Waste Futures – Green Island Landfill Closure

Surface Water Report – October 2024 Update

Dunedin City Council

18 July 2024

→ The Power of Commitment

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The Power of Commitment

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1. Introduction

1.1 Background

As part of Dunedin's wider commitment to reducing carbon emissions and reducing waste going to landfill, the Dunedin City Council (Council) has embarked on the Waste Futures Programme to develop an improved comprehensive waste management and diverted material system for Ōtepoti Dunedin. The Waste Futures Programme includes the roll out of an enhanced kerbside recycling and waste collection service for the city from July 2024. The new service will include collection of food and green waste.

To support the implementation of the new kerbside collection service, the DCC are planning to make changes to the use of Green Island landfill site (Figure 1) in coming years.

The proposed changes include:

- planning for the closure of the Green Island landfill, which is coming to the end of its operational life
- developing an improved Resource Recovery Park (RRPP) to process recycling, and food and green waste
- providing new waste transfer facilities to service a new Class 1 landfill currently planned for a site south of Dunedin, at Smooth Hill.

The resource consents for the new Smooth Hill landfill were granted in May 2023. Depending on DCC decisions regarding development of Smooth Hill, time needed to undertake baseline monitoring, preparation of management plans, landfill and supporting infrastructure design and construction, DCC anticipate that the new Class I landfill facility, won't be able to accept waste until 2027/2028 at the earliest.

In the interim, DCC therefore plans to continue to use Green Island landfill for waste disposal. Based on Dunedin's current waste disposal rates, it is likely that that the Green Island landfill can keep accepting waste for another six years (until about 2029). Between now and then, and as it continues to fill up, the landfill will be closed and capped in stages. When the landfill closes completely, there will be opportunities for environmental enhancements and public recreational use around the edge of the site. Examples could be planting restoration projects and new walking and biking tracks beside the Kaikorai Estuary. Long term use and public access to the landfill site post closure will be determined in consultation with Te Rūnanga o Ōtākou, the local community and key stakeholders.

As current Otago Regional Council resource consents needed to operate a landfill at Green Island expire in October 2023, the DCC are now applying to ORC for replacement resource consents to continue to use the landfill until it closes completely, and waste disposal can be transferred to a new landfill facility. The replacement consents relate to ground disturbance, flood defence and discharges to land, water, and air. The site is subject to an operative designation (D658) in the Proposed Second-Generation Dunedin City District Plan (2GP) for the purpose of Landfilling and Associated Refuse Processing Operations and Activities.

The development of the new RRPP and waste transfer facilities at Green Island does not form part of the replacement consent applications. Resource consents for the development and operation of the RRPP were submitted in late 2023 and are under consideration by ORC.

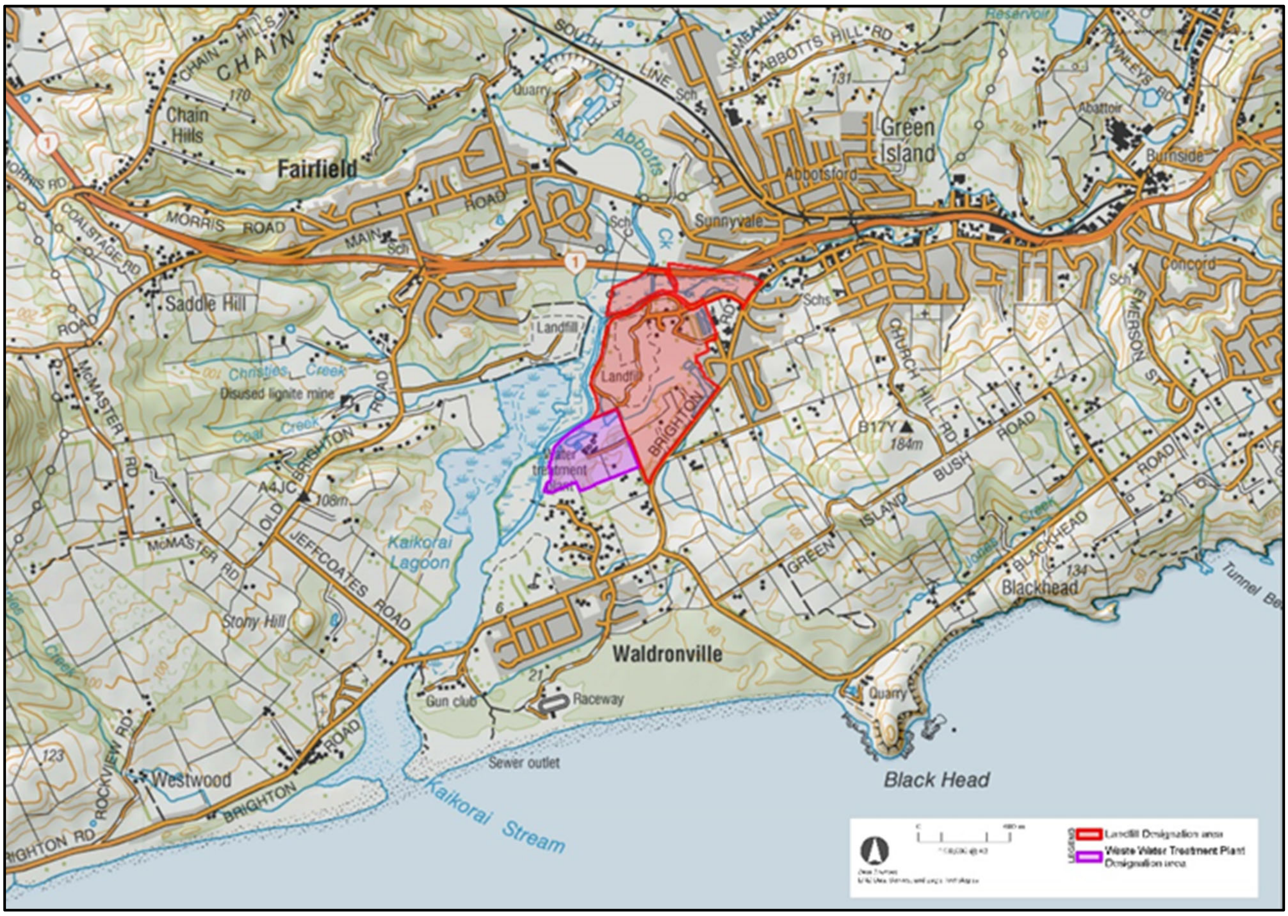

Figure 1 Green Island Landfill – site location

1.2 Purpose of this report

The purpose of this report is as follows:

– Provide an overview of the existing site hydrology, existing water management and water quality;
– Outline the proposed approach to the future operation and closure of Green Island Landfill in regard to surface water management; and
– Provide an assessment of effects on the surrounding surface water bodies associated with the current and future operation of Green Island Landfill.

This report has been updated in October 2024 to include additional information and respond to s92 questions from the ORC. This version of the report replaces the original Surface Water report issued in March 2023.

This report should be read in conjunction with the following reports:

– Green Island Landfill Design Report (GHD, 2023A)
– Groundwater Technical Report (GHD, 2024B), including Appendix D, Green Island Landfilling History and Soil Assessment Report.
– Green Island Landfill Geotechnical Factual Report (GHD, 2023C)
– Green Island Landfill Liquification and Stability Assessment (GHD, 2023D)
– Human Heath & Environment Risk Assessment (GHD, 2024)

These reports provide supporting information and context which the surface water assessment relies upon. Where appropriate, a summary of critical information is summarised in this report with crossed references to the relevant technical report.

1.3 Current landfill operation and management

1.3.1 Current consents

The operation of the Green Island Landfill, including associated waste processing operations and facilities, is currently subject to 14 existing resource consents granted by Otago Regional Council (ORC). The consents cover landfill operation activities relating to discharges to land, water, and air, taking and/or diverting water, and disturbance of a contaminated site. All consents expire on 1 October 2023.

The current consents limit the extent of landfilling through the combination of a maximum 38 ha landfill footprint, conditions limiting the deposit of waste to 270 m^3/day and 100,000 m^3/year[1] , and the 2023 term of the consents. The consent conditions do not impose any specific limit on the overall finished height, shape, or contour of the landfill. However, the plans included in the 1994 resource consent applications show a finished landfill surface rising to a maximum height of 25 m above mean sea level (amsl).

The consent conditions also require the consents are exercised in accordance with a Landfill Work Programme (LWP) prepared by the consent holder, which is to be reviewed annually or at such lesser frequency as the consent authority may approve. Among other matters, the LWP is required to describe present projections and intentions for landfill operations, and the sequencing of works[2].

1.3.2 Landfill Development and Management Plan

A Landfill Development and Management Plan (LDMP) was developed following the issuing of the consents to serve the purpose of the LWP. The LDMP is to document site-specific procedures, including monitoring and contingency actions to be implemented to ensure the landfill achieves the conditions set out in the resource consents. The LDMP is structured into the sections set out below.

1. **Introduction** – the existing resource consents, designation, and status and review of the LDMP.
2. **Site Management** – management structure, responsibilities, requirements for staff training, and community liaison.
3. **Landfill Development** – including design principles, landfill capacity, and the filling programme and sequence.
4. **Site Operations** – including controls and procedures for access control, stormwater management, leachate management, LFG management, greenwaste mulching and composting, salvage and management of diverted materials, roading and traffic management, waste acceptance and placement, waste cover, and control of nuisances.
5. **Environmental Monitoring** – including monitoring, recording, and reporting for surface water, groundwater, LFG, leachate, odour, and weather.
6. **Emergency Management** – including procedures for management of fires, hazardous waste/materials, leachate and LFG escape, extreme weather/flooding, machinery failure, accidents, and earthquakes.
7. **Closure, Reinstatement, and Aftercare** – including final capping, continued operation and maintenance of landfill infrastructure, and ongoing monitoring.

The LDMP was first provided to ORC in 1994 following the issuing of the consents and was subsequently updated in 2004, and 2007. The most recent LDMP, which reflects the current approach to landfill operation and management was provided to ORC in February 2023.

1.3.3 Landfill Operations Plan

The landfill is currently operated by Waste Management NZ Ltd. under contract to the Council. Waste Management NZ Ltd. are required to maintain a Landfill Operations Plan (LOP) which reflects the LDMP and more specifically addresses day-to-day management landfill operational matters.

[1] Resource consents 3839A V1, 3839C V1, 3839D V1, 94524 V1, 94693 V1, 94262 V1
[2] Resource consents 3839A V1, 3839B V1, 3839C V1, 3839D V1, 3840A V1, 3840C V1, 4139 V1

The LDMP (February 2023) and LOP (October 2018) will be updated after the granting of any replacement resource consents to ensure that they align with the final approved consent documentation, and any resource consent conditions.

2. Site description

2.1 Site location

The Green Island Landfill site is located approximately 8.8 km by road from central Dunedin in the suburb of Green Island. The landfill site comprises a total area of 75.6 ha, being the total designated in the Proposed Dunedin City District Plan (2GP) for landfilling related activities as shown outlined in Figure 2 below. Primary access to the site is via Brighton Road.

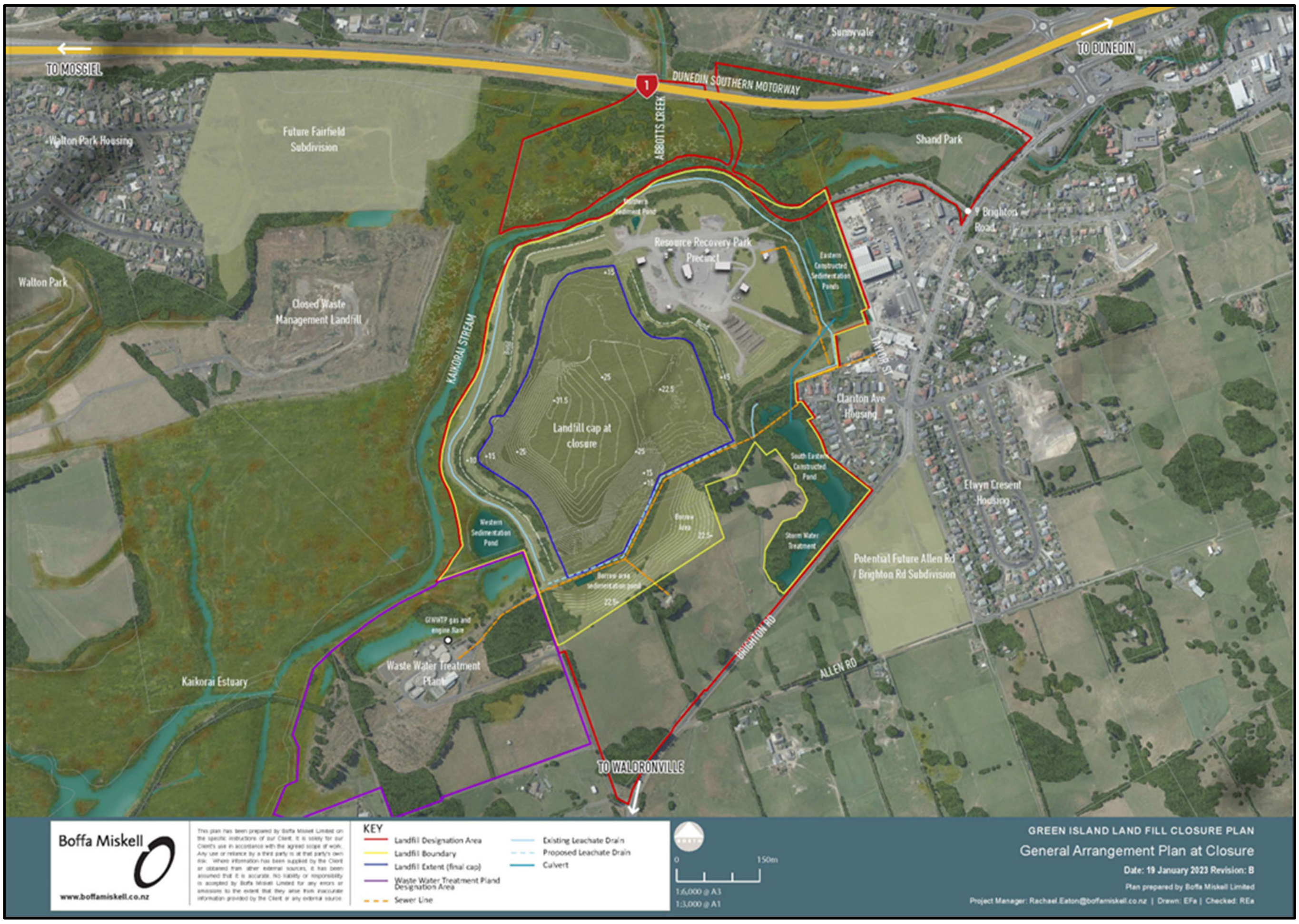

Figure 2 Green Island Landfill – site location and context

The site is generally bound by State Highway 1 to the north, the Kaikorai Stream and Estuary to the west, the Green Island Wastewater Treatment Plant (GIWWTP) to the southwest, Brighton Road to the south, and the Clariton Ave residential area and Brighton Road industrial area to the east.

The Dunedin City Council also recently rezoned a block of land between Weir Street and Brighton Road, south of Clariton Avenue, to a General Residential Zone enabling low-medium density residential living[3]

Other residential properties are located to the southeast at Elwyn Crescent, and to the north and west within Sunnyvale and Fairfield. Those residential properties are located at greater distances and separated from the landfill site by a combination of the State Highway 1 corridor, the Kaikorai Stream and Estuary, and rural and open space land. An area of undeveloped land zoned General Residential exists within Fairfield, accessed from Walton Park Avenue.

[3] Variation 2 to the Proposed Dunedin City District Plan

The margins of the Kaikorai Stream and Estuary bordering the landfill to the north and west are identified as a Regionally Significant Wetland in the Regional Plan: Water; and an Area of Significant Biodiversity Value, and a Wāhi Tupuna of cultural significance to mana whenua in the 2GP. Low lying areas around the stream and estuary are also identified as being within a Hazard 2 Flood overlay at moderate risk of flooding in the 2GP.

2.2 Landfill development history and site context

The historical placement of waste and its distribution across the site is described in detail in Appendix D of the *Groundwater Technical Report* (GHD 2024B) and the *Landfill Design Report* (GHD, 2023A). The following provides a summary of the site history and the broader catchment context that is relevant to the surface water management at the site. Section 4 provides details of the current water management approach adopted for the landfill.

- Beca (1992[4]) provides a description of the historical land use activities in the wider catchment of the Kaikorai estuary catchment, which includes the headwaters of the Kaikorai Stream and Abbots Creek. Of note:
  - The landforms in the estuary have been significantly altered from past human activities, including drainage systems to enhance reclamation for farming, the development of two landfills (Maxwell Landfill located across from Green Island Landfill), with other industries established including a brick works and mining activities (for coal, sand and gold).
  - The catchment became the preferred location of early industrial activities in the early parts of last century, with waste disposal occurring directly to the waterways of the Kaikorai. These industries included freezing works, cement factory, mills, used oil refinery and tanneries.
  - The construction of the Green Island sewer pipeline in the early 1930s, but it was not until the middle of last century that some of the major polluters connected to the sewer, with some ongoing industrial discharges occurring through to the 1970s.
- The Green Island Landfill (waste placement started in the 1950s) and the Maxwell Landfill (which started filling in 1968) was reported by Beca (1992b[5]) as covering approximately 30% of the estuarine environment at the time. Maxwells Landfill (also referred to as Fairfield Landfill) when into closure and maintenance in 2018.
- Industrial land use within the Kaikorai estuary catchment continues to present day. Within the Abbots Creek catchment is the Fairfield Quarry, whilst the Kaikorai Stream catchment has a range of industrial activities currently occurring, including Burnside Landfill which operates as a Class 2 landfill.
- Before waste was placed at the site in the 1950s the hydrology would have been characterised as a tidal estuary associated with the upper reaches of the Kaikorai Estuary, with surface water catchments of Abbots Creek and Kaikorai Stream flowing into the estuary in the immediate vicinity of the landfill site.
- Waste was originally end dumped directly onto the estuarine muds and up against the southern estuary edge where the pre-existing landform rises gently to a hillslope to south. Historical management of stormwater and surface water at the site pre-1990s is not well understood. However, following the 1994 consent process, a range of site improvements were made to manage the effects of the landfill on the surrounding environment. These included the construction of stormwater detention basins (referred to as the eastern and western sedimentation ponds), the construction of a leachate interception trench, and some minor works associated with the conveyance of stormwater into these collection systems.
- The realignment of a section of stream channel between Brighton Road and the confluence with Abbots Creek was undertaken to facilitate the access road and new stormwater management infrastructure.
- The formation of the landfill also filled a number of small channels that drained the floodplain and blocked the flow path from the catchment to the southeast of Brighton Road, forming the South-Eastern Constructed wetlands and necessitating the piping to the Eastern Constructed Wetland (a remnant branch of the original channel) adjacent to the Brighton Road access to the site (see Drawing 12547621-01-C402).
- DCC undertook work to manage the flow-on of clean stormwater water from the hill catchment to the east. This involved the construction of South Eastern Constructed wetlands, culverts, and realignment of the

[4] Beca (1992) Environmental Impact Assessment of the Existing Green Island Landfill. Report prepared by Beca Steven, May 1992.
[5] Beca (1992b): Environmental Impact Assessment of the Extended Green Island Sanitary Landfill. Report prepared by Beca Steve, October 1992.

unnamed tributary referred to as Eastern Constructed Wetland, which discharges into the Kaikorai Street beneath Taylor Street via a culvert with flood control valve installed.

– To the south-west of the site, immediately adjacent to the western sedimentation pond, a constructed pond was established to collect and polish runoff from the eastern hill catchment. Further amendments to the hydraulic functioning of the Western Sedimentation Pond and the SW Pond were undertaken in the early 2000's. These changes are documented in Appendix C.
– Recent improvements to the surface water management at the site have been made as a result of the placement of final capping to parts of the landfill, which has resulted in stormwater being directed away from the open areas of the landfill and towards the constructed sedimentation ponds.

The redevelopment of the site and installation of the leachate collection system combined with the constructed ponds and wetlands in the 1990s has formed the foundations of the current surface water management systems in operation at the site. In addition, more recent improvements to the leachate collection system have been made by DCC. These improvements include the installation of horizontal drainage to collect leachate from areas in the north and south-west of the landfill, areas where waste filling has been recently completed or still occurring. These drains are directly piped to pump stations 3 and 5 on the leachate interception trench (Figure 3). This work also included the construction of the Northern Leachate Pond, which is located near the weighbridge at the northern part of the landfill, as shown in Appendix A of the Design Report (2023A). Other related systems, including leachate management, are described in the Design Report (2023A) and the Groundwater Technical Assessment report (2024B).

The construction of the Northern Leachate Pond in 2019 was undertaken to collect stormwater which may be impacted by waste. There was also leachate drainage installed in the northern part of the landfill, which collects leachate and directs it to Pump Station 5. These drains are buried below capped surface and adjacent to the stormwater drainage channels, which are lined with geocomposite material (Figure 4). The Northern Leachate Pond now takes stormwater runoff from the access road that does not otherwise infiltrate and enter into the underlying leachate collection drains.

The Northern Leachate Pond was used to collect overland flow via direct swale discharge from the access road of the active waste filling area in the northern part of the landfill from 2019-2021. The pond has a piped outlet which allows trickling of impacted water to be conveyed to the leachate collection trench). Since the capping of the northern part of the landfill was completed, the Northern Leachate Pond continues to act as a sedimentation pond, as it receives stormwater runoff from open swales from the landfill access road as well as sediment laden waters from the capping works which were completed in 2022. The stormwater from the access road and the capped areas is very unlikely to be impacted by leachate generated from waste disposal at the tip face. Leachate impacted runoff from tipface activities is collected by the western leachate drainage system and discharged into PS3.

Water from this pond is directed to the GIWWTP via the rising main of the perimeter leachate system. However, in prolonged high rainfall events water from this pond may overflow where the capacity of the pond is exceeded, to the perimeter swales and discharge to the Kaikorai Stream via a culvert.

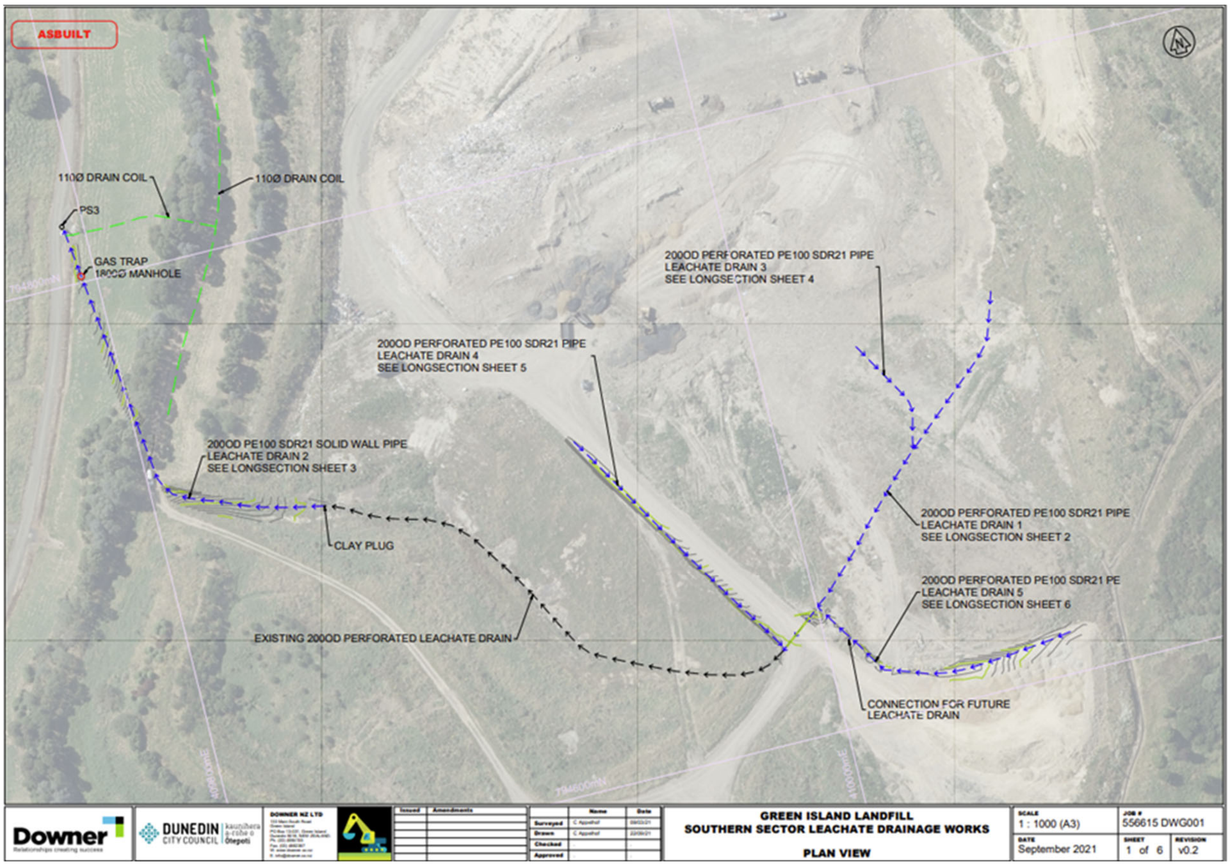

Figure 3 ***Asbuilt for horizontal leachate collection drain and connection to PS3***

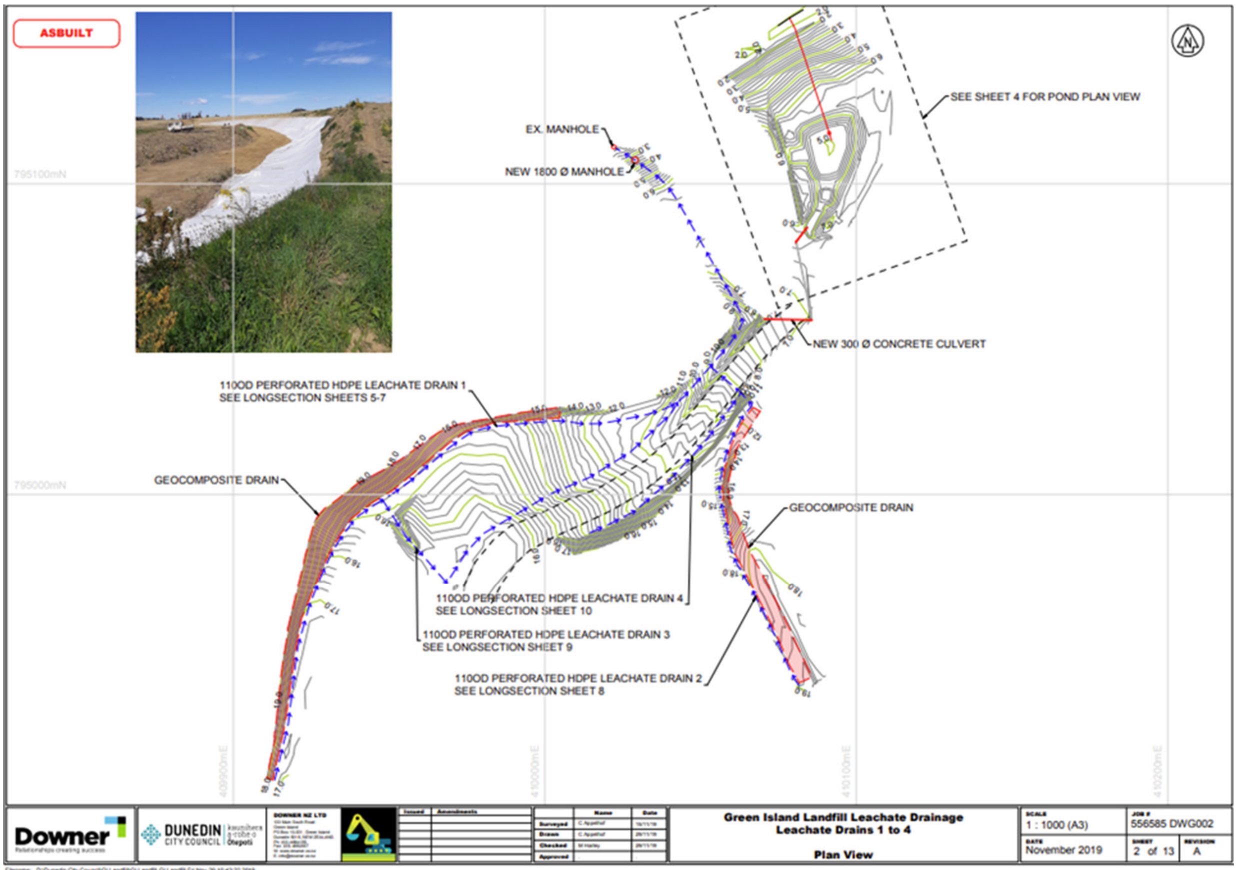

Figure 4 ***Northern leachate drains and pond***

Overflows have occurred on two occasions (pers. Comm. Lincoln Coe, Landfill Engineer, DCC). These were on 12th and 26th July 2022

The 12 July 2022 event rainfall depths and Annual Exceedance Probabilities (AEP) were as follows:

- 55.4 mm in 12 hours, 20% AEP (5 year return period)
- 79.8 mm in 24 hours, 20% AEP (5 year return period)
- 106.7 mm in 48 hours, 12.5% AEP (8 year return period)

Total rainfall for the event of was 112.7 mm.

The event commencing on 26 July generated slightly lower rainfall volumes with the 24 hour event having a 25% AEP and the 48 hour event 20% AEP. Although it is noted that this event was only two weeks after that of the 12 July and 20 mm of rainfall had fallen during this period so that the catchment will have been saturated providing little antecedent storage of rainfall.

The overflow events occurred in July 2022 when the earthworks for the capping had been completed but the vegetative cover was not yet established. With the cover now established, the percentage of rainfall discharging as surface flow will have reduced. This will reduce the frequency of pond overflows.

3. General Description of the Environment

The historical siting of the landfill within an estuary environment is not uncommon in New Zealand, with many municipal landfills located in low-lying areas adjacent to water ways or within the coastal marine area environs. The Green Island Landfill is no different, with the landfill being primarily constructed on the upper parts of the low lying Kaikorai Estuary. While the landfill extends up to a height of 25 m amsl, the land on which it has been constructed is low lying. The western perimeter access road between the landfill and Kaikorai Stream is between 1.5 m - 2.0 m amsl having been built directly over the estuary sediments.

The location of the landfill and the low-lying nature of the surrounding estuary environment poses some issues for water management at the site. The following section provides a general discussion of the environment which has the potential to affect the proposed water management approach for the site.

3.1 Climate

As the site is located in the lower parts of the Kaikorai Stream catchment, where flows from the Abbots Creek catchment discharge into the estuary, the impact of rainfall on catchment inflows and water levels in the estuary are important to characterise.

Musselburgh climate station is a NIWA station (ref No. 1572) located 7.5 km to the east of Green Island Landfill and climate information from the station will be indicative of conditions at the landfill site. The average temperatures range from 13.9oC in Summer (January) to 5.0oC in Winter (July), with frequent frost and occasional snow reported (National Institute of Water and Atmospheric Research (NIWA), 2022). The average yearly precipitation is 806 mm per year. Most precipitation falls in December with an average of 102 mm, whilst July is the driest month on 43 mm.

Table 1 Average monthly temperature and rainfall distribution for Dunedin (Source: climate-data.org)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Avg. Annual
Avg. Temperature °C	13.9	13.8	12.7	10.3	8	5.7	5	6.1	7.9	9.3	10.8	12.8	9.69
Min. Temperature °C	10.9	10.9	9.8	7.6	5.4	3.2	2.5	3.2	4.6	6	7.8	9.9	6.82
Max. Temperature °C	17.7	17.5	16.5	13.8	11.3	8.8	8.4	9.6	11.8	13.3	14.8	16.6	13.34
Rainfall (mm)	95	75	62	58	57	49	43	48	54	80	83	102	67.17
Humidity	75%	76%	76%	78%	80%	81%	79%	80%	75%	73%	72%	75%	77%
Wind speed* (km/hr)	3.2	3.1	2.8	2.9	2.6	2.6	2.7	2.7	3.1	3.3	3.1	3.2	2.94

* Wind speed has been measured over 2018 – 2021 in the Dunedin – Musselburgh weather station

3.2 Topography

The landfill is located in the Kaikorai Catchment, in the low-lying portion of the catchment near the coast. The Kaikorai Catchment rises from the coast to a high point of 668 m at Flagstaff hilltop. The Chain Hills form the western and north-western boundary of the catchment. The Kaikorai and Round Hills form the and northeast boundary, and Saddle Hill forms the west boundary. The hills surrounding the low-lying portion of the catchment are characterised by steep gradients.

3.3 Geomorphology

The estuarine environment of the Kaikorai Estuary reflects the physical processes which are associated with the interaction between the upstream hydrology and geological environment, which had resulted in erosion of sediment from the hills with the subsequent deposition of this sediment within the low energy environment of the estuary. When combined with the nearshore coastal dynamics, which influence the behaviour of the barrier arm at the mouth of the estuary and restricts the direct connection of the estuary to the sea, the estuary can be characterised as a sediment sink, with the gradual infilling of the estuary occurring over geologic time scales. The processes which affect the interaction between the estuary and the coastal zone have a direct influence on the water levels in the estuary.

The mouth of the estuary has been actively managed via the local authority to ensure that flooding of the low-lying margins of the estuary and the lower reaches of the Kaikorai Stream and Abbots Creek is minimised. The current management regime adopted by ORC is to maintain water levels at the Brighton Road bridge to be below 101.6 mRL.

3.4 Catchment Hydrology

The Kaikorai Catchment comprises natural areas of bush, but has been heavily altered by residential, industrial, and agricultural development. The landfill is located in the Kaikorai Estuary, which has a total contributing catchment of 49 km2 above the Brighton Road bridge. The Green Island and Maxwell Landfill (discussed in Section 2) have together reduced the estuarine area by approximately 30%.

The Kaikorai Stream flows from the Chain Hills upstream of the landfill to the northeast, flowing through Green Island, and discharges into the Kaikorai Estuary in the general vicinity of the landfill, downstream of the confluence of Abbots Creek and Kaikorai Stream.

The Kaikorai Stream historically ran through where the Landfill is now. However, the stream was diverted along the western boundary of the Landfill to run in a southwest and southerly direction, towards the Kaikorai Estuary and ultimately the sea. The stream forms the northern and western limits of the landfill before flowing into the Pacific Ocean near Waldronville. The Abbots Creek confluence on the Kaikorai stream is located where the Kaikorai stream borders the Green Island Landfill to the north.

There are no known continuous flow monitoring sites in the Abbotts Creek or Kaikorai Stream catchment. Beca (1992) referenced a historical flow gauge site at Donald Street, which indicated flows were on average 318 L/s (mean annual flow from 1983-1986). Donald Street is located approximately 4.5 km upstream of the Abbots Creek confluence, within the Kaikorai Valley. Beca (1992) derived a low flow for the Kaikorai Stream based on a catchment yield at low flow of 1.9 l/s/km2, which equated to a low flow for the stream at the landfill of 46 L/s.

NIWA online NZ River Map tool was used to provide a base understanding of the flow characteristics of the Kaikorai Stream and Abbots Creek. Flow statistics for FRE3[6], mean flow, and mean annual low flow for Kaikorai Stream and Abbots Creek are presented in Table 2 for the segments directly upstream and downstream of the Abbots Creek confluence. The mean flow derived from NIWA for the Kaikorai Stream is in the same order of magnitude as the historical data measured at Donald Street, whilst the mean annual low flow is very close to the value derived by Beca (1992).

Table 2 Summary data of Kaikorai Estuary catchment data (Source: NIWA NZ River Maps)

Location	FRE3	Mean flow (L/s)	Mean annual low flow (L/s)
Abbots Creek – upstream of confluence	13.3	123	29
Kaikorai Stream – upstream of Abbots Creek confluence	12.8	227	49
Kaikorai Stream – downstream of Abbots Creek confluence	12.7	368	81

The water levels in the Kaikorai Estuary are tidally influenced. Monitoring in the Kaikorai Stream adjacent to the landfill at monitoring site ST4 has occurred over the past several years using a pressure transducer. The results of the monitoring are presented in the Annual Monitoring Reports, with the most recent 2022 / 23 report provided

[6] FRE3 is the average number of high flow events per year that exceed three times the median flow.

in Appendix B. The data shows a clear tidal influence on water levels, with an amplitude of generally half a metre between low and high tides. This amplitude can be greater than half a metre when the mouth of the estuary is closed. The mouth typically following a storm event in the catchment where increases in flows creates an opening through the barrier arm, or the Otago Regional Council mechanically open it to lower water levels in the estuary.

The development of the Green Island Landfill on the estuary deposits has resulted in changes to the catchment drainage pathways for the land to the south, along Brighton Road. As part of the historical works associated with the landfill development, surface water runoff was directed to constructed wetlands between Brighton Road and Clariton Avenue (referred to as the South-Eastern Constructed Wetlands). These features were connected to another constructed wetland (Eastern Constructed Wetland) via a culvert structure (as described above). There is no specific information on flows from the hill catchment which contributes to these constructed wetlands. Runoff from the borrow area shown on Drawing 1257642-01-C402 and the immediate surrounds and hillsides above are directed towards a recently constructed Borrow Area Sediment Pond before discharging into the surface leachate drain that is directed to pump station 1 (PS1).

3.5 Surface water quality

Surface water quality upstream of the landfill in the Kaikorai Stream and Abbotts Creek has been impacted by past and current land use practices, which include heavy industrial, landfilling (including the Maxwell closed landfill on the opposite side of the estuary from Green Island landfill), quarrying, and agricultural activities. As briefly described in Section 2.2, the development of heavy industrial activities in the Kaikorai Stream catchment in the early to middle of last century had a significant impact on water and sediment quality in the catchment. Whilst in the estuary, the use of the land for waste disposal activities since the middle of last century has likely resulted in a significant impact on the estuary water quality up until actions were taken to intercept landfill leachate discharges in the 1990s (particularly with the installation of the Green Island Landfill leachate interception trench – see the *Design Report* (GHD 2023A)). Leachate control at Maxwells/Fairfield landfill is also via an interception drainage system where groundwater levels are depressed via pumping. The pumped combined leachate and groundwater is discharged at both sites into the sewer.

The Q3 2022 compliance monitoring results for Fairfield were reported by Pattle Delamore Partners (PDP) to ORC on 1st September 2022. The water quality results contained in that report included monitoring sites outside the leachate collection drainage system, within the Kaikorai Estuary and Stream. The results indicated that ammoniacal-nitrogen concentrations recorded in July 2022 at site FH40 (monitoring site within the Kaikorai Estuary near Fairfield Landfill) was 2.1 mg/L, whilst at site EW43 (which is in Kaikorai Stream near GI3) was an order of magnitude lower at 0.23 mg/L, and consistent with the concentrations recorded at GI3. The monitoring report made reference to an issue with the pumping system at Fairfield, which could have contributed to the higher results in FH40. PDP (2022) note that the result from FH40 of 2.1 mg/L was within historical ranges for that site.

The resource consents (3840A_V1 and 3839A_V1) for the Green Island landfill include a suite of conditions that require the monitoring of surface water quality. The latest annual monitoring report includes monitoring results from four surface water locations within the Kaikorai Estuary catchment and from the two sedimentation ponds, namely:

- GI1 – upstream of the landfill at the Brighton Road bridge
- GI2 – Abbotts Creek at the Main Road bridge
- GI3 – below the confluence of Abbots Creek and Kaikorai Stream, and adjacent to the landfill
- GI5 – Kaikorai Estuary – downstream of the Western Sedimentation Pond discharge
- Eastern Sedimentation Pond
- Western Sedimentation Pond

Appendix A includes a figure which shows the locations of these monitoring points relative to the Green Island Landfill. As part of the existing monitoring requirements for the operation of Green Island Landfill, surface water monitoring is undertaken on a quarterly basis, in January, April, July and October, at the specific locations at the landfill and in adjacent surface water bodies in accordance with consent conditions. An annual monitoring report is prepared for the 1 July to 30 June period each year. A copy of the Green Island Landfill Annual Monitoring Report for 2022 / 2023 is included in Appendix B of this report.

The surface water monitoring of the Kaikorai Stream is undertaken to assess / identify any leachate effects from the landfill activities downstream of the landfill.

3.5.1 Kaikorai Stream and Abbotts Creek Results

Discussion of table and figure numbers in the following sections refer to those in the annual monitoring report for 2022/2023, included in Appendix B.

The samples collected are analysed for a range of analytes including metals and nutrients in accordance with consent conditions (3839A_V1). In addition, parameters such as pH, dissolved oxygen, electrical conductivity and temperature are measured in the field during monitoring. This analytical suite provides a reliable set of parameters to use to indicate the potential for landfill leachate discharge to the surface water receiving environment, noting that the estuarine environment will have naturally elevated chloride concentrations.

The consent does not require that the results are compared to any guidelines or standards, only that they are tabulated, and trends discussed in the annual report. Nonetheless, the analytical results reported each year by the Council are compared to ANZG (2018) guidelines for freshwater and also marine water, at the 80% toxicant default guideline value (DGV) (commonly used in urban and impact stream catchments), and more recently the NPS Freshwater Management (2020) as indicators of water quality. A further comparison has been made in the table provided in Appendix C to the ORC Water Regional Plan – Schedule 15 and Schedule 16A for the surface water sites (excluding the Eastern and Western Sedimentation Ponds).

The NPS National Bottom Line (NBL) values and ANZG default guideline values have been derived for ammonia at a pH of 8 and a temperature of 20^{o}C, as the toxicity of this contaminant is influenced by these parameters. Both the ANZG and the NPS require that the laboratory reported concentration for total ammoniacal nitrogen be corrected for pH and temperature to allow for comparison with the DGVs and NBLs. The 2022 - 2023 monitoring year's data has been corrected for this and are presented in Table C-5 – Appendix B. However, the data presented on the total ammonia graph in Figure C4-4 – Appendix B has not been corrected as historical temperature data was not available.

The 80% species level of protection was chosen as the Kaikorai Stream is considered to be a highly disturbed system. In addition, the 2022 - 2023 analytical results have been compared to the historical statistical data obtained between 2007 and 2016 (Delta, 2017) and the historical data collected by GHD.

Results are presented in Table C5 of Appendix B along with laboratory reports.

The 2022 - 2023 monitoring year analytical data are plotted in Figure C4-1 to Figure C4-4 in Appendix B and a discussion of trends is provided in Section 5.5 of the annual report.

Surface water monitoring locations GI1 and GI2 are located upstream of the landfill and GI3 and GI5 are located adjacent to and slightly downstream of the landfill respectively. This allows an evaluation of the potential effects of any discharge from the existing landfill and associated operations on surface water quality. A summary of the observed trends is as follows:

- Reported concentrations in the upstream monitoring locations of aluminium, copper, nickel and lead are generally greater than or similar to those reported at the downstream monitoring locations. The trend in nitrate concentrations followed a generally similar pattern over the monitoring year at each sampling point. It can be noted that the water coming from upstream of the landfill and from Abbots Creek contributes the majority of the nitrate concentration downstream of the landfill.
- It is likely that the significant rainfall event in the middle of July 2022 affected surface water quality in both Abbotts Creek and Kaikorai Stream, leading to elevated concentrations of contaminants for a period, in particular aluminium and nitrate, at all monitoring locations.
- Cyanide was reported present at concentrations above the adopted ANZG freshwater guideline at the upstream monitoring locations GI1 and GI2, and at GI3 in January 2023. It was not reported present above the laboratory limit of reporting (LOR) at GI5 over the monitoring year.
- Based on the available analytical results, the likely sources of heavy metals (aluminium, copper and nickel) are from the Abbotts Creek catchment and the industries upgradient of the landfill in the Kaikorai Stream catchment, both contributing to the overall concentrations.

– It is apparent that the surface water quality upstream of the landfill, in both the Kaikorai Stream and Abbotts Creek, has been impacted by industrial and agricultural activities. Overall, the impact of the landfill discharges on water quality in the Kaikorai Stream is indiscernible from broader catchment influences. This indicates the leachate/groundwater control systems described in Section 2.2 are effective.
– The more elevated chloride concentrations and EC measurements at GI3 and GI5 are reflective of generally more saline, estuarine conditions than at the more upstream monitoring locations.

3.5.2 Sedimentation Pond Results

Consent required monitoring is also undertaken at the two silt retention ponds (sedimentation ponds), being the Eastern Sedimentation Pond (ESP) and Western Sedimentation Pond (WSP) at the landfill. As discussed previously, sampling of these ponds is undertaken on a quarterly basis. Note the WSP is not currently used for managing stormwater discharges from the landfill, with no direct discharges occurring (see Appendix C).

The samples collected are analysed for a range of analytes including metals and nutrients. In addition, parameters such as pH, dissolved oxygen, electrical conductivity and temperature are measured in the field during each monitoring event.

Condition 6(ii) of the consent specifies that the trigger levels to be used must be calculated from the mean value of the monthly data obtained during the first year of this consent plus or minus 3 standard deviations of the data set. As this consent was re-issued on 5th July 2007, the data collected during the 2007-2008 monitoring year has been used to derive the relevant trigger values (referred as ORC Condition 6(ii)).

