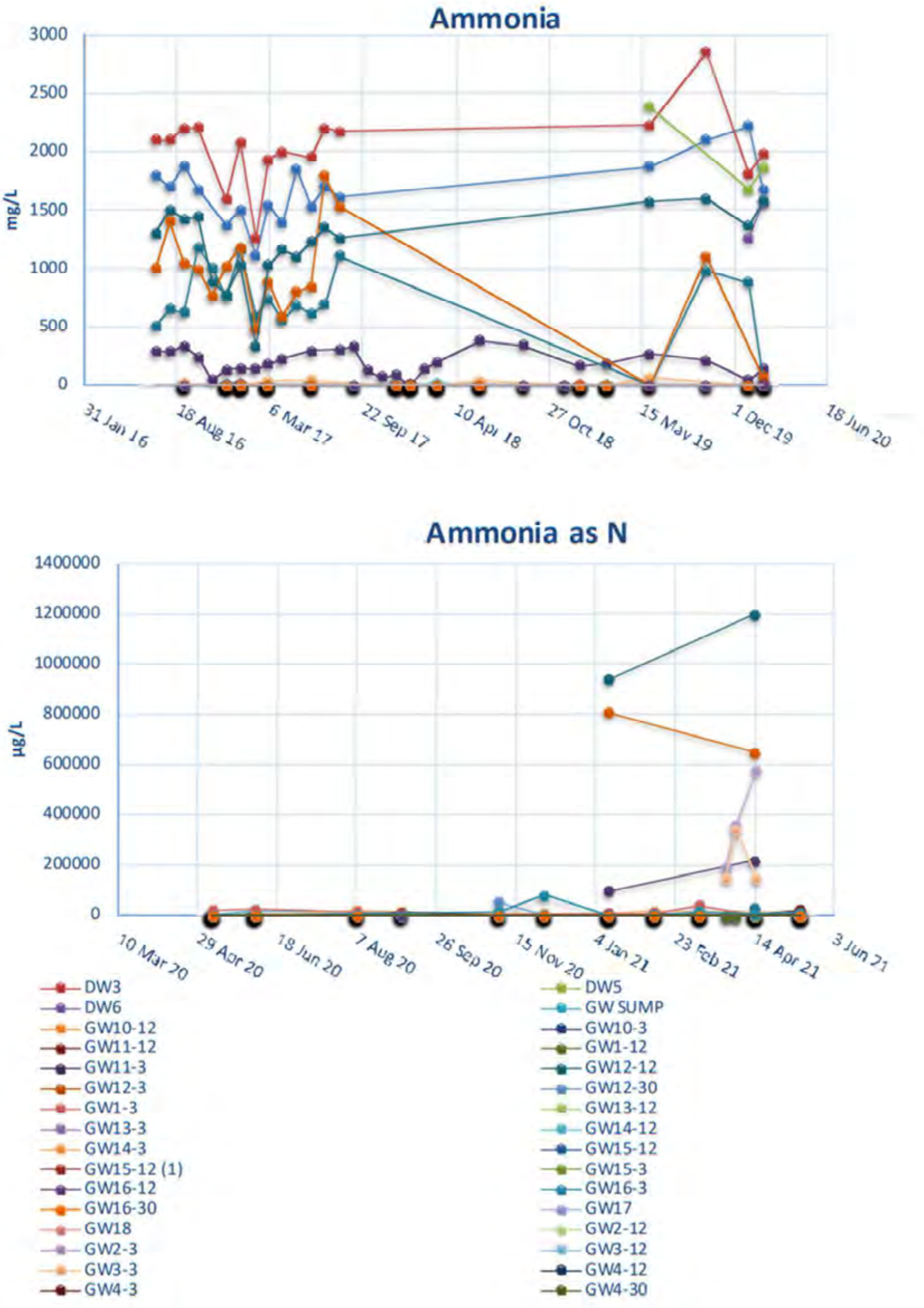


Figure 6-1 Historical Ammonia concentrations since July 2016

Seen in Figure 6-1 ammonia has experienced recent spikes in Ammonia concentrations during the 2020/2021 wet season. These spikes do not provide for a long-term trend of increased ammonia and have been recorded in leachate which can depend on the varying types of wastes and rainfall events.

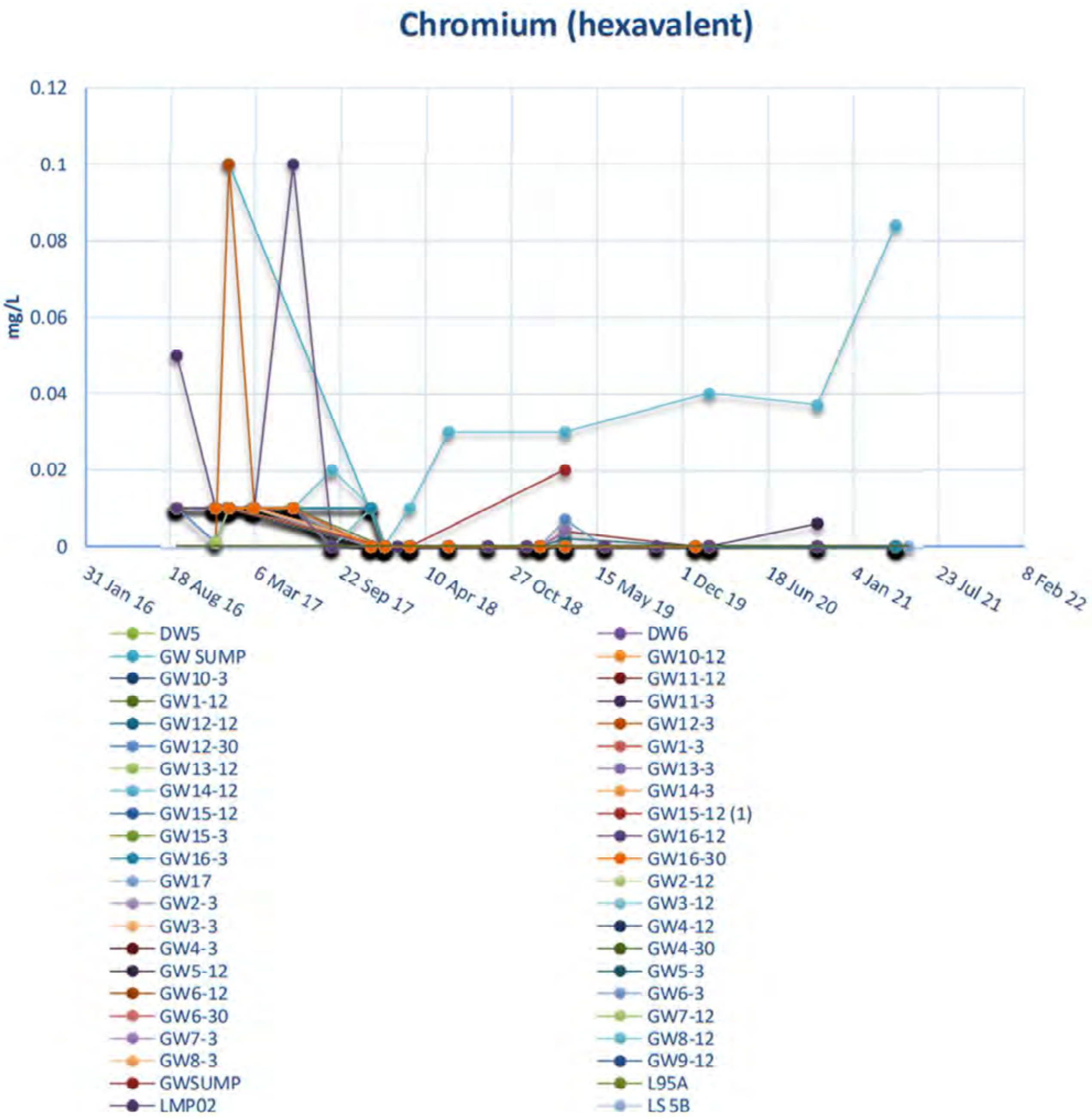


Figure 6-2 Historical Chromium (hexavalent) concentrations since July 2016

Illustrated above in Figure 6-2 Chromium (hexavalent) has remained at consistet levels since 2018 with the exception of recent a recent spike found in GW14 also described in Section 4.3.

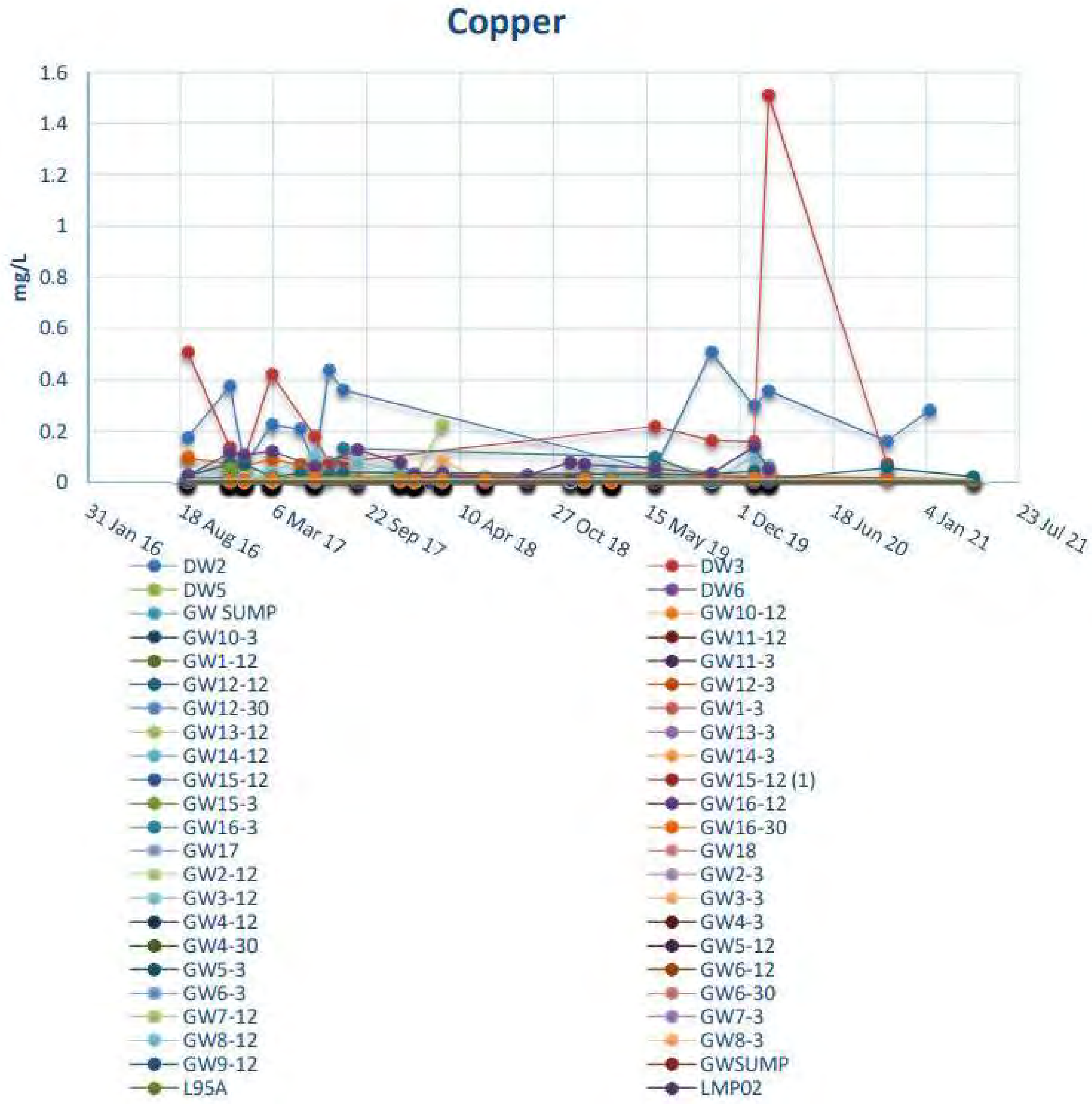


Figure 6-3 Historical Copper concentrations since July 2016

Copper continues to record overall consistent concentrations across the site as illustrated in Figure 6-3 above. No long-term increasing trends in copper concentrations at SBWMF have been observed.

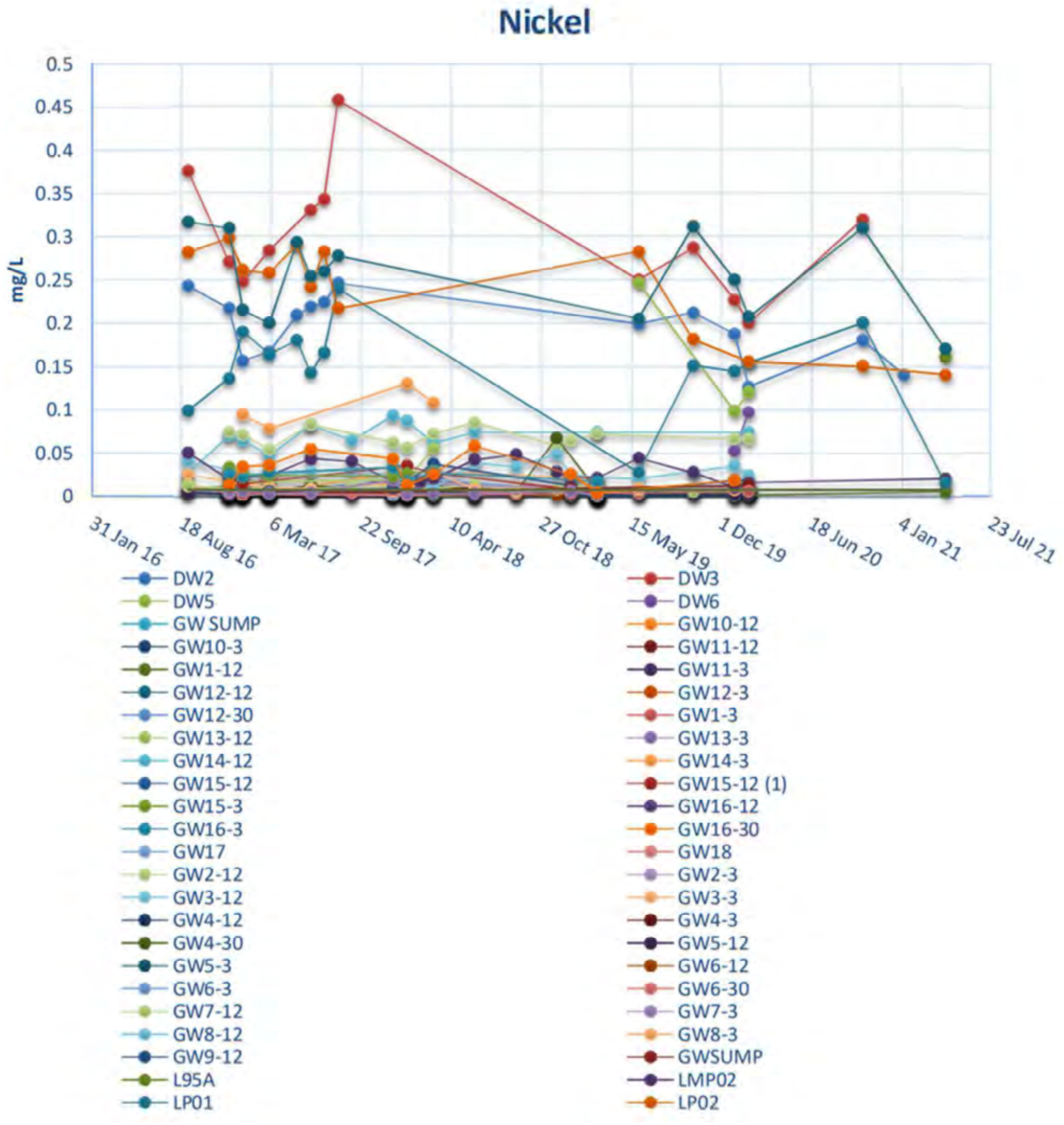


Figure 6-4 Historical Nickel concentrations since July 2016

Illustrated above in Figure 6-4, nickel has recorded consistent concentrations in water sampled at the SBWMF over the long-term and is not increasing.