In addition, the laboratory reported analytical results have been compared to ANZG (2018), 80% of species level of protection, DGVs and the NPS Freshwater (2020) NBL values, as an indication of water quality. However, as the sediment ponds are not natural water bodies but are a constructed treatment system, the use of the DGVs is simply to provide a reference to the expected receiving environment and does not account for the mixing zone associated with the discharge.

The NPS NBL values and ANZG default guideline value have been derived for ammonia at a pH of 8 and a temperature of 20^0C, as the toxicity of this contaminant is influenced by these parameters. Both the ANZG and the NPS require that the laboratory reported concentration for total ammoniacal nitrogen be corrected for pH and temperature to allow for comparison with the adopted DGV and NBLs. The 2022-2023 monitoring year’s data has been corrected for this and are presented in Appendix B - Table C-6. However, the data presented on the total ammonia graph in Appendix B - Figure C5-6 has not been corrected as historical temperature data was not available.

The 2022 - 2023 monitoring year analytical data are plotted in Figure C5-1 to Figure C5-6 in Appendix B and trends are discussed in Section 5.6 of the Annual report.

The analytical and field data collected during the 2022 - 2023 monitoring year, along with available historical data, have been plotted against time and plots are shown in Figures C5-1 through to C5-6 of Appendix C of the Annual report.

A summary of the results is as follows:

– An overall reduction in nitrate concentrations was observed at both ponds between June 2017 and April 2022. In the 2022 / 2023 monitoring period for the ESP, the concentrations fluctuated slightly and remained within the historical ranges while for the WSP, a significant increase in concentration was reported in July 2022 (exceeding both the Consent 3840C_V1 derived trigger value and ANZG freshwater DGV), before returning to a more consistent level in October 2022 and for the remainder of the monitoring year. This is likely due to the significant weather event which occurred at this time (over 100 mm of rain over the monitoring period).
– Fluctuations in zinc concentrations have tended to follow similar patterns in the two ponds. However, this has not been the case since April 2022 where concentrations have varied independently.
– Measured pH values have tended to be similar in each pond and follow relatively similar trends. An increase of the pH values was recorded at ESP in October 2022 and January 2023 before reducing to a more consistent level in April 2023. The pH value in January 2023 also increased in the WSP, however, not to the same extent as what was recorded for the ESP.

- In the ESP monitoring location , since April 2021 (where concentrations of lead were reported as being below the laboratory(LOR)), concentrations have increased to above the Consent 3840C_V1 derived trigger value in both July 2022 and January 2023. The lead concentration reported in April 2023 indicated a decrease in concentration. Similar to the ESP, reported concentrations of lead in the WSP increased from being below the laboratory (LOR) in October 2021 and continued to increase, exceeding the Consent 3840C_V1 derived trigger value in October 2022. Reported concentrations in January and April 2023 show a decreasing trend.
- Chloride concentrations tend to be greater in the WSP than in the ESP. Reported chloride concentrations in the WSP exceeded the Consent 3840C_V1 derived trigger value in January 2023 while reported chloride concentrations for the ESP have not exceeded the applicable trigger value over the whole monitoring period (2003 to 2023).
- It can be noted that fluctuations in concentrations for certain metals such as nickel and chromium, follow relatively similar patterns to those described above, within their respective historical ranges.
- Electrical conductivity values at the ESP tend to be relatively stable whereas those measured at the WSP fluctuate over a greater range. Values measured at the WSP have been greater than at the ESP since July 2019, which is likely due to the influence of proximity and connection with the saline waters and sediment of the estuary.
- Reported concentrations of copper have followed a similar trend in concentrations for both ponds since October 2020 until April 2023, when the concentration increased at the WSP but decreased at the ESP. A new minimum concentration has been reported in ESP in April 2023.
- Total ammoniacal nitrogen concentrations (uncorrected) have varied over five orders of magnitude since April 2007. There is a moderate correlation in the fluctuations in concentrations at the two ponds, and a decrease in concentrations is noted at the ESP following the October 2022 monitoring event while concentrations reported in the WSP increase.

3.5.3 Monitoring of the Northern Leachate Pond

As the Northern Leachate Pond was constructed after the granting of the consent (3940A_V1), monitoring is not required and as such conditions are not set. However, to understand the quality of the sediment and water within the pond, sampling was undertaken in early 2023.

A sample of the sediment at the base of the pond was collected on the 20th February 2023 and was laboratory analysed for a suite of nine heavy metals, semi volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene and xylenes (BTEX). At the time of the collection of this sediment sample, there was no water present in the pond.

Following a rainfall event (20.5 mm) on the 5th March 2023, a sample was collected of the stormwater runoff collected in the pond on the 6th March 2023. This sample was laboratory analysed for a suite of heavy metals (total and dissolved), ammonia, SVOCs, BTEX and TPH.

The results of the sediment analysis have been tabulated and compared against the following guidelines / standards:

- Adopted ANZG guidelines,
- Adopted background values
- Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS) Commercial / Industrial and Recreational land use soil contaminant standards (SCS).
- Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand.

The results of the stormwater analysis were compared against the relevant ANZG Freshwater species protection guideline values.

The analytical data collected in February and March 2023 for the sediment and stormwater is presented in Table C7-1, C7-2 and C7-3 included in Appendix C of the Annual report (Appendix B).

A summary of the results for the Northern Leachate Pond is as follows:

– Sediment:
  - Heavy metals were not reported at concentrations above any of the adopted guidelines and standards.
  - No SVOCs or BTEX were reported at concentrations above the laboratory LOR
  - Low concentrations of TPH were reported present in the C15-C36 range (heavy end).
– Stormwater
  - Dissolved oxygen was reported at a value above the 80% ANZG guideline range.
  - Total and dissolved copper were reported at concentrations above the ANZG 80% species default guideline value (DGV).
  - No BTEX, TPH or SVOCs were reported present at concentrations above the LOR.

Overall, the quality of the sediment and stormwater within the Northern Leachate Pond is reflective of the environment of the contributing catchment, with only copper being present at concentrations above the adopted guideline value. As discussed earlier in this report, while the Northern Sediment Pond is at risk of continuing to receive leachate contaminated water, discharge from the pond during all but the extreme rainfall events are to the leachate collection system.

3.5.4 Sediment Pond Quality Summary

In the WSP, the hydraulic connection to the estuary via the SW Pond is likely to have influenced the electrical conductivity values and chloride concentrations, which are higher than those measured in the ESP. Both analytes have increased between July 2022 and January 2023 before decreasing in the April 2023 monitoring event.

The reported concentrations of nitrate, zinc, chloride, pH, copper and dissolved oxygen exceeded the ANZG 80% DGVs in various monitoring events at either pond throughout the 2022 – 2023 monitoring period. Overall, the water quality in the WSP Pond is slightly better than that in the ESP.

3.5.5 Overall surface water quality comments

The results from the streams and estuary indicate that all sites exhibited the influence of an impacted urban to peri-urban catchment, with the upstream sites exhibiting dissolved metal concentrations and nutrient concentrations that would be expected in these types of land use settings. The sites adjacent to and downstream of Green Island Landfill do not exhibit any significant changes in dissolved metal concentrations that would otherwise be a strong indicator of leachate discharge to the environment. The variability in the conductivity readings that are recorded for GI3 and GI5 are reflective of the estuarine environment and the tidal influence that occurs, and the results are not a good indicator of impacts from the landfill. The nutrient suite also indicates a lack of direct and significant water quality impacts from the landfill on water quality, whilst cyanide has been recorded on occasion at all sites.

The monitoring results from the ESP and WSP contained in Table C6 of the Annual Monitoring Report (Appendix B) exhibit slightly more impacted water quality than the sites outside the landfill boundary. This is not unexpected given the hydraulic nature of the ponds (i.e. to detain water and settle sediments). Despite this, the historical data set for dissolved metals does not indicate persistent and significant levels of contamination of the pond water from landfill activities, with results from the last year all below the trigger concentrations set by condition 6(ii). This also applies to the nutrient concentrations, with Ammoniacal-Nitrogen concentrations measured in the past year below the trigger level set in Condition 6(ii). Overall, the sedimentation ponds are functioning as intended, with the water quality within expected ranges. However, when compared to ANZG (2018) guidelines, some of the analytes exceed the guideline values. This is not unexpected, as the ANZG (2018) are not intended to be used for stormwater treatment pond systems (i.e. these are not natural systems).

Water quality data for the Kaikorai Stream from a monitoring site approximately 200 m upstream of GI1 is reported by ORC and made available via the LAWA website. The monitoring is aimed at key water quality indicators associated with nutrients, sediment, and bacteria. The Kaikorai Stream is characterised as a lowland urban site, with the attribute bands (defined in the NPS-FW) and 5-year median concentrations provided in Table 3.

Table 3 Kaikorai Stream Monitoring Data from LAWA

Analyte	Attribute Band	Trend	5-year median concentration
E. coli	E	Very likely degrading	925 n/100ml
Turbidity	-	Likely degrading	3.05 NTU
Total Oxidised Nitrogen	-	Very likely degrading	0.415 mg/L
Ammoniacal-N	C	Very likely degrading	0.011 mg/L
Dissolved Reactive Phosphorus	B	Very likely degrading	0.008 mg/L

3.5.6 Additional Monitoring – PFAS

In October 2022, January, April and August 2023 and January 2024 additional water sampling was undertaken for the presence of Persistent Organic Pollutants (POP), specifically PFOS and PFOA. The sampling was undertaken as landfills and industrial activities are a known source of these contaminants. Water samples were collected from the perimeter groundwater monitoring wells, surface water monitoring sites, sedimentation ponds, and the leachate collection system. A summary of the analytical results from the surface water samples are provided in Table 4 below, with the full set of results provided in Appendix C. The reported data from October 2022 was not included due to identified laboratory contamination issues.

Table 4 Total PFAS / PFOA in Surface Water

Site	January 2023		April 2023		August 2023		January 2024	
Date	Total PFOS (µg/L)	PFOA (µg/L)	Total PFOS (µg/L)	PFOA (µg/L)	Total PFOS (µg/L)	PFOA (µg/L)	Total PFOS (µg/L)	PFOA (µg/L)
Eastern Sedimentation Pond	Not monitored	Not monitored	0.011	0.022	0.015	0.0164	0.016	0.023
Eastern Constructed Wetland (culvert outlet)	0.031	0.18	Not monitored	Not monitored	<0.00040	0.0088	Not monitored	Not monitored
Western Sedimentation Pond	Not monitored	Not monitored	0.0126	0.0137	0.0043	0.016	0.0020	0.012
South West Pond (outside designation)	0.0011	0.0020	0.0018	0.0014	0.0139	0.0063	0.0021	0.0017
GI1	0.0010	0.0011	Not monitored	Not monitored	0.0008	<0.0005	0.00094	0.00081
GI2	<0.0010	<0.0010	Not monitored	Not monitored	0.0004	<0.0005	0.00084	0.0012
GI3	0.0012	0.0012	Not monitored	Not monitored	0.0009	<0.0005	0.0014	0.0010
GI5	<0.0010	<0.0010	Not monitored	Not monitored	0.0028	0.0013	0.0017	0.0013
Estuary	<0.0010	0.0014	0.0047	0.0006	0.0009	0.0007	<0.00010	0.00049

The highest concentrations of PFAS substances were reported present at the eastern constructed wetland (culvert outlet) monitoring location. The most likely cause of the elevated contaminant concentrations at this location are discussed in the section below.

As can be seen from the data in the table, PFAS substances are present in the surface water upstream of the landfill at low concentrations. The limited data set available indicates that concentrations increase slightly at monitoring locations GI3 and/ or GI5 but that the concentrations have generally decreased to levels similar to those measured at the upstream monitoring locations at the Estuary monitoring location.

PFAS concentrations are generally similar to each other in the two sedimentation ponds or at least within one order of magnitude. There is no clear trend in concentrations at the different monitoring locations, due in part to the limited data set. Further assessment of the water quality effects is provided in the Human Health & Environment Risk Assessment Report (GHD HHRA, 2024).

3.5.7 Eastern Constructed Wetland Culvert

Investigations undertaken in 2022 as part of the preparatory work for the consent applications identified a possible issue between the leachate interception trench and the clean water culvert bypass, located on the north-eastern part of the site. The alignment of the culvert indicated that it crossed the leachate trench immediately upstream of its point of discharge into the Eastern Constructed Wetland (Figure 5).

Surface water sampling at the outlet of the culvert identified elevated parameters indicative of leachate contamination, suggesting leachate is seeping into the culvert (see Drawings 12547621-01-C204; 12547621-01-C402). This seepage is not considered to be a significant source of contamination into the Kaikorai Stream and estuary. A pipe inspection was undertaken on the culvert in early 2023 and the inspection findings and the proposed remedial measures are described in Section 6.3.

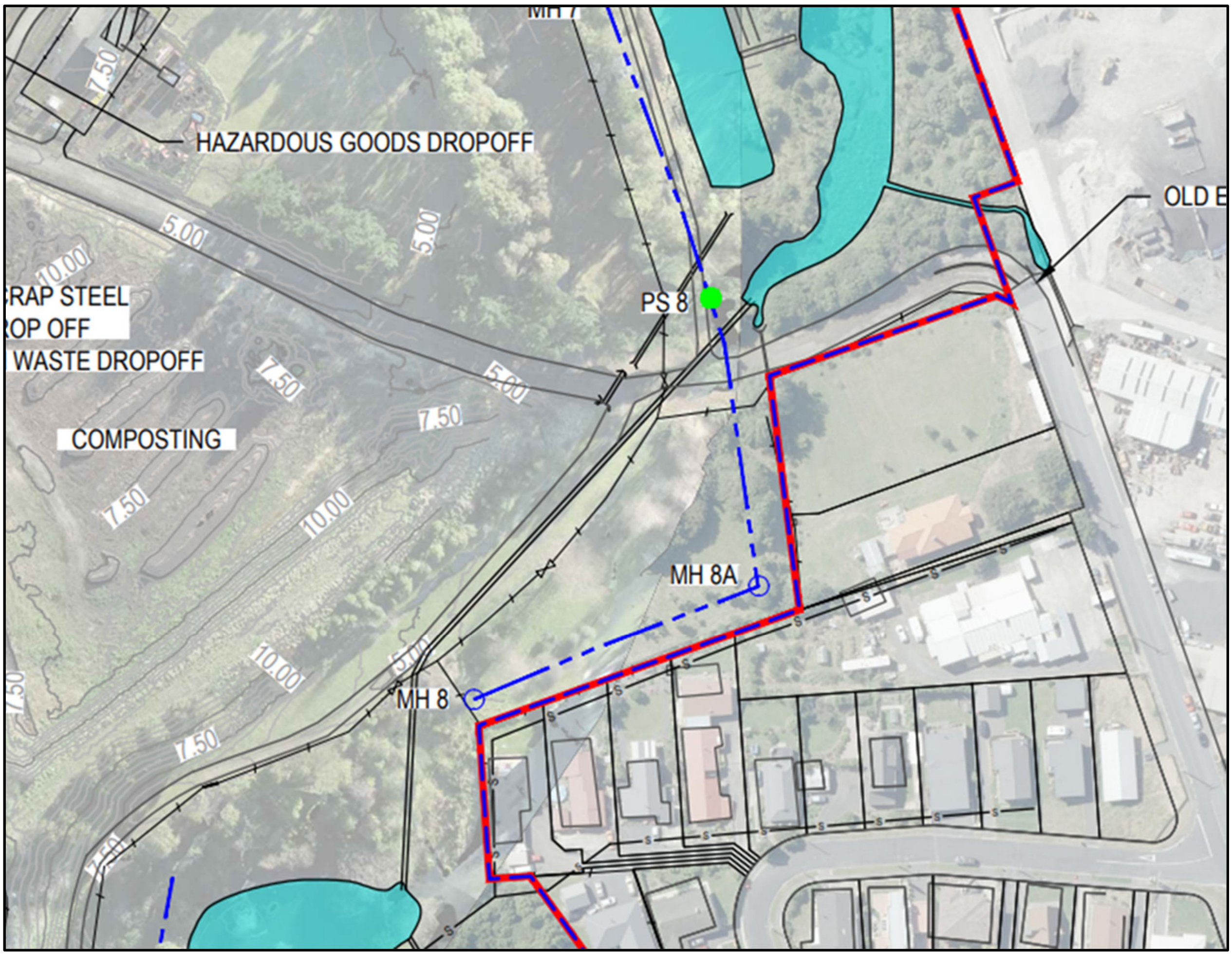

Figure 5 SE Constructed Wetland Culvert and Leachate Interception Trench Alignment (snip from Drawing C204)

3.6 Natural Hazards

A review of the ORC Natural Hazard maps indicates that the land in and around the landfill is subject to inundation risk associated with flooding from the Kaikorai Stream and from storm surge. This is reflected in the 2GP which identifies the low-lying areas around the stream and estuary as being within a Hazard 2 Flood overlay at moderate risk of flooding, which is discussed in more detail in this report.

3.6.1 Fluvial Flooding

The ORC hazard map for flood risk associated with river-based flooding for the Kaikorai Estuary catchment is shown in Figure 6 below.

Figure 6 ***Fluvial flood risk area (Source: ORC Online Natural Hazards Portal, www.,maps.orc.govt.nz)***

The risk area, shown in light blue in Figure 4, is taken from the ORC Natural Hazards Portal flood map which was based on the mapped extent of the 19 March 1994 flood with a level of 103.3 mRL[7]. The hatched area shows the location of the existing landfill footprint which is land that has subsequently been built up and hence this area would no longer be flooded. Therefore, while acknowledging the map is historical and approximate, it indicates that low lying areas around the perimeter of the landfill are prone to flooding due to high flows in the Kaikorai Stream. The majority of these areas are outside the footprint of the main landfill but infrastructure such as site access roads, perimeter drainage channels and the leachate collection system are within the flood zone.

The current elevation of the perimeter road at Green Island Landfill is approximately 101.8-102 mRL.

Current climate change projections, using the upper range scenario (RCP 8.5), indicate that flood flows will increase by approximately 9% by 2050. This would be expected to increase flood levels by between 60 -100 mm and will not significantly impact the flooding extent in the area of the landfill or day-to-day operations. As the stream channel in the vicinity of the landfill and the estuary are low energy environments, the risk of channel scour and erosion that may impact the landfill is very low. However, there will be an increased frequency of inundation of the perimeter areas which could impact the leachate collection located within this area. As discussed in the above paragraph, this may require modification to elements of the leachate collection system that are susceptible to flooding (i.e. electrical cabinets and manholes) to allow continued operation. This issue is discussed further in Section 4.2 of this report.

Fluvial flood risk to the landfill area is also impacted by coastal and sea level changes. ORC hazard reporting notes that Kaikorai Stream flood levels can be affected by outlet conditions from the estuary with coastal wave action forming sand banks which block the outlet resulting in increased water levels that extend upstream to the area of the landfill. The impacts of such events will be similar to those described above.

3.6.2 Climate Change

Global temperature changes associated with human activities are resulting in climate change. Current IPCC reporting shows that this will result in a rise in sea level. In addition, while annual rainfall is likely to remain similar to existing or increase slightly (<5%), there will be an increase in the frequency and intensity of extreme rainfall events. As noted above, the areas adjacent to Green Island landfill are low lying and identified as areas subject to sea level flooding (storm surge) and fluvial flooding associated with the Kaikorai Stream. The climate change impacts noted will further amplify natural hazards.

3.6.3 Sea level Rise

The ORC hazard map for storm surge risk is shown in Figure 7 below. While not specific to sea level rise, this is indicative of areas that would be expected to be impacted on a long-term basis if sea level rise of 0.5 m was to occur. Current upper range scenarios indicate a sea level rise of approximately 0.25 m by 2050. It is noted that storm surge, associated with low pressure systems and astronomical situations would be on top of the sea level rise, increasing levels and extents of the area affected.

[7] Note throughout this report two datums are used. On older figures/drawings a DCC Design Datum of AMSL +100m is used (hence a 1994 flood level of 103.3m). More recent data and the design drawings for this study use NZVD2016 as the datum.

Figure 7 ORC hazard map for storm surge risk (Source: ORC Online Natural Hazards Portal, www.,maps.orc.govt.nz)

Sea level rise may result in a general increase in water levels within the estuary and the lower reaches of Kaikorai Stream, adjacent to the landfill, and this could result in an increase in ingress of water into the leachate system via groundwater. This is discussed further in the Groundwater Technical Report (GHD 2023B).

The increase in sea level would also be expected to result in a change in beach formation which may increase the frequency of the closure/blockage of the estuary outlet. Blockage of the estuary currently occurs periodically requiring the ORC to use an excavator to re-establish the outlet. This may be required on a more frequent basis in future. As noted in Section 3, the ORC maintains the water levels in the estuary to be below 101.6 mRL. Any potential changes to the ORC management regime associated with sea level rise are unknown at this point in time.

With respect to the continued operation of the landfill until closure, the landfill is expected to continue generating leachate for several decades after ceasing of filling and the leachate collection system will need to remain in operation for this period. The proposed closure date for the landfill accepting waste is late 2029. Closure in 2029 is not expected to have a significant impact on the leachate collection system as a consequence of climate change induced hazards when compared to an October 2023 closure scenario.

4. Site Water Management

The following section provides a description of how water is managed within the landfill site and the proposed changes to the management approach that are recommended as part of the current proposal.

4.1 Existing water management

The existing footprint of the landfill is well established. The ongoing operation will not alter or increase the footprint and no further alteration of the existing channels is required.

Stormwater management for the landfill splits catchments into three categories with each being managed separately. The runoff from each will be defined as clean, stormwater or leachate. These are defined below.

1. CLEAN – non-contaminated or potentially containing low concentrations of sediment. Can flow directly to the natural environment
2. STORMWATER – non-contaminated water but potentially containing elevated sediment concentrations. Requires directing to a sedimentation pond for treatment prior to discharging to the natural environment.
3. LEACHATE – contaminated stormwater or has the potential to be contaminated from contact with waste or leachate. This contaminated water must be directed to a leachate pond, or a leachate drain or channel / swale which then goes to a leachate pump station, hence is pumped to the GIWWTP

If necessary, it is acceptable for cleaner waters to either flow to, or be directed to, a sedimentation pond, or clean and sediment laden waters to be directed to the leachate system.

Discharges to the leachate system are via direct discharge to the collection pipework or discharge to surface trenches allowing infiltration to the leachate system. Potential issues from the discharge of clean and sediment laden stormwater include clogging of the leachate collection system with sediment and generating volumes that overwhelm the pump capacity reducing the leachate collection efficiency.

The discharge to the leachate collection system via infiltration trench provides capture of sediment in the surface layer of the trench via settlement and filtration. This prevents any risk of clogging of the lower sections of the trench that could impact leachate collection. Velocities in the leachate system pipework are sufficiently high to maintain sediment loads in suspension and to resuspend sediments that may settle between periods of pumping.

Excessive discharge to the leachate system has the potential to by overwhelm the pumping capacity which would reduce the leachate collection efficiency. Monitoring of the pump operations (refer to the annual monitoring report attached as Appendix B) show even during rainfall events, the pumps are not operating continuously for prolonged periods (24 or 48 hours), indicating that even during rainfall events the capacity of the system has not been exceeded.

The high proportion of catchments currently being directed to the leachate system without resulting in the leachate pumps being overwhelmed demonstrates that this management approach is functioning well and appropriate for the site..

As areas of filling are completed and capped, rainfall that previously infiltrated into the landfill will be stored in surface soils and lost via evapotranspiration or discharging as surface runoff. Approximately 30% of rainfall would discharge as surface flow during rainfall events greater than 10 mm/day. Sedimentation ponds work by detaining water for a period of time to allow sediments to settle out. The eastern sedimentation pond has a retention time of approximately 24 hrs for the 2year 24 hr rainfall event (ECan design event for sedimentation ponds) which is sufficient to remove all but the finest particles such as very fine silts and clay material. Filling and capping in the Eastern Sedimentation pond catchment is complete and there will be no significant change to flows and retention times and no requirement to increase pond capacity.

At present there is no direct discharge from overland flow paths into the WSP, as the overland flow from the southern and western catchments of the landfill is diverted to the leachate collection system. Although previously during the development of the landfill area there were inflows to the sedimentation pond which likely contained elevated concentrations of sediment. As filling and capping progresses into the future surface runoff flows will increase, with the 'clean' stormwater runoff discharged to the WSP as discharge culverts are reinstated.

Assessment of the pond system shows that even on completion of the landfill capping at closure and rerouting of the clean water, the pond will have a retention time well in excess of 24hrs for the 2 year 24 hour event. Therefore, there is no requirement to increase the WSP holding capacity. It should be noted that as areas of the landfill are capped and vegetated the volume of sediment within the runoff will reduce to the point that post closure the runoff will be considered to be clean runoff to the extent that it could be discharged directly to the receiving environment without significant adverse effects on the water quality. The stormwater management system is shown on Drawing 12547621-01-G102 and C402.

4.2 Clean Runoff

Clean runoff is overland flow from the landfill margins, covered sides of the landfill and from the capped surface of areas where landfilling has been completed. These surfaces generally have vegetative cover, are in the final stages of landscaping after installation of the impermeable cap or are site access roads within completed areas of fill. This run-off has little or no potential for coming into contact with landfill material/leachate and suspended solids concentrations will be very low.

This clean overland flow is collected in perimeter drains which either discharge to the Kaikorai Stream via sedimentation ponds to the south-west and east of the site or, in the case of the perimeter drains along the western side and northern sides, discharge to open swales and then culverts directly to the stream.

4.3 Stormwater Runoff

This refers to runoff that is from areas with exposed earthworks or catchments being actively or recently capped.

The only contaminant in this runoff is suspended solids. This runoff will be conveyed via a sedimentation pond prior to discharging to the Kaikorai Estuary.

4.4 Leachate

Runoff that comes into contact with waste material or has the potential to come into contact with waste material will be treated as leachate. This will either infiltrate into the landfill, where it is within an active filling area, or will be collected and diverted to a leachate drain or channel which is served by a leachate pump station, and hence pumped to the GIWWTP.

4.5 Current Stormwater Regime

The landfill site is split into a series of stormwater catchments. These have varied over time as the landfill form has developed. A general layout of the current catchments is shown in Figure 8 overleaf and Drawing 12547621-01-C401 and described in the table below.

Currently there are four key discharge locations depending on the catchment.

– Catchments 1, 3a, 3b and 6b are all completed and vegetated, hence are clean water catchments that discharge via perimeter swales to the Kaikorai Stream. This will remain the same in the future.
– Catchments 2, 2a, and 5a all currently report to the northern leachate pond so are treated as leachate, even though significant portions of these catchments have been finally capped and completed in 2022. Following closure of the landfill and once there are no waste vehicles using the access road, this pond will remain in use as a sedimentation pond. In prolonged high rainfall events this pond will overflow to the perimeter swales. These swales can discharge water to the Kaikorai Estuary.
– Catchments 4,5b, 8 and 9 are currently directed to the eastern sedimentation pond, noting that they are a mix of both clean and sediment laden stormwaters. Post-closure these catchments will continue to be directed to the eastern sedimentation pond.
– Catchments 6a, 7a, 7b and 10 are currently directed to Pumpstation 1 (PS1) and the leachate system. 6a and 7a are areas of current waste placement therefore must be directed to leachate. A large area of catchment 10 is the hillside and borrow area which are clean or sediment laden waters, however due to the southern surface of the landfill north of the sewer trunk line being only intermediate cap the whole of the catchment is treated as a leachate catchment. Post-closure this catchment can be all directed to the western sedimentation

pond. A sedimentation pond has been constructed within the borrow area as part of the sediment and erosion control measures while earthworks are under way. This pond will be decommissioned as part of the borrow area remediation on completion of landfilling and capping. The location of this proposed pond is shown on Drawing 12547621-01-402.

Catchment 4a is located within catchment 4. This area has been used historically for windrowing and composting of green waste and the runoff was treated as leachate and was discharged to ground at the north-eastern corner of this area. However, with the commissioning of the new Organics Receivable Building in June 2024 as part of the Resource Recovery Park Precinct development at Green Island, this activity has ceased. Therefore, Catchment 4a is now being directed to the ESP along with the Catchment 4.

Figure 8 Site Catchments[8]

The current layout and the existing stormwater regime for the remaining areas within the landfill designation, to the north of the facility around the entrance, are not changed. This is as follows:

– Runoff from the grassed area on the northern side of the entrance road will continue to discharge north to the Kaikorai Stream;
– Runoff from the entrance road, weighbridge and Resource Recovery Area is predominantly paved with runoff discharging directly or via sumps to a channel alongside the entrance road which the discharges to the Kaikorai Stream via the constructed wetland.
– Rainfall on the grassed area to the east of the Resource Recovery Area generally infiltrates to ground except for the embankment adjacent to the sediment pond which drains to the pond.

4.6 Proposed Site Water Management

The proposed stormwater management for the proposed extension does not represent a significant change from the existing regime. This is because:

– clean waters from completed and vegetated caped areas will continue to discharge as per existing.
– stormwater from areas capped but potentially containing sediment will be directed to a sedimentation pond.
– stormwater from the active filling areas will continue to discharge into the landfill and be collected via the leachate collection system; and
– contaminated stormwater from access roads from the waste filling area will be collected and diverted to the leachate collection system.

The catchments will be approximately the same as those shown in Figure 6 above although the boundary between catchments 6a and 5a (south), and 7a and 8 will move approximately 100 m to the west.

Table 5 Summarises the stormwater classification, use and discharge point currently and post closure.

Table 5 Catchment Classification – Current and Post Closure

Catchment	Classification	DISCHARGES TO 2022	NATURE OF CATCHMENT 2022	DISCHARGES AFTER CLOSURE
4	CLEAN / STORMWATER	Eastern Sediment Pond	All Leachate / Waste touching activities in this area are directed to Sewer infrastructure and PS7	N/C
5b	STORMWATER	Eastern Sediment Pond	Vegetated / grassed perimeter bund	N/C
8	STORMWATER	Eastern Sediment Pond	Vast majority is area capped historically.	N/C
9	CLEAN	Eastern Sediment Pond	Vegetated / grassed perimeter bund	N/C
2	LEACHATE	Northern Leachate Pond	Includes the tipface access road which at times can have waste spilled or dropped on.	Northern Sediment Pond
2a	LEACHATE	Northern Leachate Pond	Includes the tipface access road which at times can have waste spilled or dropped on.	Northern Sediment Pond

[8] Note Catchment 4a is now part of Catchment 4 – see discussion in Section 4.5.

Catchment	Classification	DISCHARGES TO 2022	NATURE OF CATCHMENT 2022	DISCHARGES AFTER CLOSURE
5a North	STORMWATER	Northern Leachate Pond	Area of Final Capping Completed in 2022	Northern Sediment Pond
5a South	LEACHATE	Northern Leachate Pond	Area of Intermediate Cap	Eastern Sedimentation Pond
1	CLEAN	Perimeter swale to Kaikorai Stream	Vegetated / grassed perimeter bund	N/C
3a	CLEAN	Perimeter swale to Kaikorai Stream	Vegetated / grassed perimeter bund	N/C
3b	CLEAN	Perimeter swale to Kaikorai Stream	Vegetated / grassed perimeter bund	N/C
6b	CLEAN	Perimeter swale to Kaikorai Stream	Vegetated / grassed perimeter bund	N/C
6a	LEACHATE	PS1 via Open Leachate Swale	Area of Active Waste Filling	Western & Eastern Sedimention Ponds
7a	LEACHATE	PS1 via Open Leachate Swale	Area of Active Waste Filling	Western & Eastern Sedimention Ponds
7b	CLEAN / LEACHATE	PS1 via Open Leachate Swale	Majority is completed perimeter bund above the open leachate swale with some receiving active waste.	Western Sedimentation Pond
10	ALL	PS1 via Open Leachate Swale	Grassed virgin hillside (CLEAN), open borrow area (STORMWATER) and southern edge of landfill only intermediate capped (LEACHATE)	Western Sedimentation Pond
4a	LEACHATE	To Ground	To Ground	Note with the commissioning of the Organic Receivable Building in June 2024 this discharge will be part of Catchment 4.
Entrance and Resource recovery area	CLEAN/ STORMWATER	Direct discharge to Kaikorai Stream or to ground	Direct discharge to Kaikorai Stream or to ground	NC

4.7 Existing Stormwater Flows

An assessment of stormwater flows for the site has been carried out and documented in this report. The results of this assessment are shown in Table 6 below.

The flows provided are peak stormwater flows for the catchments. They are based on current rainfall intensities as the increase in rainfall intensity due to climate change for the remaining 6 yrs of operational filling (through to the end of 2029) is likely to be in the order of 2 – 3% and within the accuracy of the flow assessment.

As noted above, filling of the catchments to the north of the landfill is completed and they have been capped and the flows provided are final flows. Catchments to have ongoing filling have no surface runoff or reduce runoff where part of the catchment is to have additional landfilling (Catchment 8). As the phased landfilling progresses and areas are completed and capped, rainfall will discharge as surface runoff rather than infiltrating into the landfill. Table 7 shows the peak stormwater flows for the catchments on completion of filling and capping.

The future flows can be accommodated within the existing sediment ponds without any increase in size required. It is noted that as capping and vegetation of areas are completed, sediment volumes in the stormwater discharging to the ponds will decrease due to reduced exposure to rainfall and reduced surface flow velocities.

Table 6 Current Peak Runoff

Catchment	Intensity (mm/hr)		Area (Ha)	Runoff coefficient C	Runoff (l/s)	
	10 yr	50 yr			10 yr	50 yr
4	23.8	36.7	1.65	0.7	76.1	117.8
5b	44.3	69.0	1.00	0.35	42.9	66.8
8	23.8	36.7	2.35	0.18	28.0	43.2
9	42.6	66.4	1.70	0.35	70.3	109.5
2	31.3	48.5	1.58	0.60	82.6	128.1
2a	47.5	74.1	0.54	0.35	24.8	38.6
5a North	28.2	43.6	0.78	0.35	21.3	33.0
5a South	28.2	43.6	0.96	0.00	0.0	0.0
1	47.5	74.1	1.17	0.35	54.2	84.5
3a	47.5	74.1	0.71	0.35	32.6	50.8
3b	44.3	69.0	0.48	0.35	20.8	32.4
6b	47.5	74.1	0.86	0.35	39.5	61.7
6a	22.8	35.2	3.87	0.00	0.0	0.0
7a	25.0	38.7	2.68	0.00	0.0	0.0
7b	41.0	63.9	2.37	0.35	94.7	147.4
10	47.5	74.1	8.98	0.35	414.7	646.9

Table 7 Peak runoff on completion of landfill capping and closure

Catchment	Intensity (mm/hr)		Area (Ha)	Runoff coefficient C	Runoff (l/s)	
	10 yr	**50 yr**			**10 yr**	**50 yr**
4	23.8	36.7	1.65	0.7	76.1	117.8
5b	44.3	69.0	1.00	0.35	42.9	66.8
8	23.8	36.7	4.49	0.35	103.8	160.5
9	42.6	66.4	1.70	0.35	70.3	109.5
2	31.3	48.5	1.58	0.60	82.6	128.1
2a	47.5	74.1	0.54	0.35	24.8	38.6
5a North	28.2	43.6	0.78	0.35	21.3	33.0
5a South	28.2	43.6	1.58	0.35	43.3	67.1
1	47.5	74.1	1.17	0.35	54.2	84.5
3a	47.5	74.1	0.71	0.35	32.6	50.8
3b	44.3	69.0	0.48	0.35	20.8	32.4
6b	47.5	74.1	0.86	0.35	39.5	61.7
6a	22.8	35.2	2.80	0.35	62.0	95.9
7a	25.0	38.7	0.99	0.35	24.0	37.1
7b	41.0	63.9	2.37	0.35	94.7	147.4
10	47.5	74.1	8.98	0.35	414.7	646.9

4.8 Response to Climate Change

As described in Section 2.5 a number of factors could influence long term water levels in the Kaikorai Stream adjacent to the landfill. The Groundwater Technical Report (GHD 2024B) modelled a 0.5 m rise in water levels associated with the stream to reflect the possible impacts of climate change over the operational and foreseeable closure period of the landfill. The modelled impact on leachate volumes is in the order of an additional 0.5 L/s. The installed system is capable of managing an increase of this amount.

The modelling assumed that additional seepage will occur in response to an elevation in the Kaikorai Stream level and additional seepage through the sediments between the stream and leachate trench. An additional risk is that flooding of the landfill perimeter will result in inundation of the leachate trench. The planned response to this hazard is to raise the level of the perimeter road berm that runs around the landfill between the adjacent Kaikorai Stream and leachate trench by approximately 1.0 m to prevent inundation by surface waters. In addition, any manholes, chambers, electrical controls or similar devices will need to be raised above a potential future flood level. These proposed works are also described in the *Design Report (GHD 2023A).*

5. Assessment of Effects

5.1 Introduction

As discussed previously, the receiving environment for surface water discharges from the landfill is the Kaikorai Stream and Estuary via sedimentation / collection ponds and constructed wetlands. The following section provides an assessment of the potential effects of the continued operation and closure of the landfill on water quality in the Kaikorai Stream and Estuary. Further assessment of the water quality impacts on human health and the environment of the Kaikorai is provided in the HHERA (GHD HHRA 2024).

5.2 Surface Water Quality Effects

As noted in Section 4, stormwater not influenced by leachate from the landfill discharges to the Kaikorai Stream via a perimeter drainage system which discharges directly to the stream or discharges via sediment ponds on the eastern and western side of the landfill.

Potential contaminant sources in the stormwater discharges from the site include the following;

- exposed earthworks associated with daily capping activities, landfill haul/access roads, final capping construction and establishment.
- vehicle related activities including cartage of materials and construction vehicle movements for placing and daily covering of landfilled material.
- water making direct contact with waste materials being landfilled or potential breakouts or seepage through the capping that allow leakage of leachate to the surface water system.

While there are significant areas of exposed earthworks that may result in sediment discharges, the majority of these areas are within the active landfilling zone and stormwater from these areas discharges into the landfill and is managed as leachate.

Construction of the final capping within specific areas has potential to provide a significant source of sediment that may be entrained in runoff. This only occurs on completion of filling within that zone so is relatively short term and a specific erosion and sediment controls plan is established for this work to control discharges from the site. Longer term the establishment of vegetative cover provides an effective prevention measure for large scale sediment discharge.

Vehicle related contaminants in runoff from the site are metals, hydrocarbons and sediments (Total Suspended Solids (TSS)). Loadings in runoff are expected to be typical of those associated with low to medium density roading although vehicle activities on unpaved haul roads for the transport of cover material will generate high TSS. Metals and the hydrocarbons associated with vehicles are predominantly bound to sediments and the capture of sediments provides an effective method for removal of the majority of the hydrocarbon and metal loading.

Leachate contamination of surface water associated with breakouts through the capping has occurred at site but is relatively rare. Breakouts are visually obvious allowing early identification and remedial works to be undertaken. They have generally occurred at lower levels of the landfill sides as a result of elevated volumes of leachate following heavy rainfall events increasing hydrostatic pressure. As filling is completed within areas of the landfill and the final impermeable capping is placed, leachate volumes in the landfill and the risk of breakout reduces. This will be assisted by the additional leachate control measures described in Section 6.

Stormwater controls at the site include two main sedimentation ponds receiving water from the perimeter drainage system and a more recent (2019) leachate pond near the site entrance which receives runoff from the entrance area and the main access road that leads up onto the landfill (Design Report, GHD 2023 - Drawing 12547621-01-C401).

Stormwater from the entrance area and the Resource Recovery Area discharges to a constructed wetland adjacent to the Eastern Sedimentation Pond via a shallow overgrown channel. Little or no treatment of runoff from this area is provided apart from coarse sediment removal within mudtanks servicing the Resource Recovery Area and sedimentation that will occur within the shallow channel. However, inspection of the discharge point to the shallow channel shows no evidence of debris, oily staining or sediment accumulation which would be expected to be visible if there was a high contaminant load.

While monitoring of surface water quality has not been carried out during heavy rainfall events, surface water quality monitoring is carried out on a quarterly basis, and this includes the sedimentation ponds. The quality of the water within the sediment ponds is assumed to be indicative of the quality of the discharge that will be occurring to the Kaikorai Stream. Sampling is carried out at the outlet into the pond before any settlement of sediment and adsorption of contaminants to sediment occurs. Therefore, the sampling results are considered to represent a conservative view of water quality in the sedimentation ponds before discharge to the surrounding environment.

Details of the sampling locations and results of the water quality sampling in the sediment ponds and in Abbots Creek, Kaikorai Stream and at sites upstream and downstream of the landfill are provided in Section 3 and Appendix B and Appendix C, along with relevant guidelines for comparison. The sampling includes a range of metals, pH and nutrients. Review of the results shows the following:

The analytical data from the streams and estuary monitoring indicate that all sites exhibited the influence of an impacted urban to peri-urban catchment, with the upstream sites exhibiting dissolved metal concentrations and nutrient concentrations that would be expected in these types of land use settings. The sites adjacent to and downstream of Green Island Landfill do not exhibit any significant changes in dissolved metal concentrations that would otherwise be a strong indicator of leachate discharge to the environment. The variability in the conductivity readings that are recorded for monitoring locations GI3 and GI5 are reflective of the estuarine environment and the tidal influence that occurs at these locations, and the results are not a good indicator of impacts from the landfill. The nutrient suite also indicates a lack of direct and significant water quality impacts from the landfill on water quality, whilst cyanide has been recorded on occasion at all sites, upstream, adjacent to and downstream of the landfill.

The monitoring results from the ESP and WSP contained in Table C6 of the Annual Monitoring Report (Appendix B) exhibit slightly more impacted water quality than the sites outside the landfill boundary. This is not unexpected given the hydraulic purpose of the ponds (i.e. to detain water and settle sediments). Despite this, the historical data set for dissolved metals does not indicate persistent and significant levels of contamination of the pond water from landfill activities, with results from the last year all below the trigger concentrations set by condition 6(ii). This also applies to the nutrient concentrations, with ammoniacal-nitrogen concentrations measured in the past year below the trigger level set in Condition 6(ii). Overall, the sedimentation ponds are functioning as intended, with the water quality within expected ranges. However, when compared to ANZG (2018) guidelines, some of the analytes exceed the guideline values. This is not unexpected, as the ANZG (2018) are not intended to be used for stormwater treatment pond systems (i.e. these are not natural systems).

Given that the ponds are well established and working as intended, the effects associated with the ongoing discharge of stormwater via the ponds to the environment is considered to be low. Furthermore, as the landfill is progressively capped as it moves to closure and aftercare maintenance, the water quality discharging from the sedimentation ponds into the Kaikorai is expected to improve.

Additional sampling for PFAS and PFOA was undertaken in October 2022, January, April and August 2023 and January 2024 at selected monitoring locations.

PFAS concentrations are generally similar to each other in the two sedimentation ponds or at least within one order of magnitude. There are no clear either increasing or decreasing trends in concentrations apparent at the different monitoring locations.

The sample results indicated a few notable characteristics:

- The highest concentrations of PFAS were reported present at the Eastern Constructed Wetland culvert inflow monitoring location. This location is impacted by leachate seepage, which is likely the source of the PFAS/PFOA concentrations measured at that site. Remedial works are underway to prevent this continuing and are expected to be completed by March 2025..
- The data indicates that PFAS substances are present in the surface water upstream of the landfill at low concentrations.

– The limited data set available indicates that concentrations increased slightly at monitoring locations GI3 and / or GI5 but that the concentrations have generally decreased to levels similar to those measured at the upstream monitoring locations at the Estuary monitoring location.
- All reported analytical PFAS results for the surface water samples from the Kaikorai Stream, Abbots Creek, Estuary and sedimentation ponds, were below the PFAS National Environment Management Plan version 2.0 95% species protection guideline values.

Based on the results of the sampling that has been undertaken there are no demonstrable adverse effects on surface water quality within the Kaikorai Stream associated with the surface water discharges from the site, noting that the catchment is a heavily modified catchment. To better understand the risk to human health from PFAS, which has been measured at low levels in most of the surface water monitoring sites, an interim human health and environmental risk assessment (HHERA) has been undertaken to better inform the public about the risks associated with the recreational use and food gathering which occurs in the catchment. The HHRA should be read in conjunction with this report.

The HHERA has evaluated whether contamination originating from the landfill may represent a risk to the human users or environment of the catchment. The overarching purposes of this assessment were to:

– Better understand the risk to human health from PFAS which has been measured at low levels in most of the surface water monitoring sites.
– Provide additional information to ORC for potential future use in broader catchment monitoring programs addressing contamination in the Kaikorai Stream.

The HHERA provided an interim assessment, which can be built upon if additional data is collected. A Tier 1 risk assessment was undertaken, whereby the concentrations of chemicals measured onsite and within the receiving environment were compared with conservative screening levels provided by National or International Guidelines and the chemical concentrations measured upstream of the landfill. This assessment identified that the chemical concentrations measured in surface water samples collected downstream of the landfill have generally been consistent with those measured upstream and/or below the relevant Tier 1 screening criteria. On this basis, it was concluded that discharges from the site into the receiving environment of the Kaikorai Stream generally represent a low risk to human users of the waterway and the aquatic environment. A number of chemicals, including nitrate, zinc and PFAS were identified at concentrations above the Tier 1 screening criteria, in samples collected both upstream and downstream from the landfill, suggesting contributions from across the catchment. A broader catchment approach by the ORC to the ongoing monitoring of these contaminants was recommended to inform the public about the risks associated with the recreational use and food gathering within the catchment and to support public engagement that ORC may wish to undertake, with a focus on understanding the following:

– Nutrient inputs, toxicity and eutrophication at a catchment scale.
– Metal inputs, bioavailability and toxicity at a catchment scale.
– PFAS inputs at a catchment-scale.
– PFAS bioaccumulation in the aquatic food chain and the nature and extent of fishing in the waterway.