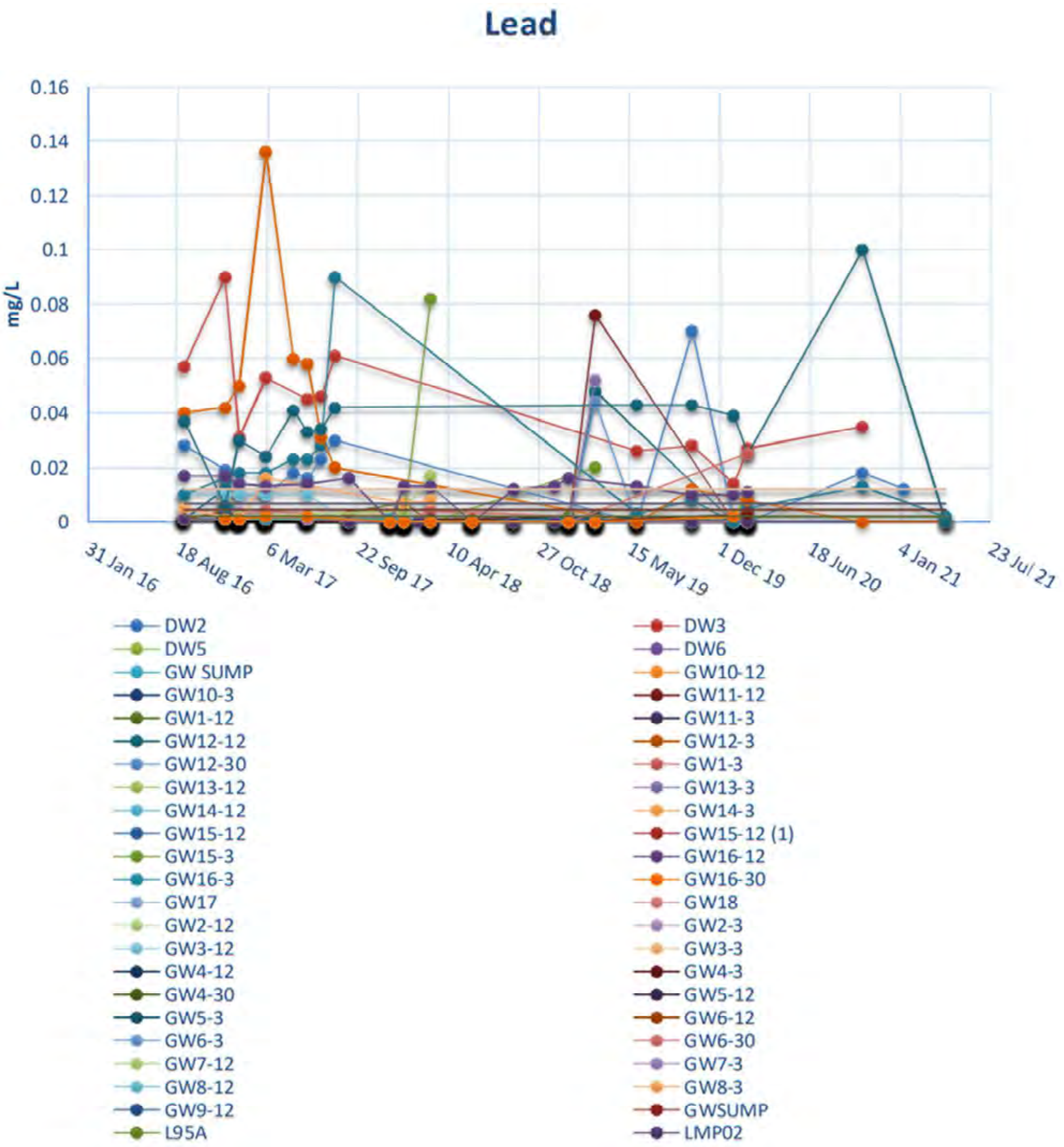


Figure 6-5 Historical Lead concentrations since July 2016

Lead consistently exceeds adopted trigger levels, however continues to record overall consistent concentrations across the site illustrated in in Figure 6-5 above. No long-term increase in lead concentrations at SBWMF can be observed.

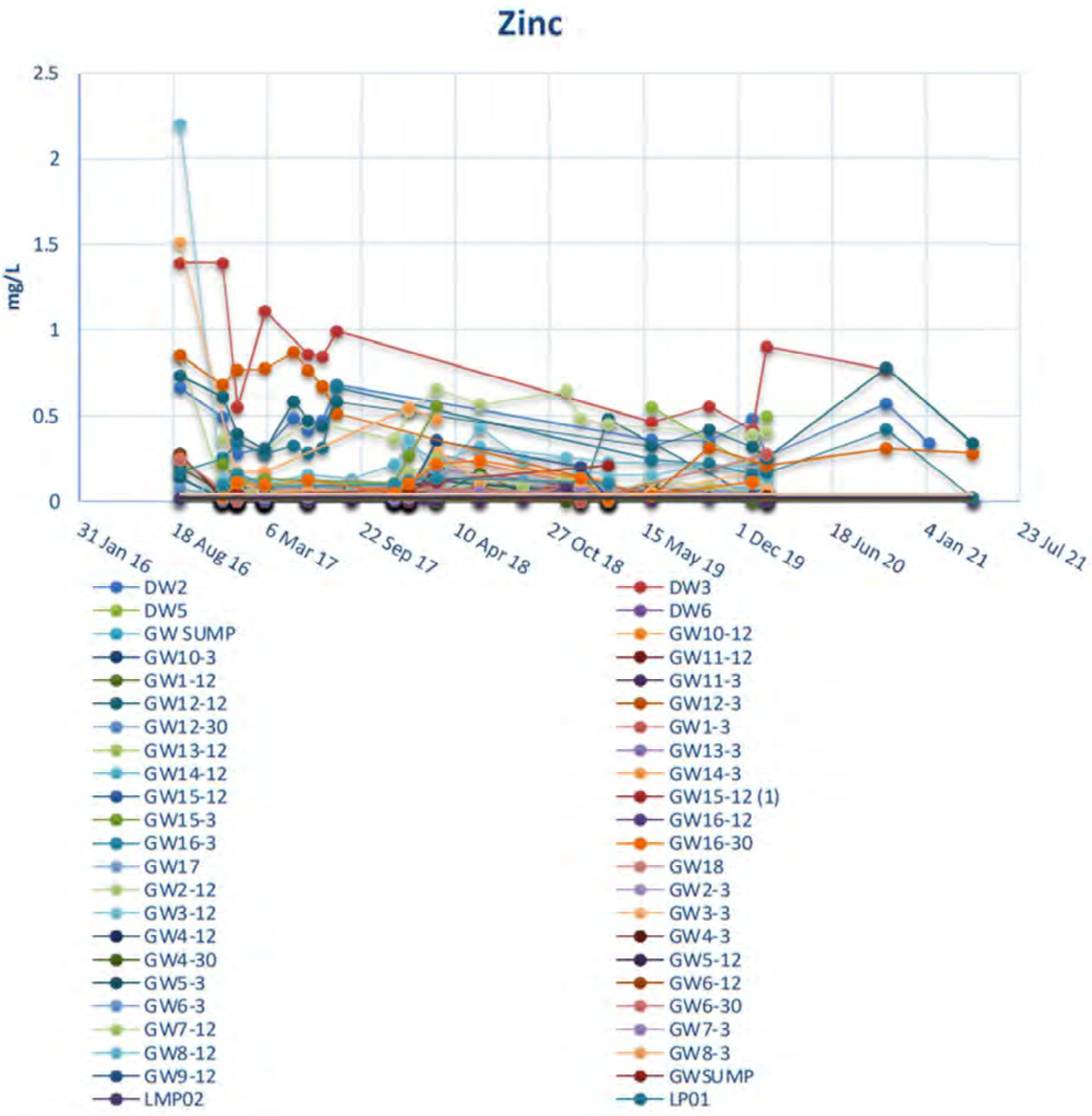


Figure 6-6 Historical Zinc concentrations since July 2016

Zinc produces the highest number of exceedances at the SBWMF though due to the widespread nature of zinc exceedances, the groundwater is to a degree possibly naturally elevated in zinc and has not increased over the long term seen in Figure 6-6 above.

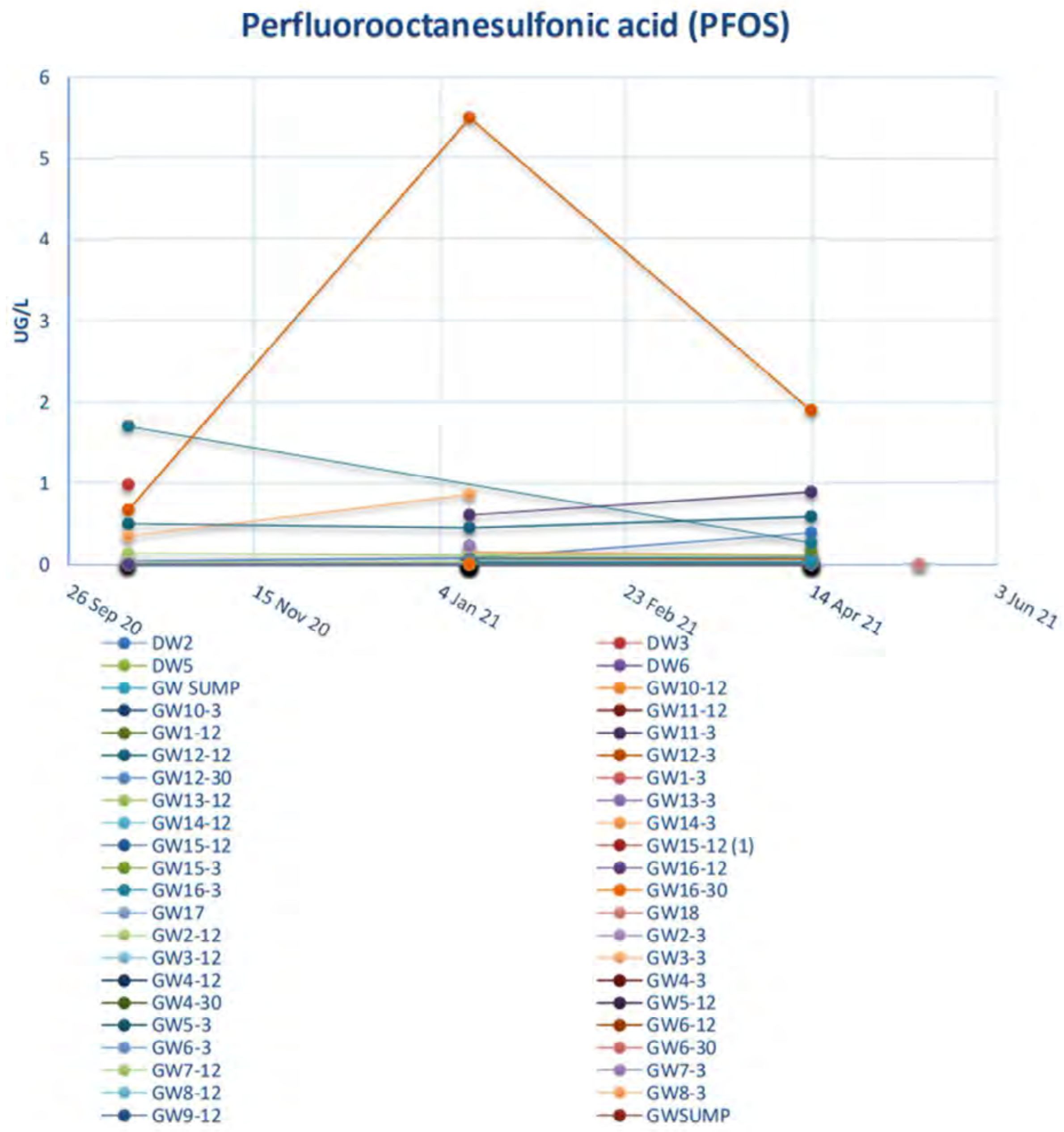


Figure 6-7 Historical PFOS concentrations since September 2020

PFOS concentrations at the SBWMF have remained at low consistent levels, predominantly detected in leachate samples and only marginally exceeding laboratory detection limits in a select few groundwater monitoring wells. There is no a long-term increasing trend of PFOS concentrations while PFOA was also consistently recorded at low concentrations.

7 Conclusions and Recommendations

During this reporting period the majority of sampling events followed the now superseded URS Water Monitoring Plan (URS, 2016) and thus reported the majority of exceedances based on its sampling schedule and assessment criteria. Analysis suites and sampling frequencies have transitioned to comply with the EPL188-01 and Soil & Water Monitoring Plan developed by EcOz (EcOz, 2021). EPL188 has again been recently updated to its third version EPL188-03 which will include additional downstream surface water sampling sites and groundwater monitoring wells. EPL-03 also stipulates the development of a surface water, sediment and biological monitoring plan for the adjacent Mickett Creek and Buffalo Creek environments which serve to assess offsite impacts.

Analytical results and the hydraulic gradient of the site detailed in Section 2.3 of this report indicates the migration of leachate in groundwater and/or surface water flowing from the Site are occurring to the southwest of the stage 5 landfill; north west of the Stage 3 and 4 landfills; west of the Stage 1 landfill and between Stage 2 and 3 landfills (GW16).

There were exceedances in several metals from the newly installed monitoring wells, however, being recently installed wells, the bore chemistry may not have stabilised yet and/or requiring further recharge during the coming wet season to provide an accurate representation of the local groundwater chemistry.

Elevated levels of zinc found in sediment samples is consistent with groundwater monitoring data which consistently reports elevated zinc levels across the site. Given the consistent widespread nature of Zinc exceedances in ground water and soil across the site, the soil and groundwater are potentially naturally elevated in Zinc. Monitoring of existing and/or installing of new upgradient monitoring bores would allow for a broader assessment of the area and evaluation of the contribution of SBWMF.

Long-term trends of those contaminants prescribed by the relevant guidelines and adopted trigger values for the Site, have not shown evidence that they are increasing over time, as detailed in Section 6.

8 References

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3. HEPA, 2020, *PFAS National Environmental Management Plan v2.0*
4. BoM 2019, Climate Data Online. [online] Available at Bureau of Meteorology (BoM). Available at http://www.bom.gov.au/climate/data/index.shtml?bookmark=200 (Accessed, July 2020)
5. CoD 2016, Shoal Bay Waste Management Facility Environmental Management Plan, June 2016, City of Darwin (CoD), Darwin.
6. URS 2015, Shoal Bay Waste Disposal Site, Hydrogeological Investigation, November 2015, Report prepared by URS Australia Pty Ltd for John Holland Pty Ltd, Darwin.
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8. Australian Government Department of the Environment and Energy (DoEE) (2018). PFAS National Environmental Management Plan. January 2018, Report prepared by the Heads of EPAs Australia and New Zealand (HEPA), Australia.
9. Cardno 2020, *Annual Monitoring Review, Shoal Bay Waste Management Facility Water Quality Monitoring 1 July 2019 – 30 June 2020,* Report prepared by Cardno for City of Darwin.
10. EcOz 2021, *Soil and Water Monitoring Plan - Shoal Bay Waste Management Facility*, 7 April 2021, Prepared for City of Darwin.

APPENDIX

A

EMISSIONS MONITORING

Assured Environmental

SOURCE EMISSIONS MONITORING – SHOAL BAY BENEVAP SYSTEM

BENETERRA

Project ID. 13439

R_0

DATE OF RELEASE: 1/04/2021

ABN: 87 604 851 078

Unit 7, 142 Tennyson Memorial Avenue – Tennyson – Queensland – 4105

DOCUMENT CONTROL PAGE

Project Title: Source Emissions Monitoring – Shoal Bay Benevap System

Project Reference ID: 13439

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Table 1: History of Revisions

Revision	Date	Issued to	Changes
R_0	1/04/2021	N. Sharma	Formal report release. Updates to Table 3.
DRAFT_2	22/02/2021	N. Sharma	Draft release for review
DRAFT_1	3/02/2021	N. Sharma	Draft release with summary statement
DRAFT_0	1/02/2021	N. Sharma	Draft release for comment

ACCREDITED FOR COMPLIANCE TO ISO/IEC 17025 (TESTING)

The results of the tests, calibrations and/or measurements included in this document is traceable to Australian/national standards.

Accreditation number: 19703

NATA
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ACCREDITATION
NATA ID: 19703

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EXECUTIVE SUMMARY

Assured Environmental (AE) conducted source emissions monitoring from the mobile BeneVap Leachate Treatment Facility located at the Shoal Bay Waste Facility in Darwin, Northern Territory on 15th to 17th December 2020.

A summary of results is presented below from the testing conducted on the single release point stack. The process is understood to have been operating at a stable and representative load for the duration of the monitoring.

In comparison to the emission limits outlined in EPL188-01 (Attachment 7), all measured parameters were within those limits specified. Results are reported at dry, 273.15°K and 101.325 kPa (STP).

As per the conditions of the EPL, this testing was performed during the commissioning stages of the Benevap unit. It is understood that the commissioning involves many elements so that the unit operates at optimal levels at each individual site and type of leachate encountered. Therefore the sampling was occurring while optimisation of the process was underway and one facet of optimisation is controlling the anti-foaming process. While the process is not fully optimised, any foam carry over may lead to increased emissions of certain parameters, which may be reflected in the below results.

Table 2: Summary of measured parameters

Parameter	Result	Emission limit	Unit	Reference
Average source temperature	85	-	°C	-
Flue gas water vapour content	55	-	vol-%	-
Carbon dioxide concentration	9.7	-	vol-%	STP - dry
Oxygen concentration	7.3	-	vol-%	STP - dry
Flue gas molecular weight - dry	1.3	-	kg/Nm^3	STP - dry
Flue gas velocity	3.3	-	m/sec	STP - dry
Flue gas volume flow	19.1	-	Nm^3/min	STP - dry
Oxides of nitrogen (as NO_2)	121	350	mg/Nm^3	STP - dry
- emission rate	2.3	-	g/min	
Carbon monoxide	48	125	mg/Nm^3	STP - dry
- emission rate	0.91	-	g/min	
Total heavy metals (lower)	0.23	1	mg/Nm^3	STP - dry
- emission rate	0.0046	-	g/min	
Cadmium	0.0026	0.2	mg/Nm^3	STP - dry
- emission rate	5.2E-05	-	g/min	
Mercury	0.00014	0.2	mg/Nm^3	STP - dry
- emission rate	2.7E-06	-	g/min	
Fluorine (as HF)	< 4.9	50	mg/Nm^3	STP - dry
- emission rate	< 0.098	-	g/min	
Hydrogen chloride	< 2.3	100	mg/Nm^3	STP - dry
- emission rate	< 0.043	-	g/min	
Chlorine	< 2.3	200	mg/Nm^3	STP - dry
- emission rate	< 0.043	-	g/min	
Ammonia (in condensate)	2,070	-	mg/Nm^3	STP - dry
- emission rate	39	-	g/min	
Ammonia (gaseous)	228	-	mg/Nm^3	STP - dry
- emission rate	4.3	-	g/min	
Hydrogen sulfide	< 0.8	5	mg/Nm^3	STP - dry
- emission rate	< 0.01	-	g/min	
Sulfur dioxide	< 3.0	-	mg/Nm^3	STP - dry
- emission rate	< 0.06	-	g/min	
Sulfuric acid mist (as H_2SO_4)	< 1.0	100	mg/Nm^3	STP - dry
- emission rate	< 0.02	-	g/min	
Total VOCs (as n-propane)	< 1.0	40	mg/Nm^3	STP - dry
- emission rate	< 0.02	-	g/min	
Average odour	7,523	-	ou	STP - wet
- emission rate	319,908	-	ou-m^3/min	
Dioxins & Furans (i-TEQ) - lower	0.00067	0.1	ng/Nm^3	STP - dry
- emission rate	1.2E-11	-	g/min	
PCBs (i-TEQ) - lower	0.00066	-	ng/Nm^3	STP - dry
- emission rate	1.2E-11	-	g/min	

Table 3: Summary of PFAS results

Parameter		Result ng/Nm^3		Emission Rate g/min	Reference
Per- and polyfluoroalkyl substances					
Perfluorobutanesulfonic acid		**707**		**1.36E-05**	**STP**
Perfluoropentanesulfonic acid	<	0.3	<	6.45E-09	STP
Perfluorohexanesulfonic acid		**67.9**		**1.31E-06**	**STP**
Perfluoroheptanesulfonic acid		**3.1**		**5.92E-08**	**STP**
Perfluorooctanesulfonic acid PFOS		**50.5**		**9.72E-07**	**STP**
Perfluorodecanesulfonic acid	<	0.7	<	1.29E-08	STP
Perfluorobutanoic acid		**55.1**		**1.06E-06**	**STP**
Perfluoropentanoic acid		**104**		**2.01E-06**	**STP**
Perfluorohexanoic acid		**119**		**2.29E-06**	**STP**
Perfluoroheptanoic acid		**68.9**		**1.33E-06**	**STP**
Perfluorooctanoic acid PFOA		**202**		**3.88E-06**	**STP**
Perfluorononanoic acid		**81.7**		**1.57E-06**	**STP**
Perfluorodecanoic acid		**46.5**		**8.94E-07**	**STP**
Perfluoroundecanoic acid		**20.7**		**3.99E-07**	**STP**
Perfluorododecanoic acid		**7.2**		**1.38E-07**	**STP**
Perfluorotridecanoic acid		**3.3**		**6.36E-08**	**STP**
Perfluorotetradecanoic acid	<	8.4	<	1.61E-07	STP
4:2 FTS	<	0.3	<	6.45E-09	STP
6:2 FTS		**40.5**		**7.78E-07**	**STP**
8:2 FTS		**2.5**		**4.78E-08**	**STP**
10:2 FTS	<	0.7	<	1.29E-08	STP
Perfluorooctane sulfonamide	<	1.7	<	3.22E-08	STP
N-Methyl perfluorooctane sulfonamide	<	1.7	<	3.22E-08	STP
N-Ethyl perfluorooctanesulfon amide	<	1.7	<	3.22E-08	STP
N-Me perfluorooctanesulfonamid oethanol		**31.4**		**6.03E-07**	**STP**
N-Et perfluorooctanesulfonamidoethanol	<	83.8	<	1.61E-06	STP
MePerfluorooctanesulf-amid oacetic acid		**7.9**		**1.53E-07**	**STP**
EtPerfluorooctanesulf-amid oacetic acid		**4.5**		**8.69E-08**	**STP**

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1 INTRODUCTION

BeneTerra's mobile BeneVap leachate treatment plant was transported to Darwin and setup at the Shoal Bay Waste Management facility. The plant was run for the duration of the testing period at a stable capacity.

Assured Environmental (AE) was appointed by BeneTerra to sample and analyse source emissions from the BeneVap Leachate Treatment system. Sampling was conducted by AE from 15th to 17th December 2020 during typical site operations.

AE was responsible for the collection and analysis of samples, unless otherwise indicated. The samples were recovered and stored in the appropriate manner until their return to the laboratory where the samples were prepared and analysed according to the methodologies listed below in this report.

2 METHODOLGY & EQUIPMENT

2.1 Sampling methodology

All sampling and analysis was carried out in accordance with the listed requirements in Table 4. Any specific comments about the sampling and analysis have been documented where required.

Table 4: Test methods

Parameter	Reference Test Method	Test Method (NSW)	NATA accreditation	Analysis by
Sample location	AS4323.1	TM-1	Yes	1
Velocity & flow rate	USEPA Method 2	TM-2	Yes	1
Stack gas density	USEPA Method 3	TM-23	Yes	1
Oxygen	USEPA Method 3A	TM-25	Yes	1
Carbon dioxide	USEPA Method 3A	TM-24	Yes	1
Water vapour content	USEPA Method 4	TM-22	Yes	1
Sulphur dioxide	USEPA Method 6	TM-4	Yes	1
Oxides of nitrogen (as NO_2)	USEPA Method 7E	TM-11	Yes	1
Sulfuric acid mists	USEPA Method 8	TM-3	Yes	1
Carbon monoxide	USEPA Method 10	TM-32	Yes	1
Hydrogen sulfide	USEPA Method 15	TM-5	Yes	1
Total VOCs	USEPA Method 18	TM-34	Yes	2
Hydrogen chloride	USEPA Method 26A	TM-8	Yes	2
Chlorine	USEPA Method 26A	TM-7	Yes	2
Fluoride (as HF)	USEPA Method 13B	TM-9	Yes	2
Heavy metals	USEPA Method 29	TM-12/13/14	Yes	2
PFAS – suite	USEPA SW846 Method 0010	Mod TM-18	No	3
Dioxins & furans	USEPA SW846 Method 0010	TM-18	No	4
Polychlorinated biphenyls	USEPA SW846 Method 0010	TM-18	Yes	2
Ammonia	Modified USEPA Method 26	Mod TM-4	Yes	2
Odour	AS4323.3	OM-7	Yes	1

Table 5: Analysis performed by

Note	Company	Work performed	NATA ID	Report Number
1	Assured Environmental	Sampling & analysis	19703	13439
2	Envirolab Services	Analysis	2901	258710 259851
4	National Measurement Inst.	Organics analysis	198	DAU21_035

Table 6: Sampling comments

Note	Comment
Sample location	Sample location is compliant but non ideal as per AS4323.1. The sample location is greater than two, but less than six diameters downstream from a disturbance. The temperature and velocity survey showed that the sample position was in compliance to items (a) to (f) as per AS4323.1.
Calibrations	Analyser calibration performed in the laboratory prior to conducting field work and post field work in AE lab.
H_2S	A sample of exhaust gas was passed through a buffer solution to remove any potential SO_2 present before being captured in a specialised gas sampling bag. Analysis for H_2S was performed using GC-FPD within 30 hours of collection.
Heavy metals	Type 1 substances: Antimony, Arsenic, Cadmium, Lead Mercury. Type 2 substances: Beryllium, Chromium, Cobalt, Manganese, Nickel, Selenium, Tin, Vanadium.
PFAS	A modified version of the USEPA SW846 Method 0010 sample train was employed to sample for Per- and poly-fluoroalkyl substances (PFAS) material in the flue gas emission. Refer to section 2.2 for further information.
Ammonia	The ammonia sampling was performed using a modified sampling train. A condensate removal trap was placed in front of the collection trap to separate condensing ammonia from gaseous ammonia passing through the initial stage and into the collection media. Both the condensate captured in the trap and the sorbent solution are analysed for ammonia. Ammonia results are reported in the condensate and gaseous phase separately and as NH_3.
Odour	Due to the high levels of moisture in the emission the odour samples bags were diluted beyond the suggested limit in AS4323.3. This is required to avoid condensation forming in the sample bags.

2.2 Per- and poly-fluoroalkyl substances sample methodology

There are currently no promulgated reference methods for performing emissions monitoring for Per- and poly-fluoroalkyl substances (PFAS) from stationary emission sources. As such a procedure was employed using a reference method designed for similar compounds, in this case USEPA SW846 Method 0010 which was originally intended to sample isokinetically for semivolatile principal organic hazardous compounds, which may exist in either particulate or gaseous form. A summary of the sample train is;

- Gaseous and particulate pollutants are withdrawn from an emission source at an isokinetic sampling rate and are collected in a multi-component sampling train. The sample train contains a high-efficiency glass fibre filter and a packed bed of porous adsorbent resin. The filter is used to collect organic-laden particulate materials and the porous polymeric resin to adsorb semi-volatile organic species. Semi-volatile species are defined as compounds with boiling points greater than 100°C. The impingers downstream of the resin trap are loaded with water to knock-out any water vapour prior to metering the gas. These impingers are not routinely analysed for S-VOCs.

The modifications made to this sample train in order to target PFAS materials included;

- Sorbent material is XAD-2 and XAD-4.
- The resin traps are spiked with a surrogate standard to test for retention. A known quantity of standard is injected into the trap during preparation, the trap is then shipped, sampled and returned to the laboratory for analysis. The analysis includes detecting the injected standard, which provides a measure of the recovery efficiency. Factors that may affect the recovery efficiency include, sample transport and handling procedures, sampling temperatures (the resin must be chilled during sampling and maintained below 20°C) and sample preparation at the laboratory, including the extraction of the sample from the resin.

- The impingers downstream of the resin trap are loaded with a sodium solution and is intended to be a breakthrough detector. Following the sampling, the impinger contents are measured and placed in a sample bottle for shipment to the laboratory. The final impinger of the sample train is then analysed separately to the filter, resin trap and front half methanol rinse so as to provide a measure of possible breakthrough. The intent of this sample train component is to provide a measure of breakthrough from the primary sampling components. Where no detections of PFAS material is made in this sample component, the limit of detection is not added to the sample result.
- Following the sampling onsite, all sample train components that have been in contact with the sample are rinsed thoroughly with methanol and stored in a sample container to be analysed as part of the sample.
- Sample train component material. According to documented water and soil PFAS sampling procedures, the use of glass, Teflon and stainless steel should be avoided and the use of polypropylene (PE) is recommended. PE is not considered to be conducive to source emissions sampling due to the temperatures of the flue gas. PE or HDPE cannot be used in the probe or filter box due to its low melting point, instead, all sampling components upstream of the resin trap was constructed of glass. Following sampling, all glassware was thoroughly rinsed with methanol at least three times to quantitatively recovery any possible PFAS material deposited on this surface.

For the analysis, the samples are extracted using a solvent desorption technique, with the filter and front half methanol rinse extract combined prior to analysis for the PFAS species. The XAD resin trap is then analysed in isolation as is the condensate downstream of the trap to gain an understanding of where the PFAS is captured within the sample train. The analysis is performed using LC/MS/MS instruments, with each analysis performed using the surrogate spikes to determine sample specific recoveries.

2.2.1 PFAS blank corrections

In the field, a full field blank is performed, where the sampling train is constructed as normal, however no sample is passed through it. It is then cleaned and recovered following the standard recovery procedures and the filter, resin trap and rinsate kept and analysed along with the sample.

The following details the procedures used to correct for detections of PFAS species in the blank samples.

- Where the blank result is a non-detection, no adjustment to the sample result is made.
- Where the blank result returns a positive detection, but is less than half of the sample result, the blank value is subtracted from the sample result and reported as a positive detection.
- Where the blank value returns a positive detection, and is exceeding half of the sample result, no adjustments are made to the sample result, but it is reported as a non-detection.

2.3 Sample Location

The images and figures below show the sample location and site details.

Figure 1: Benevap treatment system stack

Table 7: Sample location summary

Sample location	Benevap Treatment System
Stack Shape	CIRCULAR
Stack Diameter (m)	0.60
Stack Cross Section Area (m^2)	0.28
Distance to upstream disturbance (m)	1.3
Diameters (D)	2..2
Distance to downstream disturbance (m)	0.7
Diameters (D)	1.1
Total traverse point factors	1.15 , 1.05 , 1.21
Port size (mm)	100
Port Thread Type	BSP
Number of traverses	2
Number of points per traverse	6
Total number of traverse points	12
Flow & temperature compliance check	YES

2.4 Test equipment

The sampling equipment was transported to site and specifically setup at the test location. Sampling was performed using heated probes and filters, with a constant flow and isokinetic sample console.

Equipment used during the course of the testing is sourced from Apex Instruments and Testo, industry leaders in the supply of source testing equipment.

Figure 2: Constant flow sample equipment

Figure 3: Combustion gas analyser

3 MEASUREMENT UNCERTAINTY

There is an inherent uncertainty associated with any scientific measurement, including stack emissions monitoring. The measurement uncertainty can be controlled with strict adherence to the reference methodology along with utilising appropriate calibration standards with corresponding acceptable uncertainty reports.

Many source sampling methods do not outline exact procedures for establishing direct measurement uncertainty. In the absence of a defined procedure, the uncertainty budgets presented are based on estimations using ISO-GUM method.