Whilst the sampling undertaken to date may not adequately capture situations where pulses of surface water from the landfill ponds flow into the Kaikorai Stream, the monitoring data does not indicate a discernible impact to surface water quality from the landfill. However, to address these data gaps, some targeted additional investigations could be undertaken to assess the hydrology of the onsite ponds and the nature and extent of any discharge events from the onsite ponds into the Kaikorai Stream. This could supplement any work that the ORC may wish to progress in terms of a broader programme of work to better understand the catchment water quality issues associated with the historical and current land uses in the Kaikorai Stream catchment.

5.3 Northern Leachate Pond

Section 4 - Site Water Management describes the surface stormwater management for the landfill, which splits catchments into three categories; clean, stormwater or leachate, and provides the definition of the categories. The runoff from each of the categories is managed separately.

Details of the Northern Leachate Pond are discussed in Section 2. From an effects assessment perspective, the Northern Leachate Pond was constructed when filling of this area with waste was occurring, and modification to the access road onto the landfill was also undertaken. While a large proportion of rainfall would have infiltrated into the landfill, or collected in the leachate drainage system and directed to PS5, any runoff from the access road that did occur had the potential for contact with waste material. As such, stormwater from this area was categorised as Leachate under the stormwater classification system. Hence, the collection pond was referred to as the Northern Leachate Pond and this naming convention has remained since. Treating the contaminated stormwater as leachate was considered an appropriate precautionary approach, , given the dilution that would occur with stormwater flows and the relatively low concentrations of contaminants that would have been present.

In 2021 waste placement in the contributing catchment areas was completed and in 2022 the surface of the landfill was capped. The earthworks associated with completion and capping resulted in isolation of stormwater runoff from landfill waste material, and the associated contamination, with a corresponding increase in sediment loads from exposed surfaces (until grass had established) and increased surface flows with the reduction of infiltration into the landfill. During this phase the pond was primarily acting as sediment retention pond. However, its classification and name as a Leachate Pond was retained due to the continued use of the access road. The access road runs through the catchment and the associated potential for dropping/spillage of waste or tracking of waste from the tipping area, which was adjacent to the top of the catchment at this time, remained a potential pathway for contaminants.

The capping for the landfill area contributing runoff to the Northern Leachate Pond is now completed and the vegetative cover established reducing runoff volumes and erosion and entrainment of sediment discharges. The capping effectively prevents contact between landfill waste material and stormwater and the associated contamination. However, the Landfill Development Management Plan acknowledges that the access road still runs through the pond catchment and identifies the risk of spillage of waste or tracking of waste from the fill area, albeit minor. It is also noted that active filling area has moved further south away from the pond catchment, further reducing the risk of waste tracking.

The pond will be retained during the proposed remaining filling and closure phases, with the pipe outlet connected to the leachate trench. This is a precautionary measure as runoff quality will be approaching the Clean Water criteria, as set out above, and the role of treating waste contaminated runoff and high sediment loads is redundant. Current and future runoff quality will contain low concentrations of sediments consistent with that from the surrounding rural areas along with metals and hydrocarbons associated with vehicle activity at concentrations typically associated with urban road runoff.

As indicated above, the discharges occurring from the Northern Leachate Pond during the proposed remaining filling stage and the closure phase will be at or approaching the Clean Stormwater criteria above. Sediment concentrations in runoff will be consistent with the surrounding rural area and metals and hydrocarbon concentrations similar to that of urban runoff. The runoff passes through the pond which will continue to act as a sedimentation pond providing a degree of treatment, via capture of sediments and adsorbed contaminants. Even during overflows a small degree of treatment will be provided by the pond via capture of the coarser fraction of sediments.

Overflows from the pond discharge to the swale alongside the access road which will provide further retention and treatment prior to discharge through culverts under the access road to the stream.

Given that overflows from the Northern Leachate Pond to the stream will be of a relatively high quality and are infrequent (an AEP of less than 20%), the risk to estuary water quality and the receiving environment is considered less than minor for the remaining years of filling, It is also noted that overflows would coincide with high flows in the stream further diluting any potential for an adverse effect on the stream and estuary. Following the capping of the landfill and closure and aftercare management practices are implemented, it is expected that water quality associated with the site discharges will improve.

5.4 Eastern Constructed Wetland Culvert

As noted in Section 3 sampling of the discharge from the culvert carrying flow from the South Eastern Constructed wetland to the Eastern Constructed wetland, adjacent to the eastern sediment pond, has identified the presence of leachate. A preliminary assessment of the culvert has been completed and the potential source of the leakage and proposed mitigation measures are underway, as described in Section 5.5. Site observations and sampling indicate that volumes of leachate seeping into the culvert are very small. The CCTV footage from the culvert inspection which was carried out in very low flow (when sampling has shown leachate concentrations are at their highest) did not show any identifiable change in flow or colouration.

Given the very small flows and dilution that occurs in the Eastern Constructed Wetland and the Kaikorai Stream, any impact on water quality in the Kaikorai Stream is expected to be undiscernible. This is consistent with monitoring that has been carried out in the stream.

The surface water monitoring within the Kaikorai Stream shows no discernible adverse effects on the water quality downstream of the discharge point into the Kaikorai main channel, which is consistent with leachate volumes being very small. However, remedial works are underway and are expected to be completed by March 2025, as outlined in Section 6.3.

5.5 Surface Water Quality for Proposed Works

The proposed works at Green Island Landfill are for the continued filling and final capping of the landfill to reach the final landfill surface.

The continued filling of the landfill will be carried out in accordance with current site procedures and include maintaining existing site controls such as the sedimentation ponds. These are set out in the latest version of the LMDP. Therefore, there is not expected to be any adverse effect on the quality of stormwater discharges from the site and the capping and vegetation of an existing area of landfill will reduce the risk of leachate contamination due to breakouts from within this area. The increased volume of clean runoff to the sedimentation ponds may also result in a slight improvement in stormwater quality, although this is likely to be minor.

Based on this the proposed continuation of filling of the Green Island landfill will not adversely affect the current regime which as noted above.

The potential sources of PFAS in the catchment are not limited to the Green Island site. However, the waste acceptance criteria together with the site water management approach and the progressive capping of the landfill over time will reduce the potential for contaminants from the landfill to enter the environment. In addition, the proposed installation of a new leachate collection trench along the base of the landfill's southern embankment combined with the horizontal collection drains beneath the future waste filling areas will further enhance contaminant containment and reduce risks to the environment. Based on the performance of the leachate collection trench system around the remainder of the site, this is expected to provide an effective means of further preventing a discharge to occur in the future.

5.6 The Potential Adverse effects associated with flood defence works

The assessment of natural hazards associated with flooding and climate change have identified a potential risk to the landfill, insofar as intermittent flooding of the lower margin of the landfill area where the perimeter road and leachate interception trench is located is anticipated. The Design Report (GHD 2023A) states that to address this risk to the critical infrastructure to manage leachate migrating offsite and to protect against potential erosion of the main landfill bund, that the access road (and leachate trench infrastructure) would be raised as part of the closure programme of works (following completion of filling activities).

Increasing the elevation of the perimeter road to form the bund will result in a very small reduction in the width of the floodplain over which flood waters can spread and this can result in an increase in flood levels.

While a detailed hydraulic assessment has not been undertaken, a desk top review has been carried out. Reviews were carried out at sections just upstream and just downstream of the Abbotts Creek confluence. These are the two critical sections of the floodplain where the impact on flood levels would be greatest.

The review showed that for the 1% annual exceedance probability event (100 year event) the loss in flood channel capacity was minor and the increase in flood level would be:

– Approximately 35 mm downstream of the confluence, where the floodplain is wider but includes flows from Abbotts Creek; and

– Approximately 40 mm upstream of the confluence which is narrower but only includes flows from the Kaikorai Stream.

The increase in flood level would reduce with distance upstream of these sections and would not extend upstream of Brighton Road. This is a conservative assessment as the channel area that would be lost is unlikely to contribute significantly to flood capacity due the vegetation that separates it from the main channel providing a flow barrier. The estimated increase of 35-40 mm in peak flood levels for the 1% AEP event is considered to be very small and is within the limits of accuracy for hydraulic modelling. In addition, there would be no anticipated increase in flood risk to residential dwellings as a result of these works.

Based on the desktop assessment of the effects associated with raising the perimeter road on flood flows and levels in the lower Kaikorai Stream, Abbotts Creek, and Kaikorai Estuary are considered to be less than minor. Furthermore, the sensitivity of the flooding extent in the Kaikorai Estuary is influenced by the status of the opening of the estuary to the sea.

6. Recommended Additional Mitigation Measures

6.1 Quantity

No mitigation measures are proposed from a volumetric perspective. Continued waste filling operations will still allow infiltration of rainfall into the landfill although this will reduce as areas are completed and capped (as discussed in the Groundwater Technical Report (2024B)). On completion and capping of the landfill runoff will increase, however, the existing sediment ponds will continue to provide attenuation of flows. The sediment points are of sufficient capacity to cope with the expected flows, including allowance for increased intensity of rainfall from climate change. Long term the flow regime will move more towards, although not match, the pre-landfill flows due to infiltration and evapotranspiration losses.

Review of the NIWA River Maps website indicates that Mean Annual Low Flows and Mean Annual Flows in the Kaikorai Stream are 368 L/s and 81 L/s respectively. Losses from the stream to the leachate collection system, provided in the Groundwater Report (GHD 2024B), are approximately 1 L/s or less. This is considered very minor and will have no significant impact on the flow regime. It is also noted that the tidal backwater effect results in increases in water levels in the area of the landfill which further reduces any impact of the small losses to the leachate system. Therefore, any effect is expected to be less than minor.

6.2 Quality

Existing mitigation measures include site management procedures such as separation of clean runoff from contaminated runoff and treating contaminated runoff as leachate. This contaminated runoff is captured via the leachate collection system and discharged to the GIWWTP.

The clean runoff generally discharges via sediment ponds allowing settlement of suspended solids along with metals that are adsorbed to this material, however some catchments flow via swales and pipes under the leachate road bund directly to the stream or estuary. The sediment ponds, along with the management procedures, provide an effective level of treatment with the quality of the stormwater, in all but a few cases, achieving 80% of the toxicant guideline values in the Australia and New Zealand guidelines for fresh and marine water quality (ANZG) 2018 prior to discharge to the Kaikorai Stream. As noted in section 4.0 above, the sediment ponds have capacity to accommodate the future site flows.

While the there is no evidence of a significant contaminant load in the discharge from the entrance and Resource Recovery Area, the retrofitting of Enviropods (fine filter bags) in the existing mudtanks would provide a significant improvement in capture of suspended solids and adsorbed contaminants for little cost.

6.3 Pond Culvert Leachate Ingress

A culvert located on the eastern side of the landfill has been identified as a potential pathway for leachate seepage. The culvert transfers surface water between the South Eastern Constructed Wetlands and the Eastern Constructed Wetlands as shown on Figure 3, Figure 9 (photograph of culvert outlet), and Drawing 12547621-01-C402. The Eastern Constructed Wetlands discharge via a further culvert to a small tributary of the Kaikorai Stream. Regular surface water sampling in the Eastern Constructed Wetland and the outlet to the tributary has identified elevated parameters indicative of leachate contamination (namely ammoniacal-Nitrogen, sulphate), confirming that leachate is seeping into the culvert. The culvert was constructed in the 1990s and is closely aligned with the landfill side and with the leachate cutoff trench at this location, hence it is assumed this is the source of leachate seepage.

Figure 9 SE Constructed Wetland Culvert Outlet photo (date: 2 Dec 2021, 10:41 am)

The culvert has been surveyed using a CCTV device and the results indicate the most likely source of leachate seepage is through a pipe joint that has deflected due to localised settlement of the pipeline.

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Works are underway to address this issue and are expected to be completed by the end of March 2025. Once this work is completed the pathway for the leachate seepage will be addressed.

6.4 Emergency Stormwater Management

An unexpected release of leachate or other contaminant to stormwater runoff will initially make its way into one of the site stormwater ponds. It may be possible to control or manage the release in some way while retained within the stormwater ponds. To assist in this approach the site sedimentation ponds will be fitted with shut off valves at the pond outlets to allow containment for a period. Under most climatic conditions the flow through the ponds is modest and the pond could be contained for several days to allow action to be taken before overtopping occurred.

6.5 Response to Climate Change/Sea Level Rise

As described in Section 2 a number of factors could influence long term water levels in the Kaikorai Stream adjacent to the landfill. The *Groundwater Technical Report (GHD 2024B)* modelled a 0.5 m rise in water levels associated with the stream to reflect the possible impacts of climate change over the operational and foreseeable closure period of the landfill. The modelled impact on leachate volumes is in the order of an additional 0.5 L/s. The installed system is capable of managing an increase of this amount.

The modelling assumes that additional seepage will occur in response to an elevation in the Kaikorai Stream level and additional seepage through the sediments between the stream and leachate trench. An additional risk is that flooding of the landfill perimeter will result in inundation of the leachate trench. The planned response to this threat is to raise the level of the perimeter road berm that runs around the landfill between the adjacent Kaikorai Stream and leachate trench by approximately 1.0 m to prevent inundation by surface waters. In addition, any electrical controls or similar devices will need to be raised above a potential future flood level. This work will be completed at least 6 months prior to final receipt of waste.

7. Recommended Monitoring

A consolidated recommended monitoring programme for surface water and groundwater is described in Section 5 of the Groundwater Technical Report (2023).

Current monitoring of the surface water for the operation of the landfill includes Kaikorai Stream upstream of the landfill, below the Abbotts Creek confluence and downstream of the landfill, in Abbotts Creek, and at the outlets to the sediment ponds and the constructed wetlands. This sampling has provided a baseline for the operation against which the effect of any future works can be assessed. It is considered that the surface monitoring should be continued on a quarterly basis as currently occurs with additional sampling only required if quality adversely deviates from the historical baseline.

The recommended surface water monitoring is summarised as follows:

– Quarterly surface water monitoring of the following sites:
  - GI1 – Kaikorai Stream, upstream of the landfill
  - GI2 – Abbots Creek
  - GI3 – adjacent to the landfill
  - GI5 – adjacent to Western Sedimentation Pond, downstream of the discharge point
  - GI6 - Estuary (NEW) – at Brighton Road Bridge, Waldronville
  - Eastern Sedimentation Pond
  - Western Sedimentation Pond
  - South Western Pond NEW
  - Eastern Constructed Wetland – immediately downstream of culvert discharge from the South Eastern Constructed Wetlands NEW
  - South Eastern Constructed Wetland (NEW)

– Water Levels recorded in the Kaikorai Estuary, at GI3 (referred to as ST4). Water levels should be recorded using a pressure transducer to measure water levels and temperature.

– The recommended analytical suite for surface water includes an indictor suite to be sampled for every quarter and a full suite to be sampled for once per year. The quarterly indicator suite for surface water sites includes the following:
  - pH (field)
  - EC (field)
  - Dissolved Oxygen (field)
  - Nutrients (Ammoniacal-N, Nitrate-Nitrogen, DRP)
  - Boron
  - Chloride
  - PFAS and PFOA*

The recommended annual sampling includes the quarterly suite plus the following:

– Major ions (Na, K, Mg, Ca, HCO, SO4
– Dissolved metals (Al, Ar, Cd, Cr, Pb, Fe, Mn, Ni, Zn)
– Volatile Organic Compounds (VOC)
– Semi-Volatile Organic Compounds (SVOC)
– Cyanide
– PFAS and PFOA

*The sampling for PFAS and PFOA for the first three years is to be undertaken on a quarterly basis, reverting to annual sampling thereafter.

A HHERA has been undertaken, with the results of the analysis indicating that there are no broader risks to people and the environment based on the current contamination concentrations of PFAS and PFOA measured in the Kaikorai. The HHERA found that these contaminants were ubiquitous in the broader catchment (upstream and downstream of the site), and that a broader catchment approach is needed to improve water quality outcomes.

As a condition of consent, it is recommended that the HHERA is updated following the three years of data collection, which should be provided to the Regional Council within six months of the three-year data set being compiled. However, it should be recognised that the potential sources of PFAS contamination in the environment is a catchment wide issue and not solely attributed to the historical filling at Green Island Landfill.

The results obtained from the surface water sampling from Kaikorai Stream, Abbots Creek, Kaikorai Estuary, the constructed wetlands (Eastern Constructed Wetland and the South Eastern Constructed Wetland) and the Western Pond should be compared against the following guidelines:

– ANZG (2018) Freshwater 80% Toxicant Default Guideline Value
– ANZG (2018) Marine 80% Toxicant Default Guideline Value
– ORC Water Plan – Schedule 16A for Ammoniacal-N and Nitrate-N & Nitrite-N
– NPS-FW (2020) – Table 5 Ammonia (toxicity) Ammoniacal-N for 80% Species protection level.
– NPS-FW (2020) – Table 6 Nitrate (toxicity) Nitrate-N for National Bottom Line.

In addition, comparisons of the results to historical ranges is recommended to understand if there is any changes in water quality behaviour outside the normal range.

The samples collected from the internal water management facilities (i.e. Eastern Sedimentation Pond, Western Sedimentation Pond) are recommended to be compared against the historical data sets and the trigger values that were established for the expiring consents.

7.1 Tidal and Rainfall Conditions

The sampling for the surface water sites has historically been required to be undertaken around the low tide. It is recommended that this approach is continued with, with sampling to be undertaken from the surface water monitoring sites outside the landfill designation within three hours of the low tide. It Is also recommended to monitor water levels in the Kaikorai Stream using an automatic water level pressure transducer, set to record water levels at a frequency no less than 3 hourly. The data from this logger would be downloaded quarterly and reported annually as part of an annual compliance monitoring report. The water levels would be used to compare the surface water quality data and rainfall events.

For surface water sampling from the constructed wetlands and sedimentation ponds, the timing of sampling is not contingent on tide conditions. Therefore, it is recommended that the timing for the collection of samples from these sites is not restricted to the tide. However, consideration should be given to sampling of the sedimentation ponds and wetlands during at least one rainfall event per annum (i.e. within 24 hrs of a significant rainfall event of >15 mm in 24 hrs, once per year).

7.2 Reporting

It is recommended that the results of the monitoring is reported to the Otago Regional Council on an annual basis as part of an annual monitoring report. The annual report should include a commentary on the water quality results for the year and any trends that are observable in the data, and any remedial actions that may be required to address an adverse trending water quality.

The data obtained from the laboratory sampling on a quarterly basis should be made available to the ORC if requested, with the following exceptions:

– Where an adopted guideline value is exceeded then the data should be forwarded to the ORC within 4 weeks of receiving the data.
– Where a sample result is above the historical maximum recorded for the site, the data will be forwarded to ORC within 5 working days.

8. Limitations

This report: has been prepared by GHD for Dunedin City Council and may only be used and relied on by Dunedin City Council for the purpose agreed between GHD and Dunedin City Council as set out in Section 1 of this report. GHD otherwise disclaims responsibility to any person other than Dunedin City Council and Council officers, consultants, the hearings panel and submitters associated with the resource consent and notice of requirement process for the Green Island Landfill Closure Project arising in connection with this report.

GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report.

GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Dunedin City Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

9. References

Australian Government Initiative – Water Quality Australia 2018, Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Beca (1992) Environmental Impact Assessment of the Existing Green Island Landfill. Report prepared by Beca Steven, May 1992.

Beca (1992b): Environmental Impact Assessment of the Extended Green Island Sanitary Landfill. Report prepared by Beca Steve, October 1992.

GHD(A), Feb 2023. Waste Futures – Green Island Landfill Closure – Design Closure Report

GHD(B), Feb 2024. Waste Futures – Green Island Landfill Closure – Groundwater Technical Assessment

GHD(C), Feb 2023. Waste Futures – Green Island Landfill Closure – Factual Geotech Report

GHD(D), Feb 2023. Waste Futures – Green Island Landfill Closure – Liquefaction and Stability Assessment

GHD (2024) Green Island Landfill. Interim Human Health and Environmental Risk Assessment. Dated 20 May 2024. Project reference: 12613624

Appendices

Appendix A

Water Monitoring Locations Plan

FOR CONTINUATION SEE INLET

ENVIRONMENTAL MONITORING PLAN

SCALE 1:2500

FOR CONSENT NOT FOR CONSTRUCTION

Rev	Description	Checked	Approved	Date
A	PRELIMINARY ISSUE	PM*	PD*	16.12.22

Author R.LOPEZ — Drafting Check

Designer — Design Check

0 25 50 75 100 125m

SCALE 1:2500 AT ORIGINAL SIZE

DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti

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Project No. 12547621

Client DUNEDIN CITY COUNCIL

Project GREEN ISLAND LANDFILL CLOSURE

Status PRELIMINARY — Status Code S2

Drawing Title ENVIRONMENTAL MONITORING PLAN

Size A1

Drawing No. 12547621-C601

Rev A

Plot Date: 13 March 2023 - 8:40 AM Plotted by: Riken Joshua Lopez File Name: C:\12d\SW\data\P-00-12D-001\51-12547621 - Green Island Landfill_1439\CADD\Drawings\12547621-01-C601.dwg

Appendix B

Green Island Landfill – Annual Compliance Monitoring Report 2022 / 2023

Green Island Landfill

Annual Compliance Monitoring Report July 2022 – June 2023

Dunedin City Council

11 October 2023

→ **The Power of Commitment**

Project name	DCC Landfills 0203
Document title	Green Island Landfill | Annual Compliance Monitoring Report July 2022 – June 2023
Project number	12587765
File name	Green Island Landfill 2022 – 2023 Report_Rev0

Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S3	Draft V1	Hayden Erasmus and Cecilia Gately	Cecilia Gately and Stephen Douglass		Stephen Douglass		02 October 2023
S4	Rev0	Cecilia Gately	Stephen Douglass	pp Cecilia Gately	Stephen Douglass	pp Cecilia Gately	11.10.23

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Executive Summary

This report is subject to, and must be read in conjunction with, the limitations set out in section 1 and the assumptions and qualifications contained throughout the Report.

GHD Limited (GHD) has compiled this report on behalf of Dunedin City Council (DCC) in fulfilment of its annual environmental monitoring requirements for the Green Island Sanitary Landfill for the 1 July 2022 to 30 June 2023 period.

Condition 11 of the discharge permit consent no. 3839A_V1 requires that the Consent Holder (DCC) provide the Consent Authority (Otago Regional Council (ORC)) with a Landfill Monitoring Report by the 1st of October each year. The report is to contain all results obtained for all leachate, groundwater, surface water and leachate pumping system monitoring undertaken to meet the requirements of this consent for the previous year. The report is to provide an interpretation of the data in regard to landfill performance, development and isotope analyses undertaken. Trends are to be identified and discussed.

While upwards trends in concentrations in some analytes such as chloride and ammonia in the deeper groundwater and some metals, pesticides and phenols in the leachate can be noted, it is considered that these increases are not significant and that there has been no significant deterioration in the landfill performance or significant increase in landfill leachate effects on the groundwater and surface water quality beneath or adjacent to the landfill.

A summary of exceedances of the adopted guidelines and notable trends in the data are detailed below:

Leachate quality

It should also be noted that the leachate sample was collected on the 14th July 2022, during a significant rainfall event with 63.9 mm of rainfall the previous day and 29.4 mm recorded on the day the sample was collected. The pump station alarms indicated that PS3 had been at high level for two days. A significant portion of the leachate discharging into pump station PS3 is sourced from an area of the landfill bounded by sludge areas as well as recent waste. This area of the landfill did not historically have recent waste placement or sludge pits. This source is likely influencing the quality of the leachate sample collected in July 2022.

– Reported concentrations of ammoniacal nitrogen have been above the adopted Trade Waste guideline value since 2007 (based on graphs in the Delta 2016-2017 report). An upward trend was noted between 2012 to 2017, when the upwards trend flattened out. An overall decreasing trend in ammoniacal concentrations can be noted from 2017 through to 2022.
– Electrical conductivity values were relatively stable between 2012 and 2017. Since October 2017 to July 2022, an overall decreasing trend can be noted with measured values falling from 10,250 to 5,240 µS/cm.
– Reported chloride concentrations have fluctuated over time with an overall downward trend noted since December 2015 to July 2022.
– An overall upward trend in Chemical Oxygen Demand (COD) concentrations can be noted from December 2012 to July 2021 and remained relatively constant in July 2023 (from July 2021).
– Reported iron concentrations have fluctuated over time, however, an upward trend in concentrations can be noted from July 2018, 0.42 mg/L, to July 2022, with a concentration of 8.5 mg/L.
– The field measured pH value was recorded as pH 6.75, which falls below the range of the historical values and within the trade waste guideline values (6.0 – 9.0).
– An overall decreasing trend in alkalinity from 2013 (2,700 mg/L) to July 2012 (1,210 mg/L) can be noted.
– Total Biological Oxygen Demand (BOD5) values have fluctuated over time, however an overall increasing trend in concentrations from January 2017 (170 mg/L) to 330 mg/L in July 2012 can be noted.
– Sulphate concentrations have fluctuated over time, with a new minimum concentration of 24.1 mg/L reported in July 2021 and a new maximum concentration in July 2022 of 540 mg/L.

- Reported faecal coliform numbers increased to >16,000 MPN in the sample collected in July 2022. However, this value needs to be treated with caution as the sample did not reach the laboratory within the required 24 time period from collection. Historically, faecal coliforms have been reported at values ranging between 10 and 12,000 cfu/100ml (July 2019 and July 2020 respectively).
- The increasing trend in volatile fatty acids (VFA) was noted from July 2019 to July 2021 when a concentration of 164,000 µg/L was reported, which was a new maximum value for the data set. A decrease in concentration has been observed in July 2022 with a reported concentration of 35,000 µg/L.
- Following an increasing concentration of total organic carbon (TOC) between October 2017 and July 2021, concentrations have stabilised, with a small decrease from 291,000 µg/L in July 2021 to 290,000 µg/L in July 2022.
- New maximum concentrations were reported for acid soluble arsenic, chromium, copper, lead, manganese and mercury and new minimum for barium and boron.
- Toluene, ethylbenzene and xylenes and three monoaromatic hydrocarbons (MAHs) were reported at concentrations above the LOR. All of these reported concentrations were new maximum concentrations for each of those particular analytes.
- A decrease in the reported concentration of phenol was observed between the July 2021 and July 2022 monitoring events, from 150 µg/L to 68 µg/L, respectively.
- An overall upwards trend in BOD, nickel, manganese, lead, copper, zinc and iron can be noted from the graphs.
- An overall downward trend in cyanide, ammoniacal nitrogen and chloride is observed, while COD remains relatively stable.
- The isotopic analytical data available for the monitoring period 2017 / 2023 indicates that the isotopic results from the samples collected from pump stations PS3 and PS4 (combined leachate/groundwater) suggest a mature stage of leachate methanogenesis with little change in leachate signature.

Deep wells water quality:

- Total ammoniacal nitrogen concentrations were reported present in monitoring wells MW2D, MW4D and MW7D at concentrations of 22 mg/L, 11.1 mg/L and <0.01 mg/L respectively. The corrected value for MW2D was greater than both the NPS NBL annual median and annual maximum values. The corrected ammonia value for the sample collected at MW4D did not exceed any of the adopted guidelines. A new maximum concentration for total ammoniacal nitrogen was reported at MW4D.
- The zinc concentration in monitoring well MW2D was reported at a concentration of 1.68 mg/L, exceeding the ANZG freshwater and marine GVs of 0.008 mg/L. It is noted that the laboratory limit of reporting (LOR) for zinc was 0.1 mg/L and that the reported concentrations for zinc at MW4D and MW7D were <0.1 mg/L. Historically zinc values at these monitoring locations were reported at concentrations ranging between <0.001 and <1. It is possible that zinc was present at these locations at concentrations less than 0.1 mg/L.
- There were no other exceedances of the adopted guidelines for the laboratory reported analytical data.
- The reported concentrations of lead were less than the laboratory LOR of 0.01. It is noted that due to dilution of the sample at the laboratory, the level of detection was raised. Historical reported concentrations for lead have been in the range <0.00005 and 0.0056 mg/L and as such, lead may have been present at these locations but were at concentrations less than the LOR used.
- The reported nitrate as nitrogen concentration was reported below the LOR of 0.1 mg/L at MW2D and 0.13 mg/L and 0.38 mg/L at MW4D and MW7D, respectively.
- Chloride was reported at a concentration above its historical maximum value at monitoring well locations MW4D and MW7D. However, the increase in value was small at all locations (e.g., 9,500 mg/L for MW4D reported in 2022, historical maximum was 9,410 mg/L).
- The field measured pH values for every monitoring round were outside of the adopted range of 7.3-8.0 at all of the deep monitoring wells. Values were reported as being slightly acidic, ranging from 6.41 to 6.98. The pH measured at MW2D tends to be closer to 7 than the others. One new minimum value was recorded in MW4D in April 2023.

– The following laboratory reported analytes exceeded the historical maximum concentrations at the following locations in October 2022:
  - Zinc at MW2D
  - Chloride at MW4D and MW7D monitoring well locations
  - Sulfate and total Anions at MW7D
  - Iron, BOD and total organic carbon (TOC) at MW2D and MW4D
– TOC was reported at a new historical minimum value at MW7D in October 2022.
– New maximum values for field measured electrical conductivity were recorded at MW2D and MW4D during the July 2022 and January and April 2023 monitoring events. New maximum values were also recorded for MW7D in January and April 2023.
– All field dissolved oxygen (%) values were recorded as being below the ANZG (2018) GV. All field measured dissolved oxygen (mg/L) measurements were below the NPS (2020) NBL values.

Based on the elevated ammoniacal nitrogen, chloride and more acidic pH, the water quality data suggests that landfill leachate may be having a minor impact on the groundwater quality in the deep groundwater monitoring wells, but with the majority of analytes being reported within their long term historical ranges. Overall, no significant change in groundwater chemistry was noted since the 2021 - 2022 monitoring year.

Surface water monitoring points:

The surface water monitoring locations analytical data were compared against ANZG DGVs for 80% species protection and the NPS NBLs as an indication of water quality. The Kaikorai Stream is considered as a disturbed system and as such the 80% level of protection was adopted.

– Overall, the reported nitrate concentrations for all locations were consistent with previous data, with the exception of GI5 in October 2022, when the concentration decreased over two orders of magnitude. The elevate nitrate concentrations reported for all locations in July 2022 is most likely attributable to the significant rainfall event which occurred before and during the monitoring event.
– Reported concentrations of lead for monitoring locations GI1, GI3 and GI5 are showing similar fluctuations in values over time and are of similar magnitude. However, the concentrations of lead at GI2 (Abbotts Creek location) tend to be lower than at the others and not fluctuate to the same degree, with the exception of April 2023, when the concentration increased at GI2 above the other locations. The concentration of lead at GI1 decreased in April 2023 when values at GI3 and GI5 remained relatively stable.
– Reported nickel concentrations at GI2 tend to be greater than those reported at the other monitoring locations. A similar pattern was noted in April 2023 with the concentration increasing at GI1 and decreasing at GI2.
– The measured pH values at GI2 were the generally lowest and generally highest at GI1, with the exception of April 2023 when this pattern reversed.
– An overall increasing trend in EC values and chloride concentrations at all monitoring locations can be noted over the monitoring year, with the exception of chloride at GI2 in April 2023.
– Chromium concentrations have tended to follow similar patterns and be of a similar magnitude. However, the data for the 2022 / 2023 monitoring period has been more disperse with values in April 2023 for GI2 and GI3 being greater than that at the other two locations when they have generally tended to be less than the values reported for GI1 and GI5.
– Reported copper concentrations fluctuated over the monitoring year at monitoring locations GI1, GI2 and GI5. Concentrations reported for GI3 were above the ANZG freshwater guideline over the whole monitoring year and were relatively stable.
– Total cyanide concentrations remained at concentrations below the laboratory LOR at all monitoring locations over the monitoring year with the exception for January 2023 when the reported concentration at GI1, GI2 and GI3 were elevated above the adopted ANZEEC guideline values.
– Reported total ammoniacal nitrogen (uncorrected) concentrations were relatively stable over the first part of the monitoring year. As ammonia concentrations at GI2 (Abbots Creek) are similar to or greater than (except

for April 2023) those reported for downstream monitoring locations, it is likely that the ammonia concentrations reported present at GI3 and GI5 are attributable mainly to the input from Abbots Creek.

– Chloride concentrations at monitoring locations GI1 and GI2 have remained relatively stable and are of similar magnitude since October 2019. Fluctuations in concentrations at sample locations GI3 and GI5 are similar to one another but are greater in magnitude than those at GI1 and GI2. The higher values noted at GI3 and GI5 are likely influenced by these sample points being located in intertidal zones.

It is likely that the significant rainfall event in the middle of July 2022 affected surface water quality in both the Abbotts Creek and Kaikorai Stream, leading to elevated concentrations of contaminants, in particular aluminium and nitrate, at all monitoring locations in July 2022.

Based on the 2022/2023 analytical results, the likely sources of heavy metals (aluminium, copper and nickel) are from the Abbots Creek catchment and the industries upgradient of the landfill in the Kaikorai Stream catchment, both contributing to the overall concentrations.

It is apparent that the surface water upstream of the landfill, in both the Kaikorai Stream and Abbots Creek, has been impacted by industrial and agricultural activities. Overall, the influence of the landfill leachate on water quality in the Kaikorai Stream does not appear to be significant.

The more elevated chloride concentrations and EC measurements at GI3 and GI5 are likely reflective of a generally more saline, estuarine conditions than at the more upstream monitoring locations.

Sediment Ponds Water Quality:

The surface water monitoring locations analytical data were compared against were the ANZG DGVs for 80% species protection and the NPS NBLs as an indication of water quality. As these ponds discharge into the Kaikorai Stream, the same level of species protection DGVs were adopted.

Eastern Pond

– The field measured pH was greater (more alkaline) than the upper guideline value for a lowland river in October 2022 and January 2023.
– The field measured DO values were outside of the guideline range for a lowland river on all sampling occasions during the 2022 / 2023 monitoring year. Three were below the guideline range and were between 16.1 % and 67.0 % and the other was above the range at 252.2%.
– The reported concentrations of chloride at all monitoring events were above the ANZG freshwater DGV (0.013 mg/L) and ranged between 46 and 494 mg/L.
– Total ammoniacal nitrogen concentrations were reported present with concentrations ranging between less than the laboratory level of detection (0.005) and 0.53 mg/L. The corrected values for the Eastern Pond were less than the NPS NBL annual median and annual maximum values.
– The reported concentrations of copper in July and October 2022 exceeded the ANZG freshwater DGV of 0.0025 mg/L with values of 0.0037 and 0.0038 mg/L, respectively.
– The reported zinc concentration in January 2023 exceeded the ANZG freshwater DGV of 0.0.031 mg/L with a concentration of 0.043 mg/L.
– A new maximum value for dissolved oxygen was recorded in January 2023.
– A new minimum concentration for copper was reported in April 2023 and two new minimums for total ammoniacal nitrogen were recorded in January and April 2023.

Western Pond

– The field measured pH was greater (more alkaline) than the upper guideline value for a lowland river in January 2023.
– The field measured DO values were outside of the guideline range for a lowland river on all sampling occasions during the 2022 / 2023 monitoring year, with values ranging between 30.7 and 75.7 %.
– The reported concentrations of chloride at all monitoring events were above the ANZG freshwater DGV (0.013 mg/L) and ranged between 1,240 (July 2022) and 2,210 mg/L (January 2023). The concentration reported in January 2023 also exceeded the Consent 3840C_V1 derived trigger value of 2,068 mg/L.

- The reported concentration of copper in July 2022 exceeded the ANZG freshwater DGV of 0.0025 mg/L with a value of 0.0048 mg/L.
- The reported nitrate concentration in July 2022 exceeded both the Consent 3840C_V1 derived trigger value of 1.690 mg/L and ANZG freshwater DGV of 17 mg/L with concentration of 18.3 mg/L (a new maximum concentration). This is likely due to the sample being collected during a significant rainfall event and the pond receiving stormwater (and contaminants) being flushed from the upper catchment.
- No other exceedances were reported and all reported values for these analytes were within their historical ranges.

In the Western Pond, the proximity to the estuary is likely to have influenced the electrical conductivity values and chloride concentrations, which are higher than those measured in the Eastern Pond. Both analytes have increased between July 2022 and January 2023 before decreasing in the April 2023 monitoring event.

The reported concentrations of nitrate, zinc, chloride, pH, copper and dissolved oxygen exceeded the ANZG 80% DGVs in various monitoring events at either pond throughout the 2022 – 2023 monitoring period. Overall, the water quality in the Western Pond is slightly better than that in the Eastern Pond as there are less analyte exceedances over the monitoring period in the Western Pond than were reported in the Eastern Pond.

Compliance with consent conditions was achieved with the exception of the following:

- Nitrogen-15 isotope in nitrate was not analysed for during the 2022 – 2023 monitoring year.
- Documentation relating to the July 2022 monitoring event for landfill gas monitoring wells adjacent to Clariton Avenue was lost and as such no monitoring data is available for this period.
- Water levels in the Kaikorai Stream were not measured as the gauges were unreadable due to sediment and algae adherence and a recommendation that they be cleaned or replaced has been given. While these gauges are cleaned periodically, it was not possible to take measurements from these gauges on all monitoring occasions.
- The flow rate in the Kaikorai Stream could not be estimated due to the low flow velocity in the upper reaches.
- The condition of the estuary mouth, whether open or closed, was not noted.
- Odours were noted beyond the landfill boundary on several occasions. There are intermittent issues with odour due mainly to waste received from the WWTPs. This is managed by burying and covering the waste as quickly as possible and with the use of an odour suppression system (litter fence mist system, odour cannon and addition of lime). Enforcement action was taken by the Otago Regional Council (ORC) in relation to the odour issues. A list of action items was drawn up for DCC to undertake, with the majority of them being actioned by the end of June 2023.
- Windblown litter also remains as an issue which is managed by a litter fence and undertaking intermittent hand picks of the litter.
- No monitoring was undertaken at monitoring well MW9D as is has been lost due to landfilling activities. Monitoring well MW7D was monitored instead.

2022 / 2023 works programme and audit findings

The findings of the landfill audits indicated that several major projects had been undertaken over the monitoring year, including the completion of the construction of a final cap over the northern portion of the landfill and the installation of new landfill gas collection and transfer infrastructure.

Other works and observations of note are detailed below:

- Landfilling moved into the south / southwest portion of the Site.
- New sludge containment pits were constructed in various locations in the western portion of the landfill.
- Additional landfill gas infrastructure was constructed near the tip face to capture landfill gas being generated in this area and to accommodate the expansion of the landfill.
- Due to very high rainfall in July 2022, inundation of portions of the leachate collection trench and the stormwater collection / transfer infrastructure occurred.

– A new access track and two new sedimentation ponds (a large and small) were constructed in the south western portion of the site, associated with the borrow pit.
– A new culvert in the eastern portion of the site, servicing the haul road, was installed adjacent to the green waste disposal area.

Pumped volumes

The volume of pumped leachate over the 2022 - 2023 monitoring year was approximately 80,229 m^3, which was higher than the volume pumped during the 2021 - 2022 monitoring year and the 2020 – 2021 monitoring year (50,663 m^3 and 65,988 m^3 respectively). This is equivalent to approximately 9,158 L/hour of combined leachate / groundwater pumped during the 2022 – 2023 monitoring year.

The increase in volume pumped compared to the previous monitoring year is considered be a result of there being higher rainfall during the 2022 – 2023 monitoring year than the previous year.

Leachate quality

Historical data, along with the data collected in July 2022, indicate that there have been fluctuations within the previously observed trends as discussed above. Leachate chemistry is highly variable as demonstrated in the graphs and historical data presented in Table C2.

Groundwater quality

The generally high EC values at monitoring locations MW2D and MW4D indicate either a leachate or estuarine influence from the Kaikorai stream / estuary or a combination of both. The low pH values (slightly acidic) recorded at all deep wells may indicate landfill leachate influence.

Based on the elevated ammoniacal nitrogen, chloride and more acidic pH, the water quality data suggests that landfill leachate may be having a minor impact on the groundwater quality in the deep groundwater monitoring wells, but with the majority of analytes being reported within their long term historical ranges. Overall, no significant change in groundwater chemistry was noted since the 2021 - 2022 monitoring year.

The pH of the leachate measured at the manholes was generally less than or similar to the pH of the groundwater in the monitoring wells, with the exception of Well Lines 1 and 5. There is no apparent trend in pH values in the monitoring wells either side of the leachate trench. Values measured in monitoring wells “C” do not appear significantly different to those measured at the “A” and “B” wells, with the exception of Well line 2 where the pH values measured at monitoring wells “C” and “D” are very similar to those measured in the leachate trench and separate to those measured at MW2A and MW2B. The electrical conductivity values measured at the “A” and “B” wells often follow similar trends and are of similar magnitude.

The isotopic analysis indicates that the landfill leachate is at a mature stage of methanogenesis.

Contents

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Appendices

1. Introduction

1.1 Purpose of this report

This Green Island Landfill Annual Environmental Monitoring Report has been prepared by GHD Limited (GHD) for the monitoring year 1st July 2022 to the 30th June 2023 on behalf of Dunedin City Council (DCC). The Otago Regional Council (ORC) has granted a number of resource consents in relation to this landfill to DCC, further details of which are provided section 2.3.

Monitoring of the leachate pumps operation, groundwater depths and quality, surface water quality and landfill gas volumes is required to comply with resource consent conditions for the landfill, in addition to other requirements as set out in the consents. An annual landfill compliance monitoring report is required to be provided to the Consent Authority, ORC, in relation to these consents by 1 October each year.

1.2 Limitations

This report: has been prepared by GHD for Dunedin City Council and may only be used and relied on by Dunedin City Council for the purpose agreed between GHD and Dunedin City Council as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Dunedin City Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

GHD has prepared this report on the basis of information provided by Dunedin City Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD excludes and disclaims all liability for all claims, expenses, losses, damages and costs, including indirect, incidental or consequential loss, legal costs, special or exemplary damages and loss of profits, savings or economic benefit, Client may incur as a direct or indirect result of the ESdat DCC landfills database, for any reason being inaccurate, incomplete or incapable of being processed on Dunedin City Council's equipment or systems or failing to achieve any particular purpose. To the extent permitted by law, GHD excludes any warranty, condition, undertaking or term, whether express or implied, statutory or otherwise, as to the condition, quality, performance, merchantability or fitness for purpose of the DCC landfill ESdat database.

GHD does not guarantee that the DCC landfill ESdat database is free of computer viruses or other conditions that may damage or interfere with data, hardware or software with which it might be used. Dunedin City Council absolves GHD from any consequence of Dunedin City Council's or other person's use of or reliance on, the ESdat DCC landfills database.

1.3 Scope

The scope of work comprised the following:

- Undertake quarterly groundwater, surface water and other monitoring, as specified by consent conditions, at the Green Island Landfill, Dunedin, in accordance with the relevant resource consents conditions.
- Undertake quarterly environmental auditing and reporting.
- Obtain monthly groundwater and landfill gas monitoring data collected by Waste Management and incorporate the data and assessment into the report.
- Obtain landfill gas flow data, landfill gas composition and pumped leachate volumes from DCC, assess and include in the annual monitoring report.
- Prepare an annual compliance monitoring report detailing the site works undertaken and reported analytical results. The report is required to provide discussion on consent non-compliance and trends in reported data.

1.4 Assumptions

It is assumed that the data and information provided to GHD by Dunedin City Council, subconsultants, subcontractors and government agencies is true and correct.

2. Site information

2.1 Site setting

The Green Island Landfill (the Site) is a municipal landfill facility situated on Taylor Street, to the west of Brighton Road, approximately 8 km southwest of central Dunedin. The facility is currently managed and operated by Waste Management Ltd., on behalf of DCC who own the landfill. A Site Location Plan is provided as Figure 1.

The Site is located in a reclaimed wetland area within the Kaikorai Estuary, which is part of the larger Kaikorai Catchment; a 55 km^2 area bounded by the Kaikorai Stream and Abbots Creek and the topography of Chain Hills, to the northwest and north, Kaikorai and Round Hills to the north and northeast and Saddle Hill, to the west. The Kaikorai Stream historically ran through the Site but was later diverted along the western boundary of the Site to run in a southwest and southerly direction, towards the Kaikorai Lagoon and ultimately the sea. The stream forms the northern and western limits of the landfill before flowing into the Pacific Ocean near Waldronville.

The landfill is approximately 38 hectares in size and is delineated by the legal descriptions in Table 1 below.

Table 1 Legal description of Green Island Landfill

Legal Description
Pt Pt Secs 44 and 45 Green Island Bush SD
Secs 54-55, 63, 65 Block VII
Section 119 Block VII Dunedin and East Taieri SD

Several activities are currently being undertaken on the landfill including municipal waste disposal, compost production, a waste transfer station and a recycling centre operation, and liquid waste and sludge disposal.