Each individual source and test may have a unique associated uncertainty, due largely to the stack sample location in relation to the positioning requirements of AS4323.1.

Table 8: Sample specific uncertainty budgets

Parameter	Reference method	Limit of measurement	Unit of measure	Uncertainty ± %
Oxygen	USEPA Method 3A	0.3	%-vol	5.0
Carbon dioxide	USEPA Method 3A	0.3	%-vol	8.0
Water vapour content	USEPA Method 4	0.5	%-vol	5.0
Sulphur dioxide	USEPA Method 6	2.0	mg/sample	15
Oxides of nitrogen (as NO_2)	USEPA Method 7E	2.1	mg/sample	15
Sulfuric acid mists	USEPA Method 8	2.0	mg/sample	15
Carbon monoxide	USEPA Method 10	1.5	mg/sample	15
Hydrogen sulfide	USEPA Method 15	1.0	mg/sample	20
Total VOCs	USEPA Method 18	1.0	mg/sample	20
Hydrogen chloride	USEPA Method 26A	1.0	mg/sample	15
Chlorine	USEPA Method 26A	1.0	mg/sample	15
Fluoride (as HF)	USEPA Method 13B	1.0	mg/sample	15
Heavy metals	USEPA Method 29	0.3 to 50	µg/sample	10
PFAS – suite	USEPA SW846 Method 0010	1 to 50	ng/sample	25
Dioxins & furans	USEPA SW846 Method 0010	1	pg/sample	15
Polychlorinated biphenyls	USEPA SW846 Method 0010	20	pg/sample	15
Ammonia	Modified USEPA Method 26	1	mg/sample	25
Odour	AS4323.3	100	ou	25

4 QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

AE operates within a quality system based upon the requirements of ISO17025. Our quality system defines specific procedures and methodologies to ensure any project undertaken by AE is conducted with the highest level of quality given the specific confines of each project. The overall objective of our QA/QC procedures is to representatively sample and accurately analyse components in the gas streams and therefore report valid measurements of emission concentrations.

To ensure representativeness of field work, our quality procedures target:

1. Correct sampling locations
2. Sample time
3. Frequency of samples and
4. Method selection & adherence

To ensure representativeness of lab work, our quality procedures target:

1. Sample preservation
2. Chain of custody (COC)
3. Sample preparation and
4. Analytical techniques

AE maintains strict quality assurance throughout all its sampling programs, covering on-site 'field work' and the analytical phase of our projects. Our QA program covers the calibration of all sampling and analytical apparatus where applicable and the use of spikes, replicate sample and reference standards. The test methodologies used for this project are outlined in section 2 of this document. Field test data has been recorded and calculated using direct entry into Microsoft Excel spreadsheets following the procedures of the appropriate test methods. Determination of emission concentrations has been performed using the same Microsoft Excel spreadsheets which are partially supplied as an attachment to this report. More detailed information can be supplied upon request.

QA/QC checks for this project will use validation techniques and criteria appropriate to the type of data and the purpose of the measurement to approve the test report. Records of all data will be maintained. Complete chain of custody (COC) procedures have been followed to document the entire custodial history of each sample. The COC forms also served as a laboratory sheet detailing sample ID and analysis requirements.

Table 9: Sampling data QA/QC checklist

Sampling Data QA/QC Checklist	Comment
Use of appropriate test methods	Yes
'Normal' operation of the process being tested	Yes – as instructed by client
Use of properly operating and calibrated test equipment	Yes
Use of high purity reagents	Yes
Performance of leak checks post sample (at least)	Yes

Table 10: Laboratory data QA/QC checklist

Laboratory Data QA/QC Checklist	Comment
Use of appropriate analytical methods	Yes
Use of properly operating and calibrated analytical equipment	Yes
Precision and accuracy comparable to that achieved in similar projects	Yes
Accurate reporting	Yes

Table 11: Olfactometer QA data

Item	Comment
Methodology	AS/NZ4323.3:2001 "determination of odour concentration by dynamic olfactometry".
Sample Media	Odour samples collected into Nalophan™ sample bags
Sample identification	All samples are labelled uniquely immediately following collection according to Assured Environmental identification procedure. Each sample has the following recorded: project ID, sample number, location, date, time, dilution and any deviations to AS/NZ4323.3.
Timing	All measurements were conducted within 30 hours of sampling as specified by AS/NZ4323.3
Traceability	All panel results are traceable to reference standards held by Assured Environmental
Analysis conditions	Room temperature maintained at 22 °C ± 3 °C
Odour panel location	7/142 Tennyson Memorial Avenue Tennyson, Qld. 4105
Reference odourant	40 ppm n-butanol
Odour panel threshold	100 ou

4.1 PFAS quality control

The recoveries of surrogate standards from the sampling and analysis are presented in the table below. The expected QC recovery for measurements in the ppb to ppt levels is in the range of 60 to 120%. The results are not corrected for the recovery.

Table 12: PFAS surrogate recovery (%)

Surrogate	PFAS	
	Filter	Trap
Analytical surrogate		
Extracted ISTD $^{13}C_4$ PFOS	68	55
Extracted ISTD $^{13}C_4$ PFOA	107	100
Field surrogate		
Surrogate ^{13} C_8 PFOS	95	79
Surrogate ^{13} C_8 PFOS	112	100

Analysis of the final bubbler containing a sodium borate solution was performed separately to the front of the sampling train in order to assess the potential for breakthrough. The results of this analysis are provided below.

Table 13: Breakthrough analysis

Perfluorinated surfactants	Abbreviation	Breakthrough analysis
Perfluorobutanesulfonic acid	PFBS	ND
Perfluoropentanesulfonic acid	PFPeS	ND
Perfluorohexanesulfonic acid	PFHxS	ND
Perfluoroheptanesulfonic acid	PFHpS	ND
Perfluorooctanesulfonic acid PFOS	PFOS	ND
Perfluorodecanesulfonic acid	PFDS	ND
Perfluorobutanoic acid	PFBA	ND
Perfluoropentanoic acid	PFPeA	ND
Perfluorohexanoic acid	PFHxA	ND
Perfluoroheptanoic acid	PFHpA	ND
Perfluorooctanoic acid PFOA	PFOA	ND
Perfluorononanoic acid	PFNA	ND
Perfluorodecanoic acid	PFDA	ND
Perfluoroundecanoic acid	PFUdA	ND
Perfluorododecanoic acid	PFDoA	ND
Perfluorotridecanoic acid	PFTrDA	ND
Perfluorotetradecanoic acid	PFTeDA	ND
4:2 FTS	4:2 FTS	ND
6:2 FTS	6:2 FTS	ND
8:2 FTS	8:2 FTS	ND
10:2 FTS	10:2 FTS	ND
Perfluorooctane sulfonamide	FOSA	ND
N-Methyl perfluorooctanesulfonamide	N-MeFOSA	ND
N-Ethyl perfluorooctanesulfonamide	n-EtFOSA	ND
N-Me perfluorooctanesulfonamidoethanol	n-MeFOSE	ND
N-Et perfluorooctanesulfonamidoethanol	n-EtFOSE	ND
MePerfluorooctanesulf-amidoacetic acid	N-MeFOSAA	ND
EtPerfluorooctanesulf-amidoacetic acid	N-EtFOSAA	ND

5 DEFINITIONS

The following terms and abbreviations may be used in this report:

Table 14: Definitions

Symbol	Definition
<	The analytes tested for was not detected; the value stated is the reportable limit of detection
Am^3	Gas volume in cubic metres at measured conditions
AS	Australian Standard
BH	Back half of sample train (filter holder and impingers) (referred to during sample recovery)
°C	Degrees Celsius
CARB	California Air Resources Board methods
dscm	dry standard cubic meters
FH	Front half of sample train (probe and filter holder) (referred to during sample recovery)
g	Grams
Heavy metals	Sum of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Manganese, Nickle, Selenium, Tin, Vanadium & Mercury. Also known as Type 1 and Type 2 hazardous substances. Total heavy metals refers only to those metals found in the sample and doesn't not include limit of detection values.
kg	Kilograms
Lower range	The sum of a list of a particular group of compounds, where only those individual congeners/compounds that are detectable in the sample have been included in the total. Results below the limit of detection have not been included. Unless otherwise indicated, the lower range is reported for dioxins & furans, PCBs, heavy metals and PFAS analysis suites.
m	Metres
m^3	actual gas volume in cubic metres as measured
mbar	Millibars
mg	Milligrams (10^{-3} grams)
min	Minute
ml	Millilitres
mmH_2O	Millimetres of water
Mole	SI unit that measures the amount of substance
N/A	Not applicable
ng	Nanograms (10^{-9} grams)
Nm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa)
NMI	National Measurement Institute
NM VOC	Non methane volatile organic compound
NR	Not required on this occasion
ou	Odour unit
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
sec	Second
Sm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa) and corrected to a standardised value (e.g. 15% O_2)
STP	Standard temperature and pressure (0°C and 101.3 kPa) & dry
USEPA	United States Environmental Protection Authority

6 RESULTS

Table 15: Sample information – PFAS

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 0010 - ISOKINETIC
Run ID		8
Test Parameter		PFAS
Test Date	dd/mm/yyyy	17/12/2020
Start Time	hh:mm	8:10
End Time	hh:mm	11:20
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1001
Moisture Content	% v/v	54.8
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	1.03
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	19
Percent Isokinetic Rate	%	95
Pollutant PFAS species	Concentration standard conditions ng/Nm^3	Emission Rate standard conditions g/min
Perfluorobutanesulfonic acid	707	1.36E-05
Perfluoropentanesulfonic acid	< 0.3	< 6.45E-09
Perfluorohexanesulfonic acid	67.9	1.31E-06
Perfluoroheptanesulfonic acid	3.1	5.92E-08
Perfluorooctanesulfonic acid PFOS	50.5	9.72E-07
Perfluorodecanesulfonic acid	< 0.7	< 1.29E-08
Perfluorobutanoic acid	55.1	1.06E-06
Perfluoropentanoic acid	104	2.01E-06
Perfluorohexanoic acid	119	2.29E-06
Perfluoroheptanoic acid	68.9	1.33E-06
Perfluorooctanoic acid PFOA	202	3.88E-06
Perfluorononanoic acid	81.7	1.57E-06
Perfluorodecanoic acid	46.5	8.94E-07
Perfluoroundecanoic acid	20.7	3.99E-07
Perfluorododecanoic acid	7.2	1.38E-07
Perfluorotridecanoic acid	3.3	6.36E-08
Perfluorotetradecanoic acid	< 8.4	< 1.61E-07
4:2 FTS	< 0.3	< 6.45E-09
6:2 FTS	40.5	7.78E-07
8:2 FTS	2.5	4.78E-08
10:2 FTS	< 0.7	< 1.29E-08
Perfluorooctane sulfonamide	< 1.7	< 3.22E-08
N-Methyl perfluorooctanesulfonamide	< 1.7	< 3.22E-08
N-Ethyl perfluorooctanesulfonamide	< 1.7	< 3.22E-08
N-Me perfluorooctanesulfonamidoethanol	31.4	6.03E-07
N-Et perfluorooctanesulfonamidoethanol	< 83.8	< 1.61E-06
MePerfluorooctanesulf-amid oacetic acid	7.9	1.53E-07
EtPerfluorooctanesulf-amid oacetic acid	4.5	8.69E-08
TOTAL		
Sum of positive detections	1,624	3.12E-05

Table 16: Sample information – Odour

Site		Shaol Bay Landfill
Sample Location		BeneVap
Reference Method		AS4323.3 - CONSTANT FLOW
Run ID		9
Test Parameter		Odour
Test Date	dd/mm/yyyy	17/12/2020
Start Time	hh:mm	9:50
End Time	hh:mm	10:02
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1001
Moisture Content	% v/v	54.8
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	-
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	19
Percent Isokinetic Rate	%	N/A
Pollutant	concentration	emission rate
Odour	ou	ou.m^3/min
Odour Sample 1	7,786	331,114
Odour Sample 2	7,259	308,703
Average Odour	7,523	319,908

Table 17: Sample information – Hydrogen sulfide

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA M15 - CONSTANT FLOW
Run ID		10
Test Parameter		H2S
Test Date	dd/mm/yyyy	17/12/2020
Start Time	hh:mm	10:10
End Time	hh:mm	10:15
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1001
Moisture Content	% v/v	54.8
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	-
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	19
Percent Isokinetic Rate	%	N/A
Pollutant	concentration	emission rate
H2S	mg/Nm^3	g/min
Hydrogen sulfide	< 0.8	< 0.01

Table 18: Sample information – Oxides of Sulfur

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 8 - ISOKINETIC
Run ID		1
Test Parameter		Sox
Test Date	dd/mm/yyyy	15/12/2020
Start Time	hh:mm	16:25
End Time	hh:mm	17:43
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	999
Moisture Content	% v/v	54.5
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.8
Sample Volume (dry gas meter)	Nm^3	0.43
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	$\text{m}^3\text{/min}$	56
Dry Standard Stack Flow Rate	$\text{Nm}^3\text{/min}$	19
Percent Isokinetic Rate	%	93

Pollutant		concentration		emission rate
Sox		mg/Nm^3		g/min
SO2	<	3.0	<	0.06
SO3 (as H2SO4)	<	1.0	<	0.02

Table 19: Sample information – Acid gases

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 26A - ISOKINETIC
Run ID		3
Test Parameter		HCl, NH3
Test Date	dd/mm/yyyy	17/12/2020
Start Time	hh:mm	12:15
End Time	hh:mm	13:25
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1001
Moisture Content	% v/v	54.9
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	0.44
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	$\text{m}^3\text{/min}$	56
Dry Standard Stack Flow Rate	$\text{Nm}^3\text{/min}$	19
Percent Isokinetic Rate	%	98

Pollutant		concentration		emission rate
HCl, NH3		mg/Nm^3		g/min
HCl	<	2.3	<	0.04
Cl2	<	2.3	<	0.04

Table 20: Sample information – Heavy metals

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 29 - ISOKINETIC
Run ID		2
Test Parameter		Metals
Test Date	dd/mm/yyyy	16/12/2020
Start Time	hh:mm	16:40
End Time	hh:mm	18:16
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	998
Moisture Content	% v/v	55.7
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	0.73
Stack Gas Velocity	m/sec	3.5
Actual Stack Flow Rate	m^3/min	60
Dry Standard Stack Flow Rate	Nm^3/min	20
Percent Isokinetic Rate	%	96

Pollutant Metals		concentration μg/Nm^3		emission rate g/min
Antimony	<	7.8	<	1.5E-04
Arsenic	<	7.8	<	1.5E-04
Beryllium	<	0.6	<	1.2E-05
Cadmium		2.6		5.2E-05
Chromium		38		7.6E-04
Cobalt		0.8		1.6E-05
Lead		77		1.5E-03
Manganese		88		1.7E-03
Nickel		15		3.0E-04
Selenium		11		2.2E-04
Tin	<	19	<	3.8E-04
Vanadium	<	10	<	1.9E-04
Mercury		0.14		2.7E-06
Total Heavy Metals (Sum of positive detections)		233		4.6E-03

Table 21: Sample information – Volatile organic compounds

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 18 - CONSTANT FLOW
Run ID		6
Test Parameter		VOCs
Test Date	dd/mm/yyyy	16/12/2020
Start Time	hh:mm	10:30
End Time	hh:mm	11:50
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	999
Moisture Content	% v/v	53.8
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	0.03
Stack Gas Velocity	m/sec	3.1
Actual Stack Flow Rate	m^3/min	53
Dry Standard Stack Flow Rate	Nm^3/min	18
Percent Isokinetic Rate	%	N/A
Pollutant	concentration	emission rate
Total (non-methane) VOCs	mg/Nm^3	g/min
Total VOCs - as n-hexane	< 1.92	< 0.04
Total VOCs - as n-propane	< 0.98	< 0.02
Benzene	0.31	0.01