A Site layout plan is provided as Figure 2. As can be seen on this figure, in April 2023, the working face was located in the southern central portion of the Site and is expected to move soon to a more north-westerly location. The majority of liquid waste disposal was located in a specific pond towards the south-westboundary. The operational sludge pit was noted to be situated to the north of the working face in April 2023. The location of operational sludge pits have moved around the Site throughout the 2022 / 2023 monitoring period as pits are opened, filled and capped. The composting area is situated on the north-eastern portion of the site and the waste transfer station and recycling station is adjacent to the northern boundary. A final cap has been constructed over the northern portion of the recent landfill area over the previous year.

A network of landfill gas collection wells is also installed at the landfill, with additional wells having been installed over time as landfilling operations have progressed. The configuration of the wells was adjusted in 2022 / 2023 to accommodate the landfill capping works and allow for improved gas collection. Several upgrades to the landfill gas collection and transfer infrastructure were undertaken over the monitoring year. The majority of the collected landfill gas is piped to the Wastewater Treatment Plant (WWTP) for use in the generation of electricity. However, not all of the gas wells are connected into the network all of the time and the destruction of the methane collected at these wells is by solar-spark flare burn off.

Two stormwater sedimentation ponds are located on the landfill, one on the southwestern site boundary (Western Pond) and one on the north-eastern site boundary (Eastern Pond), see Figure 4. There is also an overflow pond located south of the Western Pond. A leachate and stormwater pond is located adjacent to the northern Site boundary, and two new sedimentation ponds have been constructed along the Site’s southern boundary.

Changes to the landfill layout which have occurred over the past monitoring year are presented on Figure 2.

Map A
Paper Size A3
0 1,150 2,300 4,600 6,900 9,200
Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Legend

Site Boundary

GHD

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

Dunedin City Council

GREEN ISLAND LANDFILL

SITE LOCATION

Job Number	12587765
Revision	A
Date	07 Jun 2023

Figure 1

Map B
Paper Size A3
0 255 510 1,020 1,530 2,040
Meters

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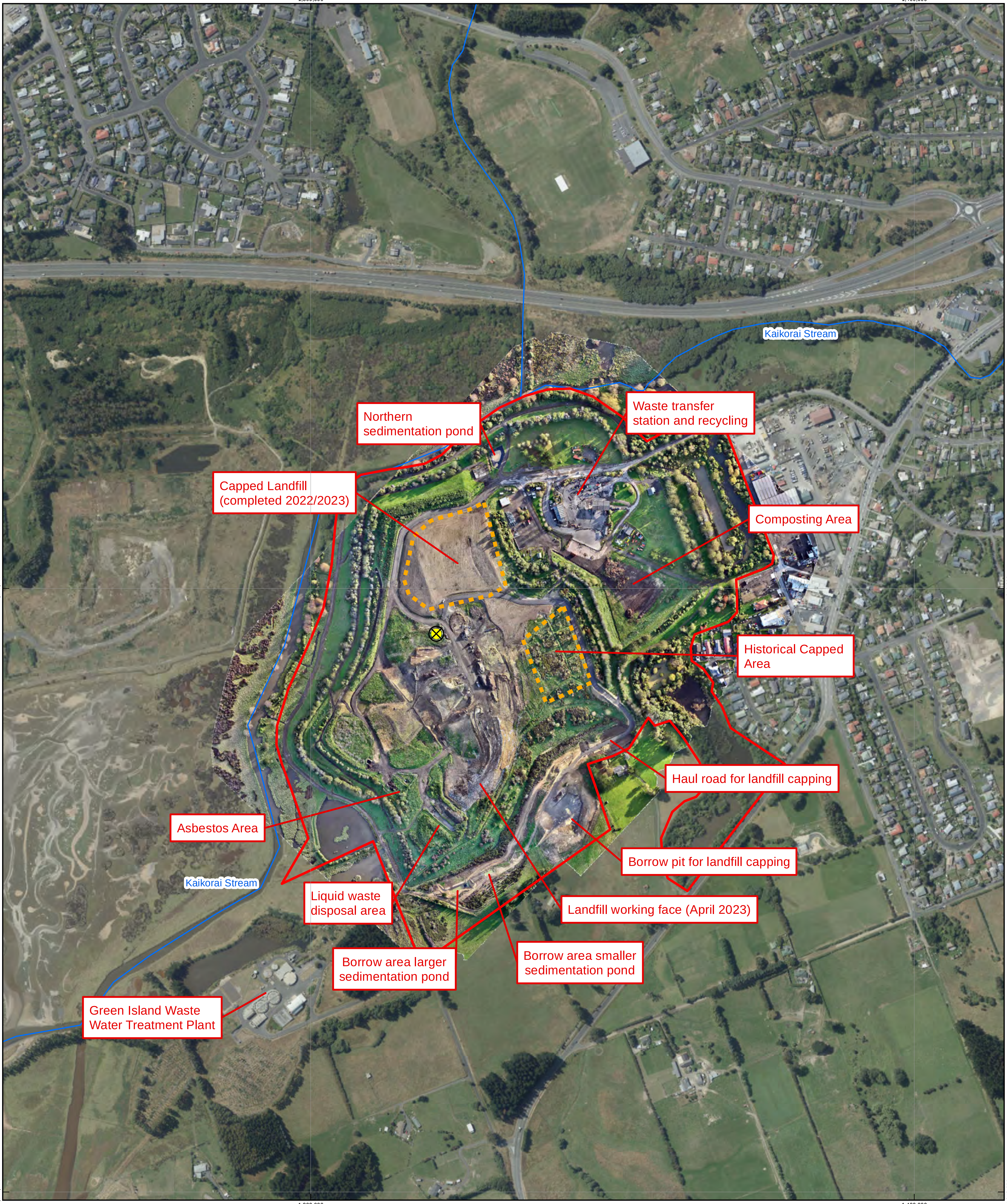
Level 3 138 Victoria Street Christchurch 8141 New Zealand **T** 64 3 378 0900 **F** 64 3 377 8575 **E** chcmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro; Imagery as at April 2019, DCC; GHD_DCC_Urban_Imagery_2013, Data (GI_Site_boundaries_GHD_20230531) Created by:herasmus



Legend

Site Boundary

Kaikorai Stream

Weather Station

Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Dunedin City Council
GREEN ISLAND LANDFILL
Site Layout April 2023

Job Number 12587765
Revision A
Date 11 Oct 2023

Figure 2

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Level 3 138 Victoria Street Christchurch 8141 New Zealand **T** 64 3 378 0900 **F** 64 3 377 8575 **E** chcmail@ghd.com **W** www.ghd.com

Data source:Service Layer Credits: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributorsCreated by:herasmus

2.2 Site history and development

A landfill has been present on the eastern side of the Kaikorai Estuary since 1954. Unregulated and uncontrolled landfilling occurred at the site until the 1990s, when DCC began to manage waste disposal activities through a national planning approach for the area. In 1995, a leachate interception trench and collection system consisting of nine (9) pump stations interconnected via a gravel-filled trench with an inbuilt perforated collector drain located around the landfill toe was retrofitted around the majority of the perimeter of the landfill (Figure 3). The pump stations, Pump stations PS1 through to PS9, associated with the trench can be seen in Figure 4.

This pump network is set up to maintain a hydraulic gradient towards the trench, minimising the amount of leachate migrating beyond the interceptor trench. The interception trench allows for the leachate to be collected and discharged to the Green Island Wastewater Treatment Plant (WWTP), located to the southwest of the landfill. There is no leachate collection trench along the south-eastern boundary of the landfill, between PS1 and PS9.

A network of groundwater / leachate monitoring wells was installed in a series of lines crossing perpendicular to the interception trench, to monitor groundwater / leachate levels across the trench to confirm hydraulic containment of the shallow groundwater. This network consists of both shallow and deep monitoring wells and each line is located approximately halfway between each pump station.

A schematic cross section plan of the landfill and the location of the leachate collection drain and monitoring well arrangement is presented below.

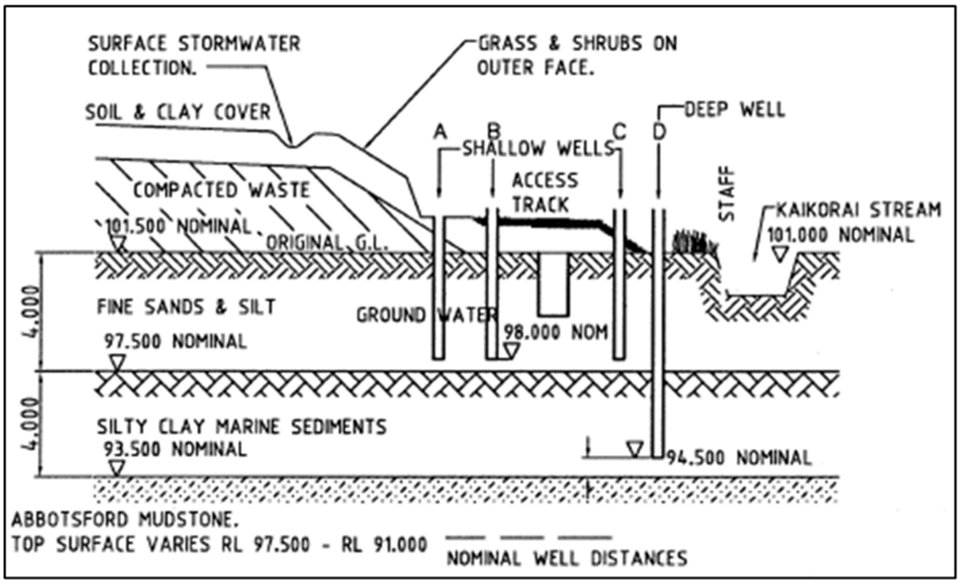
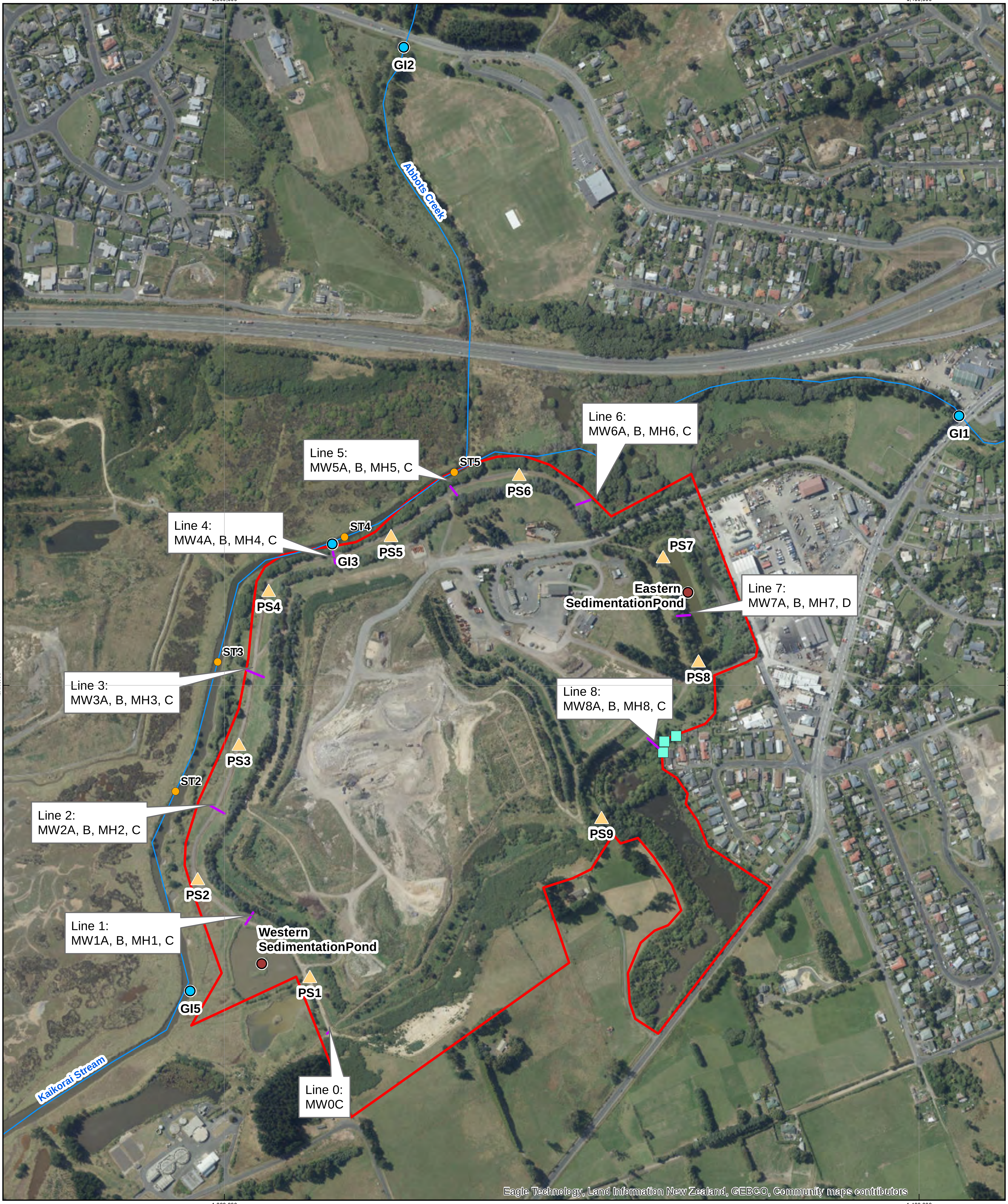


Figure 3 Cross section of the leachate trench and monitoring well set up.

A high density polyethylene (HDPE) liner has been placed between the leachate interception trench and the Kaikorai Stream to minimise flow from the stream and groundwater migrating eastwards towards the landfill. During this time, in the 1990s, a clay bund was also installed around the Site boundary to contain both the landfill and leachate. However, based on a review of the trench installation report[1], there is waste present on the outside of the trench along portions of the trench alignment. The type of waste and its thickness varies with location.

[1] Barry J Douglas Geological Consultants (2002) Green Island Landfill Leachate Collection Trench Geological Report: Trench Installation, Soil and Hydrogeological Characteristics. Prepared for Waste Services Department / City Consultants Dunedin City Council



Legend

	Site Boundary		Pump Station		Sedimentation Pond		River
	Staff Gauge		Surface Water		Landfill Gas Monitoring Well Locations		Monitoring Array

Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Dunedin City Council
Green Island Landfill 2023

Green Island Landfill
Monitoring Locations

Job Number 12587765
Revision A
Date 07 Jun 2023

Figure 4

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Level 3 138 Victoria Street Christchurch 8141 New Zealand **T** 64 3 378 0900 **F** 64 3 377 8575 **E** chcmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro; Imagery as at April 2019, DCC; GHD_DCC_Urban_Imagery_2013, Data (SIte_Boundary_GHD_20230531, GILF_Stream_GHD_20180818, GILF_Location_from_esdat_GHD_20180818, GILF_Location, GILF_location_monitoringArray_Polyline, Landfill_Gas_Monitoring_Locations). Created by:herasmus

2.3 Consents

ORC granted 11 consents to DCC (refer Table 2 below) to regulate, manage and monitor the various discharges from the Site. The consents were initially granted in either 1994 or 1995, were reissued in July 2007 to reflect updates to the consents and are due to expire on 1 October 2023.

Applications for new consents for the continued operation and closure of the landfill were lodged with the ORC in April 2023. Until a decision is made on the consent(s) application, the 2007 consents have continued use status under Section 124 of the Resource Management Act (1991).

Table 2 Consent details

Consent Number	Purpose
3839A_V1: DISCHARGE PERMIT	To discharge landfill and composting leachate to land in a manner that may enter water
3839B_V1: WATER PERMIT	To take groundwater and leachate from groundwater bores and from a leachate collection drain located at and around the Green Island Sanitary Landfill
3839C_V1 WATER PERMIT	To divert stormwater at a landfill and composting facility within a 38 hectare area bounded by a leachate collection drain
3839D_V1: WATER PERMIT	To take stormwater from a landfill and composting facility within a 38 hectare area bounded by a leachate collection drain
3840A_V1: WATER PERMIT	To divert stormwater from the non-working areas of a landfill
3840B_V1: WATER PERMIT	To take diverted stormwater from the non-working areas of a landfill
3840C_V1: DISCHARGE PERMIT	To discharge stormwater to the Kaikorai Stream
4139_V1: WATER PERMIT	To take groundwater (originating from the Kaikorai Stream) through a landfill leachate collection drain
94524_V1: DISCHARGE PERMIT	To discharge to air landfill gas, dust and odour generated from landfilling up to 100,000 m3/year of compacted municipal, domestic, hazardous and industrial waste, and including a composting operation
94693_V1: DISCHARGE PERMIT	To discharge up to 270 m3/day of municipal, domestic, hazardous and industrial waste, including a composting operation, to land in circumstances which may results in contaminants entering natural water
94262_V1: DISCHARGE PERMIT	To discharge up to 270 m3/day of municipal, domestic, hazardous, industrial waste and organic waste to land

In accordance with consent conditions, monitoring of groundwater levels, sedimentation pond water quality, surface water quality, leachate chemistry and pump operations, is required at various locations at and around the Site. Details of monitoring for the 2022 / 2023 monitoring year are provided in the following sections, and overall compliance with those consents is summarised in Section 9.

2.4 Rainfall

A graph of annual rainfall from 1960 to 2019 is presented in Figure 5 below (sourced from Statistics New Zealand). The area, Dunedin, receives an annual rainfall of between 515 mm (2001) and 926 mm (2000) (Statistics New Zealand, Average annual rainfall 2000-2019 data), with an average rainfall of 702 mm over the 2000-2019 period. Statistics New Zealand update this data on a three yearly basis and the next update is due in October 2023.

The reported rainfall for the 1st July 2022 to 30th June 2023 period at the Green Island weather station was 871.8 mm (CliFlow, Green Island Kaikorai Estuary, 2023), which is above the average for the past twenty years. It can also be noted that the rainfall volumes in July and October 2022 and March and May 2023 were higher in comparison to the monthly average of the 1991-2020 dataset, see Table 3. Further discussion and rainfall data is included in Section 4.2.2.

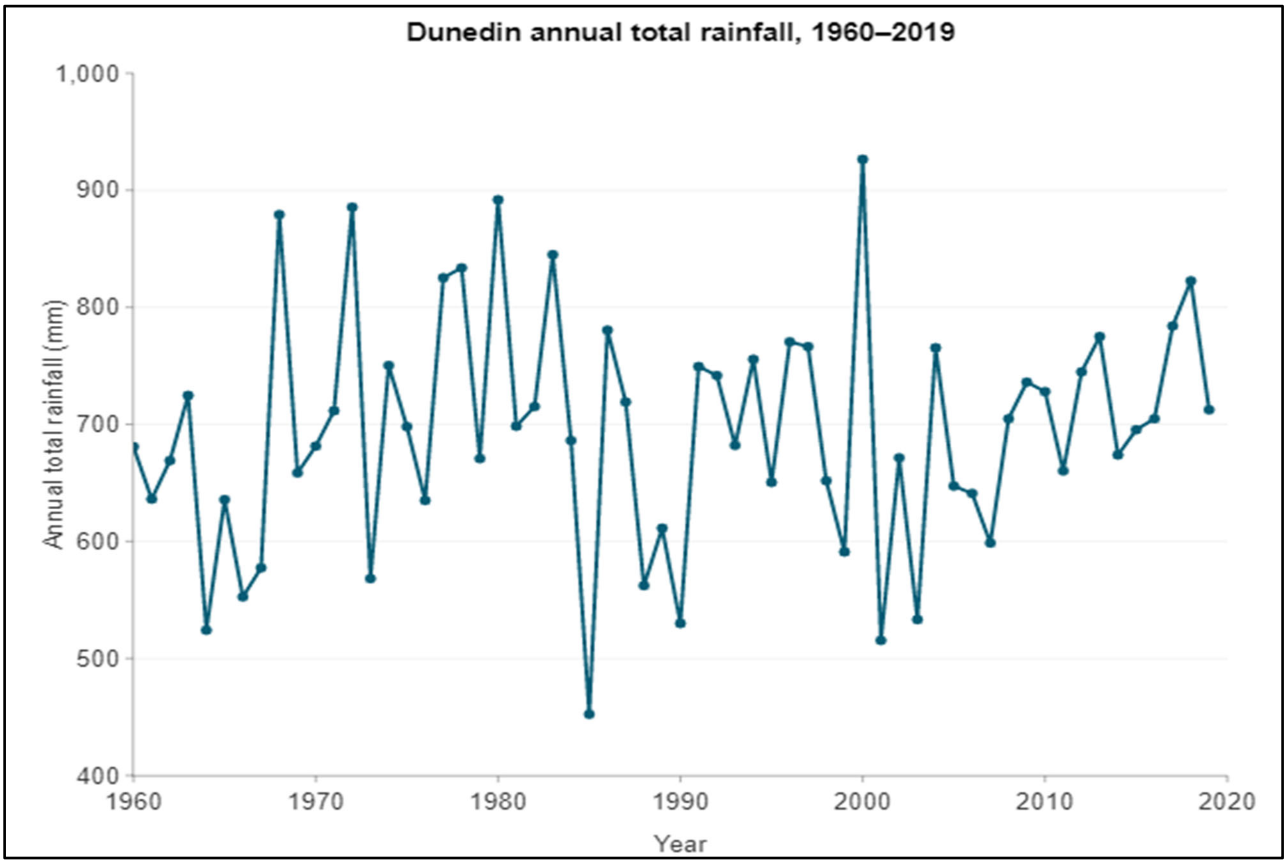


Figure 5 Annual rainfall at Musselburgh, Dunedin 1960-2019

Table 3 Historical and Current Rainfall data for the Green Island Kaikorai Estuary Weather Station

	Average Rainfall Green Island Kaikorai Station (1991-2020) (mm)	Rainfall at Green Island Kaikorai Station July 2022 – June 2023 (mm)	Variance – Current year rainfall amount compared to historical average (mm)	Variance – % of current year rainfall amount in comparison to historical average
July	59.9	265.3	+205.4	442%
August	52.4	22.5	-29.9	-43%
September	47.7	35.2	-12.5	-74%
October	63.8	71.5	+7.7	112%
November	60.3	31.9	-28.4	-53%
December	73.2	37.8	-35.4	-52%
January	77.2	34.9	-42.3	-45%
February	78.0	49.0	-29.0	-63%
March	59.4	129.7	+70.3	218%
April	67.1	40.4	-26.7	-60%
May	68.9	103.5	+34.6	150%
June	67.6	50.1	-17.5	-74%
Total	**775.5**	**871.8**	**+96.3**	**112%**

Data source: NIWA online Cliflow database (queried 24/Sept/2023)

2.5 Hydrogeology

The Site is underlain by the Kaikorai Estuary Formation sediments, a Quaternary age estuarine alluvium consisting of varying proportions of marine silty clays, silts, clay and silty sands. This in turn is underlain by the Abbotsford Formation; an Upper Cretaceous (80 Ma) sequence of sand/mud/claystones and occasional conglomerates that is up to 300 m thick.

Three aquifers have been identified beneath the site:

1. The uppermost aquifer is associated with the Kaikorai Stream. The installation of the landfill leachate collection trench has created a hydraulic barrier, with a hydraulic gradient intended to draw any potentially contaminated groundwater from the landfill into the trench to prevent leachate impact on the aquifer associated with Kaikorai Stream;
2. The second aquifer is located some 4 m below ground level (bgl); and
3. The third aquifer located at approximately 8 m bgl and is considered “least likely to be impacted by leachate from the landfill”

The Site is not within a Groundwater Protection Zone or Seawater Intrusion Risk Zone. However, it is adjacent to a Regionally Significant Wetland as defined in the ORC Regional Plan (ORC, 2018).

3. Groundwater levels monitoring

Resource Consent Number 3839B_V1 (water permit) sets out conditions for the following:

To take groundwater and leachate from groundwater bores and from a leachate collection drain located at and around the Green Island Sanitary Landfill.

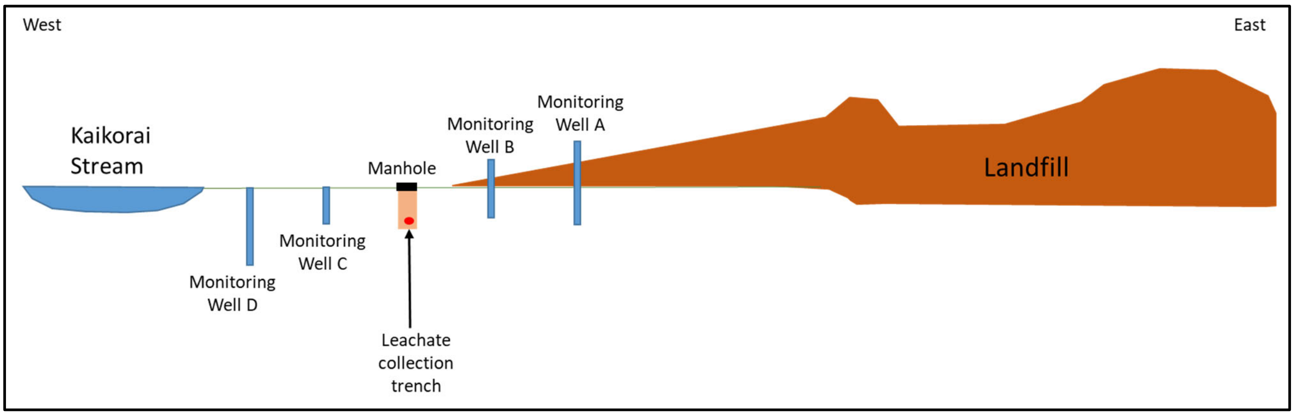
This consent expires on the 1st of October 2023 and operates alongside discharge permit 3839A_V1, which sets out conditions for the following:

To discharge landfill and composting leachate to land in a manner that may enter water.

3.1 Groundwater and leachate levels monitoring

3.1.1 Monitoring network

In accordance with consent conditions, the leachate collection trench and the network of groundwater wells and pump stations are monitored on a monthly basis at the Site. The monitoring locations are presented on Figure 4. A simplified schematic of the monitoring well set up is shown below.



Pump Stations

A network of pump stations (PS1 through to PS9) was installed along the leachate collection trench located on the south western, western, northern and north-eastern boundary of the Site, as can be seen on Figure 4.

Groundwater monitoring wells

As shown on Figure 4, there are eight lines of groundwater monitoring wells, Well Lines, located along the leachate collection trench, intersecting it on an approximate right angle. A description of the wells set up follows:

- Each Well Line is located at mid-distance between two pump stations and each line comprises three shallow wells, MWA through to MWC, with the exception of Line 7, where MWC is absent.
- At each Well Line, monitoring wells MWA and MWB are located on the landfill side of the leachate trench, approximately 20 m and 5 m from the trench respectively.
- Monitoring well MWC is located between the trench and the Kaikorai Stream / eastern sedimentation pond / eastern boundary.
- Along each Well Line, an inspection manhole is located at the point the Well Line intersects the leachate trench, between monitoring wells MWB and MWC.
- On three of the Well Lines (Well Line 2, 4 and 7), deep wells are also present and monitored, located between the leachate collection trench and the stream. They are described as MWD.

– An additional bore, MW0C located at the end of the leachate trench collection system at Well Line 0, to the south of PS1 was also monitored.
– A further monitoring well, MW9D, had been located towards the centre of the landfill, but was lost due to landfilling activities in 2015.

The water level within these wells is monitored in accordance with the consent conditions.

Manholes

Inspection manholes for the leachate collection trench are located midway between the pump stations. Seven manholes were monitored during the 2022 / 2023 monitoring year (MH1 to MH3 and MH5 to MH8). Manhole MH4 cannot be found and is likely buried. These are located along the groundwater well lines alignment.

Staff gauges

There are three water level staff gauges, ST3 through to ST5, in the Kaikorai stream monitoring network. These are located close to Well Lines 3 through to 5, respectively.

There are also staff gauges located within the Western and Eastern sedimentation ponds, one in each.

3.1.2 Monitoring Events

As per condition 4 (A) of Consent 3839B_V1, the water levels of the network specified above should be monitored on a monthly basis. The network, as listed in section 3.1.1 above, was monitored monthly from July 2022 to June 2023 by Waste Management and GHD, with the following exception:

– Condition 7A (iv) of the consent 3839A_V1 states that where the “outside landfill groundwater wells” are located adjacent to the Kaikorai Stream, then the surface water level in the Kaikorai stream should be recorded as well. The staff gauges located in the Kaikorai Stream were inspected during each of the dipping rounds, however, the gauges could only be read on limited occasions due to algal growth and accumulated dirt on the scales. Waste Management have been requested to have these cleaned or replaced.

Monthly records collected by Waste Management are presented in Appendix A, at the rear of this report, along with the quarterly water level and water quality parameters data collected by GHD.

3.1.3 Monitoring results

The leachate collection drain was originally designed and installed to maintain a depression of the groundwater surface level in order to intercept leachate that would otherwise flow from the landfill to the Kaikorai Stream. The leachate and groundwater entering the drain is directed by gravity to the pump stations (leachate collection sumps) and pumped to the foul sewer system once the level in the sumps reaches a predetermined level.

The objective of the groundwater level monitoring is to assess the effectiveness of the interception trench and the pumping regime, to ensure that groundwater and leachate is being intercepted.

Over the monitoring year July 2022 to June 2023, groundwater levels were measured at all of the available monitoring locations on a monthly basis. Figures showing drawdown and water table depression for each month (July 2022 to June 2023) for Well Line 1 through Well Line 8 are presented as Figures A-1 to A-12, included in Appendix A at the rear of this report.

Overall, measured groundwater levels indicate that the leachate collection trench is intercepting groundwater and leachate moving from the landfill towards the Kaikorai Stream and eastern boundary. The following can be noted:

– Drawdown (hydraulic gradient) into the leachate collection drain was maintained at all of the well lines over the whole monitoring year with the exception of Well Line 3 in February 2023 where it is noted that the groundwater level in monitoring well MW3C (western side (Stream)) was lower than what was measured in leachate collection trench (MH3) by approximately 0.10 m. It is noted that due to the configuration of the interception trench and pump station infrastructure, drawdown and pumped leachate volumes into the collection trench drain at PS3 is typically very small in comparison to the remainder of the network. The hydraulic gradient into the leachate / groundwater interception trench was reestablished by March 2023.
– At Well Line 1 – Rising levels has MH1 (up to 200 mm higher than average) can be noted in February and March 2023. The levels returned to normal in April 2023.

- At Well Line 2 in January 2023, the drawdown into the trench (1m higher than normal level at MH2) was not as pronounced as it was over the rest of the year. This may have been due to a measurement error.
- At Well Line 3, the drawdown into the interception trench from the estuary side was very shallow to minimal from November 2022 though to April 2023. Inspections were undertaken and foaming at the pump station was noted. This situation continues to be monitored.
- At Well Line 4, the measured drawdown into the interception trench from the landfill side of the trench was minimal over the monitoring year, with the exception of August 2022. This is consistent with the long-term history at this location and is a function of the pipe and pump levels installed.
- Well line 6 – the level measured at pump station PS6 was elevated above historical levels (approximately 400 mm) in both November and December 2022. The levels returned to normal in January 2023.
- The drawdown profile at Well Lines 5 and 7 remained relatively consistent over the monitoring year.
- The drawdown profile into the interception trench at Well Line 8 became shallower from December 2022 through to March 2023.

3.1.4 Discussion and conclusion

The groundwater levels measured during the 2022 / 2023 monitoring year and shown on the cross-sections in Figures A-1 to A-12 indicate that the trench and pumping regime are fulfilling their intended purpose and landfill leachate is being intercepted and captured into the leachate interception trench in the majority of instances. In February 2023, it was recorded at Well Line 3 that there was no drawdown from the estuary side into the interception trench. However, drawdown levels improved over the next two months from the estuary side into the trench.

It should be noted that major maintenance works were undertaken on pump stations PS3 and PS5and the leachate lines from the landfill incoming to these pumpstations in May 2023 which will have assisted the system to function optimally.

4. Interception trench pumps monitoring

4.1 Pump operation and monitoring

As required by Condition 4(B) of Resource consent 3839B_V1, the leachate interception trench pumping system should automatically trigger an alert if:

– There is a pump fault;
– Low water level in a pump wet well; and
– High water level in a pump wet well.

Pump fault events for the 2022 / 2023 monitoring year were documented by DCC. Records provided by DDC to GHD are shown in Table B1 (Pump Fault Register) and Table B2 (Overflow events, high alarms levels and pump faults summary), attached in Appendix B.

147 pump faults events were recorded from the 9th July 2022 to the 28th June 2023 on the Pump Fault Register (Table B1). There were faults recorded at all the pump stations over the monitoring year, with PS1 (28), PS2 (21), PS3 (53), PS4, PS5 and PS8 (7), PS6 (10), PS7 (6), PS9 (8).

The majority of faults (48) were high level alarms due to significant rainfall, a further 47 faults were due to power failures. 52 faults were due to low levels in the pump chambers, with similar to the 2021 / 2022 monitoring period, most were occurring at PS3.

Details of the pump faults and alarms are provided in Table B1, attached in Appendix B

Table B2 (attached in Appendix B) provides a summary of pump faults and causes grouped by event. The pump faults were grouped into 19 separate events over the monitoring year. A discussion of the various pump faults and their causes are discussed in the following sections.

4.1.1 Rainfall Events

Two major weather and several moderate to minor weather events took place over the 2022 / 2023 monitoring period. The major and moderate events took place between 13th – 15th and 26th – 28th July 2022 and on 22nd March and 24th May 2023.

The two major rainfall events (July 2022) lead to Pump Stations PS3 through to PS6 becoming inundated by the Kaikorai stream for a period of time. During the time period, all systems were running continuously for between two to four and a half days and remained operational.

Three moderate rainfall events occurred in March, May and June 2023. During these periods PS1, PS2 and PS3 reported high levels for less than 24 hours, and operated continuously before during and after. During this period all systems were constantly monitored and remained in operation.

Two minor rainfall events occurred in July 2022 and May 2023 with PS1 and PS2 reporting High Level alarms for a period of less than 14hours. During these periods the pump systems worked as expected.

4.1.2 Flowmeters

Based on periods of weeks where no flow was recorded on the flowmeter at PS2, an assessment of historical data for this pump station was undertaken. A review of the historical data indicated that this had occurred in the past. In addition, flow was recorded during rainfall events between the 13th and 24th of March, indicating that the flow meter was functional.

The data for PS6 during the 17th October to 23rd December period was also reviewed due to low flow rates and pump hours being recorded in comparison to the historical record. Hover, the review indicated that the flowmeter was functioning correctly.

Four of the events were due to a recurring foaming issue at PS3 leading to false reporting of low levels. The flow meter at Pump Station PS3 failed in April 2023 and was replaced with the one moved from PS9 on 17th May 2023.

A replacement for PS9 (historically the lowest flow pumpstation) was ordered immediately. These pumps typically have a four month lead time from order to receipt.

4.1.3 Power outages

There were two planned outages on the local network which were pre-advised and DCC and Waste Management organised for the whole site to be temporarily powered by a temporarily generator connected at the main incoming transformer. This allowed all site activities to continue, including the pumpstations.

There was an unplanned outage on the night of the 20th and 21st August for 1.5 hours affecting the wider Green Island area.

4.1.4 Planned maintenance works

Jetting of the landfill leachate line for PS3 and PS5 was undertaken between the 8th and 12th May 2023 with the waste debris being discharged into PS6 which led to a high level alarm. There was a noticeable increase in flow at PS3 following this works, though some of this increase may have been due to the replacement of a flow meter at this location over this period.

Inspections of the flowmeter and its replacement at PS3 lead to alarms being recorded.

4.1.5 Reactive maintenance works

The probe at pump station PS1 was replaced in June 2023 which rectified the false alarm reporting at this pump station.

PS3 continues to false / phantom report, a lot of the time this was due to foaming within the Pump well. On all occasions inspections were undertaken to confirm this was the case. These alarms make up the vast majority of those reported and logged.

4.2 Pumped volume monitoring

Flow rates and pump hours are continuously recorded at the pump stations on the Site. The recorded flow rates include flow contributions from both the leachate and groundwater systems by the pumping regime.

Resource consent 3839A_V1 (condition 8) requires continuous monitoring and recording of the flow rates of the pumped discharge. This condition can be met with the available monitoring records.

Condition 1 of resource consent 4139_V1 however stipulates that the water drawn from the Kaikorai Stream should not exceed 72,000 L per hour, with a nominal rate of 23,400 L per hour. It is not possible to determine the portion of the flow which is attributable to the Kaikorai Stream with the available data and therefore not possible to determine the amount of water drawn from the stream and hence determine consent compliance.

4.2.1 Results

DCC provided flow rate data collected over the 2022 / 2023 monitoring year for each of the pump stations. The following should be noted in relation to the pump flow data:

- All pump stations data was zeroed on 1st July 2023.
- The flow meter from pump station PS9 was moved to Pump Station PS3 in mid May 2023.
- Jetting of the leachate lines from the landfill incoming to PS3 and PS5 were undertaken between the 8th to the 12th of May 2023. The jetting water and debris was discharged into Pump Stations PS2 and PS6.

Pump flow rate volumes were collected on an approximate weekly basis, ranging from intervals of between 2 and 11 days, over the 2022 / 2023 monitoring year. Pump flow data including cumulative net flow, net flow between readings, flow rate between readings and cumulative pump time are presented in Tables B3-1 through to B3-4, attached in Appendix B.

A graph presenting cumulative net flow and another showing the average flow rate at each pump station along with a pie chart of the net contribution from each pump station are included in Figure B1, attached in Appendix B.

The charts and pie diagram indicate that:

– Pump Station PS1 contributed the largest volume of leachate over the monitoring year with 33% of the flow. The percentage of flow at Pump Stations PS4 and PS6 through to PS8 was very similar ranging between 8% and 11%. Pump station PS5 contributed 17% of the flow. The flows recorded for Pump Station PS3 were 2% of the overall but may have been affected by the issues leading to the replacement of the flowmeter at this pump station. The flows recorded at PS9 were affected by the removal of the flowmeter from this station in May 2023.
– As can be seen from the graph, flow rates and volumes are relatively consistent over the monitoring year. There does not appear to be much change in flow rates / volumes in response to rainfall events, with the exception of Pump Station PS1 and PS5 where a response (increased volume) can be noted after significant rainfall events as seen in February, March and May 2023. The replacement of the flow meter at PS3 can be noted in May 2023 with the step-down to restart at zero in cumulative flow volumes.
– There was an increase in average flow rates at Pump Station PS1 from the previous monitoring year. Flow rates decreased at all of the other Pump Stations in comparison to the previous monitoring year.
– An overall decrease in average flow rates since the 2017 / 2018 monitoring year can be noted at all Pump Stations.

4.2.2 Discussion and conclusion

The volume of pumped leachate over the 2022 - 2023 monitoring year was approximately 80,229 m^3, which was higher than the volume pumped during the 2021 - 2022 monitoring year and the 2020 – 2021 monitoring year (50,663 m^3 and 65,988 m^3 respectively). This is equivalent to approximately 9,158 L/hour of combined leachate / groundwater pumped during the 2022 – 2023 monitoring year.

The increase in volume pumped compared to the previous monitoring year is considered be a result of there being higher rainfall during the 2022 – 2023 monitoring year than the previous year.

Rainfall amounts recorded at the Green Island Kaikorai Estuary weather station over the past five monitoring years are presented in Table 4 below.

Table 4 Rainfall recorded at the Green Island Kaikorai Estuary weather station

Monitoring year	Rainfall (mm)
2022 – 2023	871.8
2021 – 2022	572.3
2020 – 2021	752.6
2019 – 2020	783.6
2018 - 2019	674.3

Data source: Cliflo online GIS database

The average volume of combined leachate / groundwater pumped during the 2022 – 2023 monitoring year was approximately 9,158 L/hour. This is significantly less than the nominal rate stated in consent 4139_V1 for water drawn from the Kaikorai Stream (23,400 L/hour). It can therefore be surmised that the volume of water drawn from Kaikorai Stream is generally in accordance with this consent.

There were more pump faults reported during the 2022 - 2023 monitoring year than in the previous year. This was due to multiple alarms triggering during individual events, significant weather events, planned maintenance works and repeated faults reported for foaming issue at PS3.

5. Water chemistry monitoring

Requirements for groundwater, leachate and surface water monitoring and sampling in the Kaikorai Stream are set out in Resource consent 3839A_V1.

Resource consent 3840C_V1 sets out the requirements for the monitoring and sampling of the surface water within the sedimentation ponds.

Monitoring requirements are detailed in Table 5 below:

Table 5 Green Island Landfill Surface Water Monitoring Consent Conditions

Consent Condition	Consent No. 3839A_V1
Condition 9 (A) (a)	***Combined leachate discharge to sewer*** 1 sample per year, analysed for: • Major cations, major anions, cation/anion ratio, pH, conductivity, chemical oxygen demand, biological oxygen demand, ammoniacal nitrogen, nitrate nitrogen, alkalinity, dissolved oxygen, dissolved reactive phosphorus, total organic carbon, acid soluble metals (Al, As, Ba, Br, Cd, Cr, Cu, Fe, Ni, Mn and Zn), total mercury, total cyanide, sulphide, total phenols, faecal coliforms, organochlorine pesticides, polychlorinated biphenyls, volatile fatty acids, volatile organic compounds and semi-volatile organic compounds. 1 sample every three months of the groundwater / leachate for isotope analysis. • Oxygen-18 in water from leachate • Hydrogen-2 in water from leachate • Carbon-13 in dissolved inorganic carbon from leachate • Nitrogen-15 in ammonium from leachate.
Condition 9 (B) (b)	***Leachate collection pumps and shallow and deep groundwater/leachate wells*** 1 sample every three months, analysed for: • pH and conductivity
Condition 9 (B) (c) and (d)	***Deep Groundwater Wells*** 1 sample in September or October from the deep groundwater wells and analysed for: • Biological oxygen demand, major cations, major anions, cation/anion ratio, pH, conductivity, ammoniacal nitrogen, dissolved iron, dissolved lead, dissolved, zinc, dissolved oxygen, and total organic carbon. 1 sample every three months from the deep groundwater wells MW2D, MW4D and MW9D, for isotope analysis of • Oxygen-18 in water from groundwater • Hydrogen-2 in water from groundwater • Carbon-13 in dissolved inorganic carbon from groundwater • Nitrogen-15 in ammonium from groundwater. • Nitrogen-15 in nitrate from groundwater
Condition 10 (a), (b), (c) and (d)	***Monitoring Kaikorai Estuary*** 1 sample every three months from the four sites (GI1, GI2, GI3 and GI5), timed with the outgoing tide and not within 72 hours of any measurable rainfall event. Samples to be analysed for: • pH, conductivity, chloride, dissolved oxygen, ammoniacal nitrogen, nitrate nitrogen, dissolved metals (Al, Cd, Cr, Cu, Pb and Ni), total cyanide, total organic carbon and isotopes as below. • Oxygen-18 in water from samples • Hydrogen-2 in water from samples

Consent Condition	Consent No. 3839A_V1
	• Carbon-13 in dissolved inorganic carbon from samples • Nitrogen-15 in ammonium from samples. • Nitrogen-15 in nitrate from samples On each occasion, the consent holder shall qualitatively estimate the flow in the Kaikorai Stream, record the water level, the tidal stage, rainfall over the past 7 days and whether the estuary mouth is open or closed.

Consent Condition	Consent No. 3840C_V1
Condition 6 (iv) and (v)	***Monitoring Silt Pond Discharge*** 1 sample every three months from each of the Eastern and Western stormwater retention ponds, analysed for: • pH, electrical conductivity, ammoniacal nitrogen, nitrate nitrogen, alkalinity, chloride, potassium, total organic carbon, dissolved oxygen, dissolved metals (chromium, copper, lead, nickel and zinc).

The various sampling locations are shown on Figure 4.

5.1 Stable Isotope Monitoring

The isotope analysis undertaken on the leachate, surface water and groundwater samples collected in the July 2022 to June 2023 monitoring period are presented in Table 6 below.

Table 6 Isotopic analysis undertaken in the 2022 – 2023 monitoring period

Sampling Date	Monitoring location	Isotope analysis undertaken
13th, 14th & 15th July 2022	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3	2H, 18O, 13C, 15N-NH4+
11th & 12th October 2022	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3	2H, 18O, 13C, 15N-NH4+
17th & 18th January 2023	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3	2H, 18O, 13C, 15N-NH4+
11th, 12th & 13th April 2023	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3	2H, 18O, 13C, 15N-NH4+

5.2 Leachate chemistry monitoring

A sample representative of the leachate was collected from Pump Station PS3 on 14th July 2022 in accordance with Condition 9A (a) of consent 3839A_V1. The sample was analysed for the analytes specified in the consent. Analytical results are presented in Appendix C at the rear of this report.

In addition to the quarterly sample collection, in-situ measurements for pH, electrical conductivity (EC), oxidation-reduction potential (Redox) and dissolved oxygen (DO) were made during the monitoring events undertaken by GHD during the 2022 / 2023 monitoring year. Field equipment calibration records are included in Appendix D and Laboratory reports are included in Appendix E, at the rear of the report.

5.2.1 Results

Analytical results of the leachate sampling have been compared against the DCC guidelines for Trade Waste, Bylaw 2008 (Trade Waste Guideline) and are summarised in Table C1 attached in Appendix C.

Only one exceedance of the trade waste guidelines was reported with the concentration of ammoniacal nitrogen reported at a value of 165 mg/L, compared to the trade waste guideline value of 50 mg/L, as has been the case since 2012 (earliest data available)Leachate analytical results reported in Table 13 of the Delta 2016-2017 annual monitoring report (Delta Annual Monitoring Report, Green Island Landfill July 2017) were tabulated along with the GHD 2017-2022 data and are presented in Table C2 attached in Appendix C. As can be seen from the data presented in Table C2, the current and historical data sets indicate that leachate quality is highly variable, with a number of new maximums and minimums being recorded in the July 2022 analytical data set.

It should also be noted that the leachate sample was collected on the 14th July 2022, during a significant rainfall event with 63.9 mm of rainfall the previous day and 29.4 mm recorded on the day the sample was collected. The pump station alarms indicated that PS3 had been at high level for two days. A significant portion of the leachate discharging into pump station PS3 is sourced from an area of the landfill bounded by sludge areas as well as recent waste. This area of the landfill did not historically have recent waste placement or sludge pits. This source is likely influencing the quality of the leachate sample collected in July 2022.

A selection of the analytes was plotted on time series graphs to assess trends in the data and are presented on Figures C1-1 and C1-2, included in Appendix C. A summary of the trends is as follows:

– Reported concentrations of ammoniacal nitrogen have been above the adopted Trade Waste guideline value since 2007 (based on graphs in the Delta 2016-2017 report). An upward trend was noted between 2012 to 2017, when the upwards trend flattened out. A decreasing trend can be noted for 2018, reported concentration of 288 mg/L, through to 2020, when the concentration fell to 167 mg/kg. However, a slight increase in concentrations was reported in July 2021 with a value of 208 mg/L before decreasing again to 165 mg/L in July 2022.
– Electrical conductivity values, either field or laboratory measured, were relatively stable between 2012 and 2017, with values between 10,000 and 12,000 µS/cm. Since October 2017 to July 2022, an overall decreasing trend can be noted with measured values falling from 10,250 to 5,240 µS/cm.
– Reported chloride concentrations have fluctuated over time with an overall downward trend noted since December 2015 to July 2022, from 2,400 mg/L to 460 mg/L. The value reported in July 2022 represented a new minimum value.
– Reported concentrations of Chemical Oxygen Demand (COD) have fluctuated over time, from 490 mg/L in 2012 to 1,081 in October 2017. An overall upward trend in concentrations can be noted from December 2012 to July 2021 and remained relatively constant in July 2023 (from July 2021).
– Reported iron concentrations have fluctuated over time, from 15.5 mg/L in December 2012 to 0.241 mg/L in December 2014. However, an upward trend in concentrations can be noted from July 2018, 0.42 mg/L, to July 2022, with a concentration of 8.5 mg/L.
– The field measured pH value was recorded as pH 6.75, which falls below the range of the historical values and within the trade waste guideline values (6.0 – 9.0).
– An increasing trend in alkalinity from 2013 (2,700 mg/L) to July 2019 (3,467 mg/L) can be noted. However, this upward trend ceased in July 2020 when a concentration of 1,828 mg/L was reported in July 2020. A slight upward trend was noted in July 2021 with a concentration of 1,882 mg/L being reported before decreasing to 1,210 mg/L in July 2022.
– Total Biological Oxygen Demand (BOD5) values have fluctuated over time from 170 mg/L in January 2017 to 20.6 mg/L in July 2019. However, there was a large increase in concentrations from July 2020, 66.9 mg/L, to that reported in July 2021, 422 mg/L, a new maximum value for the data set. A slight decrease to 330 mg/L was observed in July 2022.
– Sulphate concentrations have fluctuated over time, with a new minimum concentration of 24.1 mg/L reported in July 2021 and a new maximum concentration in July 2022 of 540 mg/L.
– Reported faecal coliform numbers increased to >16,000 MPN in the sample collected in July 2022. However, this value needs to be treated with caution as the sample did not reach the laboratory within the required 24 time period from collection. Historically, faecal coliforms have been reported at values ranging between 10 and 12,000 cfu/100ml (July 2019 and July 2020 respectively).
– The increasing trend in volatile fatty acids (VFA) was noted from July 2019 to July 2021 when a concentration of 164,000 µg/L was reported, which was a new maximum value for the data set. A decrease in concentration has been observed in July 2022 with a reported concentration of 35,000 µg/L.
– Following an increasing concentration of total organic carbon (TOC) between October 2017 and July 2021, concentrations have stabilised, with a small decrease from 291,000 µg/L in July 2021 to 290,000 µg/L in July 2022.

- New maximum concentrations were reported for acid soluble arsenic, chromium, copper, lead, manganese and mercury and new minimum for barium and boron.
- Toluene, ethylbenzene and xylenes and three monoaromatic hydrocarbons (MAHs) were reported at concentrations above the LOR. All of these reported concentrations were new maximum concentrations for each of those particular analytes.
- A decrease in phenol was observed between the July 2021 and July 2022 monitoring events, from 150 µg/L to 68 µg/L, respectively.
- An overall upwards trend in BOD, nickel, manganese, lead, copper, zinc and iron can be noted from the graphs.
- An overall downward trend in cyanide, ammoniacal nitrogen and chloride is observed, while COD remains relatively stable.

5.2.2 Summary

Historical data, along with the data collected in July 2022, indicate that there have been fluctuations within the previously observed trends as discussed above. Leachate chemistry is highly variable as demonstrated in the graphs and historical data presented in Table C2.

5.2.3 Isotope analysis

In accordance with condition 9 (A) (b) of resource consent 3839A_V1, a leachate sample was collected from pump station PS3 in July and October 2022 and January and April 2023 for isotopic analysis as detailed in Table 5. The consent requires the analysis for the isotopes oxygen-18 (^{18}O), hydrogen-2 (^{2}H), carbon-13 (^{13}C) and nitrogen-15 in ammonium ($^{15}N\text{-}NH_4^+$) in the leachate.

The isotopic analytical data available for the monitoring period 2017 / 2023 indicates that the isotopic results from the samples collected from pump stations PS3 and PS4 (combined leachate/groundwater) suggest a mature stage of leachate methanogenesis with little change in leachate signature.

Further details of the sampling and analysis undertaken, a discussion of the isotopic trends and findings of the monitoring is contained in the interpretative isotopic report attached in Appendix F.

5.3 Deep wells chemistry monitoring

The groundwater within the deep wells of the groundwater monitoring network (MW2D, MW4D and MW7D (in place of MW9D)) at the Site were sampled in accordance with consent conditions 3839A_V1 9(B). The locations of the monitoring wells are shown on Figure 4. Sampling was carried out as follows:

- In October 2022 for the analytes specified in Condition 9B (c) of Consent 3839A_V1.
- Quarterly in July and October 2022 and January and April 2023 for the analysis of oxygen-18, hydrogen-2, nitrogen-15 (ammonium) and carbon-13 isotopes.
- Quarterly, in July and October 2022 and January and April 2023, for in-situ analysis of pH, EC, Redox and DO.

Low flow sampling was undertaken according to the GHD procedure E14 with an advanced peristaltic pump and a water quality meter (YSI ProDSS or YSI Pro). The quarterly field data is presented in Appendix A and the field equipment calibration records are included in Appendix D, at the rear of the report.

5.3.1 Groundwater quality

Although not a requirement of the consent condition, the laboratory reported analytical results have been compared to The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), 95% of species level of protection, Default Guideline Values (DGVs) for both fresh and marine waters and the National Policy Statement for Freshwater Management (NPS, 2020) National bottom line (NBL) values, as an indication of water quality. Analytical results are presented in Table C3 attached in Appendix C.

The NPS Freshwater was included as its objective is to ensure that natural and physical resources are managed in a way that prioritises the health and well being of water bodies above other uses.

The NPS NBL values and ANZG default guideline value have been derived for ammonia at a pH of 8 and a temperature of 20^{o}C, as the toxicity of this contaminant is influenced by these parameters. Both the ANZG and the NPS require that the laboratory reported concentration for total ammoniacal nitrogen be corrected for pH and temperature to allow for comparison with the DGVs and NBLs. The current monitoring year's data has been corrected for this and are presented in Table C-3. However, the data presented on the total ammonia graph in Figure C2-2 has not been corrected as historical temperature data is not currently available.

The results were also compared with the statistical data derived from data collected between 2007 and 2015 (Delta, 2015) and the data collected by GHD since 2017. Laboratory reports are included in Appendix E at the rear of this report.

A summary of the analytical data collected during the 2022 / 2023 monitoring year is as follows:

– Total ammoniacal nitrogen concentrations were reported present in monitoring wells MW2D, MW4D and MW7D at concentrations of 22 mg/L, 11.1 mg/L and <0.01 mg/L respectively. The corrected value for MW2D was greater than both the NPS NBL annual median and annual maximum values. The corrected ammonia value for the sample collected at MW4D did not exceed any of the adopted guidelines. A new maximum concentration for total ammoniacal nitrogen was reported at MW4D.
– The zinc concentration in monitoring well MW2D was reported at a concentration of 1.68 mg/L, exceeding the ANZG freshwater and marine GVs of 0.008 mg/L. It is noted that the laboratory limit of reporting (LOR) for zinc was 0.1 mg/L and that the reported concentrations for zinc at MW4D and MW7D were <0.1 mg/L. Historically zinc values at these monitoring locations were reported at concentrations ranging between <0.001 and <1. It is possible that zinc was present at these locations at concentrations less than 0.1 mg/L.
– There were no other exceedances of the adopted guidelines for the laboratory reported analytical data.
– The reported concentrations of lead were less than the laboratory LOR of 0.01. It is noted that due to dilution of the sample at the laboratory, the level of detection was raised. Historical reported concentrations for lead have been in the range <0.00005 and 0.0056 mg/L and as such, lead may have been present at these locations but were at concentrations less than the LOR used.
– The reported nitrate as nitrogen concentration was reported below the LOR of 0.1 mg/L at MW2D and 0.13 mg/L and 0.38 mg/L at MW4D and MW7D, respectively.
– Chloride was reported at a concentration above its historical maximum value at monitoring well locations MW4D and MW7D. However, the increase in value was small at all locations (e.g., 9,500 mg/L for MW4D reported in 2022, historical maximum was 9,410 mg/L).
– The field measured pH values for every monitoring round were outside of the adopted range of 7.3-8.0 at all of the deep monitoring wells. Values were reported as being slightly acidic, ranging from 6.41 to 6.98. The pH measured at MW2D tends to be closer to 7 than the others. One new minimum value was recorded in MW4D in April 2023.
– The following laboratory reported analytes exceeded the historical maximum concentrations at the following locations in October 2022:
  - Zinc at MW2D
  - Chloride at MW4D and MW7D monitoring well locations
  - Sulfate and total Anions at MW7D
  - Iron, BOD and total organic carbon (TOC) at MW2D and MW4D
– TOC was reported at a new historical minimum value at MW7D in October 2022.
– New maximum values for field measured electrical conductivity were recorded at MW2D and MW4D during the July 2022 and January and April 2023 monitoring events. New maximum values were also recorded for MW7D in January and April 2023.
– All field dissolved oxygen (%) values were recorded as being below the ANZG (2018) GV. All field measured dissolved oxygen (mg/L) measurements were below the NPS (2020) NBL values.

Graphs for ammoniacal nitrogen, chloride, pH, electrical conductivity and dissolved oxygen (DO), have been plotted and are shown in Figure C-2-1 and Figure C2-2 of Appendix C. In summary:

– pH values measured at MW2D, MW4D and MW7D have been less than pH7 since October 2019.
– EC values measured at MW2D tend to be higher than at the other two deep groundwater monitoring wells. The three wells follow relatively similar trends, with values measured at MW7D tending to be the lowest.
– Measured DO values have fluctuated over an order of magnitude since 2017. There is no clear pattern to the measurements.
– Total ammoniacal Nitrogen (uncorrected) concentrations are highest at MW2D, generally between 19 and 23 mg/L. The next highest concentrations are reported at MW4D with values between 87 and 10 mg/L, it is noted that a new maximum concentration of 11.1 mg/L was reported during the October 2023 monitoring event. The lowest values are reported for MW7D with values of around 1 mg/L. During the October 2023 monitoring event, a concentration of less than the laboratory LOR (0.01 mg/L) was reported at MW7D.
– Chloride concentrations are highest at MW2D, generally around 11,000 mg/L. The next highest concentrations are reported at MW4D with values around 9,000 mg/L. The lowest values are reported for MW7D with values of around 5,000 mg/L. Reported concentrations in MW4D and MW7D have been relatively stable since 2018, with a slight upward trend in concentrations noted at MW7D.

5.3.2 Isotopes

The isotopic analytical data available for the monitoring period 2017-2023 indicates that the data for the groundwater monitoring locations have different signatures to the leachate, i.e. their trend lines plot separately. This is most pronounced for the ^{13}C data, where the groundwater data plot below (depleted – below -10 $\delta^{13}C$‰) the leachate data (enriched - above 5 $\delta^{13}C$‰).

The isotopic data is more varied for the ^{18}O and N-NH_4^+ data, but generally the data for MW2D and MW4D plot above the leachate data and plot closely together. The data for MW7D is more varied but generally plots above the leachate data.

The data for the groundwater monitoring locations tends to plot below the global meteoric water line (GMWL). Whereas the isotope data for the leachate samples plot above both the GMWL and the Dunedin meteoric water line (DMWL). In addition, the majority of the isotopic data for deep wells MW2D, MW4D and MW7D plot along the DMWL.

The data for the deep wells MW2D and MW4D cluster towards the top of the DMWL with the majority of the data falling within ±5% of the line, whereas the data for MW7D is more disperse but with the majority plotting either within ±5% of the line or beneath the line. The data for the leachate and MW9D (landfill well) plot above the DMWL line.

Further details of the sampling and analysis undertaken, a discussion of the isotopic trends and findings of the monitoring is contained in the interpretative isotopic report attached in Appendix F.

5.3.3 Summary

The generally high EC values at monitoring locations MW2D and MW4D indicate either a leachate or estuarine influence from the Kaikorai stream / estuary or a combination of both. The low pH values (slightly acidic) recorded at all deep wells may indicate landfill leachate influence. DO values have historically followed a relatively similar trend within the three deep monitoring wells.

The corrected ammoniacal nitrogen concentration was reported above the adopted NPS NBLs in the deep monitoring well MW2D. The corrected concentration for ammoniacal nitrogen at MW74D did not exceed the adopted ANZG guideline values or the NPS NBL values. The total ammoniacal nitrogen concentration was reported as being less than the LOR at sample location MW7D. All reported concentrations were within their respective historical ranges with the exception of MW7D which was reported at a new minimum historical concentration.

Zinc was reported at a concentration which exceeded the ANZG GV in monitoring location MW2D. A number of analyte concentrations including iron, zinc, chloride, sodium, potassium, sulfate, BOD and COD were reported as being new maximum values at monitoring events throughout the 2022 / 2023 monitoring period.

Based on the elevated ammoniacal nitrogen, chloride and more acidic pH, the water quality data suggests that landfill leachate may be having a minor impact on the groundwater quality in the deep groundwater monitoring wells, but with the majority of analytes being reported within their long term historical ranges. Overall, no significant change in groundwater chemistry was noted since the 2021 - 2022 monitoring year.

5.4 Shallow wells, pump stations and manhole chemistry monitoring

The chemistry of the shallow wells (MWA, MWB and MWC) of the groundwater monitoring network as well as the manholes (MH) and the pump stations (see section 2.1.1) were monitored on a quarterly basis for pH, and electrical conductivity (EC) in accordance with condition 9B(b) of Consent 3839A_V1.

In addition, field measurements for DO and Redox were also collected while the groundwater level monitoring was being undertaken at these points. The quarterly field data is presented in Appendix A and field equipment calibration records are included in Appendix D, at the rear of the report.

5.4.1 Results

Results for all four parameters have been tabulated into Table C4 attached in Appendix C.

Time series for each well line for pH and electrical conductivity (EC) have been plotted and are shown in Figure C3-1 through to C3-5 included in Appendix C. The electrical conductivity data prior to July 2017 was not used in the graphs as the units of measurement were not considered accurate.

Well Line 0 – MW0C

As can be seen from Figure C3-5, an overall increasing trend in pH values can be noted from April 2021 (pH 6.39) to March 2022 (pH 7.39). Since then an overall decreasing trend can be noted. pH values fluctuated over the 2022 – 2023 monitoring year between 6.76 and 6.59.

Measured EC values have fluctuating between 1,942 µS/cm (July 2017) and 2,649 µS/cm (April 2023). An overall increasing trend in values can be noted from January 2021, when a value of 1,511 µS/cm was measured, to January 2023. However, a slight decrease in values between January and April 2023 can be seen, with values decreasing from 2,710 µS/cm to 2,649 µS/cm.

Well Line 1 – MW1A, B and C and Manhole MH1

As can be seen from Figure C3-1, measured pH values at the different wells / manhole along Well Line 1 followed relatively similar trends with an increase noted for the three wells from October 2022 to April 2023.

Measured EC values at all the groundwater monitoring locations along Well Line 1 followed relatively similar trends over the monitoring year. The EC values measured at the manhole tended to be lower than those in the wells and generally follow the same trend. However, values decreased at the manhole in April 2023, whereas it remained stable in the wells. A large increase was noted in MW1B between July and October 2022 and it remained elevated for the remainder of the monitoring year.

Well Line 2 – MW2A, B, C and D and Manhole MH2

As can be seen from Figure C3-1, the measured pH values followed a relatively similar trend at the Well Line 2 monitoring locations over the 2022 – 2023 monitoring year. In particular, the values collected at MW2A and MW2B plot closely with similar trends and this pattern is also noted with MW2C and MH2.

Comparably to pH levels, the EC values for each monitoring location follow relatively similar trends. An overall increase in EC levels can be noted from 2019 until January 2021 monitoring round when values at all locations decreased significantly. Values have fluctuated since then, with similar trends noted for MW2A and MW2B and MW2C and MW2D. However, values have been relatively stable over the 2022 / 2023 monitoring year with the exception of values measured at MH2 where a decrease was noted in October 2022. The measured EC value increased to values comparable to the well locations in January 2023.

Well Line 3 – MW3A, B and C and Manhole MH3

As can be seen from Figure C3-2, similar fluctuating trends were observed for pH for the shallow monitoring wells and the leachate/groundwater manhole monitoring location. In particular, the values collected at MW3A and MW3B plot closely with similar trends. A decreasing trend in pH values can be noted over the 2022 / 2023 period at all monitoring locations along line 3 with the exception of the values measured at MH3 where an overall increasing trend is noted.

The measured EC of monitoring wells A and B and the manhole followed similar trends over the monitoring year. The measured EC values at MW3C have remained relatively stable since 2018, though a slight increasing trend in values can be noted since January 2022. The values measured at MW3C are consistently lower than that measured at the other wells along this line.

Well Line 4 – MW4A, B, C and D

As can be seen from Figure C3-2, similar trends are observed in the pH values for monitoring well MW4B, MW4C and MW4D from July 2022 to January 2023. However, in April 2023, values at the MW4B and MW4D decreased slightly whereas that at MW4C increased. For MW4A, the measured value increased in October 2022 but decreased between October 2022 and April 2023.

The EC values for MW4A and MW4B follow similar trends and were similar in magnitude. The EC values for MW4C and MW4D also followed similar trends and were of similar magnitude. However, the values measured at the A and B wells were significantly less than those measured at the C and D wells.

Well Line 5 – MW5A, B and C and Manhole MH5

As can be seen from Figure C3-3, measured pH values fluctuated over the monitoring year with no pattern between the various wells, with values measured at the manhole tending to be lower than the rest.

The measured EC values for the wells and manhole along this line did not follow any relational trend over the monitoring year. There has been an overall increase in EC values at MW5B and MW5C since July 2017.

Well Line 6 – MW6A, B, C and Manhole MH6

As can be seen from Figure C3-3, measured pH values have fluctuated over the monitoring year with no clear trends apparent, other than all values increased between January and April 2023. Measured values at MW6A have remained quite stable since April 2021. While the measured values fluctuate, the range within which the fluctuations occur has reduced since the 2017 / 2018 monitoring year.

The measured EC values at MH6 and MW6A followed a similar trend over the monitoring year. Measured values at MW6B and MW6C followed a similar trend over the majority of the monitoring year. Measured values were relatively stable over the monitoring year at MW6A, MW6B and MH6. After an increase in value in July 2022, the measured value at MW6C reduced and was relatively stable for the remainder of the monitoring year.

Well Line 7 – MW7A, B, D and Manhole MH7

As can be seen from Figure C3-4, measured pH values at MW7A and MW7B followed similar trends over the monitoring year and were similar in magnitude. Measured values at MW7D had a larger increase and decrease than those measured at the other wells. In addition, the measured value increased in April 2023 at MW7D but decreased at the other wells. Values remained within the respective historical ranges.

The EC values measured at MW7A and MW7B followed a relatively similar trend with values in the same magnitude (less than 2,000 µS/cm). The EC values measured at MH7 and MW7D follow relatively similar trends since October 2019 and are of a greater magnitude than those measured in MW7A and MW7B. Values at MW7D tend to be greater than those at the manhole.

Well Line 8 – MW8A, B, C and Manhole MH8

As can be seen from Figure C3-4, the pH measured at MW8B and MW8C followed relatively similar trends over the monitoring year. There was an overall decreasing trend in pH values noted from July 2021 for each of the monitoring wells.

The measured EC values of the monitoring wells and manhole followed very similar trends over the monitoring year and were similar in magnitude with no significant fluctuations.

Pump stations PS1 through to PS9

As can be seen from Figure C3-5, the pH of the leachate at the majority of the pump stations followed relatively similar trends over the monitoring year. All other measured pH values were within the historical ranges, with the exception of PS9.

The EC of the leachate measured at the pump stations generally followed similar trends. It appears that there is an overall upward trend in values measured at all pump station since July 2021, with the largest increases seen at PS2, PS3 and PS4.

5.4.2 Summary

As noted in the previous annual monitoring report, the pH of the leachate measured at the manholes was generally less than or similar to the pH of the groundwater in the monitoring wells, with the exception of Well Lines 1 and 5. There is no apparent trend in pH values in the monitoring wells either side of the leachate trench. Values measured in monitoring wells "C" do not appear significantly different to those measured at the "A" and "B" wells, with the exception of Well line 2 where the pH values measured at monitoring wells "C" and "D" are very similar to those measured in the leachate trench and separate to those measured at MW2A and MW2B.

The electrical conductivity values measured at the "A" and "B" wells often follow similar trends and are of similar magnitude.

5.5 Kaikorai stream chemistry monitoring

Monitoring of the surface water in the Kaikorai Stream is undertaken above, adjacent to, and below the Green Island landfill to identify any leachate effects from landfill activities downstream of the operational landfill and outside of the leachate collection trench. There are three monitoring locations on the Kaikorai Stream, and one monitoring location on Abbots Creek (as shown in Figure 4). A description of the four sample locations is as follows:

– GI1, in the Kaikorai Stream, upstream of the Green Island landfill, at the Brighton Road bridge.
– GI2, in Abbots Creek, a tributary of the Kaikorai stream, at State Highway 1 Bridge at Sunnyvale, 630 m north of the confluence with the Kaikorai Stream.
– GI3, in the Kaikorai Stream, 200 m below the Abbots Creek confluence.
– GI5, downstream of the landfill adjacent to the western sedimentation pond.

Sampling at these surface water monitoring locations was undertaken on a three-monthly basis in July and October 2022, and January and April 2023 for the analytes specified in condition 10(c) of Consent 3839A_V1. Surface water sampling was undertaken in accordance with GHD procedure E16.

5.5.1 Results

The quarterly measurements of field parameters pH, EC, temperature, DO and Redox are presented in the field sheets in Appendix A at the rear of this report and field equipment calibration records are included in Appendix D.

Although not a requirement of the consent condition, the laboratory reported analytical results have been compared to The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), 80% of species level of protection, Default Guideline Values (DGVs) and the National Policy Statement for Freshwater Management (NPS, 2020) National bottom line (NBL) values, as an indication of water quality.

The NPS Freshwater was included as its objective is to ensure that natural and physical resources are managed in a way that prioritises the health and well being of water bodies above other uses.

The NPS NBL values and ANZG default guideline value have been derived for ammonia at a pH of 8 and a temperature of 20°C, as the toxicity of this contaminant is influenced by these parameters. Both the ANZG and the NPS require that the laboratory reported concentration for total ammoniacal nitrogen be corrected for pH and temperature to allow for comparison with the DGVs and NBLs. The current monitoring year's data has been corrected for this and are presented in Table C-5. However, the data presented on the total ammonia graph in Figure C4-4 has not been corrected as historical temperature data is not currently available.

The 80% species level of protection was chosen as the Kaikorai Stream is considered to be a highly disturbed system. In addition, the 2022-2023 analytical results have been compared to the historical statistical data obtained between 2007 and 2016 (Delta, 2017) and the historical data collected by GHD.

Results are presented in Table C5 attached in Appendix C and laboratory reports are included in Appendix E.

A summary of the chemical results for **GI1** (Upstream of the landfill on the Kaikorai Stream) is as follows:

- The reported concentration of aluminium was above the adopted ANZG freshwater guideline in July 2022 but less than the guideline value on the other monitoring occasions.
- Reported concentrations of copper were above the adopted ANZG freshwater guideline in July 2022 and January 2023 but less than the guideline value on the other monitoring occasions.
- The measured dissolved oxygen values were outside of the adopted range on all monitoring occasions, with the exception of July 2022. Reported values ranged between 64.5 and 115.3%.
- The field measured pH values were outside of the adopted range on all monitoring occasions, with the exception of July 2022.
- The reported concentration of cyanide was above the ANZG guideline values in January 2023.
- The reported concentration of nitrate was above the NPS NBL annual median value of 2.4 mg/L in July 2022.
- New maximum values for aluminium, lead, nitrate and TOC were reported in July 2022.
- A new maximum value for dissolved oxygen was reported in October 2022.
- A new maximum value for chloride was reported in April 2023.
- New minimum values for electrical conductivity and dissolved oxygen were reported in January and April 2023 respectively.
- All other analytes tested for were within the historical ranges and were reported at concentrations less than the adopted DGVs and NBLs.
- It should be noted that the July 2022 sample was collected immediately after a significant rainfall event (over 93 mm of rain in the previous 48 hours) and most likely had an effect on surface water quality, which is evidenced by the new maximum values for aluminium, lead, nitrate and TOC being reported.

A summary of the analytical results for **GI2** (upstream of landfill on the Abbotts Creek) is as follows:

- The reported concentration of aluminium was above the adopted ANZG freshwater guideline in July 2022 but less than the guideline value on the other monitoring occasions.
- The reported concentration of copper was above the adopted ANZG freshwater guideline in April 2023 but less than the guideline value on the other monitoring occasions.
- The measured % dissolved oxygen values were outside of the adopted range on all monitoring occasions. Reported values ranged between 7.3 and 91.2%.
- The measured dissolved oxygen concentration in mg/L was measured less than the NPS NBL values in January 2023.
- The field measured pH values were outside of the adopted range on all monitoring occasions.
- The reported concentration of cyanide was above the ANZG guideline values in January 2023.
- The reported concentration of nitrate was above the NPS NBL annual median value of 2.4 mg/L in July 2022.
- New maximum values for aluminium, nitrate and TOC were reported in July 2022.
- New maximum concentrations for copper and lead were reported in April 2023.
- New minimum values for dissolved oxygen (% and mg/L) were reported in January 2023.
- New minimum TOC values were reported in October 2022 and January and April 2023.
- A new minimum concentration for chloride was reported in April 2023.
- All other analytes tested for were within the historical ranges and were reported at concentrations less than the adopted DGVs and NBLs.

- It should be noted that the July 2022 sample was collected immediately after a significant rainfall event (over 93 mm of rain in the previous 48 hours) and most likely had an effect on surface water quality, which is evidenced by the new maximum values for aluminium, nitrate and TOC being reported.

A summary of the analytical results for **GI3** (adjacent to landfill) is as follows:

- The reported concentration of aluminium was above the adopted ANZG freshwater guideline in July 2022 but less than the guideline value on the other monitoring occasions.
- The reported concentration of copper was above the adopted ANZG freshwater guideline value on all monitoring occasions.
- The measured % dissolved oxygen values were outside of the adopted range on all monitoring occasions. Reported values ranged between 59.5 and 88.6%.
- The field measured pH values were outside of the adopted range in October 2022 and April 2023.
- The reported concentration of cyanide was above the ANZG guideline values in January 2023.
- The reported concentration of nitrate was above the NPS NBL annual median value of 2.4 mg/L in July 2022.
- New maximum concentrations for aluminium were reported in July and October 2022 and April 2023.
- New maximum concentrations for lead were reported in July 2022 and April 2023.
- New maximum concentrations for nitrate and TOC were reported in July 2022.
- A new minimum pH value was reported in April 2023.
- All other analytes tested for were within the historical ranges and were reported at concentrations less than the adopted DGVs and NBLs.
- It should be noted that the July 2022 sample was collected immediately after a significant rainfall event (over 93 mm of rain in the previous 48 hours) and most likely had an effect on surface water quality, which is evidenced by the new maximum values for aluminium, lead, nitrate and TOC being reported.

A summary of the analytical results for **GI5** (most downstream monitoring location) is as follows:

- The reported concentration of aluminium was above the adopted ANZG freshwater guideline in July 2022 but less than the guideline value on the other monitoring occasions.
- The reported concentration of copper was above the adopted ANZG freshwater guideline in July 2022 but less than the guideline value on the other monitoring occasions.
- The measured % dissolved oxygen values were outside of the adopted range on all monitoring occasions. Reported values ranged between 14.1 and 57.7%.
- The measured dissolved oxygen concentration in mg/L was measured less than the NPS NBL values on all monitoring occasions with the exception of January 2023.
- The field measured pH values were outside of the adopted range in October 2022 and April 2023.
- The reported concentration of nitrate was above the NPS NBL annual median value of 2.4 mg/L in July 2022.
- New maximum concentrations for aluminium and nitrate were reported in July 2022.
- A new minimum pH value was reported in October 2022.
- A new minimum total ammoniacal nitrogen concentration was reported in April 2023.
- Measured dissolved oxygen (mg/L) was recorded as new minimums on each of the monitoring occasions.
- All other analytes tested for were within the historical ranges and were reported at concentrations less than the adopted DGVs and NBLs.
- It should be noted that the July 2022 sample was collected immediately after a significant rainfall event (over 93 mm of rain in the previous 48 hours) and most likely had an effect on surface water quality, which is evidenced by the new maximum values for aluminium and nitrate being reported.

The 2022 - 2023 monitoring year analytical data are plotted in Figure C4-1 to Figure C4-4 attached in Appendix C, and trends are highlighted below:

- Overall, the reported nitrate concentrations for all locations are consistent with previous results, with the exception of GI5 in October 2022, when the concentration decreased over two orders of magnitude.
- The elevated nitrate and aluminium concentrations at all locations in July 2022 are most likely due to the sampling being undertaken immediately after a significant rainfall event and contaminants being flushed through the system from the upper catchments.
- Reported concentrations of lead for monitoring locations GI1, GI3 and GI5 are showing similar fluctuations in values over time and are of similar magnitude. However, the concentrations of lead at GI2 (Abbotts Creek location) tend to be lower than at the others and not fluctuate to the same degree, with the exception of April 2023, when the concentration increased at GI2 above the other locations. The concentration of lead at GI1 decreased in April 2023 when values at GI3 and GI5 remained relatively stable.
- Reported nickel concentrations at GI2 tend to be greater than those reported at the other monitoring locations. A similar pattern was noted in April 2023 with the concentration increasing at GI1 and decreasing at GI2.
- The measured pH values at GI2 were the generally lowest and generally highest at GI1, with the exception of April 2023 when this pattern reversed.
- An overall increasing trend in EC values and chloride concentrations at all monitoring locations can be noted over the monitoring year, with the exception of chloride at GI2 in April 2023.
- Chromium concentrations have tended to follow similar patterns and be of a similar magnitude. However, the data for the 2022 / 2023 monitoring period has been more disperse with values in April 2023 for GI2 and GI3 being greater than that at the other two locations when they have generally tended to be less than the values reported for GI1 and GI5.
- Reported copper concentrations fluctuated over the monitoring year at monitoring locations GI1, GI2 and GI5. Concentrations reported for GI3 were above the ANZG freshwater guideline over the whole monitoring year and were relatively stable.
- Total cyanide concentrations remained at concentrations below the laboratory LOR at all monitoring locations over the monitoring year with the exception for January 2023 when the reported concentration at GI1, GI2 and GI3 were elevated above the .adopted ANZEEC guideline values.
- Reported total ammoniacal nitrogen (uncorrected) concentrations were relatively stable over the first part of the monitoring year. As ammonia concentrations at GI2 (Abbots Creek) are similar to or greater than (except for April 2023) those reported for downstream monitoring locations, it is likely that the ammonia concentrations reported present at GI3 and GI5 are attributable mainly to the input from Abbots Creek.
- Chloride concentrations at sample locations GI1 and GI2 have remained relatively stable and are of similar magnitude since October 2019. Fluctuations in concentrations at sample locations GI3 and GI5 are similar to one another but are greater in magnitude than those at GI1 and GI2. The higher values noted at GI3 and GI5 are likely influenced by these sample points being located in intertidal zones.
- Results for the remaining analytes presented in the Figures C4-1 and C4-2 of Appendix C fluctuated over the monitoring year but remained relatively stable over the monitoring year within historical ranges.

5.5.2 Isotope analysis results

The isotopic analytical data available for the monitoring period 2017-2023 indicates that the data for the surface water monitoring locations have different signatures to the leachate, i.e. their trend lines plot separately. This is most pronounced for the ^{13}C data, where the surface water data plot below (depleted – below -10 $\delta^{13}C$‰) the leachate data (enriched - above 5 $\delta^{13}C$‰).

The isotopic data is more varied for the ^{18}O and ^{2}H data, but generally the surface water data plots below the leachate data and plot closely together.

The data for the surface water monitoring locations tends to plot within ±5% of the global meteoric water line (GMWL). Whereas the isotope data for the leachate samples plot above both the GMWL and the Dunedin meteoric water line (DMWL). In addition, the majority of the isotopic data for surface water locations plot along the DMWL.

The data for the surface water locations cluster towards the middle of the DMWL with the majority of the data falling within ±5% of the line. The data for the leachate and MW9D (landfill well) plot above the DMWL line.

While the majority of the surface water isotopic data plots on the DMWL, there are some data points which plot below and above the DMWL and amongst the leachate data, including data for GI2 (Abbots Creek) and GI1 (Kaikorai Stream upstream of the landfill).

The data would suggest that there is some contamination source influence on the surface water, and since some data points for GI1 and GI2 also plot close to the leachate data points, there is likely to be a source upstream of the landfill (Industrial estate, quarry activities etc.) as well as landfill leachate affecting these results.

Further details of the sampling and analysis undertaken, a discussion of the isotopic trends and findings of the monitoring is contained in the interpretative isotopic report attached in Appendix F.

5.5.3 Summary

Due to their location upstream of the landfill, the water quality at surface water monitoring locations GI1 and GI2 should theoretically be better than at monitoring locations GI3 and GI5. However, reported concentrations of aluminium, copper, nickel and lead are generally greater than or similar to those reported at the downstream monitoring locations.

The trend in nitrate concentrations followed a generally similar pattern over the monitoring year at each sampling point. It can be noted that the water coming from upstream of the landfill and from Abbots Creek contributes the majority of the nitrate concentration downstream of the landfill.

It is likely that the significant rainfall event in the middle of July 2022 affected surface water quality in both the Abbotts Creek and Kaikorai Stream, leading to elevated concentrations of contaminants, in particular aluminium and nitrate, at all monitoring locations.

Cyanide was reported present at concentrations above the adopted ANZECC freshwater guideline at upstream monitoring locations GI1 and GI2 and GI3 in January 2023. It was not reported present above the laboratory LOR at GI5 over the monitoring year.

Based on the 2022/2023 analytical results, the likely sources of heavy metals (aluminium, copper and nickel) are from the Abbots Creek catchment and the industries upgradient of the landfill in the Kaikorai Stream catchment, both contributing to the overall concentrations.

It is apparent that the surface water upstream of the landfill, in both the Kaikorai Stream and Abbots Creek, has been impacted by industrial and agricultural activities. Overall, the influence of the landfill leachate on water quality in the Kaikorai Stream does not appear to be significant.

The more elevated chloride concentrations and EC measurements at GI3 and GI5 are likely reflective of a generally more saline, estuarine conditions than at the more upstream monitoring locations.

Condition 10 (d) requires that on each sampling occasion the flow in the Kaikorai Stream be qualitatively estimated and that the water level, the tidal stage, and rainfall over the previous 7 days be recorded. In addition, whether the estuary mouth is open or closed is also to be noted. Table 7 below details the required rainfall, tidal stage data and estuary mouth status.

Table 7 Rainfall, tidal stage and estuary mouth status during monitoring events

Sample Date	Rainfall previous 72 hours (mm)	Rainfall previous 7 days (mm)	Tidal stage at Green Island	Estuary mouth status at Brighton Spit (open / closed)
15th July 2022	93.8	121.8	Low tide at the coast at 09:51 GI5 sampled at 08:52	Unknown
12th October 2022	0.0	25.3	Low tide at 11:29 GI5 sampled at 13:10	ORC undertook works to open the mouth of the estuary on the 12th October 2022.
18th January 2023	0.0	4.8	Low tide at 06:27 GI5 sampled at 08:30	Unknown
11th April 2023	0.0	1.0	Low tide at 12:46 GI5 sampled at 14:45	Unknown

GHD have been advised by ORC that works were also undertaken on 4th November 2022 and 23rd February 2023 to open the mouth of the Kaikorai River estuary at the spit.

5.6 Sedimentation pond chemistry monitoring

There are two silt retention ponds (sedimentation ponds) located at the landfill, one on the north eastern boundary (Eastern Pond) and the other on the southwestern boundary (Western Pond) of the landfill (see Figure 4) which require monitoring as per consent conditions. In addition to these ponds, there are three further sedimentation ponds on the landfill, one known as the Northern Sedimentation pond and the other two associated with the borrow pit on the southwestern boundary of the landfill.

The stormwater drains and soak holes network at the landfill collects the stormwater runoff from the landfill and re-directs it to the sedimentation ponds. There, sediment in the water settles out and the water is discharged back to the Kaikorai Stream. The sediments are removed from the ponds periodically and disposed of at the landfill. The Western Pond currently does not receive any stormwater runoff from the landfill unless there is an extreme weather event.

Consent 3840C_V1 provides conditions to discharge stormwater to the Kaikorai Stream, which involves the water quality monitoring of the sedimentation ponds.

Sampling of the water in the two sedimentation ponds was undertaken three monthly in July and October 2022, and January and April 2023. The collected samples were analysed as per Condition 6(v) of Consent 3840C_V1. Field collected data is presented in Appendix A and equipment calibration records are included in Appendix D.

Additional sampling was undertaken of both the sediment and stormwater within the Northern Sedimentation pond in February and March 2023 respectively. This monitoring was not required by the consent but was undertaken to obtain baseline data for this pond.

5.6.1 Results

Condition 6(ii) specifies that the trigger levels to be used be calculated from the mean value of the monthly data obtained during the first year of this consent plus or minus 3 standard deviations of the data set. As this consent was re-issued on 5th July 2007, the data collected during the 2007-2008 monitoring year has been used to derive the relevant trigger values (referred as ORC Condition 6(ii)).

Although not a requirement of the consent condition, the laboratory reported analytical results have been compared to The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), 80% of species level of protection, Default Guideline Values (DGVs) and the National Policy Statement for Freshwater Management (NPS, 2020) National bottom line (NBL) values, as an indication of water quality. However, as the sediment ponds are not flowing water bodies, the use of the DGVs is simply to provide a reference to the expected receiving environment and does not account for the mixing zone associated with the discharge.

The NPS Freshwater was included as its objective is to ensure that natural and physical resources are managed in a way that prioritises the health and well being of water bodies above other uses.

The NPS NBL values and ANZG default guideline value have been derived for ammonia at a pH of 8 and a temperature of 20°C, as the toxicity of this contaminant is influenced by these parameters. Both the ANZG and the NPS require that the laboratory reported concentration for total ammoniacal nitrogen be corrected for pH and temperature to allow for comparison with the DGVs and NBLs. The current monitoring year's data has been corrected for this and are presented in Table C-6. However, the data presented on the total ammonia graph in Figure C5-6 has not been corrected as historical temperature data is not currently available.

A summary of the results for the **Eastern Pond** is as follows:

– The field measured pH was greater (more alkaline) than the upper guideline value for a lowland river in October 2022 and January 2023.
– The field measured DO values were outside of the guideline range for a lowland river on all sampling occasions during the 2022 / 2023 monitoring year. Three were below the guideline range and were between 16.1 % and 67.0 % and the other was above the range at 252.2%.
– The reported concentrations of chloride at all monitoring events were above the ANZG freshwater DGV (0.013 mg/L) and ranged between 46 and 494 mg/L.
– Total ammoniacal nitrogen concentrations were reported present with concentrations ranging between less than the laboratory level of detection (0.005) and 0.53 mg/L. The corrected values for the Eastern Pond were less than the NPS NBL annual median and annual maximum values.
– The reported concentrations of copper in July and October 2022 exceeded the ANZG freshwater DGV of 0.0025 mg/L with values of 0.0037 and 0.0038 mg/L, respectively.
– The reported zinc concentration in January 2023 exceeded the ANZG freshwater DGV of 0.0.031 mg/L with a concentration of 0.043 mg/L.
– A new maximum value for dissolved oxygen was recorded in January 2023.
– A new minimum concentration for copper was reported in April 2023 and two new minimums for total ammoniacal nitrogen were recorded in January and April 2023.

A summary of the results for the **Western Pond** is as follows:

– The field measured pH was greater (more alkaline) than the upper guideline value for a lowland river in January 2023.
– The field measured DO values were outside of the guideline range for a lowland river on all sampling occasions during the 2022 / 2023 monitoring year, with values ranging between 30.7 and 75.7 %.
– The reported concentrations of chloride at all monitoring events were above the ANZG freshwater DGV (0.013 mg/L) and ranged between 1,240 (July 2022) and 2,210 mg/L (January 2023). The concentration reported in January 2023 also exceeded the Consent 3840C_V1 derived trigger value of 2,068 mg/L.
– The reported concentration of copper in July 2022 exceeded the ANZG freshwater DGV of 0.0025 mg/L with a value of 0.0048 mg/L.
– The reported nitrate concentration in July 2022 exceeded both the Consent 3840C_V1 derived trigger value of 1.690 mg/L and ANZG freshwater DGV of 17 mg/L with concentration of 18.3 mg/L (a new maximum concentration). This is likely due to the sample being collected during a significant rainfall event and the pond receiving stormwater (and contaminants) being flushed from the upper catchment.
– No other exceedances were reported and all reported values for these analytes were within their historical ranges.

The analytical and field data collected during the 2022 / 2023 monitoring year, along with available historical data, have been plotted against time and plots are shown in Figures C5-1 through to C5-6 of Appendix C.

A summary of the results is as follows:

– An overall reduction in nitrate concentrations was observed at both ponds between June 2017 and April 2022. In the 2022 / 2023 monitoring period for Eastern Pond, the concentrations have fluctuated slightly and remained within the historical ranges while for the Western Pond, a significant increase in concentration was reported in July 2022 (exceeding both the Consent 3840C_V1 derived trigger value and ANZG freshwater DGV), before returning to a more consistent level in October 2022 and for the remainder of the monitoring year. This is likely due to the significant weather event which occurred at this time (over 100 mm of rain over the monitoring period).
– Reported concentrations of potassium have remained relatively stable at both ponds since July 2017, with concentrations in the Western Pond being generally higher than those in the Eastern Pond. Potassium concentrations fluctuate with similar trends at the two ponds.
– Fluctuations in zinc concentrations have tended to follow similar patterns in the two ponds. However, this has not been the case since April 2022 where concentrations have varied oppositely.
– Measured pH values have tended to be similar in each pond and follow relatively similar trends. An increase of the pH values was recorded at Eastern Pond in October 2022 and January 2023 before reducing to a more consistent level in April 2023. The pH value in January 2023 also increased in Western Pond however, not to the same extent as what was recorded for Eastern Pond.
– In monitoring location Eastern Pond, since April 2021 (where concentrations of lead were reported as being below the laboratory limit of reporting (LOR)), concentrations have increased to above the Consent 3840C_V1 derived trigger value in both July 2022 and January 2023. The lead concentration reported in April 2023 indicated a decrease in concentration. Similar to Eastern Pond, reported concentrations of lead in Western Pond increased from being below the laboratory LOR in October 2021 and continued to increase, exceeding the Consent 3840C_V1 derived trigger value in October 2022. Reported concentrations in January and April 2023 show a decreasing trend.
– Chloride concentrations tend to be greater in the Western Pond than in the Eastern Pond. Reported Chloride concentrations in Western Pond exceeded the Consent 3840C_V1 derived trigger value in January 2023 while reported chloride concentrations for the Eastern Pond have not exceeded the applicable trigger value over the whole monitoring period (2003 to 2023).
– It can be noted that fluctuations in concentrations for certain metals such as nickel and chromium, follow relatively similar patterns, within their respective historical ranges.
– Electrical conductivity values at the Eastern Pond tend to be relatively stable whereas those measured at the Western Pond fluctuate over a greater range. Values measured at the Western Pond have been greater than at the Eastern Pond since July 2019, which is likely due to the influence of proximity and connection with the saline waters and sediment of the estuary.
– Reported concentrations of alkalinity have remained relatively stable in both Eastern and Western Ponds since July 2019, with a notable increase for Western Pond in both January and April 2022, and decrease in Eastern Pond in July 2022 before returning to a more consistent level.
– Reported concentrations of copper have followed a similar trend in concentrations for both ponds since October 2020 until April 2023, when the concentration increased at the Western Pond but decreased at the Eastern Pond. A new minimum concentration has been reported in Eastern Pond in April 2023.
– Total ammoniacal nitrogen concentrations (uncorrected) have varied over five orders of magnitude since April 2007. There is a moderate correlation in the fluctuations in concentrations at the two ponds, and a decrease in concentrations is noted at the Eastern Pond following the October 2022 monitoring event while concentrations reported in Western Pond increase.