Table 22: Sample information – Ammonia

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		Mod USEPA M26 - CONSTANT FLOW
Run ID		7
Test Parameter		NH3
Test Date	dd/mm/yyyy	17/12/2020
Start Time	hh:mm	12:15
End Time	hh:mm	13:15
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1001
Moisture Content	% v/v	54.9
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	0.05
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	56
Dry Standard Stack Flow Rate	Nm^3/min	19
Percent Isokinetic Rate	%	N/A
Pollutant	concentration	emission rate
NH3	mg/Nm^3	g/min
Ammonia (as NH3) - Condensate dropout	2,070	39.2
Ammonia (as NH3) - gaseous	228	4.3
Total Ammonia (as NH3)	2,299	43.5

Table 23: Sample information – Combustion gases

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 3A, 7E & 10
Run ID		Various
Test Parameter		O_2, CO_2, NOx, CO
Test Date	dd/mm/yyyy	15/12/2020
Start Time	hh:mm	16:25:00
End Time	hh:mm	13:25:00
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1000
Moisture Content	% v/v	55.0
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.8
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	19
Pollutant	concentration	emission rate
O2, CO2, NOx, CO	STP	g/min
Oxygen (% v/v)	7.3	-
Carbon dioxide (% v/v)	9.7	-
Carbon monoxide (mg/m^3)	48	0.91
Oxides of nitrogen (mg/m^3)	121	2.3

Table 24: Sample information – Fluoride

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 13B - ISOKINETIC
Run ID		4
Test Parameter		Fluoride
Test Date	dd/mm/yyyy	16/12/2020
Start Time	hh:mm	18:55
End Time	hh:mm	20:00
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	998
Moisture Content	% v/v	53.9
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.8
Sample Volume (dry gas meter)	Nm^3	0.43
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	58
Dry Standard Stack Flow Rate	Nm^3/min	20
Percent Isokinetic Rate	%	90
Pollutant	concentration	emission rate
Fluoride	mg/Nm^3	g/min
Fluorine - (as total HF)	< 4.9	< 0.1

Table 25: Sample information – Dioxins & furans

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 23 - ISOKINETIC
Run ID		1
Test Parameter		DF & PCB
Test Date	dd/mm/yyyy	16/12/2020
Start Time	hh:mm	8:10
End Time	hh:mm	16:15
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1002
Moisture Content	% v/v	56.2
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	2.29
Stack Gas Velocity	m/sec	3.1
Actual Stack Flow Rate	m^3/min	53
Dry Standard Stack Flow Rate	Nm^3/min	18
Percent Isokinetic Rate	%	90

Pollutant DF & PCB		concentration ng/Nm^3		emission rate g/min
2378 TCDF		0.0048		8.5E-11
Total TCDF isomers		0.038		6.8E-10
2378 TCDD	<	0.00087	<	1.5E-11
Total TCDD isomers		0.0043		7.6E-11
12378 PeCDF	<	0.00087	<	1.5E-11
23478 PeCDF	<	0.00087	<	1.5E-11
Total PeCDF isomers		0.0070		1.2E-10
12378 PeCDD	<	0.00026	<	4.6E-12
Total PeCDD isomers	<	0.0017	<	3.1E-11
123478 HxCDF	<	0.00044	<	7.7E-12
123678 HxCDF		0.00066		1.2E-11
234678 HxCDF	<	0.00031	<	5.4E-12
123789 HxCDF	<	0.00035	<	6.2E-12
Total HxCDF isomers		0.0031		5.5E-11
123478 HxCDD	<	0.00031	<	5.4E-12
123678 HxCDD	<	0.00031	<	5.4E-12
123789 HxCDD	<	0.00031	<	5.4E-12
Total HxCDD isomers		0.0037		6.5E-11
1234678 HpCDF		0.0014		2.4E-11
1234789 HpCDF	<	0.00044	<	7.7E-12
Total HpCDF isomers		0.0027		4.8E-11
1234678 HpCDD		0.0079		1.4E-10
Total HpCDD isomers		0.012		2.2E-10
OCDF		0.0016		2.8E-11
OCDD		0.029		5.2E-10
Sum of congeners Sum of positive detections		0.10		1.8E-09
Total I-TEQ Sum of positive detections		0.00067		1.2E-11

Table 26: Sample information – PCBs

PCBs (USEPA Method 23)				
		ng/Nm^3		g/min
PCB#77		0.50		8.8E-09
PCB#81		0.026		4.6E-10
PCB#126		0.0040		7.0E-11
PCB#169	<	0.0039	<	6.9E-11
PCB#105		1.7		3.0E-08
PCB#114		0.13		2.3E-09
PCB#118		4.6		8.2E-08
PCB#123		0.057		1.0E-09
PCB#156		0.22		3.9E-09
PCB#157		0.048		8.5E-10
PCB#167		0.087		1.5E-09
PCB#189		0.0040		7.1E-11
Sum of PCB Congeners				
Sum of positive detections		7.4		1.3E-07
Total TEQ				
Sum of positive detections		0.00066		1.2E-11

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MARCH 2021

SOURCE EMISSIONS MONITORING – SHOAL BAY BENEVAP SYSTEM

CLIENT: BENETERRA
PROJECT ID: 13546
DATE: 1/04/2021 RELEASE: R_0

DOCUMENT CONTROL PAGE

Project Title: Source Emissions Monitoring – Shoal Bay Benevap System

Project Reference ID: 13546

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Table 1: History of Revisions

Revision	Date	Issued to	Changes
R_0	1/04/2021	N. Sharma	Formal report release
DRAFT_0	31/03/2021	N. Sharma	Draft release for comment

ACCREDITED FOR COMPLIANCE TO ISO/IEC 17025 (TESTING)

The results of the tests, calibrations and/or measurements included in this document is traceable to Australian/national standards.

Accreditation number: 19703

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EXECUTIVE SUMMARY

Assured Environmental (AE) conducted source emissions monitoring from the mobile BeneVap Leachate Treatment Facility located at the Shoal Bay Waste Facility in Darwin, Northern Territory from 3rd to 5th March 2021.

A summary of results is presented below from the testing conducted on a single release point. The process is understood to have been operating at a stable and representative load for the duration of the monitoring.

In comparison to the emission limits outlined in EPL188-01 (Attachment 7), all measured parameters were within those limits specified. Results are reported at dry, 273.15°K and 101.325 kPa (STP).

The carbon monoxide concentration during this testing was found to be slightly elevated in comparison to historical data. It is understood that the reason being is a stress fracture above the water level in the combustion chamber and that works are being conducted to repair this.

Table 2: Summary of measured parameters

Parameter		Result	Emission limit	Unit	Reference
Average source temperature		85	-	°C	-
Flue gas water vapour content		52	-	vol-%	-
Carbon dioxide concentration		7.4	-	vol-%	STP - dry
Oxygen concentration		10.8	-	vol-%	STP - dry
Flue gas molecular weight - dry		1.3	-	kg/Nm^3	STP - dry
Flue gas velocity		3.3	-	m/sec	STP - dry
Flue gas volume flow		20.5	-	Nm^3/min	STP - dry
Oxides of nitrogen (as NO_2)		66	350	mg/Nm^3	STP - dry
- emission rate		1.3	-	g/min	
Carbon monoxide		113	125	mg/Nm^3	STP - dry
- emission rate		2.44	-	g/min	
Total heavy metals		0.10	1.0	mg/Nm^3	STP - dry
- emission rate		0.0018	-	g/min	
Cadmium		0.0011	0.2	mg/Nm^3	STP - dry
- emission rate		2.1E-05	-	g/min	
Mercury		0.047	0.2	mg/Nm^3	STP - dry
- emission rate		8.4E-04	-	g/min	
Fluorine (as HF)	<	2.1	50	mg/Nm^3	STP - dry
- emission rate	<	0.042	-	g/min	
Hydrogen chloride	<	2.7	100	mg/Nm^3	STP - dry
- emission rate	<	0.058	-	g/min	
Chlorine	<	1.9	200	mg/Nm^3	STP - dry
- emission rate	<	0.041	-	g/min	
Ammonia (total)		1,050	-	mg/Nm^3	STP - dry
- emission rate		22	-	g/min	
Ammonia (NH_3) - in condensate		974	-	mg/Nm^3	STP - dry
- emission rate		21	-	g/min	
Ammonia (NH_3) - gaseous		76	-	mg/Nm^3	STP - dry
- emission rate		1.6	-	g/min	
Hydrogen sulfide	<	0.8	5	mg/Nm^3	STP - dry
- emission rate	<	0.02	-	g/min	
Sulfur dioxide		4.3	-	mg/Nm^3	STP - dry
- emission rate		0.09	-	g/min	
Sulfuric acid mist (as H_2SO_4)		8.0	100	mg/Nm^3	STP - dry
- emission rate		0.17	-	g/min	
Total VOCs (as n-propane)	<	1.0	40	mg/Nm^3	STP - dry
- emission rate	<	0.02	-	g/min	
Average odour		5,687	-	ou	STP - wet
- emission rate		252,866	-	ou-m^3/min	
Dioxins & Furans (i-TEQ)		0.0016	0.1	ng/Nm^3	STP - dry
- emission rate		3.32E-11	-	g/min	
PCBs (i-TEQ)		0.0013	-	ng/Nm^3	STP - dry
- emission rate		2.84E-11	-	g/min	

Table 3: Summary of PFAS results

Parameter		Result ng/Nm^3		Emission Rate g/min	Reference
Per- and polyfluoroalkyl substances					
Perfluorobutanesulfonic acid		**123**		**2.40E-06**	**STP**
Perfluoropentanesulfonic acid	<	1.5	<	3.01E-08	STP
Perfluorohexanesulfonic acid		**14.0**		**2.72E-07**	**STP**
Perfluoroheptanesulfonic acid	<	1.6	<	3.05E-08	STP
Perfluorooctanesulfonic acid PFOS		**17.0**		**3.32E-07**	**STP**
Perfluorodecanesulfonic acid	<	3.1	<	6.03E-08	STP
Perfluorobutanoic acid		**10.4**		**2.02E-07**	**STP**
Perfluoropentanoic acid		**30.7**		**5.97E-07**	**STP**
Perfluorohexanoic acid		**40.0**		**7.79E-07**	**STP**
Perfluoroheptanoic acid		**12.8**		**2.49E-07**	**STP**
Perfluorooctanoic acid PFOA		**33.9**		**6.61E-07**	**STP**
Perfluorononanoic acid		**2.5**		**4.82E-08**	**STP**
Perfluorodecanoic acid	<	7.7	<	1.51E-07	STP
Perfluoroundecanoic acid	<	7.7	<	1.51E-07	STP
Perfluorododecanoic acid	<	7.7	<	1.51E-07	STP
Perfluorotridecanoic acid	<	7.7	<	1.51E-07	STP
Perfluorotetradecanoic acid	<	38.7	<	7.54E-07	STP
4:2 FTS	<	1.5	<	3.01E-08	STP
6:2 FTS		**12.4**		**2.42E-07**	**STP**
8:2 FTS	<	3.1	<	6.03E-08	STP
10:2 FTS	<	3.1	<	6.03E-08	STP
Perfluorooctane sulfonamide	<	7.7	<	1.51E-07	STP
N-Methyl perfluorooctanesulfonamide	<	7.7	<	1.51E-07	STP
N-Ethyl perfluorooctanesulfonamide	<	7.7	<	1.51E-07	STP
N-Me perfluorooctanesulfonamidoethanol	<	7.7	<	1.51E-07	STP
N-Et perfluorooctanesulfonamidoethanol	<	93.9	<	1.83E-06	STP
MePerfluorooctanesulf-amid oacetic acid	<	3.7	<	7.16E-08	STP
EtPerfluorooctanesulf-amid oacetic acid	<	3.4	<	6.60E-08	STP

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1 INTRODUCTION

BeneTerra's mobile BeneVap leachate treatment plant was transported to Darwin and setup at the Shoal Bay Waste Management facility. The plant was run for the duration of the testing period at a stable capacity.

Assured Environmental (AE) was appointed by BeneTerra to sample and analyse source emissions from the BeneVap Leachate Treatment system. Sampling was conducted by AE from 3rd to 5th March 2021 during typical site operations.

AE was responsible for the collection and analysis of samples, unless otherwise indicated. The samples were recovered and stored in the appropriate manner until their return to the laboratory where the samples were prepared and analysed according to the methodologies listed below in this report.

2 METHODOLGY & EQUIPMENT

2.1 Sampling methodology

All sampling and analysis was carried out in accordance with the listed requirements in Table 4. Any specific comments about the sampling and analysis have been documented where required.

Table 4: Test methods

Parameter	Reference Test Method	Test Method (NSW)	NATA accreditation	Analysis by
Sample location	AS4323.1	TM-1	Yes	1
Velocity & flow rate	USEPA Method 2	TM-2	Yes	1
Stack gas density	USEPA Method 3	TM-23	Yes	1
Oxygen	USEPA Method 3A	TM-25	Yes	1
Carbon dioxide	USEPA Method 3A	TM-24	Yes	1
Water vapour content	USEPA Method 4	TM-22	Yes	1
Sulphur dioxide	USEPA Method 6	TM-4	Yes	1
Oxides of nitrogen (as NO_2)	USEPA Method 7E	TM-11	Yes	1
Sulfuric acid mists	USEPA Method 8	TM-3	Yes	1
Carbon monoxide	USEPA Method 10	TM-32	Yes	1
Hydrogen sulfide	USEPA Method 15	TM-5	Yes	1
Total VOCs	USEPA Method 18	TM-34	Yes	2
Hydrogen chloride	USEPA Method 26A	TM-8	Yes	2
Chlorine	USEPA Method 26A	TM-7	Yes	2
Fluoride (as HF)	USEPA Method 13B	TM-9	Yes	2
Heavy metals	USEPA Method 29	TM-12/13/14	Yes	2
PFAS – suite	USEPA SW846 Method 0010	Mod TM-18	No	3
Dioxins & furans	USEPA SW846 Method 0010	TM-18	Yes	4
Polychlorinated biphenyls	USEPA SW846 Method 0010	TM-18	Yes	2
Ammonia	Modified USEPA Method 26	Mod TM-4	Yes	2
Odour	AS4323.3	OM-7	Yes	1

Table 5: Analysis performed by

Note	Company	Work performed	NATA ID	Report Number
1	Assured Environmental	Sampling & analysis	19703	13546
2	Envirolab Services	Analysis	2901	263908
4	National Measurement Inst.	Organics analysis	198	DAU21_101

Table 6: Sampling comments

Note	Comment
Sample location	Sample location is compliant but non ideal as per AS4323.1. The sample location is greater than two, but less than six diameters downstream from a disturbance. The temperature and velocity survey showed that the sample position was in compliance to items (a) to (f) as per AS4323.1.
Calibrations	Analyser calibration performed in the laboratory prior to conducting field work and post field work in AE lab.
H_2S	A sample of exhaust gas was passed through a buffer solution to remove any potential SO_2 present before being captured in a specialised gas sampling bag. Analysis for H_2S was performed using GC-FPD within 30 hours of collection.
Heavy metals	Type 1 substances: Antimony, Arsenic, Cadmium, Lead Mercury. Type 2 substances: Beryllium, Chromium, Cobalt, Manganese, Nickel, Selenium, Tin, Vanadium.
PFAS	A modified version of the USEPA SW846 Method 0010 sample train was employed to sample for Per- and poly-fluoroalkyl substances (PFAS) material in the flue gas emission. Refer to section 2.2 for further information.
Ammonia	The ammonia sampling was performed using a modified sampling train. A condensate removal trap was placed in front of the collection trap to separate condensing ammonia from gaseous ammonia passing through the initial stage and into the collection media. Both the condensate captured in the trap and the sorbent solution are analysed for ammonia. Ammonia results are reported in the condensate and gaseous phase separately and as NH_3.
Odour	Due to the high levels of moisture in the emission the odour samples bags were diluted beyond the suggested limit in AS4323.3. This is required to avoid condensation forming in the sample bags.