Monitoring of the Northern Sedimentation Pond

A sample of the sediment at the base of the pond was collected on the 20th February 2023 and was laboratory analysed for a suite of nine heavy metals, semi volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene and xylenes (BTEX). At the time of the collection of this sediment sample, there was no water present in the pond.

Following a rainfall event (20.5 mm) on the 5th March 2023, a sample was collected of the stormwater runoff collected in the pond on the 6th March 2023. This sample was laboratory analysed for a suite of heavy metals (total and dissolved), ammonia, SVOCs, BTEX and TPH.

The results of the sediment analysis have been tabulated and compared against the following guidelines / standards:

– Adopted ANZG guidelines,
– Adopted background values
– Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS) Commercial / Industrial and Recreational land use soil contaminant standards (SCS).
– Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand.

The results of the stormwater analysis have been compared against the ANZG 90% and 95% Freshwater species protection guideline values.

The analytical collected in February and March 2023 for the sediment and stormwater is presented in Table C7-1, C7-2 and C7-3 included in Appendix C.

A summary of the results for the **Northern Sedimentation Pond** is as follows:

– Sediment:
  - Heavy metals were not reported at concentrations above any of the adopted guidelines and standards.
  - No SVOCs or BTEX were reported at concentrations above the laboratory limit of reporting (LOR)
  - Low concentrations of TPH were reported present in the C15-C36 range (heavy end).
– Stormwater
  - Dissolved oxygen was reported at a value above the adopted range.
  - Total chromium, copper and zinc were reported at a concentration above their respective ANZG 95% species default guideline values (DGV).
  - Total copper was reported present at a concentration above both the ANZG 80% and 90% species protection DGV.
  - Dissolved copper was reported present at a concentration above the ANZG 80%, 90% and 95% species protection DGV.
  - No BTEX, TPH or SVOCs were reported present at concentrations above the LOR.

Overall, the quality of the sediment and stormwater within the Northern Sedimentation pond is reflective of the environment of the catchment of the pond, with certain metals in particular copper being present at concentrations above the adopted guideline values.

5.6.2 Summary

In the Western Pond, the proximity to the estuary is likely to have influenced the electrical conductivity values and chloride concentrations, which are higher than those measured in the Eastern Pond. Both analytes have increased between July 2022 and January 2023 before decreasing in the April 2023 monitoring event.

The reported concentrations of nitrate, zinc, chloride, pH, copper and dissolved oxygen exceeded the ANZG 80% DGVs in various monitoring events at either pond throughout the 2022 – 2023 monitoring period. Overall, the water quality in the Western Pond is slightly better than that in the Eastern Pond as there are less analyte exceedances over the monitoring period in the Western Pond than were reported in the Eastern Pond.

According to the Delta 2015-2016 annual monitoring report, the sediment from the base of both ponds was cleaned out in July 2014 and the Eastern Pond as dredged in June 2016.

Condition 3 of resource consent 3840B_V1 states that “All silt retention ponds shall be designed for the runoff arising from storms having a return period of 1 in 2 years with a design storm duration of 24 hours (from the control levels)”.

To ensure that there was adequate storage remaining in the Western Pond and that dredging works were not required, a bathometric and topographic survey was undertaken in December 2019. The survey showed that the pond had an area of approximately 7,000 m^2 and a volume of 3,376 m^3. There is also an additional volume capacity when overflowing of 2,310 m^3.

There is currently no upstream catchment inputting to the Western sedimentation pond, as all of the inflow culverts to it are blocked. As such, the only water that this pond receives is from rainwater falling on it, the area of the surface of the perimeter bunds and any overland flow during extreme rainfall events. The area of the pond and bunds is approximately 1,650 m^2. On this basis, it is considered that the pond has sufficient capacity to comply with the consent.

6. Landfill gas monitoring, dust and odour management

6.1 Landfill gas survey

6.1.1 Inspections of the landfill

In accordance with consent 94524_V1 condition 13, visual inspections of the surface of landfill were carried out by GHD staff on a quarterly basis while carrying out the groundwater level monitoring round and by Waste Management Staff on a monthly basis.

Detailed inspections of the whole landfill were not possible due to large portions of the landfill being either heavily vegetated or being part of the operational areas (working face, trafficked areas or recycling centre areas etc.) of the landfill. Further details of the inspections undertaken are included in the audit reports presented in Appendix G.

During the quarterly monitoring, the groundwater well heads were allowed to vent prior to the water level and field parameter measurements being made. There were no alarms for the presence of landfill gases recorded on the lower explosive limit (LEL) meter carried by GHD staff over the 2022 / 2023 monitoring year.

6.1.2 Landfill gas monthly monitoring

Resource consent 94524_V2 condition 11 requires that the landfill gas monitoring well (gas tube 1 (G1)) located adjacent to the eastern Site boundary close to Clariton Avenue, be monitored on a monthly basis using a portable gas detector for methane (CH_4), carbon dioxide (CO_2) and oxygen (O_2) percent compositions. Historically there were four such gas monitoring wells along this boundary. However, they fell into disrepair and were no longer suitable for monitoring purposes.

In May 2020, three new landfill gas monitoring wells were installed adjacent to the original G2, G3 and G4 locations, as shown on Figure 4. A letter report detailing the works undertaken and the installation details of each well was included in the 2019 – 2020 Green Island Landfill annual monitoring report[2].

The landfill gas measurements were collected on a monthly basis by Waste Management over the monitoring year, using a GA5000 landfill gas measurement instrument, and are provided in Table 7. In addition to the consent required gases, carbon monoxide (CO) and hydrogen sulfide (H_2S) concentrations were also measured. It should be noted that there are no measurements presented for July 2022. This is due the record documentation being lost.

As can be seen from Table 8, no CH_4 or H_2S was detected present in the gas wells. However, CO_2 was recorded present in the wells on several occasions with values ranging from 0.0% to 8.2%. A review of the logs and installation details for these wells indicate that the well screens are located in natural soil material and not waste (which could act as a source).

The New South Wales Environmental Protection Agency (NSW EPA), Assessment and management of hazardous ground gases: Contaminated land guidelines states in Table 2 that soil has background concentrations of CO_2 in the 0-10% range and wetlands and water logged soils can have CO_2 concentrations in the 0-5% range. No background concentration for CO_2 has been established for the Site and so it is difficult to determine what percentage of this gas can be attributed to natural sources and what percentage is from another source(s).

These wells are located to the north of a wetland area and also to the east of the landfill. The leachate collection trench passes immediately adjacent to the landfill gas wells locations and the pipe from the south eastern wetland to the north eastern wetland passes approximately 20 m to the west of the well locations. It is possible that gases are present in these pipes and may be migrating into the wells.

[2] GHD (2020) Green Island Landfill, 2019-2020 Annual Monitoring Report. February 2021. Project number: 12509201.

There is no guidance contained in the WasteMINZ Disposal to land guidelines for trigger values for CO_2 concentrations. In enclosed spaces, corrective actions are required above 1.5% CO_2 (above natural established background levels). From the data collected, it is not considered likely that these concentrations of CO_2 pose a risk. However, further investigation is recommended to assess the source of this landfill gas.

Table 8: Clariton Avenue - Landfill Gas Monitoring Well Measurements 2022 / 2023

Landfill gas monitoring well	Date / Time	Temperature (°C)	Pressure	CH_4 %	CO_2 %	O_2 %	CO ppm	H_2S ppm	Balance	Air pressure (mBar)	Weather Comments
G2	July 2022	Landfill gas monitoring well measurements collected in July 2022 are unable to be reported due to missing documentation									
G3											
G4											
G2	01 August 2022 / 1500	13	-	0.0	0.2	20.7	0.0	0.0	79.1	1,014	Partly cloudy, mild, wet
G3				0.0	1.3	18.6	0.0	0.0	80.1		
G4				0.0	0.6	19.4	1.0	0.0	79.9		
G2	12 Septeber 2022 / 1400	16	-	0.0	5.5	14.4	2.0	0.0	80.1	994	Clear, mild, dry
G3				0.0	5.1	11.3	2.0	0.0	83.6		
G4				0.0	5.1	16.8	2.0	0.0	78.1		
G2	03 October 2023 / 1215	10	-	0.0	5.6	15.7	0.0	0.0	78.8	1,005	Partly cloudy, cool, dry
G3				0.0	0.1	20.5	0.0	0.0	79.3		
G4				0.0	0.2	20.6	0.0	0.0	79.2		
G2	04 November 2022 / 0900	10	-	0.0	6.9	15.8	0.0	0.0	77.3	1,004	Clear, mild, dry
G3				0.0	8.2	12.8	0.0	0.0	79.0		
G4				0.0	5.3	19.8	0.0	0.0	79.0		
G2	07 December 2022 / 1430	13	-	0.0	2.6	18.8	2.0	0.0	78.6	1,014	Sunny, dry
G3				0.0	3.9	18.0	2.0	0.0	78.1		
G4				0.0	0.0	20.6	2.0	0.0	79.4		
G2	12 January 2023 / 1600	14	-	0.0	2.5	18.8	3.0	0.0	78.7	1,014	Cloudy, dry, sunny
G3				0.0	2.4	18.9	4.0	0.0	78.7		
G4				0.0	6.8	12.7	3.0	0.0	80.5		
G2	10 February 2023 / Afternoon	15	-	0.0	2.1	18.8	2.0	0.0	79.1	1018	Partly cloudy, dry, sunny
G3				0.0	1.5	19.1	3.0	0.0	79.4		
G4				0.0	4.3	14.4	2.0	0.0	81.4		
G2	02 March 2023 / Afternoon	21	-	0.0	2.2	19.1	0.0	0.0	78.8	1,008	Clear, sunny, dry
G3				0.0	1.8	19.3	0.0	0.0	78.9		
G4				0.0	4.1	15.8	1.0	0.0	80.1		
G2	04 April 2023 / Morning	16	-	0.0	2.2	15.4	0.0	0.0	82.4	1,020	Clear, sunny, dry
G3				0.0	3.6	14.1	0.0	0.0	82.4		
G4				0.0	4.1	14.1	0.0	0.0	81.8		
G2	02 May 2023 / Afternoon	15	-	0.0	4.9	15.3	0.0	0.0	79.8	1,011	Clear, sunny, dry
G3				0.0	5.7	13.3	0.0	0.0	80.9		
G4				0.0	7.2	12.9	0.0	0.0	79.8		
G2	07 June 2023 / Afternoon	7	-	0.0	6.0	12.5	0.0	0.0	81.5	1,030	Clear, sunny, damp
G3				0.0	5.8	10.0	0.0	0.0	84.2		
G4				0.0	6.5	14.0	0.0	0.0	79.5		

Note:
A hyphen (-) indicates that a parameter is not available

6.1.3 Gas Walkover

A landfill gas survey, also known as instantaneous surface monitoring (ISM), was undertaken by GHD on the 26th of January 2023 in accordance with GHD Procedure E24.

The survey was undertaken using an Eagle 4 Gas Monitor which contained sensors to measure methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO) and oxygen (O_2). The undertaking of an ISM is not a requirement of the consent conditions, but it was carried out to provide DCC with additional data to assist in the management of the landfill.

A length of plastic tubing was fitted to the Eagle monitor, the tubing was then attached to a rigid stick and the open end of the tubing was held approximately 5 cm above the ground surface, until the readings stabilised. The gas monitor works by drawing (pumping) the air from the ground surface through the tubing into the machine and over the sensors where the concentration of the gasses in parts per million (ppm) or percentage (%) can be measured.

On the day of the survey, there were very light winds (approximately 8 km/h to the east north east) and the temperature was approximately 24$^{°C}$. The atmospheric pressure on the day (at the Green Island weather station) was recorded as 1,016 hPa. The atmospheric pressure for the four days preceding the survey is displayed in Table 9. As can be seen the survey was undertaken when atmospheric pressure was falling slightly, which is recommended.

Table 9 Atmospheric pressure readings

Date of reading	Pressure (hPa)
22-Jan-23	1,014.3
23-Jan-23	1,017
24-Jan-23	1,018.5
25-Jan-23	1,018.4
26-Jan-23 (date of survey)	1,016

The survey was undertaken over the grassed areas and paddocks adjacent to and to the south east of the transfer station and over the older capped area to the east of the current tip face. The remainder of the landfill was inaccessible due to capping construction works and operational activities.

Locations where readings were taken during the ISM are shown on Figure G1, included in Appendix G. Readings of between 400 ppm and 500 ppm CO_2 were recorded at each location (shaded blue) which is considered as the background range for CO_2. There was no CO recorded present and O_2 readings were stable, recording measurements between 19.3 and 19.7 Vol% during the ISM. CH_4 concentrations of 500 ppm were recorded in 11 gas sampling points across the Site (shaded red), four in the western corner of the northern paddock, and seven in the area to the east of the current tip face. The findings of the ISM indicated that there were certain areas of the Site where low concentrations of methane is escaping from the landfill cap. Further investigation is recommended to assess the risk and develop remediation options such as the placement of additional capping material over these areas (if required). Results indicate there are no significant fugitive emissions of landfill-influenced gases escaping the cap / gas collection system.

6.2 Dust and odour mitigation

6.2.1 Complaints register

As part of consent 94524_V2 condition 10, DCC are required to maintain a register to record any complaints received in relation to the Site. Over the 2022 - 2023 monitoring year, DCC received 20 complaints relating to the Site. The register is attached in Appendix G as Table G1.

A summary of the complaints received is as follows:

– All complaints were in regard to nuisance odour.

- The majority of the complaints came from people living close to the landfill and when the wind was blowing from a south westerly direction.
- Some of the complaints occurred when trenches were being dug on the landfill exposing old waste or when liquid wastes were received and were being buried.
- ORC made two visits to the landfill to investigate odour complaints.
- The odour cannon was used when needed.
- No complaints were reported in relation to dust or windblown litter.

The ORC served and infringement notice in late June 2023 on the DCC and Waste Management in relation to the odour complaint received on 18 April 2023.

Over the period of 31st May to 5th June 2023, five complaints were made in relation to odours from the landfill. During this period, ORC visited the site and neighbourhood to undertake an investigation. As a consequence of this, various action items were agreed upon for DCC to undertake.

Action items as follows:

- Improvement of the complaints logging and communication procedure
- Updated communications with the odorous waste carriers as to the procedure for managing their loads.
- Re-installation of the odour suppression system on top of the letter fence (completed on 15 June 2023).
- Ensure the performance and reliability of the gas engine and flare through regular maintenance and upgrades.
- Connection of landfill gas collection wells to the network as soon as possible and continuing improvements to the gas-field.
- Stabilisation of the biosolids sludges using lime.
- Managing odorous loads effectively by burial and covering as soon as they arrive at the relevant disposal area of the landfill.
- Ensure that the odour canon to be operational, positioned appropriately and used when needed.
- Placement of daily cover and intermediate cover to minimise the escape of fugitive odours. Focus on good housekeeping in and around the tipface.

The majority of these items have either been completed or substantive progress / operational improvements have been achieved. The outstanding items (as of 30 June 2023) mainly relate to the connection of the landfill gas collection wells to the network.

6.2.2 Landfill gas collection system

The information contained in section 6.2.2 was provided to GHD by the DCC landfill engineer.

A landfill gas extraction system has been operational at Green Island landfill since 2009. A total of thirty six (36) gas extraction wells to date have been installed at the Site. No new wells were connected to the collection network over the 2022 / 2023 monitoring year. However, five (5) new wells were progressively installed within the waste being placed and are to be connected to the collection network in the near future.

As part of the final capping of the northern sector of the landfill, all landfill gas pipes in this area were placed below the cap, with careful sealing of cap around wellheads. Landfilling operations were focussed in the central – southern sector of the landfill for the majority of the year, with some of these newer wells in this area not being connected to the main gas-field network at the time of this report (30 June 2023). At any given time during the year more than 30 of the 36 gas-wells are connected and under constant vacuum, with as many as possible of the remainder connected to the solar flare.

A stand-alone solar-spark flare has continued to operate for the majority of the monitoring year. It was connected for a period, north of the tipface, to the high productivity wells (GW28, GW38 and GW39), and also for a period of time to the main adjacent GW36 acting as a backup for wells in that area. This initiative still continues to benefit both worker safety and environmental performance immediately in and around the area of the active tip-face operation where it is very difficult to hook up the main gas network.

Figures 6 and 7, show the layout of the gas-field network at the end of June 2022 and July 2023 respectively.

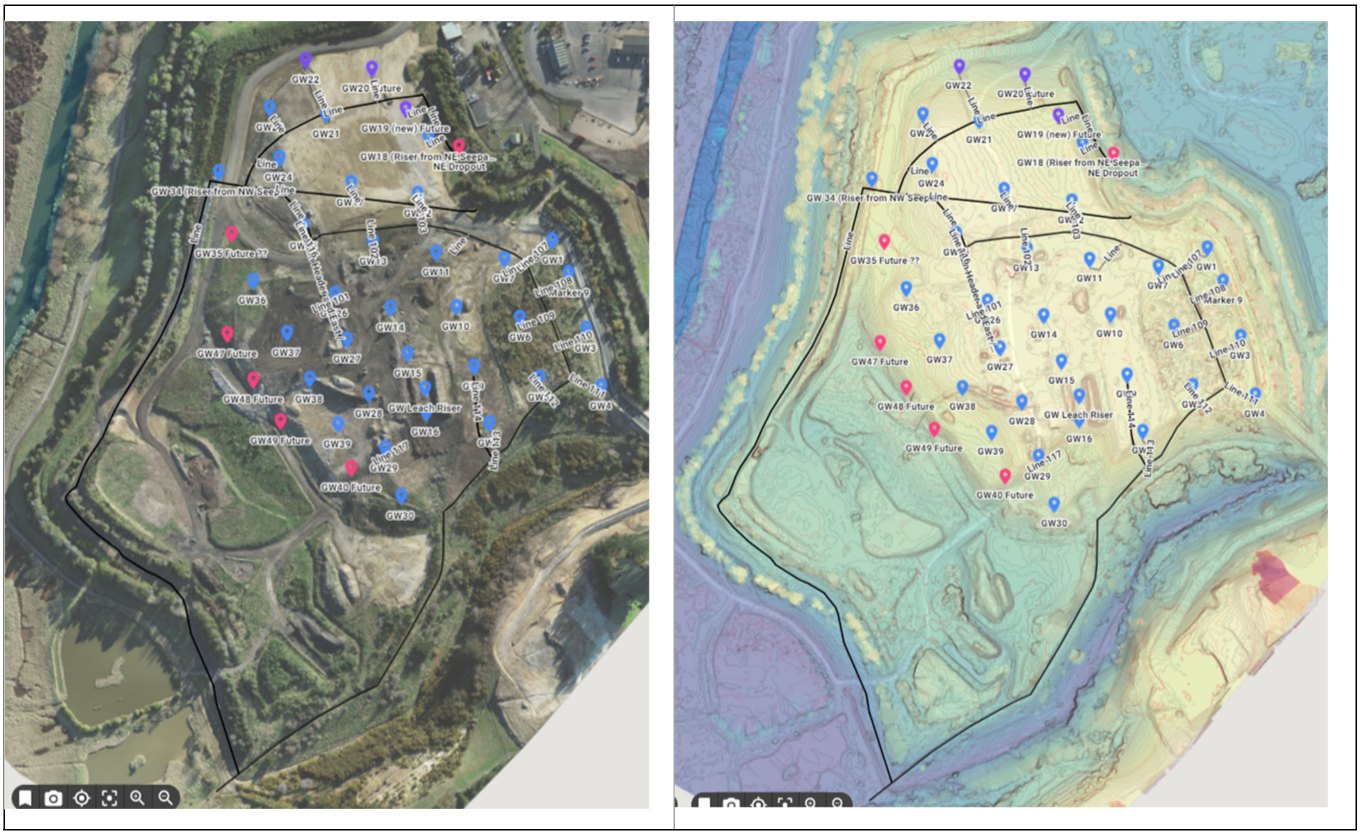


Figure 6 ***Landfill Gas Well Field and Network July 2022***

Note: The tip face is located towards the south of the landfill. The wells in this location were not connected to the collection network at the end of July 2023.

Figure 7 ***Landfill Gas Well Field and Network July 2023***

The blue wells represent existing gas wells and the red ones indicate where gas collection wells will likely be placed in the future. The purple wells represent wells that have been installed but not yet connected to the network. The light blue (turquoise) coloured wells represent valve positions.

Flows at individual wellheads were not collected for some of the year due to that particular gas analyser instrument being shipped internationally for major service and repair. From the methane concentration data, valve position and historical performance, it is known that the most productive landfill gas collection wells are the nine (9) wells designated as GW14, GW15, Breather, GW17, GW21, GW24, GW25, GW26 and GW37. The majority of these wells are located in areas of more recent waste filling (majority <5yrs). The wells in historic waste (between 10-15yrs old) such as GW1 to GW12 still give some gas and are monitored and are online at various times depending on conditions.

Landfill gas is extracted via the wellheads with the piped network taking that gas to the Green Island Wastewater Treatment Plant (WWTP), where destruction of that gas is either by gas engine and/or flare. Methane (ie biogas) from the WWTP digestors can also be mixed at times with landfill methane and destroyed via the gas engine, which also produces heat to assist the WWTP biological processes. No digester gas was used this year due to the abundance of landfill gas.

The gas collection system is monitored on a daily basis by the landfill operator (Waste Management Ltd) for flow rate, methane content, temperature and pressure, with full weekly rounds of the whole field completed. The data collected was supplied to GHD and the DCC, by Waste Management for assessment.

Over the 2022-2023 monitoring period, landfill gas was destroyed at an average rate of 7,110 m^3/day, an increase on the 6,038 m^3/day in the year prior. A graph of the daily flow rate as well as methane percentage, is shown on Figure 8 below.

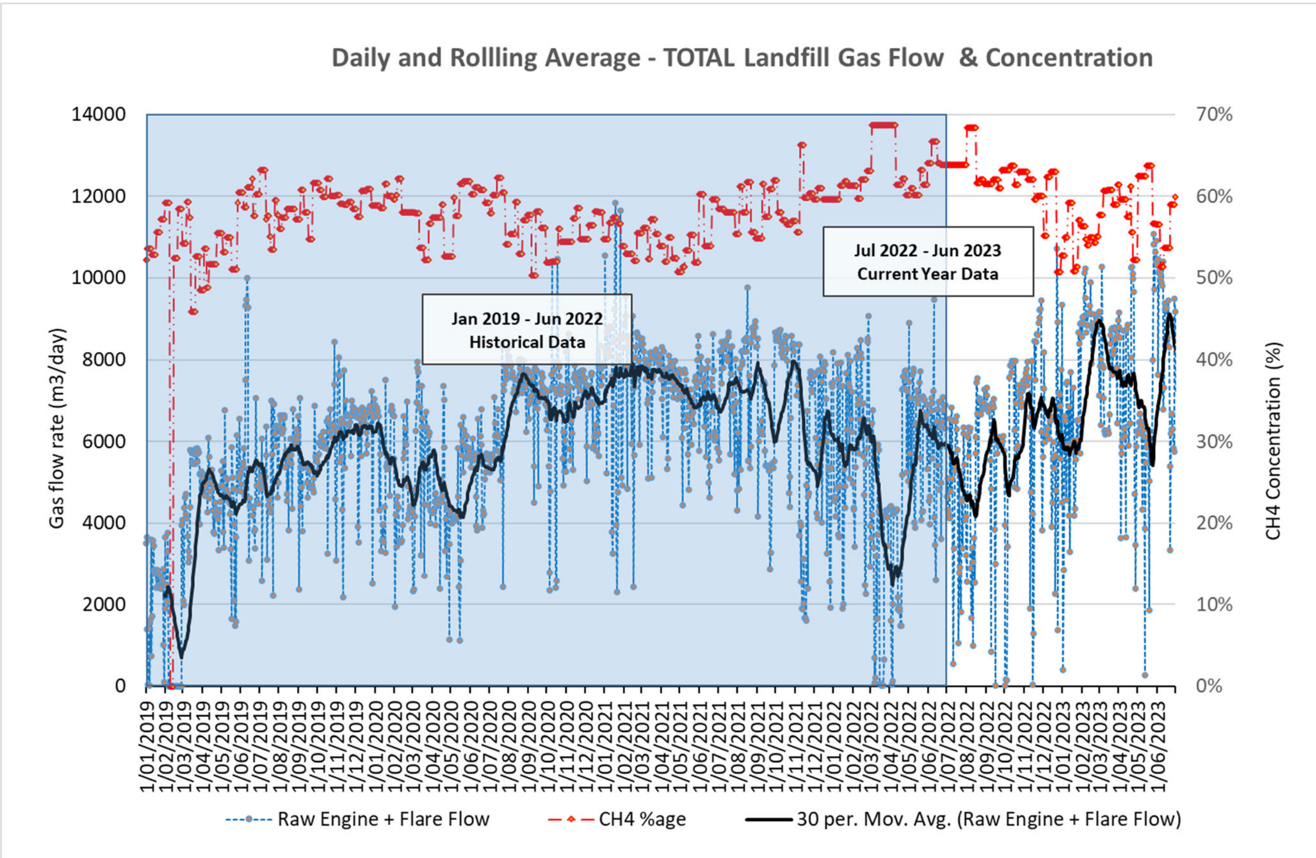


Figure 8 ***Gas engine and gas flare flow rates compared against methane %***

Good reliability of the gas engine and flare were achieved during most of the year, although in the periods December 2022 and January 2023 and also April 2023, a period of high daily flare flows were a result of engine breakdowns / unreliability and a major maintenance outage.

An upgrade to the flare was completed in December 2022 which has resulted in greater flow of gas able to be destroyed. Increasing the total daily flow through the engine and flare from December 2022 has resulted in a reduction in the methane concentration in 2023.

The methane percentage of landfill gas measured at the gas engine and/or flare immediately prior to destruction varied between maximum and minimum of 68.4% and 50.7% compared to 68.7% and 54.9% over the 2021 / 2022 monitoring year. The average percentage of 59.8% compares to 60.0% for the year prior, with July 2022 to December 2022 average of 62.3% compared with January 2023 to June 2023 an average of 57.4%, see Figure 9. This reduction in methane concentration in the second half of the monitoring year is a result of greater flow and hence greater suction on the gas-field. The target percentage for optimal performance at the WWTP generator is between 55-60%, hence this year operated nearer the top as well as nicely within that range.

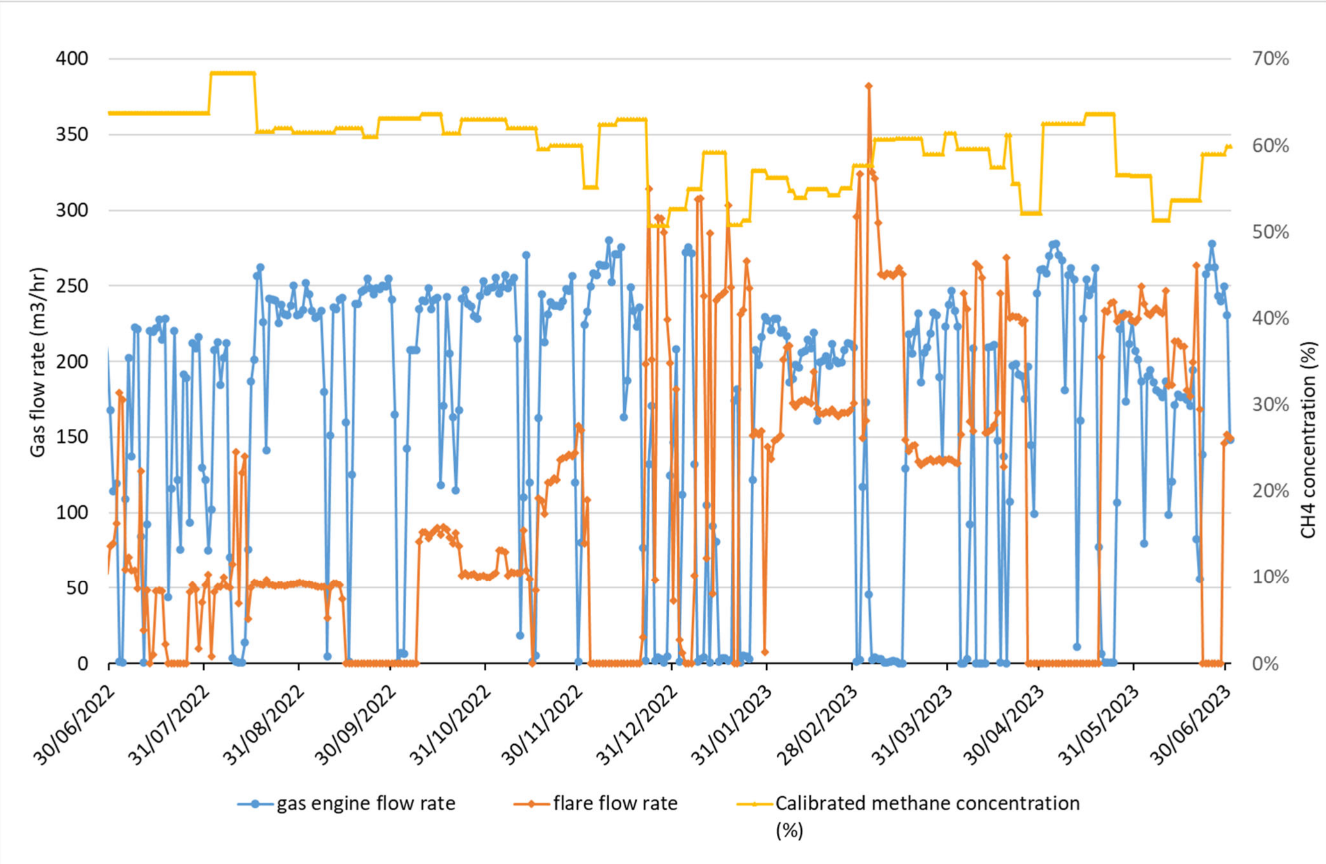


Figure 9 ***Methane concentrations, gas engine and flare flow rates 2021 - 2022***

Overall the total gas yield from the field as well as performance was good and reflective of greater yields from the newly capped northern sector, and operational focus on connecting wells in recently placed waste as quickly as possible. The focus continues to be to have as many gas-wells online at any time, and also to achieve the best reliability of flare and engine possible. The new flare blower and major engine maintenance completed this year will increase reliability and hence overall performance.

DCC applied to the NZEPA in January 2022 for a UEF (Unique Emissions Factor) in accordance with the 2009 Climate Change (Unique Emissions Factors) Regulations. This resulted in a UEF of 0.564 being granted which was a significant improvement on the 0.832 factor from calendar year 2021. Significant costs saving in ETS (Emissions Trading Scheme) were therefore made by the DCC for calendar year 2021.

6.2.3 Odour mitigation system

A litter fence was constructed around the landfill face area over the 2019 - 2020 monitoring year. An additional odour control system which allows for the dispersing of odour neutralising chemical by misting was added to the top of the litter fence. This is an automated system which is utilised during operating hours as needed and when there is a westerly wind blowing. However, this system was inoperative for a period of time when the litter fence was being repositioned to the new tip face location.

In addition, a mobile spray stream odour suppression system is utilised when receiving odorous waste and during light to medium wind conditions. It consists of a fan driven cannon with a dosing drum attached and mounted on a trailer. A product known as “Odour Neutraliser PLUS” is added to water in the drum and once operational a mist is produced from the cannon. The odour canon is used to minimise the impact of the odorous waste and can be placed where required depending on the wind direction and where the waste is being placed.

The landfill receives biosolids sludge and grit screenings from the Green Island WWTP and Tahuna WWTP, which can pose a significant nuisance odour issue. This is controlled by digging pits to place the waste into and then covering with clean fill material in as short a period of time as possible. Biosolids from both WWTP’s were stabilised using lime from February 2023 onwards which has the effect of neutralising the strong and offensive sewage odour. Historically the tonnage of these materials has been a high proportion of the odorous loads received at the landfill.

The landfill also receives odorous waste consisting of offal and remains from animal processing. These loads are buried and covered as soon as is practicable to manage the odour.

Additional focus has been placed on the placement of daily and intermediate cover to minimise the potential for any escape of fugitive odours.

The efficient management of the landfill gas extraction wells also helps to mitigate this issue.

Section 6.1 above identifies areas of operational improvement undertaken over the period May-June 2023.

6.2.4 Dust mitigation system

Dust is controlled on the landfill roads with the application of water from a water truck on dry windy days. Crushed waste asphalt and glass have also been used as surface dressing on some of the roads around the landfill, both as a sustainable use of waste material in roading which also acts as a dust suppressant.

For health and safety purposes, the landfill will close on days when it is judged necessary due to wind conditions. This is to protect both landfill staff and members of the public. The decision to close is based both on the wind speed and direction and the type of waste present on the surface at the working face. It is understood that there were no closures due to wind conditions during the 2022 - 2023 monitoring year.

7. Operational and capital works

The information contained in the following section was received from the DCC landfill engineer.

7.1 Waste placement

Waste was initially placed in an area centrally on the western side of the ridgeline, until a shift in October 2022 to the southern end of the main ridgeline. Sludge areas were created low down on historical waste, in similar areas and locations to waste placement. Figure 10 below shows the areas of waste placement. Leachate drains were installed in the southern area in the period October 2022 to December 2022 which will have the effect of keeping leachate levels in this area as low as possible. Waste placement in all these areas are mostly below existing consented cap level, however the waste in the southern area has reached the southern batter which will form a short section of the future southern batter of the landfill.

Figure 10 Areas of waste placement over the 2022 – 2023 monitoring year

7.2 Capping works and Borrow area Works

Contract capping works were paused for the winter period in 2022 with the majority of the capping material placed, but requiring more favourable weather to complete topsoiling and grassing. Work commenced back onsite in October 2022 and was ready for grassing by 20 December 2022.

In April 2023 re-sowing of all grassed areas was undertaken. This work completed the full capping of approximately 30,000 m^2 of was placed during 2020-2021, and some reshaping of the contours over waste placed in 2013-2014.

The haul road to the clay borrow area had grassing and seeding of permeant slopes during April 2023, and a sedimentation pond was developed in the Southwest corner to the Site to receive sediment laden waters from the borrow pit. These features are shown on Figure 2.

7.3 Gas Field and Network

No major expansion of the gas-field network was undertaken over the July 2022 to June 2023 period. However, the installation of the new western ring main down the western edge of the site and the new network under the capped northern sector has improved performance of the gas-field and increased yields. Progressive installation of temporary lines in and around the tip-face operations continued to occur, for example the connection of GW28, GW38 and GW39 back onto the main network after the tipface shifted in Oct 2022.

8. Landfill audits

Landfill inspection and environmental audits were undertaken on a quarterly basis in July and October 2022 and in January and April 2023. Copies of the audit reports are included in Appendix H.

Over the 2022 – 2023 monitoring year, the landfill continued to evolve with several significant projects being undertaken which meant that there were changes to the layout and working areas of the landfill. The main changes and updates to the landfill over the monitoring year are as follows:

- New sludge containment pits were constructed in various locations in the western portion of the landfill.
- The construction of a final cap over the northern portion of the landfill was completed and hydroseeded.
- Windblown litter and the sea bird population continue to be a problem and a number of cats were observed around the Site.
- Landfilling moved into the south / southwest portion of the Site.
- Additional landfill gas infrastructure was constructed near the tip face to capture landfill gas being generated in this area and to accommodate the expansion of the landfill.
- Due to very high rainfall in July 2022, volumes of stormwater overloaded the leachate collection trench and overflow out of the PS1 manhole was observed. The overflow (leachate / groundwater) was noted flowing across the access track and discharging into the Western Sedimentation Pond overflow pond which discharges to the Kaikorai Stream.
- Potential damage to the final cap in the eastern portion of the landfill is taking place due to mature vegetation growth.
- Monitoring well MW4D has recorded basal depths of 12.2 m over the monitoring year. Prior to this, a maximum depth of 8.3 m was recorded. Historical DCC well installation details indicate that the well was drilled to a depth of 10.5 m below ground level (bgl). It is recommended that an inspection of MW4D be undertaken and the well depth confirmed.
- Piezometer well caps have been installed on all of the groundwater wells.
- New access track and two new sedimentation ponds (a large and small) were constructed in the south western portion of the site, associated with the borrow pit.
- It was recommended that staff gauges be cleaned of algal growth and sediment adherence so that they could be read accurately.
- A new culvert in the eastern portion of the site, servicing the haul road, was installed adjacent to the green waste disposal area.

9. Consent compliance

Quarterly monitoring in accordance with the conditions of the Green Island landfill water and discharge permit resource consents was undertaken by GHD in July and October 2022 and January and April 2023. In addition to the works undertaken by GHD, certain tasks such as the monthly groundwater levels measurements and the leachate pumps and landfill gas collection system is monitored by DCC and Waste Management.

Details are provided in the following table regarding compliance with the various consent conditions.

Table 10 Consent Compliance

ORC Consent No 3839A_V1 To discharge landfill and composting leachate to land in a manner it may enter water	**Compliant / Not Compliant**
Condition 1 The waters and bed sediments of the Kaikorai Stream and estuary shall be substantially free of contaminants due to landfill activities	Compliant
Condition 2 The groundwaters outside of the landfill and leachate collection system shall be substantially free of contaminants due to landfill activities	Compliant
Condition 3 The leachate collector drain shall be installed and pumped to maintain a depression in the phreatic groundwater level surface at all times	Generally Compliant
Condition 4 Ensure effective long term containment, collection and monitoring of contaminated leachate to protect all waters	Compliant
Condition 5 The geology of the area around the trench is to be assessed during installation	Compliant
Condition 6 The consent shall be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant
Condition 7 (A) Monitoring of groundwater levels	Compliant – with the exception of monitoring MW9D which was lost
Condition 7 (B) Monitoring of pump operation	Compliant
Condition 8 Monitoring pumped leachate, groundwater volume	Compliant
Condition 9 Monitoring leachate chemistry	Compliant
Condition 10 Monitoring Kaikorai Estuary	Generally Compliant – with the exception of: - Undertaking of monitoring within 72 hours of rainfall events, - The measurement of water levels in the stream (gauges obscured by algae and sediment), - The measurement of flow not being undertaken.
Condition 11 Provision of an annual report to the consent authority by 1 October each year which includes information as set out in the consent condition	Not Compliant – An annual report was not provided by 1 Oct. However, this report was provided on 11th October 2023.

ORC Consent No 3839A_V1 To discharge landfill and composting leachate to land in a manner it may enter water	**Compliant / Not Compliant**
Condition 12 Section 128 Review by the consent authority	Not applicable
Condition 13 This consent is to be reviewed at five yearly intervals	Not applicable
Condition 14 Bond Provision	Not applicable
Condition 15 All laboratory analysis is to be performed by an accredited laboratory	Compliant
Condition 16 Closure work programme	Compliant
Condition 17 An archaeological survey shall be undertaken	Not compliant

ORC Consent No 3839B_V1 To take groundwater and leachate from groundwater bores and from a leachate collection drain located at and around the Green Island Sanitary Landfill	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with discharge permit 3839A_V1	Compliant
Condition 2 The leachate collector drain shall be installed and pumped to maintain a depression in the phreatic groundwater level surface at all times	Generally Compliant
Condition 3 The consent shall be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant
Condition 4 Monitoring groundwater levels and Pump operation	Compliant with the exception of the landfill monitoring well MW9D
Condition 5 Monitoring pumped leachate / groundwater volume	Compliant
Condition 6 Reporting shall be in accordance with condition 11 of consent 3839A_V1	Compliant
Condition 7 Section 128 review by the consent authority	Not applicable
Condition 8 This consent is to be reviewed at five yearly intervals	Not applicable

ORC Consent No 3839C_V1 To divert stormwater at a landfill and composting facility within a 38 hectare area bounded by a leachate collection drain	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with discharge permit 3839A_V1	Compliant
Condition 2 The consent shall be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant

ORC Consent No 3839C_V1 To divert stormwater at a landfill and composting facility within a 38 hectare area bounded by a leachate collection drain	**Compliant / Not Compliant**
Condition 3 Section 128 review by the consent authority	Not applicable
Condition 4 This consent is to be reviewed at five yearly intervals	Not applicable

ORC Consent No 3840A_V1 To divert stormwater from the non-working areas of a landfill	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with discharge permit 3840C_V1	Compliant
Condition 2 The consent shall be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant
Condition 3 Appropriate silt retention pond(s) shall be in place prior to the exercise of this consent	Compliant
Condition 4 All silt retention ponds shall be designed for the runoff as described in the condition	Compliant
Condition 5 All practicable steps are to be taken to prevent contamination of stormwater by suspended solids or exposed landfill material or runoff via appropriate landfill management practices	Compliant
Condition 6 Works associated with the exercise of this consent shall be in accordance with best engineering standards	Compliant
Condition 7 Section 128 review by consent authority	Not applicable
Condition 8 This consent is to be reviewed at five yearly intervals	Not applicable
Condition 9 Bond Provision	Not applicable
Condition 10 A closure works programme shall be prepared	Compliant
Condition 11 An archaeological survey shall be undertaken	Not compliant

ORC Consent No 3840B_V1 To take diverted stormwater from the non-working areas of a landfill	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with discharge permit 3840C_V1	Compliant
Condition 2 Appropriate silt retention pond(s) shall be in place prior to the exercise of this consent	Compliant
Condition 3 All silt retention ponds shall be designed for the runoff as described in the condition	Compliant
Condition 4 Section 128 review by consent authority	Not applicable

ORC Consent No 3840B_V1 To take diverted stormwater from the non-working areas of a landfill	Compliant / Not Compliant
Condition 5 This consent is to be reviewed at five yearly intervals	Not applicable

ORC Consent No 3840C_V1 To discharge stormwater to the Kaikorai Stream	Compliant / Not Compliant
Condition 1 This consent is to be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant
Condition 2 Appropriate silt retention pond(s) shall be in place prior to the exercise of this consent	Compliant
Condition 3 All silt retention ponds shall be designed for the runoff as described in the condition	Compliant
Condition 4 All practicable steps are to be taken to prevent contamination of stormwater by suspended solids or exposed landfill material or runoff via appropriate landfill management practices	Compliant
Condition 5 Works associated with the exercise of this consent shall be in accordance with best engineering standards	Compliant
Condition 6 Monitoring of silt pond discharge	Compliant
Condition 7 All analysis is to be undertaken by a laboratory accredited to undertake the specified analysis	Compliant
Condition 8 The consent authority can undertake a review of this consent under Section 128 of the RMA	Not applicable
Condition 9 Reporting – a landfill monitoring report shall be provided to the consent authority by 1 October each year	Compliant
Condition 10 This consent is to be reviewed at five yearly intervals	Not applicable
Condition 11 Bond provision	Not applicable
Condition 12 A closure works programme is to be prepared by the consent holder	Compliant
Condition 13 An archaeological survey is to be undertaken	Not compliant

ORC Consent No 4139_V1 To take groundwater through a landfill leachate collection drain	Compliant / Not Compliant
Condition 1 The rate of taking shall be nominally 23,400 litres per hour and shall not exceed 72,000 litres per hour	Compliant

ORC Consent No 4139_V1 To take groundwater through a landfill leachate collection drain	**Compliant / Not Compliant**
Condition 2 This consent shall be exercised in conformity with a landfill work programme prepared by the consent holder	Compliant
Condition 3 Monitoring pumped leachate /groundwater volume	Compliant
Condition 4 This consent is to be reviewed at five yearly intervals	Not applicable
Condition 5 The consent authority can undertake a review of this consent under Section 128 of the RMA	Not applicable
Condition 6 A closure works programme is to be prepared by the consent holder	Compliant
Condition 7 The objectives to be met at all stages of this management is to ensure the effective long term containment collection and monitoring of leachate and to protect the Kaikorai Stream	Compliant
Condition 8 An archaeological survey is to be undertaken	Not compliant

ORC Consent No 94524_V1 To discharge to air landfill gas, dust and odour generated from landfilling up to 100,000 cubic meters a year of compacted municipal domestic hazardous and industrial waste and including a composting operation.	**Compliant / Not Compliant**
Condition 1 The consent authority may serve notice to review this consent	Not applicable
Condition 2 This consent shall be exercised in conjunction with consent numbers 3839A_V1, 3839B_V1, 3839C_V1, 3839D_V1, 3840A_V1, 3840B_V1, 3840C_V1, 4139_V1, 4140, 4185, 94262_V1 and 94693_V1	Compliant
Condition 3 This consent shall be exercised in conformity with the landfill work programme prepared by the consent holder	Compliant
Condition 4 Best practicable options to avoid and/or mitigate any adverse effect on the environment resulting from the discharge of contaminants to air to be adopted	Compliant
Condition 5 All practicable steps to be taken to collect the landfill gas generated from the refuse less than 12 years old.	Compliant
Condition 6 No odour caused by discharges from the landfill that are deemed objectionable or offensive	Not compliant
Condition 7 Dust emissions shall be kept to a practicable minimum	Compliant
Condition 8 The intentional burning of rubbish is not allowed	Compliant
Condition 9 Any hazardous waste accepted shall be managed appropriately	Compliant

ORC Consent No 94524_V1 To discharge to air landfill gas, dust and odour generated from landfilling up to 100,000 cubic meters a year of compacted municipal domestic hazardous and industrial waste and including a composting operation.	**Compliant / Not Compliant**
Condition 10 A log of all complaints is to be kept	Compliant
Condition 11 Monitoring for methane and carbon dioxide and oxygen shall be undertaken monthly at gas tube 1 adjacent to Clariton Avenue	Partially Compliant – Results for the July 2022 monitoring event were lost.
Condition 12 All laboratory analysis is to be undertaken by a laboratory accredited to do so	Compliant
Condition 13 Monthly inspections of the landfill are to be undertaken for evidence of landfill gas such as odour, gas bubbling in puddles or fissures in the landfill cover	Compliant
Condition 14 Any excavations on the landfill are to be undertaken in a manner to minimise the generation of odour.	Compliant
Condition 15 Only vegetation shall be included in the waste to be composted	Compliant
Condition 16 The composting operation is to be managed in such a way as to minimise the production of odour	Complaint

ORC Consent No. 94693_V1 To discharge up to 270 cubic metres per day of municipal domestic, hazardous and industrial waste, including a composting operation, to land in circumstances which may result in contaminants entering natural water	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with consent numbers 3839A_V1, 3839B_V1, 3839C_V1, 3839D_V1, 3840A_V1, 3840B_V1, 3840C_V1, 4139_V1, 4140, 4185, 94262_V1 and 94693_V1	Compliant
Condition 2 The consent holder shall take appropriate measures to prevent landfill material from moving off-site	Compliant
Condition 3 The consent holder shall ensure that the placement of material pursuant to this consent shall not impair the flow of any natural watercourse on the site	Compliant
Condition 4 This consent shall be exercised in conformity with the landfill work programme prepared by the consent holder	Compliant
Condition 5 Any hazardous waste accepted for safe disposal must be managed in accordance with the landfill management plan	Compliant
Condition 6 The disposal location and date of the deposit of hazardous waste accepted must be recorded and be made available for inspection by the consent authority	Compliant
Condition 7 The consent authority can undertake a review of this consent under Section 128 of the RMA	Not applicable

ORC Consent No. 94262_V1 To discharge up to 270 cubic metres per day of municipal, domestic, hazardous, industrial waste and organic waste to land	**Compliant / Not Compliant**
Condition 1 This consent shall be exercised in conjunction with consent numbers 3839A_V1, 3839B_V1, 3839C_V1, 3839D_V1, 3840A_V1, 3840B_V1, 3840C_V1, 4139_V1, 4140, 4185, and 94693_V1	Compliant
Condition 2 The consent holder shall take appropriate measures to prevent landfilled material from moving off site	Compliant
Condition 3 The consent holder shall ensure that the placement of material pursuant to this consent shall not impair the flow of any natural watercourse on the site	Compliant
Condition 4 This consent shall be exercised in conformity with the landfill work programme prepared by the consent holder	Compliant
Condition 5 Any hazardous waste accepted for safe disposal must be managed in accordance with the landfill management plan	Compliant
Condition 6 The disposal location and date of the deposit of hazardous waste accepted must be recorded and be made available for inspection by the consent authority	Compliant
Condition 7 The consent holder shall not dispose of any material in the landfill by burning it. Should a fire arise at the landfill it shall be extinguished immediately upon being detected.	Compliant
Condition 8 The consent authority can undertake a review of this consent under Section 128 of the RMA	Not applicable

In order to address the non-compliance related to the loss of the groundwater monitoring well located at the centre of the landfill (MW9D), DCC commissioned the replacement of this well in early 2019. However, based on advice provided by a GHD landfill technical expert, it was decided not to proceed with the installation of a replacement well. This was due to the risk of creating explosive atmospheres and encountering hazardous waste during drilling and installation of the well. In addition, it was considered likely that should the well be installed, there was a high risk of it being damaged / sheared off due to waste movement due to compaction and decomposition over time. This would provide a direct pathway for leachate from the waste to the underlying aquifer.