2.2 Per- and poly-fluoroalkyl substances sample methodology

There are currently no promulgated reference methods for performing emissions monitoring for Per- and poly-fluoroalkyl substances (PFAS) from stationary emission sources. As such a procedure was employed using a reference method designed for similar compounds, in this case USEPA SW846 Method 0010 which was originally intended to sample isokinetically for semivolatile principal organic hazardous compounds, which may exist in either particulate or gaseous form. A summary of the sample train is;

- Gaseous and particulate pollutants are withdrawn from an emission source at an isokinetic sampling rate and are collected in a multi-component sampling train. The sample train contains a high-efficiency glass fibre filter and a packed bed of porous adsorbent resin. The filter is used to collect organic-laden particulate materials and the porous polymeric resin to adsorb semi-volatile organic species. Semi-volatile species are defined as compounds with boiling points greater than 100°C. The impingers downstream of the resin trap are loaded with water to knock-out any water vapour prior to metering the gas. These impingers are not routinely analysed for S-VOCs.

The modifications made to this sample train in order to target PFAS materials included;

- Sorbent material is XAD-2 and XAD-4.
- The resin traps are spiked with a surrogate standard to test for retention. A known quantity of standard is injected into the trap during preparation, the trap is then shipped, sampled and returned to the laboratory for analysis. The analysis includes detecting the injected standard, which provides a measure of the recovery efficiency. Factors that may affect the recovery efficiency include, sample transport and handling procedures, sampling temperatures (the resin must be chilled during sampling and maintained below 20°C) and sample preparation at the laboratory, including the extraction of the sample from the resin.

- The impingers downstream of the resin trap are loaded with a sodium solution and is intended to be a breakthrough detector. Following the sampling, the impinger contents are measured and placed in a sample bottle for shipment to the laboratory. The final impinger of the sample train is then analysed separately to the filter, resin trap and front half methanol rinse so as to provide a measure of possible breakthrough. The intent of this sample train component is to provide a measure of breakthrough from the primary sampling components. Where no detections of PFAS material is made in this sample component, the limit of detection is not added to the sample result.
- Following the sampling onsite, all sample train components that have been in contact with the sample are rinsed thoroughly with methanol and stored in a sample container to be analysed as part of the sample.
- Sample train component material. According to documented water and soil PFAS sampling procedures, the use of glass, Teflon and stainless steel should be avoided and the use of polypropylene (PE) is recommended. PE is not considered to be conducive to source emissions sampling due to the temperatures of the flue gas. PE or HDPE cannot be used in the probe or filter box due to its low melting point, instead, all sampling components upstream of the resin trap was constructed of glass. Following sampling, all glassware was thoroughly rinsed with methanol at least three times to quantitatively recovery any possible PFAS material deposited on this surface.

For the analysis, the samples are extracted using a solvent desorption technique, with the filter and front half methanol rinse extract combined prior to analysis for the PFAS species. The XAD resin trap is then analysed in isolation as is the condensate downstream of the trap to gain an understanding of where the PFAS is captured within the sample train. The analysis is performed using LC/MS/MS instruments, with each analysis performed using the surrogate spikes to determine sample specific recoveries.

2.2.1 PFAS blank corrections

In the field, a full field blank is performed, where the sampling train is constructed as normal, however no sample is passed through it. It is then cleaned and recovered following the standard recovery procedures and the filter, resin trap and rinsate kept and analysed along with the sample.

The following details the procedures used to correct for detections of PFAS species in the blank samples.

- Where the blank result is a non-detection, no adjustment to the sample result is made.
- Where the blank result returns a positive detection, but is less than half of the sample result, the blank value is subtracted from the sample result and reported as a positive detection.
- Where the blank value returns a positive detection, and is exceeding half of the sample result, no adjustments are made to the sample result, but it is reported as a non-detection.

2.3 Sample Location

The images and figures below show the sample location and site details.

Figure 1: Benevap treatment system stack

Table 7: Sample location summary

Sample location	Benevap Treatment System
Stack Shape	CIRCULAR
Stack Diameter (m)	0.60
Stack Cross Section Area (m^2)	0.28
Distance to upstream disturbance (m)	1.3
Diameters (D)	2..2
Distance to downstream disturbance (m)	0.7
Diameters (D)	1.1
Total traverse point factors	1.15 , 1.05 , 1.21
Port size (mm)	100
Port Thread Type	BSP
Number of traverses	2
Number of points per traverse	6
Total number of traverse points	12
Flow & temperature compliance check	YES

2.4 Test equipment

The sampling equipment was transported to site and specifically setup at the test location. Sampling was performed using heated probes and filters, with a constant flow and isokinetic sample console.

Equipment used during the course of the testing is sourced from Apex Instruments and Testo, industry leaders in the supply of source testing equipment.

Figure 2: Constant flow sample equipment

Figure 3: Combustion gas analyser

3 MEASUREMENT UNCERTAINTY

There is an inherent uncertainty associated with any scientific measurement, including stack emissions monitoring. The measurement uncertainty can be controlled with strict adherence to the reference methodology along with utilising appropriate calibration standards with corresponding acceptable uncertainty reports.

Many source sampling methods do not outline exact procedures for establishing direct measurement uncertainty. In the absence of a defined procedure, the uncertainty budgets presented are based on estimations using ISO-GUM method.

Each individual source and test may have a unique associated uncertainty, due largely to the stack sample location in relation to the positioning requirements of AS4323.1.

Table 8: Sample specific uncertainty budgets

Parameter	Reference method	Limit of measurement	Unit of measure	Uncertainty ± %
Oxygen	USEPA Method 3A	0.3	%-vol	5.0
Carbon dioxide	USEPA Method 3A	0.3	%-vol	8.0
Water vapour content	USEPA Method 4	0.5	%-vol	5.0
Sulphur dioxide	USEPA Method 6	2.0	mg/sample	15
Oxides of nitrogen (as NO_2)	USEPA Method 7E	2.1	mg/sample	15
Sulfuric acid mists	USEPA Method 8	2.0	mg/sample	15
Carbon monoxide	USEPA Method 10	1.5	mg/sample	15
Hydrogen sulfide	USEPA Method 15	1.0	mg/sample	20
Total VOCs	USEPA Method 18	1.0	mg/sample	20
Hydrogen chloride	USEPA Method 26A	1.0	mg/sample	15
Chlorine	USEPA Method 26A	1.0	mg/sample	15
Fluoride (as HF)	USEPA Method 13B	1.0	mg/sample	15
Heavy metals	USEPA Method 29	0.3 to 50	µg/sample	10
PFAS – suite	USEPA SW846 Method 0010	1 to 50	ng/sample	25
Dioxins & furans	USEPA SW846 Method 0010	1	pg/sample	15
Polychlorinated biphenyls	USEPA SW846 Method 0010	20	pg/sample	15
Ammonia	Modified USEPA Method 26	1	mg/sample	25
Odour	AS4323.3	100	ou	25

4 QUALITY ASSURANCE & QUALITY CONTROL (QA/QC)

AE operates within a quality system based upon the requirements of ISO17025. Our quality system defines specific procedures and methodologies to ensure any project undertaken by AE is conducted with the highest level of quality given the specific confines of each project. The overall objective of our QA/QC procedures is to representatively sample and accurately analyse components in the gas streams and therefore report valid measurements of emission concentrations.

To ensure representativeness of field work, our quality procedures target:

1. Correct sampling locations
2. Sample time
3. Frequency of samples and
4. Method selection & adherence

To ensure representativeness of lab work, our quality procedures target:

1. Sample preservation
2. Chain of custody (COC)
3. Sample preparation and
4. Analytical techniques

AE maintains strict quality assurance throughout all its sampling programs, covering on-site ‘field work’ and the analytical phase of our projects. Our QA program covers the calibration of all sampling and analytical apparatus where applicable and the use of spikes, replicate sample and reference standards. The test methodologies used for this project are outlined in section 2 of this document. Field test data has been recorded and calculated using direct entry into Microsoft Excel spreadsheets following the procedures of the appropriate test methods. Determination of emission concentrations has been performed using the same Microsoft Excel spreadsheets which are partially supplied as an attachment to this report. More detailed information can be supplied upon request.

QA/QC checks for this project will use validation techniques and criteria appropriate to the type of data and the purpose of the measurement to approve the test report. Records of all data will be maintained. Complete chain of custody (COC) procedures have been followed to document the entire custodial history of each sample. The COC forms also served as a laboratory sheet detailing sample ID and analysis requirements.

Table 9: Sampling data QA/QC checklist

Sampling Data QA/QC Checklist	Comment
Use of appropriate test methods	Yes
'Normal' operation of the process being tested	Yes – as instructed by client
Use of properly operating and calibrated test equipment	Yes
Use of high purity reagents	Yes
Performance of leak checks post sample (at least)	Yes

Table 10: Laboratory data QA/QC checklist

Laboratory Data QA/QC Checklist	Comment
Use of appropriate analytical methods	Yes
Use of properly operating and calibrated analytical equipment	Yes
Precision and accuracy comparable to that achieved in similar projects	Yes
Accurate reporting	Yes

Table 11: Olfactometer QA data

Item	Comment
Methodology	AS/NZ4323.3:2001 "determination of odour concentration by dynamic olfactometry".
Sample Media	Odour samples collected into Nalophan™ sample bags
Sample identification	All samples are labelled uniquely immediately following collection according to Assured Environmental identification procedure. Each sample has the following recorded: project ID, sample number, location, date, time, dilution and any deviations to AS/NZ4323.3.
Timing	All measurements were conducted within 30 hours of sampling as specified by AS/NZ4323.3
Traceability	All panel results are traceable to reference standards held by Assured Environmental
Analysis conditions	Room temperature maintained at 22 °C ± 3 °C
Odour panel location	7/142 Tennyson Memorial Avenue Tennyson, Qld. 4105
Reference odourant	40 ppm n-butanol
Odour panel threshold	100 ou

4.1 PFAS quality control

The recoveries of surrogate standards from the sampling and analysis are presented in the table below. The expected QC recovery for measurements in the ppb to ppt levels is in the range of 60 to 120%. The results are not corrected for the recovery.

Table 12: PFAS surrogate recovery (%)

Surrogate	PFAS	
	Filter	Trap
Field surrogate		
Surrogate $^{13}C_8$ PFOS	103	80
Surrogate $^{13}C_8$ PFOS	101	130

Analysis of the final bubbler containing a sodium borate solution was performed separately to the front of the sampling train in order to assess the potential for breakthrough. The results of this analysis are provided below.

Table 13: Breakthrough analysis

Perfluorinated surfactants	Abbreviation	Breakthrough analysis
Perfluorobutanesulfonic acid	PFBS	< 0.15
Perfluoropentanesulfonic acid	PFPeS	< 0.2
Perfluorohexanesulfonic acid	PFHxS	< 0.2
Perfluoroheptanesulfonic acid	PFHpS	< 0.2
Perfluorooctanesulfonic acid PFOS	PFOS	< 0.2
Perfluorodecanesulfonic acid	PFDS	< 0.3
Perfluorobutanoic acid	PFBA	< 0.3
Perfluoropentanoic acid	PFPeA	< 0.3
Perfluorohexanoic acid	PFHxA	< 0.2
Perfluoroheptanoic acid	PFHpA	< 0.2
Perfluorooctanoic acid PFOA	PFOA	< 0.2
Perfluorononanoic acid	PFNA	< 0.2
Perfluorodecanoic acid	PFDA	< 0.8
Perfluoroundecanoic acid	PFUdA	< 0.8
Perfluorododecanoic acid	PFDoA	< 0.8
Perfluorotridecanoic acid	PFTrDA	< 0.8
Perfluorotetradecanoic acid	PFTeDA	< 3.8
4:2 FTS	4:2 FTS	< 0.2
6:2 FTS	6:2 FTS	< 0.2
8:2 FTS	8:2 FTS	< 0.3
10:2 FTS	10:2 FTS	< 0.3
Perfluorooctane sulfonamide	FOSA	< 0.8
N-Methyl perfluorooctanesulfonamide	N-MeFOSA	< 0.8
N-Ethyl perfluorooctanesulfonamide	n-EtFOSA	< 0.8
N-Me perfluorooctanesulfonamidoethanol	n-MeFOSE	< 0.8
N-Et perfluorooctanesulfonamidoethanol	n-EtFOSE	< 38.3
MePerfluorooctanesulf-amidoacetic acid	N-MeFOSAA	< 0.3
EtPerfluorooctanesulf-amidoacetic acid	N-EtFOSAA	< 0.1

Analysis of the field sample blank showed that only a small amount of PFOA was detectable in the methanol/XAD resin. The table below shows the results of the blank analysis.

Table 14: Field blank analysis

	Blank analysis		
Perfluorinated surfactants - PFAS suite	**Front half ng/sample**	**Resin Trap ng/sample**	**Breakthrough ng/sample**
Perfluorobutanesulfonic acid	< 0.2	< 0.2	< 0.20
Perfluoropentane sulfonic acid (PFPeS)	< 0.2	< 0.2	< 0.20
Perfluorohexane sulfonate (PFHxS)	< 0.2	< 0.2	< 0.20
Perfluoroheptane sulfonate (PFHpS)	< 0.2	< 0.2	< 0.20
Perfluorooctane sulfonate (PFOS)	< 0.2	< 0.2	< 0.20
Perfluorodecanesulfonic acid (PFDS)	< 0.4	< 0.4	< 0.40
Perfluorobutanoic acid	< 0.4	< 0.4	< 0.40
Perfluoropentanoic acid (PFPeA)	< 0.4	< 0.4	< 0.40
Perfluorohexanoic acid (PFHxA)	< 0.2	< 0.2	< 0.20
Perfluoroheptanoic acid (PFHpA)	< 0.2	< 0.2	< 0.20
Perfluorooctanoic acid (PFOA)	< 0.2	**0.6**	< 0.20
Perfluorononanoic acid (PFNA)	< 0.2	< 0.2	< 0.20
Perfluorodecanoic acid	< 1.0	< 1.0	< 1.00
Perfluoroundecanoic acid (PFUnA)	< 1.0	< 1.0	< 1.00
Perfluorododecanoic acid (PFDoA)	< 1.0	< 1.0	< 1.00
Perfluorotridecanoic acid (PFTrDA)	< 1.0	< 1.0	< 1.00
Perfluorotetradecanoic acid (PFTeDA)	< 5.0	< 5.0	< 5.00
4:2 Flurotelomersulphonate	< 0.2	< 0.2	< 0.20
6:2 Fluorotelomersulphonate	< 0.2	< 0.2	< 0.20
8:2 Fluorotelomersulphonate	< 0.4	< 0.4	< 0.40
10:2 Fluorotelomersulphonate	< 0.4	< 0.4	< 0.40
Perfluorooctane sulfonamide	< 1.0	< 1.0	< 1.00
N-Methyl-heptadecafluorooctane sulphonamide	< 1.0	< 1.0	< 1.00
N-Ethyl-heptadecafluorooctane sulphonamide	< 1.0	< 1.0	< 1.00
N-Me perfluorooctanesulfonamid oethanol	< 1.0	< 1.0	< 1.00
N-Et perfluorooctanesulfonamid oethanol	< 50	< 50	< 50
N-Methylperfluorooctane sulphonamidoacetic acid	< 0.4	< 0.4	< 0.40
N-Ethyl-perfluorooctane sulphonamidoacetic acid	< 0.4	< 0.4	< 0.40

5 DEFINITIONS

The following terms and abbreviations may be used in this report:

Table 15: Definitions

Symbol	Definition
<	The analytes tested for was not detected; the value stated is the reportable limit of detection
Am^3	Gas volume in cubic metres at measured conditions
AS	Australian Standard
BH	Back half of sample train (filter holder and impingers) (referred to during sample recovery)
ºC	Degrees Celsius
CARB	California Air Resources Board methods
dscm	dry standard cubic meters
FH	Front half of sample train (probe and filter holder) (referred to during sample recovery)
g	Grams
Heavy metals	Sum of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Manganese, Nickle, Selenium, Tin, Vanadium & Mercury. Also known as Type 1 and Type 2 hazardous substances. Total heavy metals refers only to those metals found in the sample and doesn't not include limit of detection values.
kg	Kilograms
Lower range	The sum of a list of a particular group of compounds, where only those individual congeners/compounds that are detectable in the sample have been included in the total. Results below the limit of detection have not been included. Unless otherwise indicated, the lower range is reported for dioxins & furans, PCBs, heavy metals and PFAS analysis suites.
m	Metres
m^3	actual gas volume in cubic metres as measured
mbar	Millibars
mg	Milligrams (10^{-3} grams)
min	Minute
ml	Millilitres
mmH_2O	Millimetres of water
Mole	SI unit that measures the amount of substance
N/A	Not applicable
ng	Nanograms (10^{-9} grams)
Nm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa)
NMI	National Measurement Institute
NM VOC	Non methane volatile organic compound
NR	Not required on this occasion
ou	Odour unit
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
sec	Second
Sm^3	Gas volume in dry cubic metres at standard temperature and pressure (0°C and 101.3 kPa) and corrected to a standardised value (e.g. 15% O_2)
STP	Standard temperature and pressure (0°C and 101.3 kPa) & dry
USEPA	United States Environmental Protection Authority

6 RESULTS

Table 16: Sample information – PFAS

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 0010 - ISOKINETIC
Run ID		8
Test Parameter		PFAS
Test Date	dd/mm/yyyy	3/03/2021
Start Time	hh:mm	9:00
End Time	hh:mm	13:55
Average Stack Temperature	°C	87
Absolute Stack Pressure	mb	1007
Moisture Content	% v/v	53.0
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.9
Sample Volume (dry gas meter)	Nm^3	1.30
Stack Gas Velocity	m/sec	3.2
Actual Stack Flow Rate	m^3/min	55
Dry Standard Stack Flow Rate	Nm^3/min	19
Percent Isokinetic Rate	%	93
Pollutant PFAS species	Concentration standard conditions ng/Nm^3	Emission Rate standard conditions g/min
Perfluorobutanesulfonic acid	123	2.40E-06
Perfluoropentanesulfonic acid	< 1.5	< 3.01E-08
Perfluorohexanesulfonic acid	14	2.72E-07
Perfluoroheptanesulfonic acid	< 1.6	< 3.05E-08
Perfluorooctanesulfonic acid PFOS	17	3.32E-07
Perfluorodecanesulfonic acid	< 3.1	< 6.03E-08
Perfluorobutanoic acid	10.4	2.02E-07
Perfluoropentanoic acid	30.7	5.97E-07
Perfluorohexanoic acid	40.0	7.79E-07
Perfluoroheptanoic acid	12.8	2.49E-07
Perfluorooctanoic acid PFOA	33.9	6.61E-07
Perfluorononanoic acid	2.5	4.82E-08
Perfluorodecanoic acid	< 7.7	< 1.51E-07
Perfluoroundecanoic acid	< 7.7	< 1.51E-07
Perfluorododecanoic acid	< 7.7	< 1.51E-07
Perfluorotridecanoic acid	< 7.7	< 1.51E-07
Perfluorotetradecanoic acid	< 38.7	< 7.54E-07
4:2 FTS	< 1.5	< 3.01E-08
6:2 FTS	12.4	2.42E-07
8:2 FTS	< 3.1	< 6.03E-08
10:2 FTS	< 3.1	< 6.03E-08
Perfluorooctane sulfonamide	< 7.7	< 1.51E-07
N-Methyl perfluorooctanesulfonamide	< 7.7	< 1.51E-07
N-Ethyl perfluorooctanesulfonamide	< 7.7	< 1.51E-07
N-Me perfluorooctanesulfonamidoethanol	< 7.7	< 1.51E-07
N-Et perfluorooctanesulfonamidoethanol	< 93.9	< 1.83E-06
MePerfluorooctanesulf-amid oacetic acid	< 3.7	< 7.16E-08
EtPerfluorooctanesulf-amid oacetic acid	< 3.4	< 6.60E-08
TOTAL		
Sum of positive detections	297	5.78E-06

Table 17: Sample information – Odour

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		AS4323.3 - CONSTANT FLOW
Run ID		9
Test Parameter		Odour
Test Date	dd/mm/yyyy	5/03/2021
Start Time	hh:mm	8:28
End Time	hh:mm	8:34
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	54.8
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.7
Sample Volume (dry gas meter)	Nm^3	-
Stack Gas Velocity	m/sec	3.5
Actual Stack Flow Rate	m^3/min	59
Dry Standard Stack Flow Rate	Nm^3/min	20
Percent Isokinetic Rate	%	N/A
Pollutant	Concentration standard conditions	Emission Rate standard conditions
Odour	ou	ou.m^3/min
Odour Sample 1	5,522	245,540
Odour Sample 2	5,852	260,192
Average Odour	5,687	252,866

Table 18: Sample information – Hydrogen sulfide

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA M15 - CONSTANT FLOW
Run ID		10
Test Parameter		H2S
Test Date	dd/mm/yyyy	5/03/2021
Start Time	hh:mm	8:45
End Time	hh:mm	8:50
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	51.1
Dry Gas Density	kg/Nm^3	1.33
Dry Gas Molecular Weight	g/g-mole	29.7
Sample Volume (dry gas meter)	Nm^3	-
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	58
Dry Standard Stack Flow Rate	Nm^3/min	22
Percent Isokinetic Rate	%	N/A
Pollutant	Concentration standard conditions	Emission Rate standard conditions
H2S	mg/Nm^3	g/min
Hydrogen sulfide	< 0.8	< 0.02

Table 19: Sample information – Oxides of Sulfur

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 8 - ISOKINETIC
Run ID		5
Test Parameter		Sox
Test Date	dd/mm/yyyy	4/03/2021
Start Time	hh:mm	7:55
End Time	hh:mm	9:05
Average Stack Temperature	°C	84
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	50.5
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.5
Sample Volume (dry gas meter)	Nm^3	0.49
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	58
Dry Standard Stack Flow Rate	Nm^3/min	22
Percent Isokinetic Rate	%	95
Pollutant	Concentration standard conditions	Emission Rate standard conditions
Sox	mg/Nm^3	g/min
SO2	4.3	0.09
SO3 (as H2SO4)	8.0	0.17

Table 20: Sample information – Acid gases

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 26A - ISOKINETIC
Run ID		3
Test Parameter		HCl, CL2
Test Date	dd/mm/yyyy	5/03/2021
Start Time	hh:mm	7:40
End Time	hh:mm	8:45
Average Stack Temperature	°C	86
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	51.1
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.6
Sample Volume (dry gas meter)	Nm^3	0.53
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	58
Dry Standard Stack Flow Rate	Nm^3/min	22
Percent Isokinetic Rate	%	91
Pollutant	Concentration standard conditions	Emission Rate standard conditions
HCl, Cl2	mg/Nm^3	g/min
HCl	< 2.7	< 0.06
Cl2	< 1.9	< 0.04

Table 21: Sample information – Heavy metals

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 29 - ISOKINETIC
Run ID		2
Test Parameter		Metals
Test Date	dd/mm/yyyy	3/03/2021
Start Time	hh:mm	14:45
End Time	hh:mm	16:28
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	56.8
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.7
Sample Volume (dry gas meter)	Nm^3	0.79
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	55
Dry Standard Stack Flow Rate	Nm^3/min	18
Percent Isokinetic Rate	%	106

Pollutant Metals		Concentration standard conditions µg/Nm^3		Emission Rate standard conditions g/min
Antimony	<	7.2	<	1.3E-04
Arsenic	<	7.2	<	1.3E-04
Beryllium	<	0.5	<	9.7E-06
Cadmium		1.1		2.1E-05
Chromium		11		2.1E-04
Cobalt		1.3		2.3E-05
Lead		20		3.7E-04
Manganese		7.1		1.3E-04
Nickel		10		1.8E-04
Selenium	<	7.2	<	1.3E-04
Tin	<	18	<	3.2E-04
Vanadium	<	9.0	<	1.6E-04
Mercury		46.6		8.4E-04
Total Heavy Metals (Sum of positive detections)		98.0		1.8E-03

Table 22: Sample information – Volatile organic compounds

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 18 - CONSTANT FLOW
Run ID		6
Test Parameter		VOCs
Test Date	dd/mm/yyyy	4/03/2021
Start Time	hh:mm	11:40
End Time	hh:mm	12:40
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	50.5
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.7
Sample Volume (dry gas meter)	Nm^3	0.03
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	21
Percent Isokinetic Rate	%	N/A
Pollutant Total (non-methane) VOCs	Concentration standard conditions mg/Nm^3	Emission Rate standard conditions g/min
Total VOCs - as n-hexane	< 2.0	< 0.04
Total VOCs - as n-propane	< 1.0	< 0.02
Benzene	0.3	0.01

Table 23: Sample information – Ammonia

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		Mod USEPA M26 - CONSTANT FLOW
Run ID		7
Test Parameter		NH3
Test Date	dd/mm/yyyy	4/03/2021
Start Time	hh:mm	13:00
End Time	hh:mm	14:00
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	50.5
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.6
Sample Volume (dry gas meter)	Nm^3	0.05
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	21
Percent Isokinetic Rate	%	N/A
Pollutant NH3	Concentration standard conditions mg/Nm^3	Emission Rate standard conditions g/min
Ammonia (NH3) - in condensate	974	20.8
Ammonia (NH3) - gaseous	76	1.6
Total Ammonia (as NH3)	1,050	22.4

Table 24: Sample information – Combustion gases

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 3A, 7E & 10
Run ID		Various
Test Parameter		O_2, CO_2, NOx, CO
Test Date	dd/mm/yyyy	4/03/2021
Start Time	hh:mm	7:55
End Time	hh:mm	8:45
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	52.1
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.6
Stack Gas Velocity	m/sec	3.3
Actual Stack Flow Rate	m^3/min	56
Dry Standard Stack Flow Rate	Nm^3/min	20
Pollutant	Concentration standard conditions	Emission Rate standard conditions
O2, CO2, NOx, CO	STP	g/min
Oxygen (% v/v)	10.8	-
Carbon dioxide (% v/v)	7.4	-
Carbon monoxide (mg/m^3)	113	2.4
Oxides of nitrogen (mg/m^3)	65	1.3

Table 25: Sample information – Fluoride

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 13B - ISOKINETIC
Run ID		4
Test Parameter		Fluoride
Test Date	dd/mm/yyyy	3/03/2021
Start Time	hh:mm	17:13
End Time	hh:mm	18:21
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1007
Moisture Content	% v/v	51.5
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.6
Sample Volume (dry gas meter)	Nm^3	0.47
Stack Gas Velocity	m/sec	3.2
Actual Stack Flow Rate	m^3/min	54
Dry Standard Stack Flow Rate	Nm^3/min	20
Percent Isokinetic Rate	%	93
Pollutant Fluoride	Concentration standard conditions mg/Nm^3	Emission Rate standard conditions g/min
Fluorine - (as total HF)	< 2.1	< 0.04

Table 26: Sample information – Dioxins & furans

Site		Shoal Bay Landfill
Sample Location		BeneVap
Reference Method		USEPA Method 23 - ISOKINETIC
Run ID		1
Test Parameter		DF & PCB
Test Date	dd/mm/yyyy	4/03/2021
Start Time	hh:mm	11:50
End Time	hh:mm	18:00
Average Stack Temperature	°C	85
Absolute Stack Pressure	mb	1006
Moisture Content	% v/v	50.5
Dry Gas Density	kg/Nm^3	1.32
Dry Gas Molecular Weight	g/g-mole	29.7
Sample Volume (dry gas meter)	Nm^3	1.80
Stack Gas Velocity	m/sec	3.4
Actual Stack Flow Rate	m^3/min	57
Dry Standard Stack Flow Rate	Nm^3/min	21
Percent Isokinetic Rate	%	94

Pollutant DF & PCB		Concentration standard conditions ng/Nm^3		Emission Rate standard conditions g/min
2378 TCDF		0.0032		6.87E-11
Total TCDF isomers		0.050		1.07E-09
2378 TCDD	<	0.0011	<	2.37E-11
Total TCDD isomers		0.011		2.25E-10
12378 PeCDF		0.0015		3.20E-11
23478 PeCDF		0.0016		3.43E-11
Total PeCDF isomers		0.034		7.22E-10
12378 PeCDD	<	0.00056	<	1.18E-11
Total PeCDD isomers		0.0083		1.78E-10
123478 HxCDF	<	0.00056	<	1.18E-11
123678 HxCDF	<	0.0011	<	2.37E-11
234678 HxCDF	<	0.00056	<	1.18E-11
123789 HxCDF	<	0.00039	<	8.29E-12
Total HxCDF isomers		0.0053		1.12E-10
123478 HxCDD	<	0.00056	<	1.18E-11
123678 HxCDD		0.00089		1.89E-11
123789 HxCDD	<	0.00056	<	1.18E-11
Total HxCDD isomers		0.014		2.96E-10
1234678 HpCDF		0.0016		3.43E-11
1234789 HpCDF		0.00039		8.29E-12
Total HpCDF isomers		0.0032		6.87E-11
1234678 HpCDD		0.016		3.43E-10
Total HpCDD isomers		0.029		6.27E-10
OCDF		0.0014		3.08E-11
OCDD		0.083		1.78E-09
Sum of congeners Sum of positive detections		0.24		5.10E-09
Total I-TEQ Sum of positive detections		0.0016		3.32E-11

Table 27: Sample information – PCBs

PCBs (USEPA Method 23)				
		ng/Nm^3		g/min
PCB#77		0.50		1.07E-08
PCB#81		0.023		4.97E-10
PCB#126		0.0100		2.13E-10
PCB#169	<	0.0011	<	2.37E-11
PCB#105		2.6		5.47E-08
PCB#114		0.18		3.79E-09
PCB#118		6.1		1.29E-07
PCB#123		0.067		1.42E-09
PCB#156		0.60		1.28E-08
PCB#157		0.122		2.60E-09
PCB#167		0.194		4.14E-09
PCB#189		0.0156		3.32E-10
Sum of PCB Congeners				
Sum of positive detections		10.3		2.20E-07
Total TEQ				
Sum of positive detections		0.0013		2.84E-11

APPENDIX

B

SAMPLING SCHEDULE

Table 8-1 URS Monitoring Plan Water Quality Analysis Suites

Sampling Frequency	Sample Type	Analysis Suite	Ad Hoc Suite
Monthly	Groundwater	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO4), NH4, TDS, COD, TOC	N/A
	Surface Water	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO4), NH4, TDS, COD, TOC	N/A
	Leachate	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* COD, TOC	
Quarterly	Groundwater	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO4), nutrients (NH4, 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 analysis for 28 separate compounds of Per- and Polyfluoroalkyl substances	BTEXN, total phenolics
	Surface Water	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO4), NH4, TDS, COD, TOC	N/A
	Leachate	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO4), COD, TOC, Nitrate as N, NH4, TON, Reactive P, metals (dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), TRHs, PAHs, BTEXN, total phenolics, PFAS analysis for 28 separate compounds of Per- and Polyfluoroalkyl substances	N/A
Annual (Wet Season)	Groundwater	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* major ions (Na, K, Ca, Mg, alkalinity, chloride, SO_4), nutrients (NH_4, 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	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing*: Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO_4), nutrients (NH_4, TON, Nitrate as N, reactive phosphorus as P), metals (Dissolved) (Cd, CrIII, CrVI, Cu, FeII, FeIII, Pb, Mn, Ni, Zn), COD, TOC	N/A
	Leachate	*In-situ testing*: pH, Temperature, EC, DO; *Laboratory Testing:* Major ions (Na, K, Ca, Mg, alkalinity, chloride, SO_4), nutrients (NH_4, 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	N/A

Attachment 3 – Surface Water Monitoring Program and Trigger Values

		Sample Locations	**Sample Locations**								
		Site Code	SW12	SW13	SW14	GW Sump	SWStg1&2	SWStg5	GWILP	GWI5	GWI6
		Easting (m E)	709035	709065	709287	709102	709724	709003	709771	708952	709811
		Northing (m S)	8630495	8630504	8630536	8629880	8629982	8630206	8630733	8630107	8629975
Parameter	**Units**	**Trigger Value**	**Frequency**								
Field Measurement											
Flow	kL/day	-	-	-	-	-	M[3]	M[3]	C[4]	C[4]	C[4]
Water Level	measure	-	M	M	M	M[5]	-	-	-	-	-
pH	pH units	6 – 8.5[1]	M	M	M	M[5]	M[5]	M[5]	Q	Q	Q
Electrical Conductivity (EC)	µS/cm	-	M	M	M	M[5]	M[5]	M[5]	Q	Q	Q
Dissolved Oxygen (DO)	% saturation	80 – 100[1]	M	M	M	M[5]	M[5]	M[5]	Q	Q	Q
Temperature	ºC	-	M	M	M	M[5]	M[5]	M[5]	Q	Q	Q
Turbidity	NTU	-	M	M	M	M[5]	M[5]	M[5]	Q	Q	Q
Metals/Metalloids (filtered (0.45µm) and unfiltered)											
Boron (B)	µg/L	-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Cadmium (Cd)		1.4[2]	A[5]	A[5]	A[5]	A[5]	A[5]	A[5]	A	A	A
Chromium (Cr)[7]		20[6]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Cobalt (Co)		14[2]	A[5]	A[5]	A[5]	A[5]	A[5]	A[5]	A	A	A
Copper (Cu)		3[2]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Lead (Pb)		6.6[2]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Nickel (Ni)		200[2]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Zinc (Zn)		23[2]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Other											
Total Organic Carbon (TOC)	mg/L	-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Chemical Oxygen Demand (COD)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Total Suspended Solids (TSS)		10[1]	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Total Dissolved Solids (TDS)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Major Ions											
Carbonate (CO_3)	mg/L	-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Bicarbonate (HCO_3)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Calcium (Ca)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Magnesium (Mg)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q
Potassium (K)		-	M[5]	M[5]	M[5]	M[5]	M[5]	M[5]	Q	Q	Q

Sodium (Na)		-	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Chloride (Cl)		-	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Sulphate (SO$_4$)		-	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Nutrients											
Ammonia (NH$_3$ as N)	µg/L	20^1	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Nitrate (NO$_3$)		-	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Nitrite (NO$_2$)		-	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Oxides of Nitrogen (NO$_x$)		20^1	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Total Nitrogen (TN)		300^1	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Total Phosphorous (TP)		30^1	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Filterable reactive phosphorous (FRP)		10^1	M^5	M^5	M^5	M^5	M^5	M^5	Q	Q	Q
Hydrocarbons											
Total Recoverable Hydrocarbons (TRH)	µg/L	-	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
Benzene		900^2	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
Toluene		-	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
Ethylbenzene		-	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
Xylene		-	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
Naphthalene		90^2	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
PFAS (per-and poly-fluoroalkyl substances) (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)											
PFOS	µg/L	2^8	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A
PFOA		632^8	A^5	A^5	A^5	A^5	A^5	A^5	A	A	A

C – Continuous
M – Monthly
Q – Quarterly (January, April, July, October)
A – Annually (January)

[1] **–** Based on Darwin Harbour Water Objectives (Shoal Bay upper area marine ambient water quality)
[2] **–** Based on 90% species protection for marine waters ANZECC Water Quality Guidelines 2018 (ANZG 2018)
[6] **–** Based on Hexavalent chromium 90% species protection ANZECC Water Quality Guidelines 2018 (ANZG 2018)

[3] **–** Estimate the flow at the time of sampling
[4] **–** Using a flow meter
[5] **–** Only during months October to April
[7] **–** Analyse for Trivalent and Hexavalent Chromium if total chromium exceeds trigger value
[8] **–** Based on PFAS NEMP 2.0 however, trigger values for the latest NEMP must be used when available

Attachment 4 - Groundwater Monitoring Program

Parameter	**Units**	**Frequency (all monitoring bores identified in Appendix 5)**
Field Measurement		
Flow	kL/day	M[1]
Standing Water Level (SWL)	m AHD	M
pH	pH units	Q
Electrical Conductivity (EC)	µS/cm	Q
Dissolved Oxygen (DO)	% saturation	Q
Temperature	ºC	Q
Reduction Oxidation Potential (REDOX)	mV	Q
Metals/Metalloids (filtered (0.45µm))		
Arsenic (As)	µg/L	A
Boron (B)		Q
Cadmium (Cd)		A
Chromium (Cr)		Q
Cobalt (Co)		A
Copper (Cu)		Q
Lead (Pb)		Q
Lithium (Li)		A
Nickel (Ni)		Q
Vanadium (V)		A
Zinc (Zn)		Q
Major Ions		
Carbonate (CO_3)	mg/L	Q
Bicarbonate (HCO_3)		Q
Calcium (Ca)		Q
Magnesium (Mg)		Q
Potassium (K)		Q
Sodium (Na)		Q
Chloride (Cl)		Q
Sulphate (SO_4)		Q
Nutrients		
Ammonia (NH_3 as N)	µg/L	Q
Ammonium (NH_4)		Q
Nitrate (NO_3)		Q
Nitrite (NO_2)		Q
Oxides of Nitrogen (NO_x)		Q
Total Nitrogen (TN)		Q
Total Phosphorous (TP)		Q
Hydrocarbons		
Total Recoverable Hydrocarbons (TRH)	µg/L	A
Benzene		A
Toluene		A
Ethylbenzene		A
Xylene		A
Naphthalene		A
PFAS (per-and poly-fluoroalkyl substances) (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)		
PFOS	µg/L	Q
PFOA		Q
Other		
Chemical Oxygen Demand (COD)	mg/L	Q
Total Organic Carbon (TOC)		Q
Total Dissolved Solids (TDS)		Q
Organophosphate Pesticides	µg/L	A

Organochlorine Pesticides		A
Polychlorinated Biphenyls		A
Tributyltin Oxide		A
Phenols		A
Escherichia Coli	CFU 100mL	A
Enterococci		A

M – Monthly
Q – Quarterly (January, April, July, October)
A – Annually (January)
[1] – If the water level is above top of casing when measuring SWLs then estimate the flow.

Attachment 6 - Leachate Monitoring Program

		Sample Locations									
	Site Code	LP01	LP02	DW2	DW3	DW5	DW6	DW7[1]	DW8[1]	TC Sump	LMP02
	Easting (m E)	709534	709531	709029	709038	709023	709041	709450	709459	709465	709938
	Northing (m S)	8630726	8630713	8630459	8630216	8630122	8630039	8630121	8630042	8630233	8629759
Parameter	**Units**	**Frequency**									
Flow	kL/day	-	-	C[2]	C[2]	C[2]	C[2]	C[2]	C[2]	C[2]	C[2]
Water Level	measure	M	M	M	M	M	M	M	M	M	M
pH	pH units	Q	Q	B	B	B	B	B	B	B	B
Electrical Conductivity (EC)	µS/cm	Q	Q	B	B	B	B	B	B	B	B
Dissolved Oxygen (DO)	% saturation	Q	Q	B	B	B	B	B	B	B	B
Temperature	ºC	Q	Q	B	B	B	B	B	B	B	B
Turbidity	NTU	Q	Q	B	B	B	B	B	B	B	B
Metals/Metalloids (filtered (0.45µm) and unfiltered)											
Aluminium (Al)	µg/L	Q	Q	B	B	B	B	B	B	B	B
Arsenic (As)		Q	Q	B	B	B	B	B	B	B	B
Boron (B)		Q	Q	B	B	B	B	B	B	B	B
Cadmium (Cd)		Q	Q	B	B	B	B	B	B	B	B
Chromium (Cr)		Q	Q	B	B	B	B	B	B	B	B
Cobalt (Co)		Q	Q	B	B	B	B	B	B	B	B
Copper (Cu)		Q	Q	B	B	B	B	B	B	B	B
Iron (Fe)		Q	Q	B	B	B	B	B	B	B	B
Lead (Pb)		Q	Q	B	B	B	B	B	B	B	B
Lithium (Li)		Q	Q	B	B	B	B	B	B	B	B
Manganese (Mn)		Q	Q	B	B	B	B	B	B	B	B
Mercury (Hg)		Q	Q	B	B	B	B	B	B	B	B
Nickel (Ni)		Q	Q	B	B	B	B	B	B	B	B
Selenium (Se)		Q	Q	B	B	B	B	B	B	B	B
Vanadium (V)		Q	Q	B	B	B	B	B	B	B	B
Zinc (Zn)		Q	Q	B	B	B	B	B	B	B	B
Major Ions											
Carbonate (CO_3)	mg/L	Q	Q	B	B	B	B	B	B	B	B
Bicarbonate (HCO_3)		Q	Q	B	B	B	B	B	B	B	B
Calcium (Ca)		Q	Q	B	B	B	B	B	B	B	B
Magnesium (Mg)		Q	Q	B	B	B	B	B	B	B	B
Potassium (K)		Q	Q	B	B	B	B	B	B	B	B

Sodium (Na)		Q	Q	B	B	B	B	B	B	B	B
Chloride (Cl)		Q	Q	B	B	B	B	B	B	B	B
Sulphate (SO_4)		Q	Q	B	B	B	B	B	B	B	B
Nutrients											
Ammonia (NH_3)	µg/L	Q	Q	B	B	B	B	B	B	B	B
Ammonium (NH_4)		Q	Q	B	B	B	B	B	B	B	B
Nitrate (NO_3)		Q	Q	B	B	B	B	B	B	B	B
Nitrite (NO_2)		Q	Q	B	B	B	B	B	B	B	B
Oxides of Nitrogen (NOx)		Q	Q	B	B	B	B	B	B	B	B
Total Nitrogen (TN)		Q	Q	B	B	B	B	B	B	B	B
Total Phosphorous (TP)		Q	Q	B	B	B	B	B	B	B	B
Filterable reactive phosphorous (FRP)		Q	Q	B	B	B	B	B	B	B	B
Hydrocarbons											
Total Recoverable Hydrocarbons (TRH)	µg/L	Q	Q	B	B	B	B	B	B	B	B
Polycyclic Aromatic Hydrocarbons (PAHs)		Q	Q	B	B	B	B	B	B	B	B
Benzene		Q	Q	B	B	B	B	B	B	B	B
Toluene		Q	Q	B	B	B	B	B	B	B	B
Ethylbenzene		Q	Q	B	B	B	B	B	B	B	B
Xylene		Q	Q	B	B	B	B	B	B	B	B
Naphthalene		Q	Q	B	B	B	B	B	B	B	B
PFAS (per-and poly-fluoro alkyl substances) (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)											
PFOS	µg/L	Q	Q	B	B	B	B	B	B	B	B
PFOA		Q	Q	B	B	B	B	B	B	B	B
Other											
Organophosphate Pesticides	µg/L	A	A	-	-	-	-	-	-	-	-
Organochlorine Pesticides		A	A	-	-	-	-	-	-	-	-
Polychlorinated Biphenyls		A	A	-	-	-	-	-	-	-	-
Tributyltin Oxide		A	A	-	-	-	-	-	-	-	-
Phenols		A	A	-	-	-	-	-	-	-	-
Chemical Oxygen Demand (COD)	mg/L	Q	Q	B	B	B	B	B	B	B	B
Total Suspended Solids (TSS)		Q	Q	B	B	B	B	B	B	B	B
Total Organic Carbon (TOC)		Q	Q	B	B	B	B	B	B	B	B
Total Dissolved Solids (TDS)		Q	Q	B	B	B	B	B	B	B	B
Escherichia Coli	CFU 100ml	A	A	-	-	-	-	-	-	-	-
Enterococci		A	A	-	-	-	-	-	-	-	-

C – Continuous
M – Monthly

Q – Quarterly (January, April, July, October)
B – Biannually (January, July)
A – Annually (July)

[1] - Sampling points for Stage 6 leachate collection only active once Stage 6 begins to accept waste
[2] **–** Using a flow meter

Attachment 7 Emissions Monitoring Program

Substance	Units	Emission Limit^	Frequency	Test Method^
Sample Plane Criteria	-	-	During commissioning and Two months after commissioning and Four months after commissioning then Quarterly (January, April, July and October)	TM-1
Oxides of Nitrogen (NO_x) (as NO_2)	mg/m^3	350		TM-11
Hydrogen Chloride	mg/m^3	100		TM-8
Carbon Monoxide	mg/m^3	125		TM-32
Carbon Dioxide	mg/m^3	-		TM-24
Fluorine compounds (as Hydrogen Fluoride)	mg/m^3	50		TM-9
Sulphuric acid mists	mg/m^3	100		TM-13
Dioxins and Furans	ng/m^3	0.1		TM-18
Type 1 and Type 2 substances in aggregate. antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, tin or vanadium or any compound containing one or more of those elements.	mg/m^3	1		TM-12 and TM-13 and TM-14
Cadmium (Cd) and cadmium compounds	mg/m^3	0.2		TM-14
Mercury (Hg) and mercury compounds	mg/m^3	0.2		TM-14
Volatile Organic Compounds (VOCs), as n-propane [1]	mg/m^3	40		TM-34 [1]
Chlorine (Cl_2)	mg/m^3	200		TM-7
Hydrogen Sulphide (H_2S) [2]	mg/m^3	5		TM-5 [2]
PFAS (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)	µg/L	- *		-
Ammonia – N [3]	mg/m^3	-		TM-3 [3]
Odour [4]	-	-		OM-7 [4]
Polychlorinated Biphenyls	mg/m^3	-		-
Sulphur Dioxide	mg/m^3	-		TM-4

* - No limit currently set. If further revisions of the PFAS NEPM include an emission limit then the new limit will apply.

^ - Based on the New South Wales Environmental Operations (Clean Air) Regulations 2010.

[1] - The prescribed method, TM-34, will be used with modification. A moisture removal trap will be placed in front of the solid sorbent media to prevent water from entering the media. Both the condensate captured in the trap and the sorbent media will be analysed for VOCs and the results will be combined and reported.

[2] - The prescribed method, TM-5, will be used with modification. A sample of exhaust gas will be passed through a buffer solution to remove any potential SO_2 present before being captured in a specialised gas sampling bag.

[3] - The prescribed method TM-3 will be used with modification. A moisture removal trap will be placed in front of the media to prevent water from entering the tube.

[4] - The odour samples bags will be diluted beyond the suggested limit in OM-7 (AS4323.3). This is required to avoid condensation forming in the sample bags.

Attachment 8 - Depositional Sampling Program

		Sample Locations			
	Site Code	DS01	DS02	DS03	DS04
	Easting (m E)	709187	709580	709788	709252
	Northing (m S)	8630904	8631014	8630614	8630601
Parameter	**Units**	**Frequency**			
Metals/Metalloids					
Aluminium (Al)	µg/L	B	B	B	B
Boron (B)		B	B	B	B
Chromium (Cr)		B	B	B	B
Cobalt (Co)		B	B	B	B
Copper (Cu)		B	B	B	B
Lead (Pb)		B	B	B	B
Lithium (Li)		B	B	B	B
Mercury (Hg)		B	B	B	B
Nickel (Ni)		B	B	B	B
Zinc (Zn)		B	B	B	B
PFAS (per-and poly-fluoro alkyl substances) (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)					
PFOS	µg/L	B	B	B	B
PFOA		B	B	B	B
B – Biannually (January, July)					

Attachment 9 – Soil Sampling Program

		Sample Locations			
Site Code		SS01	SS02	SS03	SS04
Easting (m E)		709187	709580	709788	709252
Northing (m S)		8630904	8631014	8630614	8630601
Parameter	**Units**	**Frequency**			
Metals/Metalloids					
Aluminium (Al)	μg/L	B	B	B	B
Boron (B)		B	B	B	B
Chromium (Cr)		B	B	B	B
Cobalt (Co)		B	B	B	B
Copper (Cu)		B	B	B	B
Lead (Pb)		B	B	B	B
Lithium (Li)		B	B	B	B
Mercury (Hg)		B	B	B	B
Nickel (Ni)		B	B	B	B
Zinc (Zn)		B	B	B	B
PFAS (per-and poly-fluoro alkyl substances) (Analysis on a minimum of 28 PFAS compounds using LC-MS/MS)					
PFOS	μg/L	B	B	B	B
PFOA		B	B	B	B
B – Biannually (January, July)					