Historically, the staff gauges in the Kaikorai Stream were unreadable due to sediment and algae adherence and a recommendation that they be cleaned or replaced has been given. While these gauges are cleaned periodically, it was not possible to take measurements from these gauges on all monitoring occasions.

The findings of the landfill audits indicated that several major projects had been undertaken over the monitoring year, including the construction of a final cap over the northern portion of the landfill and the installation of new landfill gas collection and transfer infrastructure.

Appendices

Appendix A

Groundwater Levels Monitoring

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: MONDAY 01 AUGUST 2022 Name of Monitor: CONOR M.

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					.250		
1	3.630	1.310	.915	3.357	1.000		
2	3.047	2.290	1.852	3.000	1.110	.985	.100
3	2.890	1.213	1.255	3.000	2.105		.100
4	3.275	2.510	1.770		2.425	1.900	.100
5	3.475	2.415	2.515	3.310	2.000		0.000
6	3.610	.220	.785	3.160	1.060		
7	3.880	1.175	1.390	3.520		1.255	
8	4.000	1.715	1.940	3.027	1.630		
8A				4.215			
9	5.640					N/A	

Comments: Please comment on anything unusual

* SOME RECORDINGS MAY BE HIGHER DUE TO EXCESSIVE RAINFALL.

Notes: For MWD ignore the top of Column

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Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: MONDAY 12 SEPT 2022 Name of Monitor: CONOR M.

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					.395		
1	3.500	1.375	1.120	3.405	1.092		
2	3.133	2.555	2.110	2.077	1.200	.360	.680
3	4.067	1.190	1.220	3.445	2.462		.600
4	3.210	2.740	1.873		2.155	2.053	.600
5	3.265	2.840	2.720	3.315	1.695		.560
6	3.732	.700	1.115	3.160	1.200		
7	3.700	1.115	1.695	3.520		1.430	
8	4.095	2.012	2.150	3.030	2.095		
8A				4.200			
9	5.670					N/A	

Comments: Please comment on anything unusual

PS 3) LEVEL PROBE DIRTY. PUMP WAS RUNNING.
CLEANED PROBE. OK NOW.

LINE #2 (MWD) > ,360

Notes: For MWD ignore the top of Column

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Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

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Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: MONDAY 03 OCTOBER 2022 Name of Monitor: CONOR M.

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					.425		
1	3.580	1.380	1.130	3.380	1.153		
2	3.043	2.568	2.075	3.020	1.180	.290	.340
3	2.857	1.195	1.250	2.930	2.410		.360
4	3.170	2.780	1.890		2.287	1.970	.400
5	3.195	2.865	2.800	3.270	1.890		.320
6	3.625	.750	1.155	3.160	1.225		
7	3.650	1.130	1.760	3.495		1.495	
8	4.065	2.085	2.170	3.030	2.155		
8A				4.237			
9	5.620					N/A	

Comments: Please comment on anything unusual

PS3> FOAMY.

PS5> FOAMY.

Notes: For MWD ignore the top of Column

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Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: TUESDAY 01 NOVEMBER 2022 Name of Monitor: CONOR M.

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					.360		
1	3.395	1.360	1.160	3.370	1.100		
2	3.135	2.635	2.182	3.074	1.080	1.260	~~[illegible]~~ >.680
3	2.840	1.217	1.305	2.905	2.390		.660
4	3.205	2.780	1.875		2.120	1.975	.660
5	3.230	2.855	2.810	3.317	1.680		.660
6	3.110	.800	1.180	3.055	1.125		
7	3.673	1.170	1.780	3.515		1.443	
8	4.240	2.070	2.130	3.030	2.130		
8A				4.130			
9	5.600					N/A	

Comments: Please comment on anything unusual

PS3> FOAMY

Notes: For MWD ignore the top of Column

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Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 8 December 2022 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					-860		
1	3.535	1.380	1.280	3.345	1.210		
2	3.100	2.710	2.255	3.045	1.490	0.735	.200
3	2.613	1.210	1.334	2.675	2.868		.180
4	3.275	2.744	1.795		2.353	2.350	.200
5	3.165	2.912	2.830	3.235	2.200		.180
6	3.114	1.060	1.638	3.069	1.733		
7	3.640	1.200	1.825	3.505		1.605	
8	4.028	2.170	2.680	3.030	2.280		
8A				4.305			
9	5.620					N/A	

Comments: Please comment on anything unusual

PS3 Foamy

Notes: For MWD ignore the top of Column

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Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 26/January/23 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					1.508		
1	3.343	1.435	1.443	3.327	1.340		
2	3.095	2.760	2.281	2.033	1.635	1.450	.340
3	2.845	1.209	1.840	2.905	3.120		.380
4	3.175	2.718	1.775		2.257	2.370	.380
5	3.176	2.892	2.864	3.240	2.072		.340
6	3.520	1.355	1.702	3.156	2.280		
7	3.640	1.235	1.863	3.499		1.648	
8	4.021	2.568	3.200	3.032	2.379		
8A				4.300			
9	5.609					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

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Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 10/02/2023 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					1.682		
1	3.665	1.458	1.560	3.297	1.360		
2	3.057	2.826	2.340	3.006	1.704	1.200	.360
3	2.575	1.210	1.385	2.622	3.159		.380
4	3.205	2.762	1.784		2.213	2.383	.400
5	3.196	2.935	2.907	3.259	2.034		.380
6	3.564	1.440	1.795	3.153	2.355		
7	3.625	1.238	1.907	3.503		1.692	
8	4.050	2.793	3.254	3.026	2.429		
8A				4.350			
9	5.627					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 03/03/2023 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					1.554		
1	3.341	1.415	1.437	3.127	1.298		
2	3.054	2.813	2.330	2.998	1.320	0.935	.140
3	2.656	1.213	1.335	2.720	2.901		.100
4	3.308	2.715	1.767		2.425	2.428	.80
5	3.199	2.860	2.853	3.270	2.244		.100
6	3.363	1.308	1.660	3.151	1.569		
7	3.608	1.252	1.847	3.487		1.654	
8	4.172	3.042	3.313	3.029	2.379		
8A				4.282			
9	5.673					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 05 April 2023 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					0.964		
1	3.425	1.316	1.261	3.357	1.210		
2	3.106	2.745	2.262	3.057	1.238	0.629	.280
3	3.100	1.207	1.317	3.081	2.439		.260
4	3.329	2.675	1.757		2.314	2.393	.300
5	3.221	2.752	2.746	3.288	1.967		.260
6	3.610	0.865	1.234	3.126	1.303		
7	3.707	1.251	1.756	3.520		1.501	
8	3.998	2.254	2.991	3.030	2.159		
8A				4.278			
9	5.590					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 02 May 2023 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					0.533		
1	3.328	1.299	1.223	3.365	1.206		
2	3.119	2.753	2.225	3.063	1.248	1.214	.380
3	2.598	1.221	1.320	2.677	2.404		.400
4	3.397	2.684	1.763		2.239	2.391	.420
5	3.497	2.676	2.741	3.267	1.884		.380
6	3.799	0.987	1.250	3.002	1.323		
7	3.703	1.248	1.765	3.515		1.503	
8	4.047	2.344	3.182	3.027	2.178		
8A				4.285			
9	6.490					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

Waste Management

Green Island Landfill - Leachate System - Water Level Recording Sheet

Pump Station / Manhole / Monitoring Well

Sheet to be emailed to the Landfill Engineer @DCC once completed.
Note: DCC Office - Sheet to be retained until O.R.C report complete.

Date Recorded: 13 June 2023 Name of Monitor: Logan McLean

To Be Measured in Metres (m) to decimal places eg 1.23m

Line No	PS	MWA	MWB	Man Hole	MWC	MWD	ST
0					0.285		
1	3.357	1.263	1.164	3.357	1.194		
2	3.122	2.687	2.174	3.061	1.257	0.708	.060
3	2.497	1.220	1.325	2.583	2.342		.040
4	3.410	2.711	1.764		2.487	2.455	.100
5	3.218	2.588	2.685	3.280	2.178		.080
6	3.676	1.028	1.275	3.118	1.274		
7	3.630	1.216	1.725	3.457		1.486	
8	4.078	1.959	2.144	3.031	2.048		
8A				4.260			
9	5.725					N/A	

Comments: Please comment on anything unusual

Notes: For MWD ignore the top of Column

Green Island Landfill
Groundwater Parameter Results - July 2022

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	8/07/2022	10:26	0.0	1.488	ND	11.2	13.7	1.43	2583	6.76	229.6	No Well Cap (NWC)
PS1	8/07/2022	10:31	0.1	3.600	ND	6.9	87.2	10.29	5515	7.87	178.5	Slight leachate odour
MW1 A	8/07/2022	10:36	0.0	1.435	ND	10.4	14.5	1.39	30034	5.78	225.6	NWC
MW1 B	8/07/2022	10:40	0.0	1.322	ND	10.1	79.3	7.69	21841	6.54	28.1	NWC
MH 1	8/07/2022	10:43	0.0	3.391	ND	11.8	11.4	1.10	25582	6.68	-59.4	NWC
MW1 C	8/07/2022	10:47	0.0	1.211	ND	8.6	45.1	4.53	27865	6.44	-66.6	NWC
PS2	8/07/2022	10:54	0.0	3.265	ND	11.6	11.3	1.17	11833	6.88	-52.4	-
MW2 A	8/07/2022	10:58	0.0	2.806	ND	14.0	20.3	1.67	28029	7.58	-123.6	NWC
MW2 B	8/07/2022	11:00	0.0	2.323	ND	13.3	20.6	1.70	27763	7.41	-146.8	NWC
MH2	8/07/2022	11:03	0.0	3.130	ND	12.5	54.2	5.14	27530	6.50	-115.4	-
MW2 C	8/07/2022	11:07	0.0	1.216	ND	11.0	21.4	1.70	29931	6.74	-85.5	NWC, iron staining within well
MW2 D	8/07/2022	11:10	0.0	0.500	ND	9.5	11.2	1.06	30186	7.01	-131.0	NWC, metallic scum on water
PS3	8/07/2022	11:17	1.3	3.020	ND	13.5	54.3	5.40	9002	7.26	-29.8	-
MW3 A	8/07/2022	11:22	0.0	1.292	ND	12.0	37.9	3.79	14024	7.84	-11.6	NWC
MW3 B	8/07/2022	11:25	0.0	1.380	ND	11.2	19.1	1.95	11669	7.79	-6.2	NWC
MH3	8/07/2022	11:29	0.0	3.142	ND	12.6	13.8	1.34	22144	6.88	-99.3	-
MW3 C	8/07/2022	11:31	0.0	2.242	ND	10.8	86.1	9.31	1754	7.65	-69.2	NWC
PS4	8/07/2022	11:36	0.0	3.210	ND	12.5	19.0	1.91	11829	6.94	-98.5	-
MW4 A	8/07/2022	11:41	0.0	2.789	ND	15.5	13.1	1.27	3121	7.05	-10.4	NWC
MW4 B	8/07/2022	11:43	0.0	1.886	ND	13.3	10.8	1.08	3218	7.52	-14.6	NWC
MW4 C	8/07/2022	11:46	0.0	2.205	ND	12.3	13.0	1.24	20560	6.94	16.6	NWC
MW4 D	8/07/2022	11:51	0.0	1.880	ND	9.4	12.8	1.29	25610	6.63	-65.0	NWC
PS5	8/07/2022	11:57	0.2	3.196	ND	9.2	40.7	4.60	2259	7.04	-31.3	-
MW5 A	8/07/2022	12:02	0.0	2.983	ND	13.6	13.9	1.33	6537	7.01	-89.8	NWC, leaf litter around well head.
MW5 B	8/07/2022	12:05	0.0	2.854	ND	12.6	18.6	1.75	4406	7.60	-67.0	NWC, well sign damaged
MH5	8/07/2022	12:08	0.0	3.206	ND	11.4	10.7	1.11	10180	6.90	-138.8	-
MW5 C	8/07/2022	12:11	0.0	1.772	ND	10.3	23.6	2.36	7053	7.51	-82.2	NWC
PS6	8/07/2022	12:16	0.0	3.874	ND	12.1	185.8	18.73	6070	6.97	-52.1	-
MW6 A	8/07/2022	12:23	0.0	0.748	ND	11.4	60.5	5.81	4888	6.93	-79.6	NWC, scum on water
MW6 B	8/07/2022	12:26	0.0	1.164	ND	9.5	102.8	11.38	1902	7.56	-66.9	NWC
MH6	8/07/2022	12:29	0.0	3.125	ND	10.6	25.3	2.65	5715	6.38	-44.1	-
MW6 C	8/07/2022	12:32	0.0	1.173	ND	10.8	38.6	4.09	6232	6.67	-43.0	NWC
PS7	8/07/2022	12:40	0.0	3.913	ND	11.0	42.9	4.59	3543	6.90	-43.3	-
MW7 A	8/07/2022	12:47	0.0	1.254	ND	12.9	12.3	1.26	1719	7.57	-21.3	NWC
MW7 B	8/07/2022	12:50	0.0	1.848	ND	13.1	55.8	5.68	1678	7.27	-21.4	NWC
MH7	8/07/2022	12:54	0.0	3.528	ND	12.9	10.8	1.04	11532	6.62	91.0	-
MW7 D	8/07/2022	12:56	0.0	1.562	ND	12.3	80.7	8.01	14731	7.21	101.5	NWC, unstable concrete base
PS8	8/07/2022	13:02	0.0	4.056	ND	11.7	18.4	1.92	2600	6.55	83.4	-
MW8 A	8/07/2022	13:14	0.0	3.482	ND	12.2	16.2	1.66	1365	7.43	99.9	Pot being used as a well cap
MW8 B	8/07/2022	13:17	0.0	3.191	ND	13.1	88.3	9.11	1167	7.00	123.3	Well cover does not sit flush with piezo. Opens/closes with wind gusts.
MH8	8/07/2022	13:21	0.0	3.912	ND	10.9	58.5	6.32	891	7.03	69.6	-
MW8 C	8/07/2022	13:23	0.0	2.296	ND	11.7	64.8	6.75	1039	7.02	65.6	NWC
PS9	8/07/2022	13:32	0.0	5.892	ND	11.3	30.3	3.20	6569	6.23	-16.7	-

Notes:
m btoc - metres below top of casing
ND - Not determined
 - No information

Green Island Landfill Groundwater Parameter Results - October 2022

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	7/10/2022	8:45	0.0	0.468	3.835	9.7	29.8	3.42	2,660	6.60	72.3	Slight scum on water, no well cap.
PS1	7/10/2022	9:11	0.1	3.410	ND	5.8	83.9	10.42	4,366	7.66	76.2	Static water level unstable due to foam, pump operational during testing.
MW1A	7/10/2022	9:17	0.0	1.372	6.241	9.7	21.5	2.15	29,074	5.59	115.4	No well cap.
MW1B	7/10/2022	9:21	0.0	1.180	5.181	9.3	11.2	1.12	32,216	6.47	68.0	Slight scum on water, no well cap.
MH1	7/10/2022	9:24	0.0	3.396	4.526	10.1	5.7	0.58	24,230	6.55	-43.3	
MW1C	7/10/2022	9:28	0.0	1.133	5.705	8.7	9.4	0.98	27,215	6.34	-42.6	No well cap.
PS2	7/10/2022	9:33	0.0	3.153	ND	9.6	12.2	1.24	7,055	6.82	-35.0	
MW2A	7/10/2022	9:37	0.0	2.694	6.221	11.7	6.6	0.61	27,656	7.39	-180.5	No well cap
MW2B	7/10/2022	9:45	0.0	2.156	5.209	11.6	80.7	8.09	27,377	7.43	-120.5	No well cap.
MH2	7/10/2022	9:49	0.0	3.905	4.789	10.9	8.3	0.85	21,666	6.53	-76.6	Sediment in base of manhole, no well cap.
MW2C	7/10/2022	10:02	0.0	1.701	5.109	10.4	74.4	7.50	28,947	6.83	-94.0	No well cap.
MW2D	7/10/2022	10:07	0.0	0.550	11.666	9.4	11.1	1.07	29,441	6.98	-115.6	Water has metallic sheen on surface, no well cap.
PS3	7/10/2022	10:16	4.5	2.530	ND	12.8	68.1	7.06	10,935	7.41	66.1	Very foamy water.
MW3A	7/10/2022	10:19	0.0	1.201	3.799	11.1	68.4	7.30	13,982	7.51	-115.9	Sediment in base of well.
MW3B	7/10/2022	10:22	0.0	1.357	5.089	10.7	22.6	1.91	12,064	7.41	-106.4	No well cap.
MH3	7/10/2022	10:24	0.0	2.658	4.456	11.2	18.2	1.92	20,706	6.93	-157.2	
MW3C	7/10/2022	10:26	0.0	2.280	4.090	9.7	57.5	6.50	1,541	7.39	-112.0	No well cap.
PS4	7/10/2022	10:31	0.0	3.204	ND	11.2	11.6	1.35	9,726	6.87	95.8	
MW4A	7/10/2022	10:35	0.0	2.286	5.570	13.9	6.1	0.56	3,261	7.94	-87.8	No well cap.
MW4B	7/10/2022	10:38	0.0	1.913	4.104	12.1	9.5	0.85	3,823	7.20	-47.3	No well cap.
MW4C	7/10/2022	10:41	0.0	2.138	4.860	10.5	17.4	1.33	19,988	6.84	-51.9	No well cap.
MW4D	7/10/2022	10:43	0.0	1.928	12.212	9.5	7.8	0.81	24,632	6.55	-73.7	No well cap.
PS5	7/10/2022	10:48	1.7	3.166	ND	9.7	26.8	3.03	4,924	7.08	-71.6	
MW5A	7/10/2022	10:51	0.0	2.896	4.340	12.2	27.9	2.93	1,951	7.40	-61.4	Sediment in base of well.
MW5B	7/10/2022	10:54	0.1	2.867	4.976	11.2	8.0	0.79	4,846	7.73	-22.3	No well cap.
MH5	7/10/2022	10:57	0.0	3.297	4.431	10.2	10.0	1.12	4,898	6.86	-1.8	Sediment in base of well.
MW5C	7/10/2022	11:01	0.0	1.695	4.822	9.5	9.6	0.98	7,699	7.11	-88.4	No well cap.
PS6	7/10/2022	11:05	0.1	3.620	ND	11.2	46.9	5.13	5,199	6.95	-60.2	
MW6A	7/10/2022	11:09	0.0	0.818	3.789	10.9	8.2	0.92	4,794	6.92	-89.2	No well cap.
MW6B	7/10/2022	11:12	0.0	1.211	3.850	10.1	40.3	4.52	2,017	7.07	-61.9	No well cap.
MH6	7/10/2022	11:13	0.1	3.158	4.256	10.6	13.6	1.47	5,001	6.87	-33.0	
MW6C	7/10/2022	11:15	0.0	1.031	5.043	9.0	57.8	6.69	1,234	7.22	-50.4	No well cap.
PS7	7/10/2022	11:25	1.5	3.675	ND	10.4	53.2	5.93	1,834	6.81	-54.8	
MW7A	7/10/2022	11:28	0.0	1.134	3.316	11.3	55.2	6.12	1,777	7.85	-87.9	Sediment in base of well, no well cap.
MW7B	7/10/2022	11:32	0.0	1.784	5.179	11.9	59.0	6.41	1,850	7.47	-55.5	No well cap.
MH7	7/10/2022	11:35	0.0	3.519	4.557	11.6	8.5	0.95	7,371	6.75	-6.0	
MW7D	7/10/2022	11:38	0.0	1.463	5.226	10.9	35.3	3.73	16,181	6.83	3.3	No well cap, unstable concrete base.
PS8	7/10/2022	12:01	0.0	4.010	ND	11.1	10.9	1.14	4,481	6.79	13.1	
MW8A	7/10/2022	12:08	0.1	2.008	4.324	10.6	103.7	9.42	1,473	6.99	-22.6	Sediment in base, no well cap.
MW8B	7/10/2022	12:12	0.0	2.164	5.117	11.5	76.0	8.35	1,301	7.44	-22.0	Sediment in base, no well cap, lid does not site flush with well.
MH8	7/10/2022	12:14	0.0	3.030	4.028	10.6	27.4	2.98	954	6.59	3.1	
MW8C	7/10/2022	12:16	0.0	2.163	3.933	10.3	69.7	7.85	928	7.16	5.8	Sediment in base, no well cap.
PS9	7/10/2022	12:36	0.0	5.741	ND	11.2	110.4	10.63	5,188	5.77	76.5	

Notes:
ND - Not Determined

Green Island Landfill
Groundwater Parameter Results - January 2023

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	16/01/2023	9:25	0.0	1.367	3.852	12.5	17.4	1.82	2,710	6.36	21.0	Clear, trace particulates, odourless.
PS1	16/01/2023	9:30	0.2	3.490	-	14.3	70.7	7.16	5,739	7.76	114.7	-
MW1A	16/01/2023	9:52	0.9	1.419	-	12.3	9.7	0.93	30,579	5.66	76.7	-
MW1B	16/01/2023	9:39	0.0	1.369	-	15.9	19.8	1.74	32,865	6.51	26.3	-
MH1	16/01/2023	9:45	0.0	3.336	-	12.6	9.9	0.95	25,569	6.56	-65.3	-
MW1C	16/01/2023	9:36	8.1	0.313	5.716	19.1	46.8	3.93	28,317	6.99	87.8	Slightly cloudy, trace particulates, odourless.
PS2	16/01/2023	10:00	0.3	3.096	-	12.7	19.7	1.96	15,228	6.78	106.2	-
MW2A	16/01/2023	10:07	0.0	2.763	-	14.7	12.5	1.14	28,541	7.24	-134.9	-
MW2B	16/01/2023	10:10	0.1	2.272	-	14.4	8.5	0.79	28,042	7.41	-160.8	-
MH2	16/01/2023	10:17	0.0	3.126	-	13.7	11.0	1.02	29,046	6.52	-124.6	-
MW2C	16/01/2023	10:24	0.3	1.588	5.104	14.0	7.3	0.67	30,058	6.70	-100.4	Brown, minor odour, trace particulates.
MW2D	16/01/2023	10:30	8.0	0.531	10.664	19.5	12.0	0.97	30,681	6.71	-95.7	Trace particulates, cloudy, odourless.
PS3	16/01/2023	10:34	0.1	2.599	-	16.9	12.8	1.17	16,687	7.40	-54.4	Brown, strong odour, minor particulates.
MW3A	16/01/2023	10:37	2.5	1.206	-	18.2	28.4	2.54	14,304	7.45	-134.4	-
MW3B	16/01/2023	10:43	0.0	1.364	-	15.5	12.6	1.15	12,301	7.31	-138.8	-
MH3	16/01/2023	10:45	0.0	2.366	-	13.8	12.1	1.16	16,267	7.38	-121.2	-
MW3C	16/01/2023	10:47	0.0	3.054	4.086	12.8	19.9	2.12	1,459	6.90	-48.4	Transparent, no particulates, odourless.
PS4	16/01/2023	10:50	0.0	3.164	-	13.4	11.9	1.18	14,079	6.96	-98.6	-
MW4A	16/01/2023	10:55	0.0	2.726	-	14.9	15.2	1.52	3,351	7.54	-44.6	-
MW4B	16/01/2023	10:59	0.0	1.786	-	14.3	9.3	0.93	3,922	7.05	-84.7	-
MW4C	16/01/2023	11:02	0.0	2.492	4.895	12.7	8.6	0.84	210,995	6.78	-56.3	Slightly cloudy, trace particulates, odourless.
MW4D	16/01/2023	11:04	0.0	2.424	12.206	17.1	18.7	1.64	25,910	6.46	-11.5	Trace particulates, cloudy, odourless.
PS5	16/01/2023	11:09	0.9	3.199	-	14.7	13.2	1.29	10,840	7.00	-103.4	-
MW5A	16/01/2023	11:15	0.0	2.909	-	13.4	18.0	1.85	2,103	7.50	-27.0	-
MW5B	16/01/2023	11:19	0.0	2.870	-	14.1	22.9	2.35	4,962	7.36	-2.3	-
MH5	16/01/2023	11:21	0.0	3.264	-	13.5	10.4	1.05	7,024	6.76	-25.0	-
MW5C	16/01/2023	11:23	0.0	2.351	4.79	14.0	9.3	0.98	7,991	7.12	-140.4	Slightly cloudy, no particulates, odourless.
PS6	16/01/2023	11:26	0.0	3.419	-	13.8	11.8	1.20	6,292	6.81	-87.3	-
MW6A	16/01/2023	11:31	0.0	1.188	-	14.1	12.4	1.23	4,813	6.87	99.9	-
MW6B	16/01/2023	11:34	0.0	1.539	-	15.5	8.0	0.80	2,080	6.88	-40.0	-
MH6	16/01/2023	11:37	0.0	3.151	-	12.6	7.0	0.74	5,953	6.81	-9.2	Slightly cloudy, trace particulates, odourless.
MW6C	16/01/2023	11:40	0.0	2.152	5.031	11.6	17.3	1.89	1,308	6.60	-54.3	-
PS7	16/01/2023	11:46	0.8	3.651	-	13.5	26.5	2.84	4,379	6.89	-65.4	-
MW7A	16/01/2023	11:52	0.0	1.121	-	13.2	12.3	1.29	1,830	7.49	-143.8	-
MW7B	16/01/2023	11:55	0.0	1.765	-	12.7	31.7	3.37	1,943	7.05	-64.7	-
MH7	16/01/2023	11:57	0.0	3.501	-	12.9	11.6	1.18	9,390	6.65	-12.2	-
MW7D	16/01/2023	12:00	0.0	1.663	5.216	14.0	11.3	1.09	17,063	6.55	-10.8	Slightly cloudy, trace particulates, slight odour.
PS8	16/01/2023	12:02	0.1	4.004	-	12.2	17.8	1.89	5,586	6.84	-0.6	-
MW8A	16/01/2023	12:10	0.7	2.325	-	13.5	15.9	1.66	1,552	7.05	109.1	-
MW8B	16/01/2023	12:14	0.0	3.144	-	12.9	14.8	1.57	1,320	7.12	-63.2	-
MH8	16/01/2023	12:26	0.7	3.026	-	12.6	8.7	0.93	1,166	7.76	-14.7	-
MW8C	16/01/2023	12:20	3.3	2.362	3.994	12.3	12.8	1.38	948	6.57	-17.6	Minor particulates, brown and cloudy, slight odour.
PS9	16/01/2023	12:30	0.0	5.691	-	-	-	-	-	-	-	Unable to meausre water parameters due to water depth.

- No data

Green Island Landfill Groundwater Parameter Results - April 2023

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	11/04/2023	9:43	0.0	0.884	3.856	14.7	45.7	4.59	2,649	6.59	190.8	-
PS1	11/04/2023	9:48	0.0	4.543	ND	13.6	77.2	7.68	6,313	7.75	155.9	-
MW1A	11/04/2023	9:52	0.0	1.300	6.259	13.3	73.1	6.72	30,332	6.19	137.5	-
MW1B	11/04/2023	9:59	0.0	1.244	5.180	13.5	61.3	5.50	32,716	6.70	106.5	-
MH1	11/04/2023	10:04	0.0	3.368	ND	13.9	79.9	7.54	19,505	6.47	123.7	-
MW1C	11/04/2023	10:05	0.0	1.211	5.719	14.0	37.0	3.35	27,266	6.77	59.8	-
PS2	11/04/2023	10:09	0.0	3.126	ND	14.3	27.8	2.69	13,299	6.67	42.2	-
MW2A	11/04/2023	10:14	0.0	2.748	6.224	16.1	9.3	0.80	28,296	7.50	-188.6	-
MW2B	11/04/2023	10:17	0.0	2.244	5.202	15.9	27.9	2.45	27,807	7.42	-107.6	-
MH2	11/04/2023	10:20	0.0	3.970	ND	14.8	12.3	1.10	28,980	6.59	-127.0	-
MW2C	11/04/2023	10:22	0.0	2.801	5.115	15.0	13.7	1.19	29,797	6.65	-61.0	-
MW2D	11/04/2023	10:25	0.0	0.605	10.664	13.5	13.3	1.21	30,213	6.75	-95.2	-
PS3	11/04/2023	10:41	0.0	2.757	ND	12.2	9.1	0.80	14,235	7.37	-152.9	-
MW3A	11/04/2023	10:44	0.0	1.223	3.806	15.4	8.6	0.80	13,747	7.43	-207.8	-
MW3B	11/04/2023	10:45	0.0	1.328	5.088	15.0	16.0	1.49	11,040	7.30	-207.7	-
MH3	11/04/2023	10:49	0.0	2.739	ND	15.1	18.0	1.67	11,023	7.16	-283.0	-
MW3C	11/04/2023	10:53	0.0	2.498	4.101	14.6	28.2	2.80	2,467	6.56	-55.0	-
PS4	11/04/2023	10:57	0.0	2.165	ND	14.8	77.2	7.51	12,926	6.98	-170.5	-
MW4A	11/04/2023	11:05	0.0	2.512	6.558	16.5	11.6	1.08	5,277	7.48	-356.0	-
MW4B	11/04/2023	11:07	0.0	1.771	4.102	15.3	6.7	0.64	4,274	7.01	-162.0	-
MW4C	11/04/2023	11:10	0.0	2.224	4.902	14.6	10.9	1.00	20,749	6.89	-98.7	-
MW4D	11/04/2023	11:12	0.0	2.460	12.178	14.5	5.5	0.51	25,609	6.36	-67.9	Iron staining on base of the well.
PS5	11/04/2023	11:20	0.0	3.198	ND	15.4	9.6	0.87	8,604	6.99	-108.5	-
MW5A	11/04/2023	11:30	0.0	2.678	4.313	14.3	9.6	0.79	2,719	6.92	-33.2	Sludge in bottom of the well, green coloured sludge.
MW5B	11/04/2023	11:32	0.0	1.528	4.920	15.4	10.4	0.93	4,955	7.16	-51.4	-
MH5	11/04/2023	11:35	0.0	3.294	ND	14.7	6.5	0.62	5,479	6.87	-61.3	-
MW5C	11/04/2023	11:40	0.0	1.794	5.829	13.4	5.6	0.52	3,979	7.30	-161.4	-
PS6	11/04/2023	11:47	0.0	4.690	ND	14.8	12.4	0.95	45,878	6.84	-55.9	Iron staining in base of the well.
MW6A	11/04/2023	11:53	0.0	0.779	4.798	15.2	5.1	0.49	4,662	7.19	-7.1	No well cap
MW6B	11/04/2023	11:56	0.0	1.209	3.848	15.0	53.6	5.30	2,096	7.19	-7.1	-
MH6	11/04/2023	12:00	0.0	3.106	ND	14.6	27.1	2.59	4,604	7.00	-33.3	-
MW6C	11/04/2023	12:05	0.0	0.976	5.009	13.1	62.5	6.38	1,327	6.90	-5.5	-
PS7	11/04/2023	12:16	0.0	3.899	ND	14.1	34.5	3.36	4,024	6.83	-82.9	-
MW7A	11/04/2023	12:23	0.0	1.241	3.303	13.7	9.7	0.94	1,803	7.28	-135.1	-
MW7B	11/04/2023	12:27	0.0	1.796	5.773	13.6	17.2	1.67	1,930	6.96	21.6	-
MH7	11/04/2023	12:31	0.0	3.618	ND	13.8	13.5	1.34	10,384	6.69	53.4	-
MW7D	11/04/2023	12:36	0.0	1.502	5.233	14.5	49.8	4.67	16,924	6.90	32.6	-
PS8	11/04/2023	12:40	0.0	3.850	ND	13.8	63.8	0.47	3,137	6.62	1.4	-
MW8A	11/04/2023	12:50	0.0	2.112	4.310	15.1	86.9	1.66	1,497	6.99	-27.1	-
MW8B	11/04/2023	12:52	0.0	2.109	5.103	14.0	23.8	2.05	1,296	7.01	-67.8	Green/ grey coloured sludge in base of the well.
MH8	11/04/2023	12:54	0.0	3.478	ND	13.4	27.0	2.68	1,213	6.95	-37.8	-
MW8C	11/04/2023	12:58	0.0	2.156	4.982	13.5	11.7	1.18	879	6.18	75.5	-
PS9	11/04/2023	13:04	0.0	5.794	ND	12.7	44.1	4.50	602	6.09	-4.7	-

Notes:
- No Comment.
ND - Not Determined
PID - Photoionisation detector (Measuring the presence of VOCs).

Green Island Landfill
Surface Water Parameter Results - July 2022

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	15/07/2022	9:54	6.0	101.9	12.56	223.1	7.37	31.8	Slightly cloudy, trace particulates, no odour.
GI2	15/07/2022	10:13	6.0	86.5	10.69	309.6	6.29	64.1	No odour, slight cloudy, trace particulates, minor sediment content.
GI3	15/07/2022	9:14	6.1	88.6	10.94	312.4	7.20	48.4	Slight brownish tinge, no odour, trace particulates.
GI5	15/07/2022	8:52	5.9	14.1	1.72	550.4	7.34	42.3	Slight brownish tinge, no visible particulates, no odour.
Eastern Pond	14/07/2022	10:45	7.2	41.6	4.95	579.3	7.37	38.5	Moderate to high sediment content no odour, no visible particulates, brownish tinge.
Western Pond	14/07/2022	9:54	6.6	66.1	7.91	4605.0	7.46	44.6	Slightly cloudy, trace particulates, slight brownish tinge, minor sediment content.

Notes:
Heavy rainfall over 48 hours prior to sampling
m btoc - metres below top of casing

Green Island Landfill
Surface Water Parameter Results - October 2022

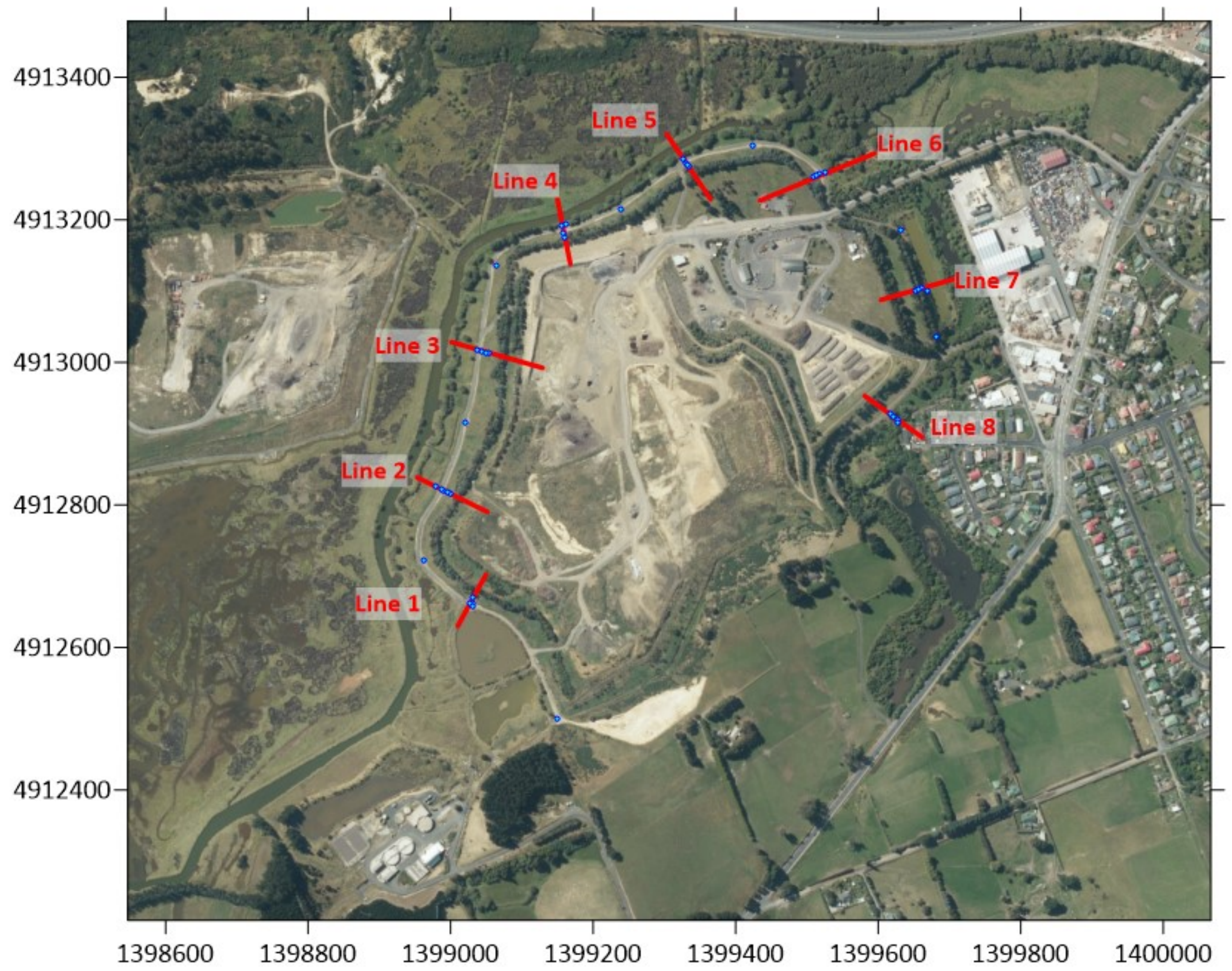
Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	12/10/2022	12:06	9.3	115.3	13.32	209.2	8.77	16.0	Trace particulates, no odour, transparent.
GI2	12/10/2022	12:30	9.2	65.0	7.60	420.1	6.47	44.1	Transparent colour, no odour, no particulates.
GI3	12/10/2022	12:52	10.0	77.7	8.86	603.9	7.08	55.3	Trace to no particulates, no odour, transparent.
GI5	12/10/2022	13:12	10.9	33.5	3.70	1753.0	6.49	77.6	Trace to minor particles, slightly cloudy, slight organic odour.
Eastern Pond	12/10/2022	10:02	11.3	67.0	7.41	1052.0	8.17	-4.0	Cloudy, minor particulates, no odour.
Western Pond	12/10/2022	13:22	12.9	52.4	5.48	6205.0	7.45	94.0	Slight yellow colour, transparent, no particulates, slight odour.

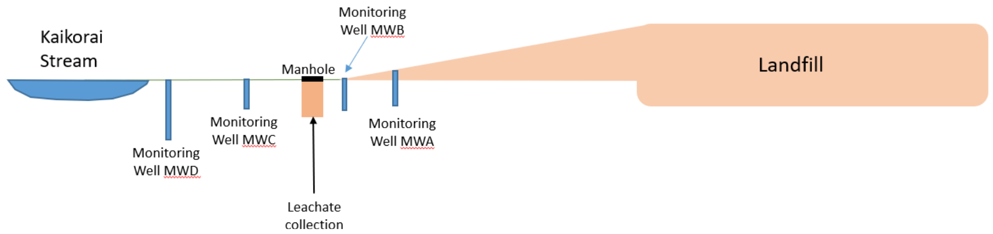
Green Island Landfill
Surface Water Parameter Results - January 2023

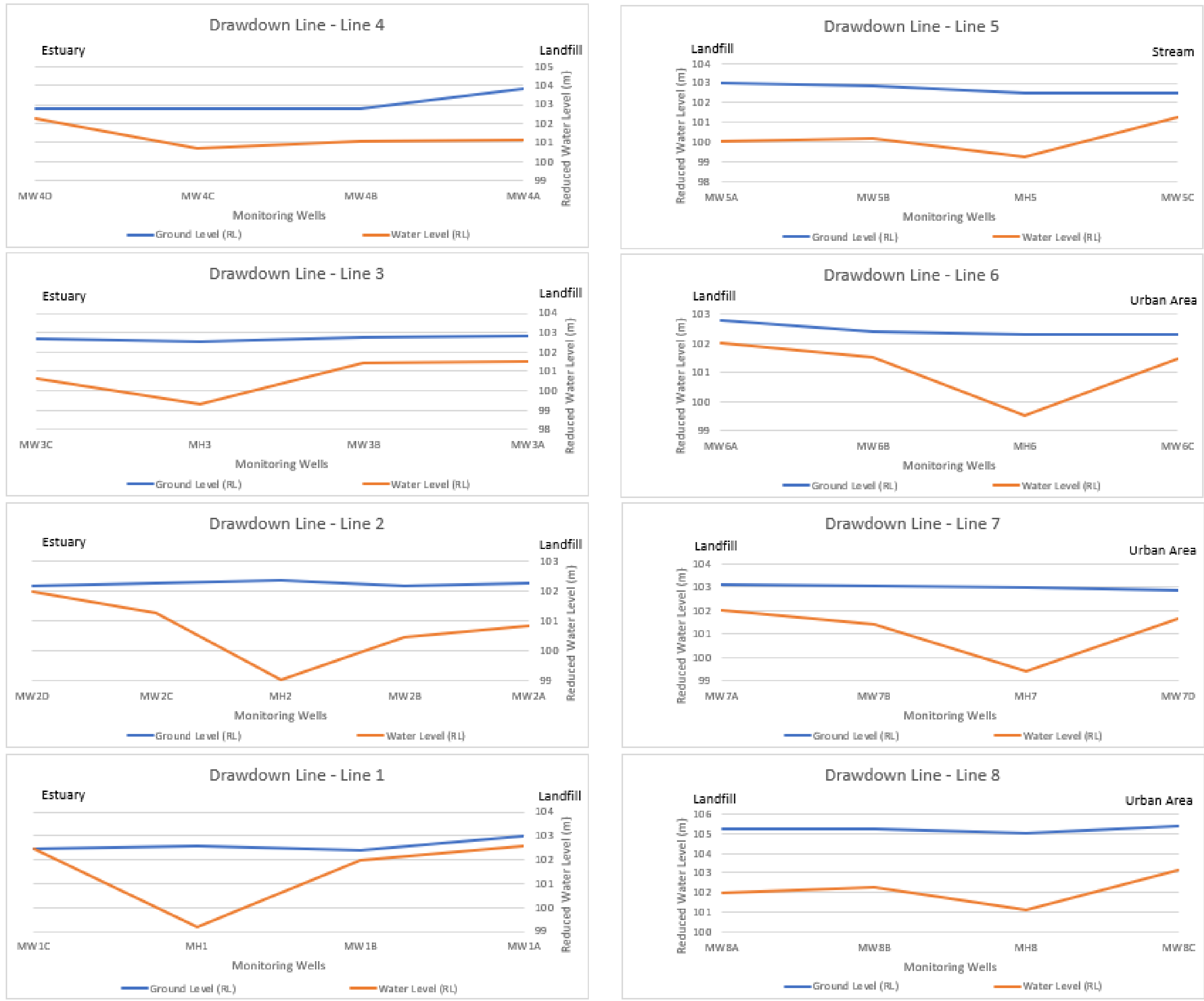
Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	18/01/2023	9:42	15.6	97.1	9.70	194	7.97	3.2	Transparent, no particulates, odourless.
GI2	18/01/2023	9:59	16.4	7.3	0.71	1,980	7.01	-157.8	Slightly cloudy, trace particulates, odourless.
GI3	18/01/2023	8:50	17	68	6.57	330.1	7.55	7.4	Slightly cloudy, trace particulates, odourless.
GI5	18/01/2023	8:35	19	57.7	5.35	719	7.53	24.7	Slightly cloudy, trace particulates, odourless.
Eastern Pond	17/01/2023	15:19	25.7	252.2	20.54	2,147	9.36	-54.30	Very high sediment content, brown, odourless.
Western Pond	17/01/2023	14:58	24.7	75.7	6.15	7,676	8.04	-44.2	Cloudy, minor particulates, odourless.

Green Island Landfill
Surface Water Parameter Results - April 2023

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	11.04.2023	15:40	13.2	64.5	6.63	515	6.28	131.0	Cloudy, brown coloured water, strong odour, minor particulates.
GI2	11.04.2023	14:39	18.9	91.2	9.24	1,228	7.91	-19.7	Cloudy, no odour, trace particulates.
GI3	11.04.2023	15:17	14.2	59.5	5.75	11,538	6.82	-18.2	Minor dark particulates, coudy, dark coloured water, no odour.
GI5	11.04.2023	14:52	16.4	30.5	2.35	677	6.86	-58.1	Cloudy, minor particulates, slight odour.
Eastern Pond	13.04.2023	9:41	13.6	16.1	1.66	1,214	7.65	-126.4	Minor particulates, no odour, cloudy and yellow coloured water.
Western Pond	12.04.2023	9:41	14.6	30.7	3.02	6,535	7.61	-182.0	Sheen on surface, strong odour, minor particulates,dark coloured water, rubbish in water







Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

Dunedin City Council

DCC Landfills 2023

Monthly Transects - Green Island
July 2022

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Figure A-1

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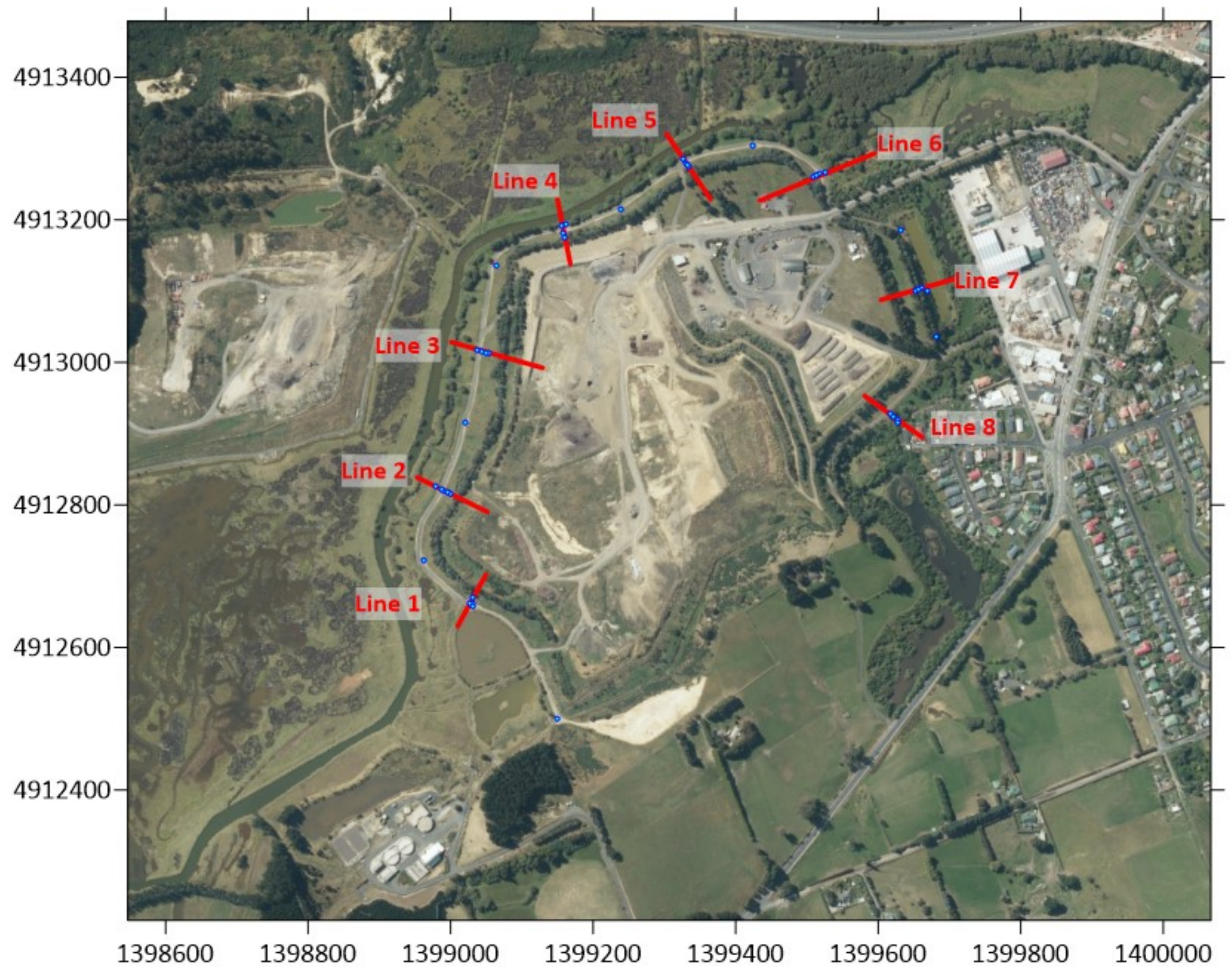

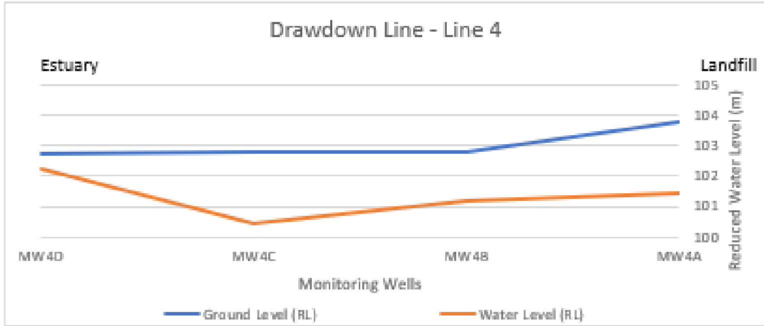

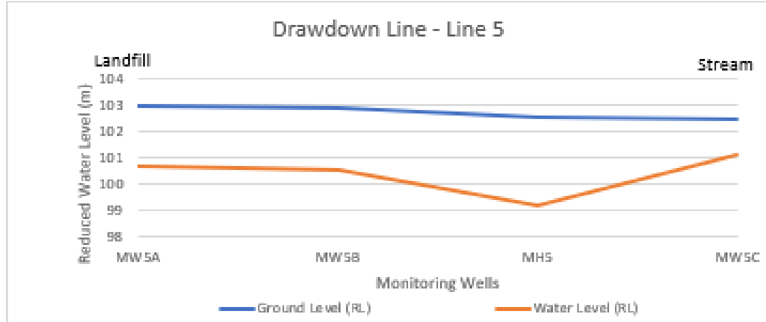

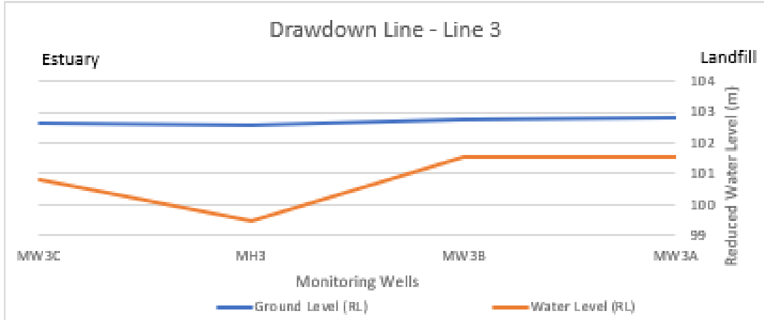

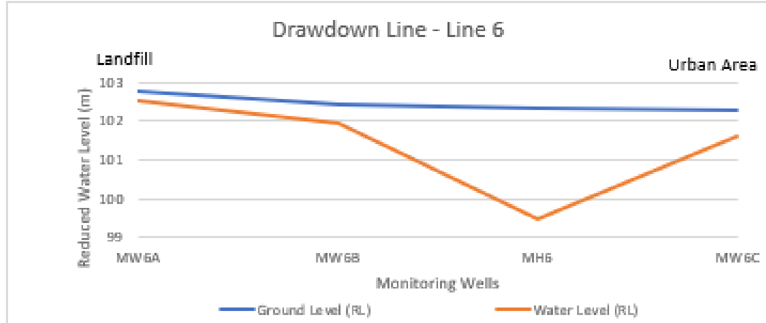

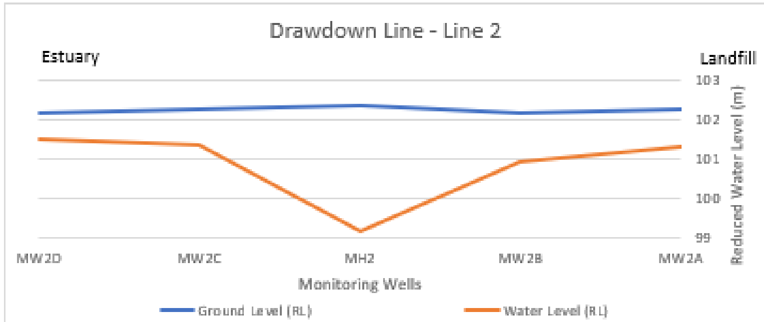

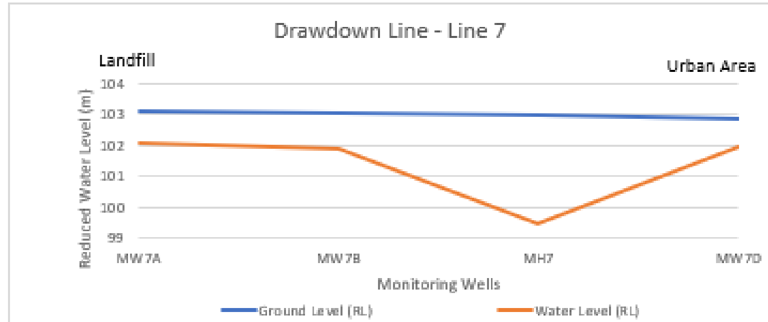

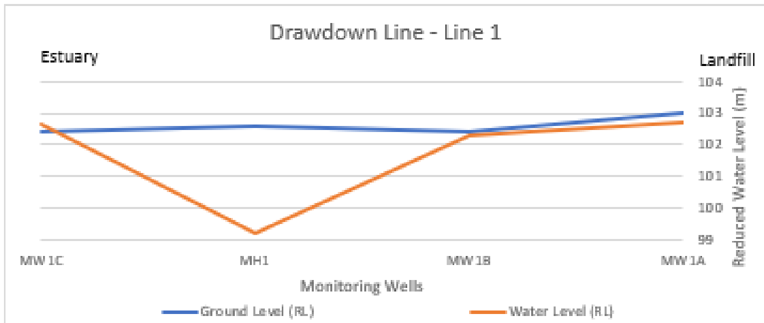

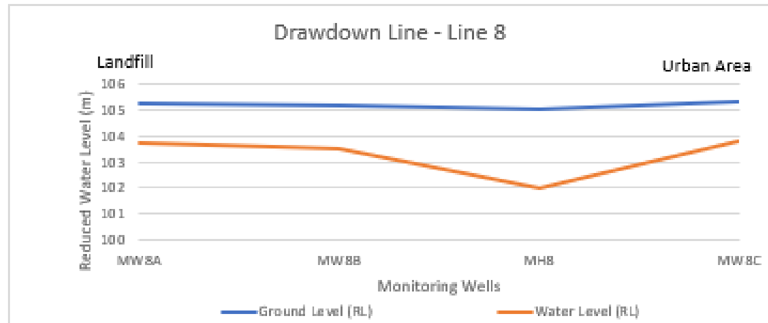

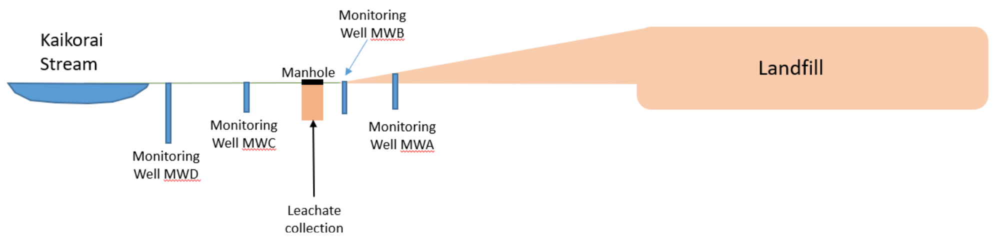

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DCC Landfills 2023

Monthly Transects - Green Island
August 2022

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Figure A-2

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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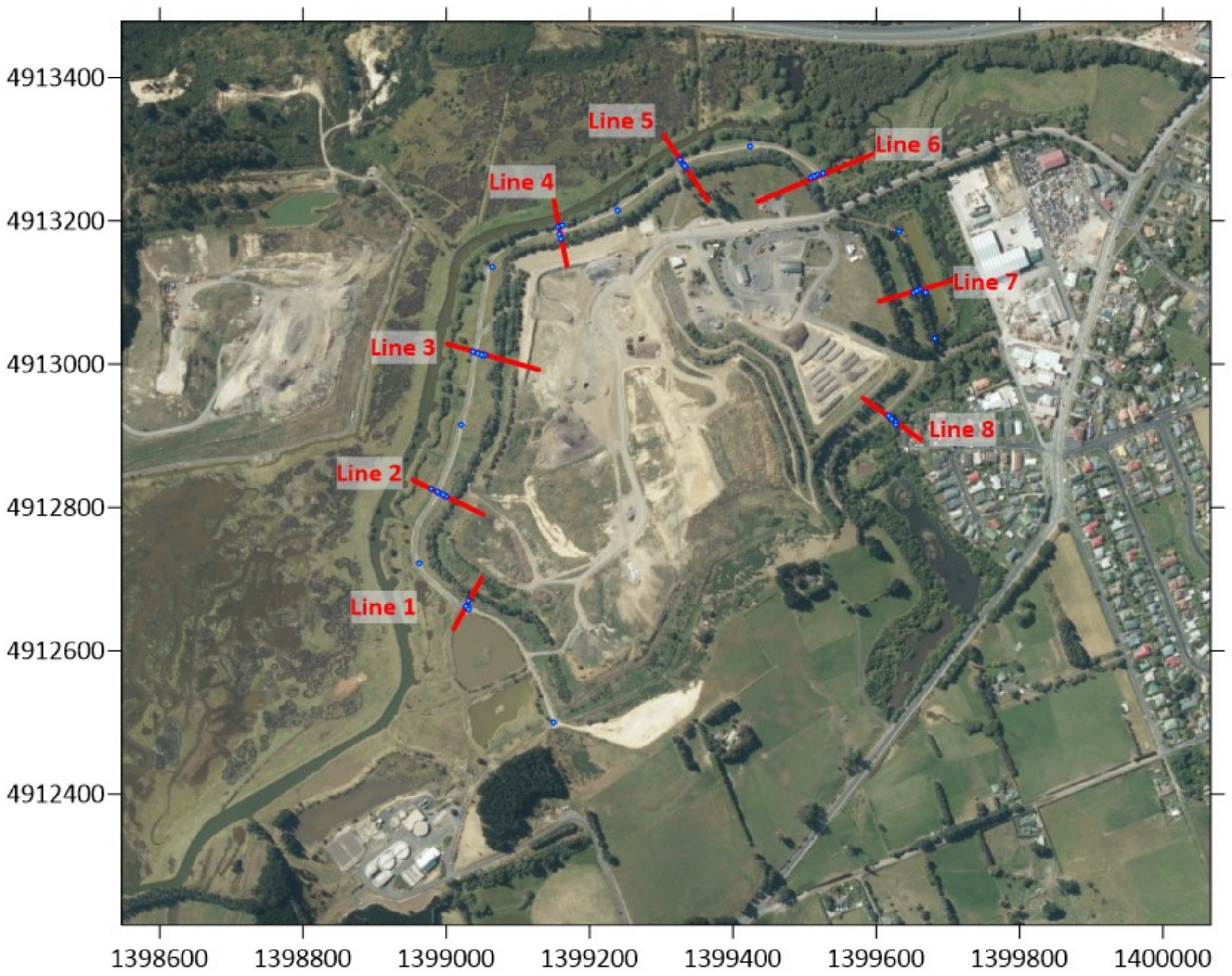

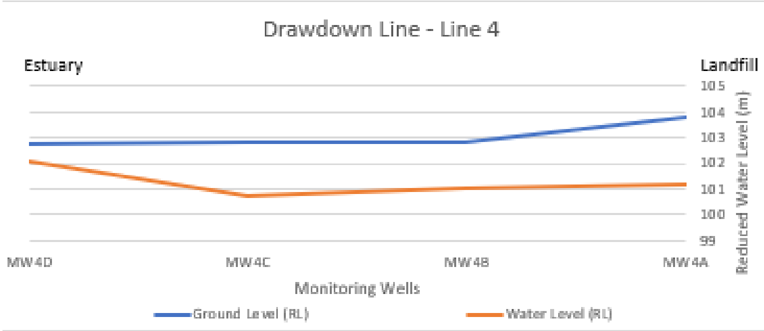

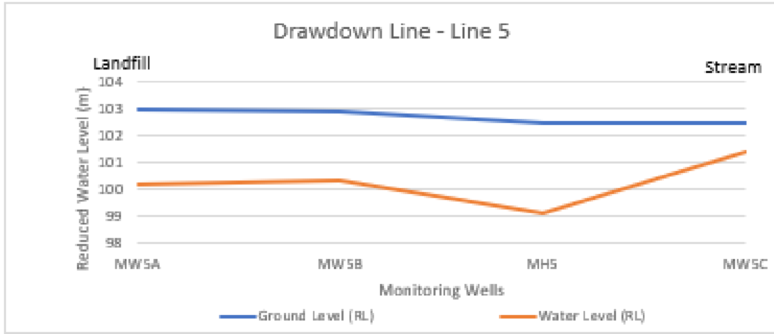

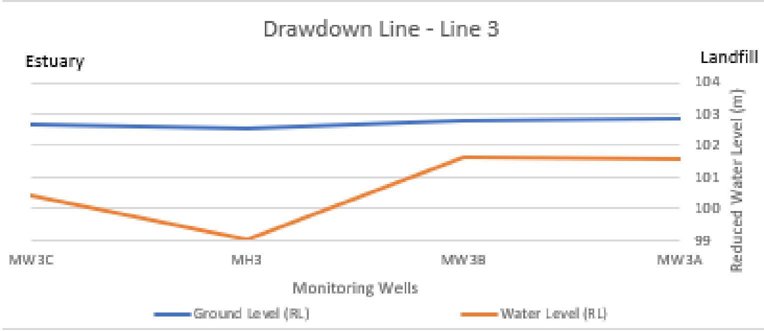

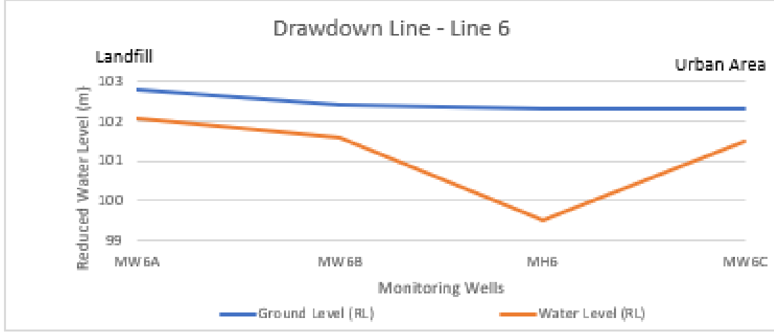

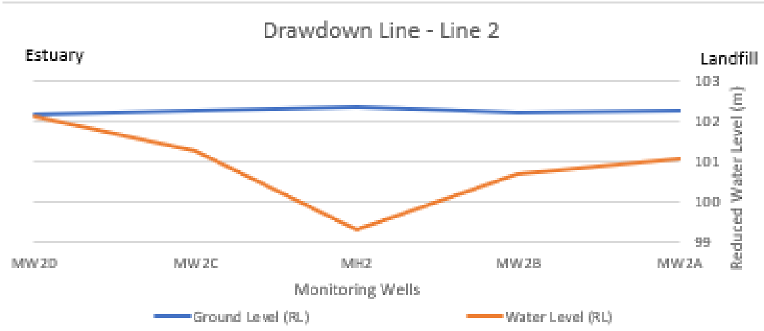

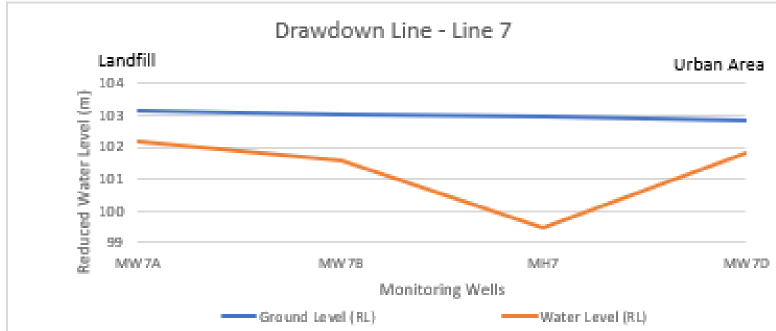

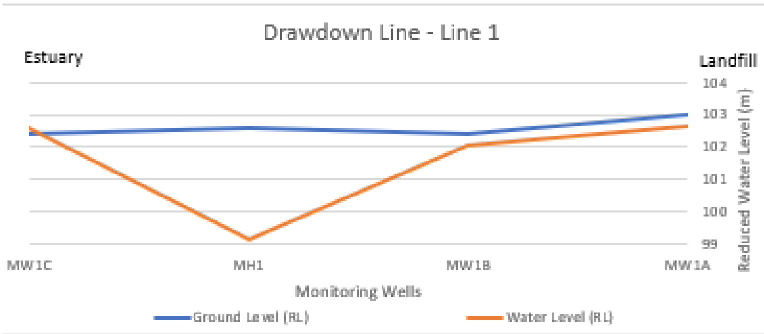

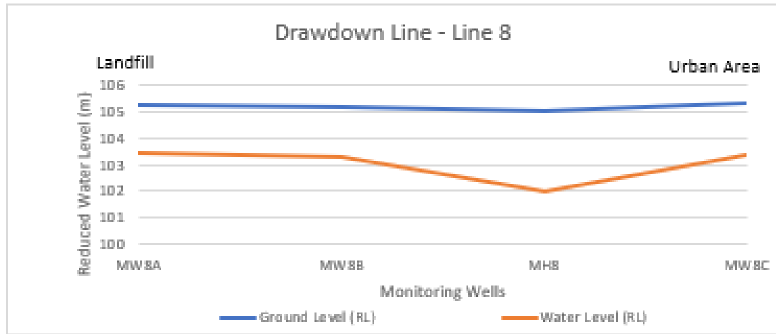

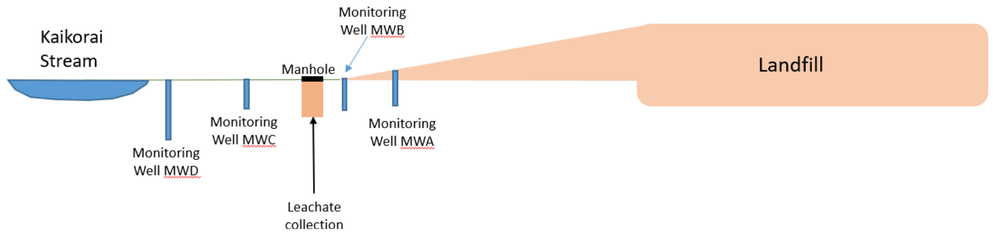

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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DCC Landfills 2023

Monthly Transects - Green Island
September 2022

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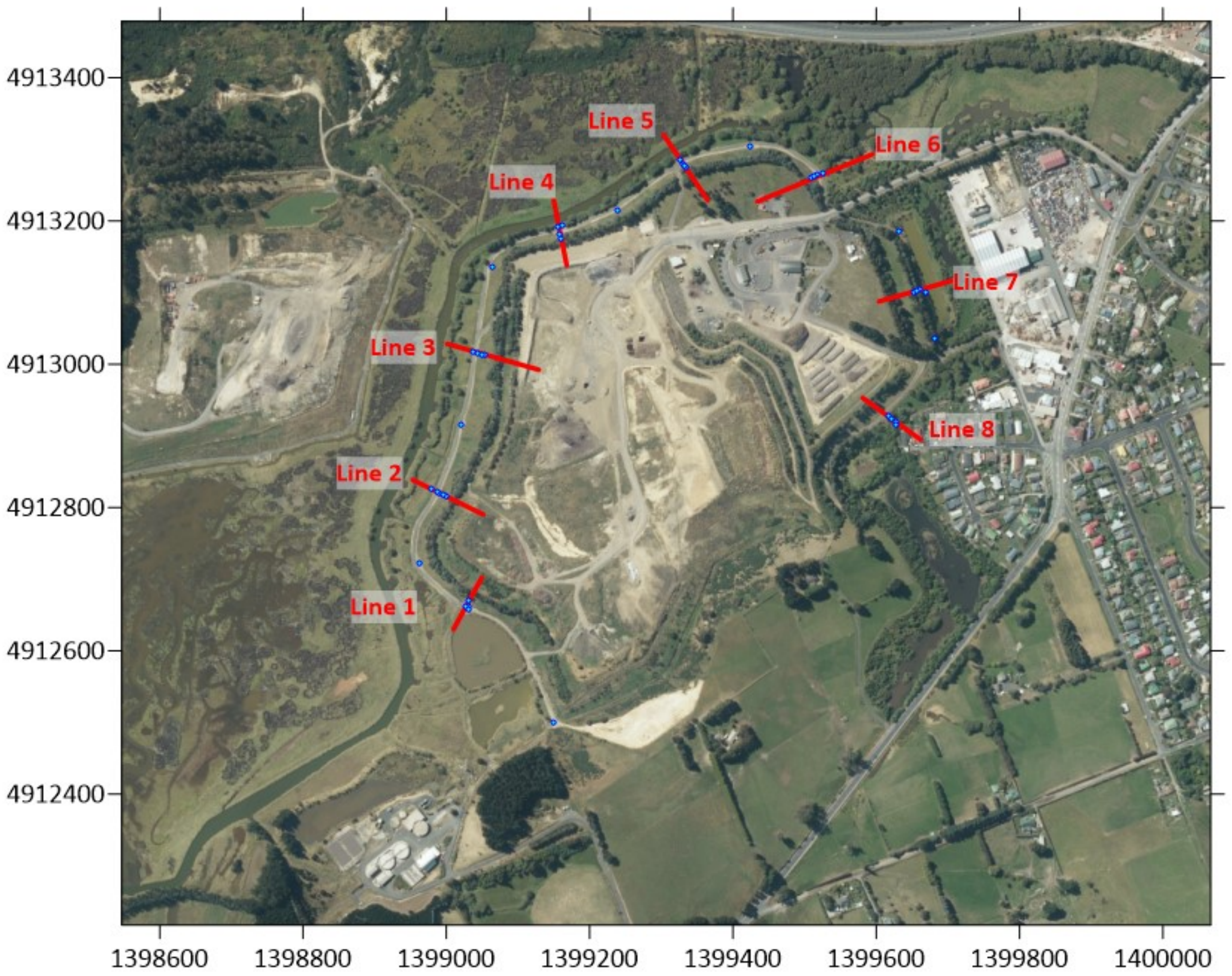
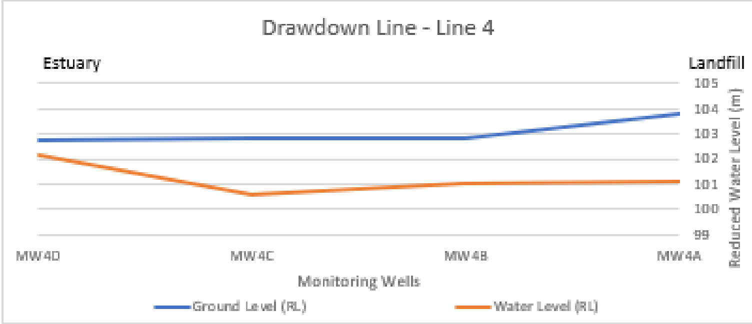
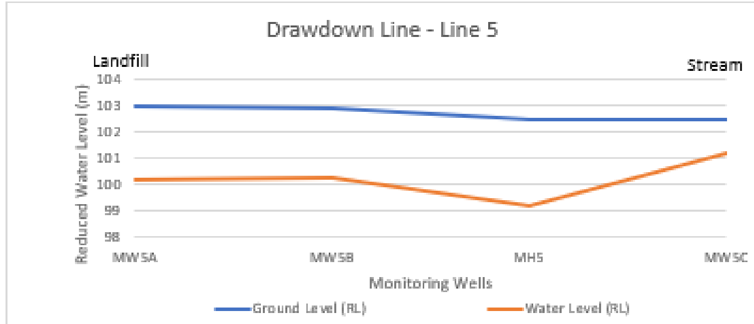
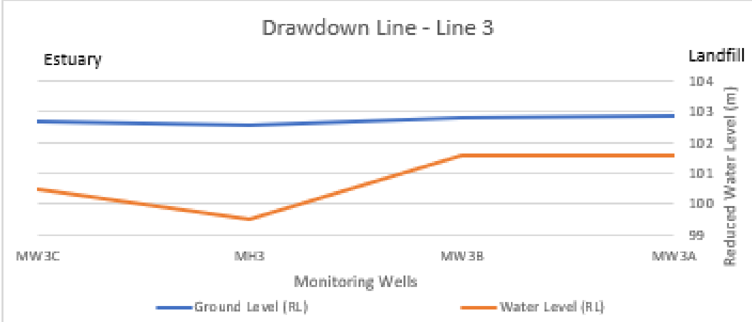
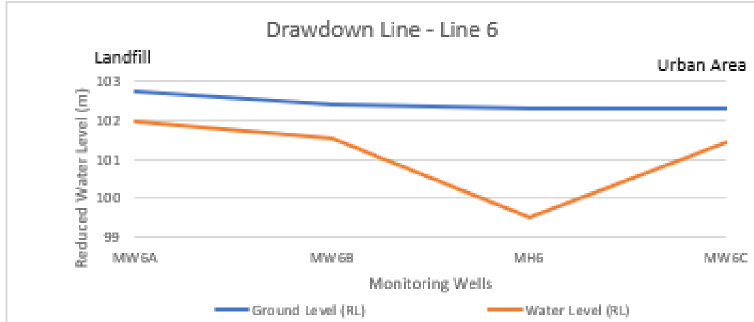
Figure A-3

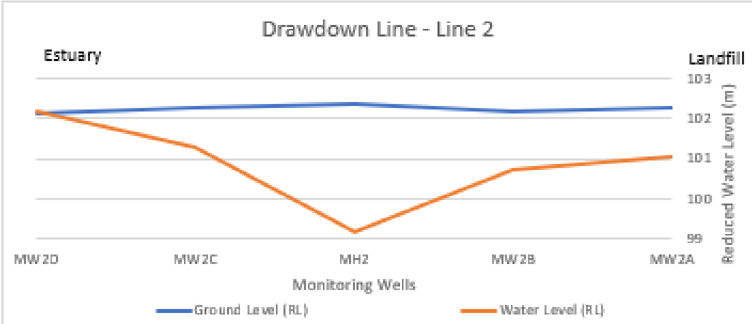


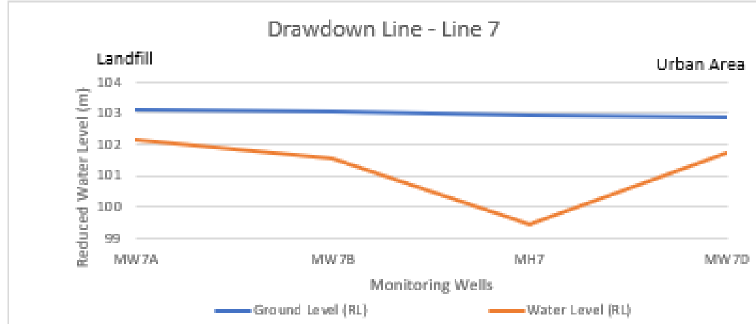


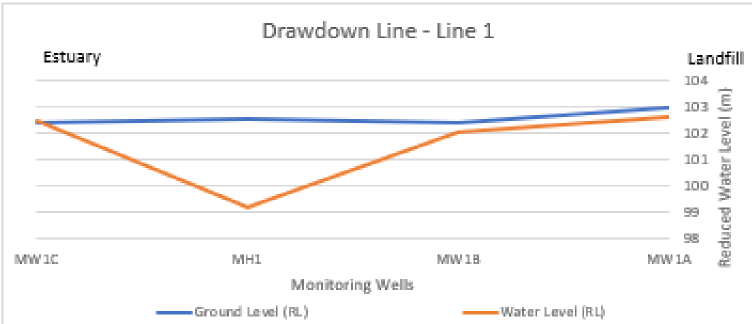


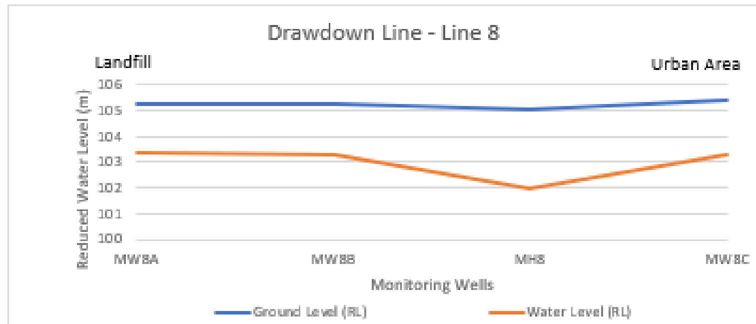


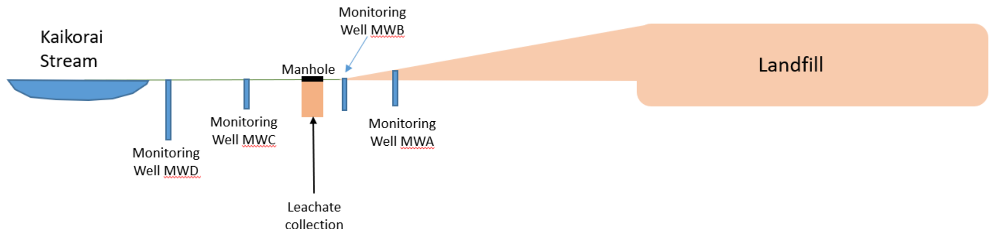












Dunedin City Council

DCC Landfills 2023

Monthly Transects - Green Island
October 2022

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Figure A-4

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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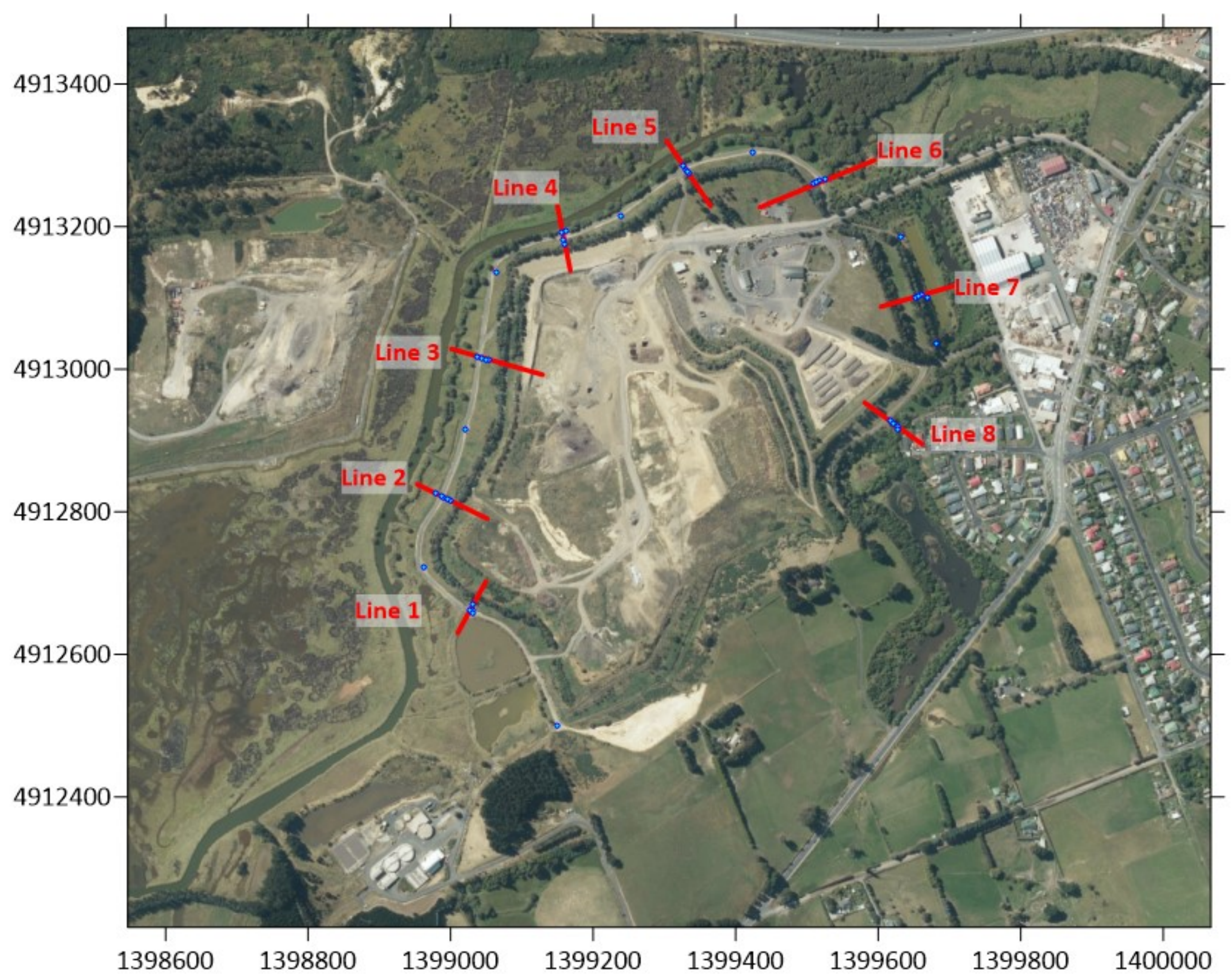

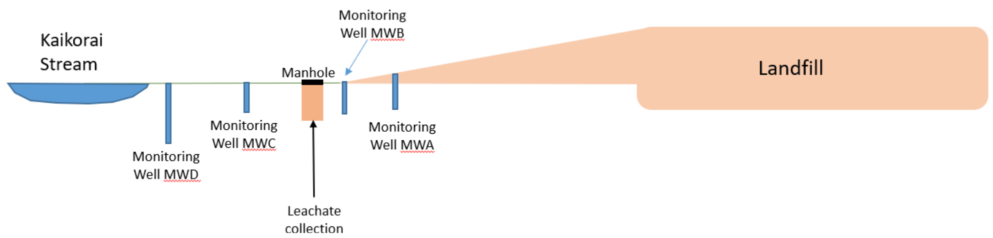

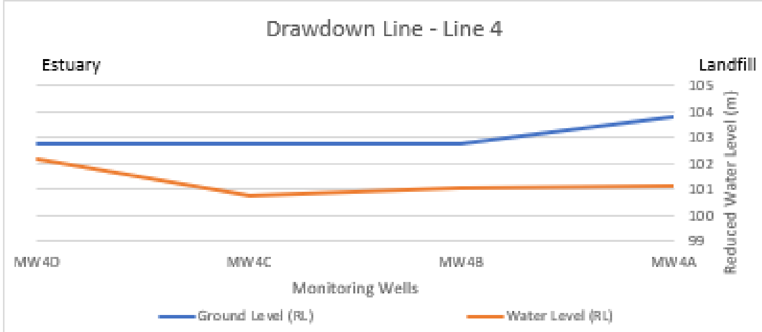

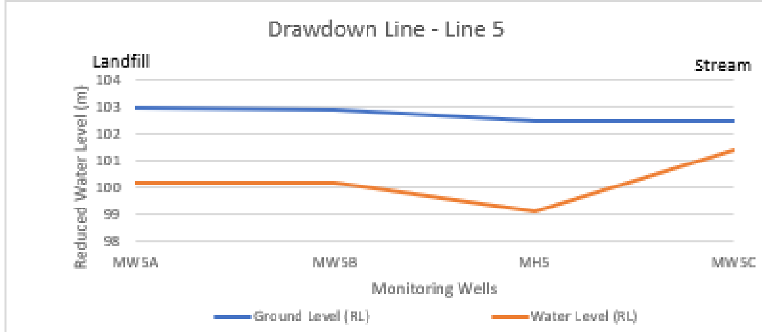

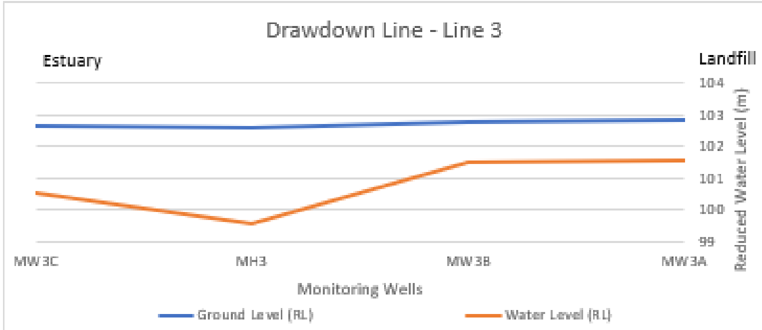

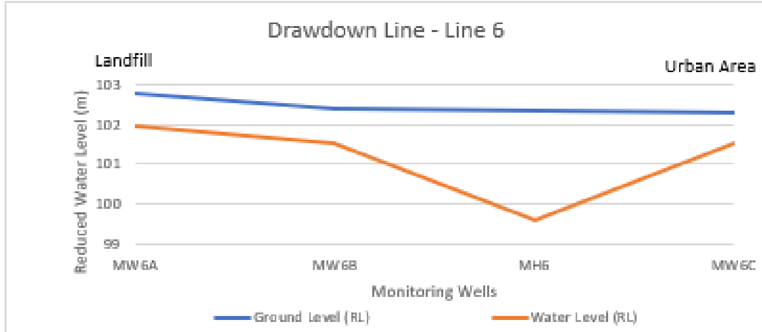

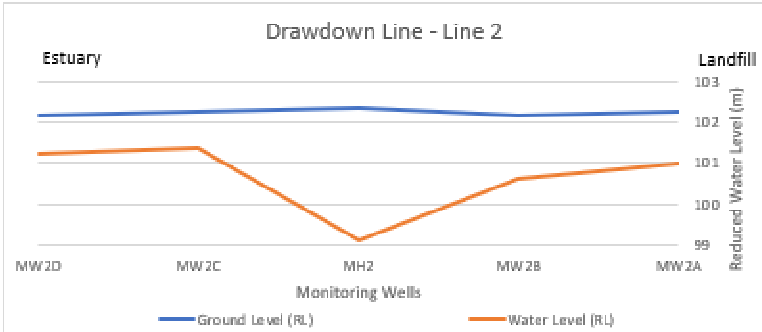

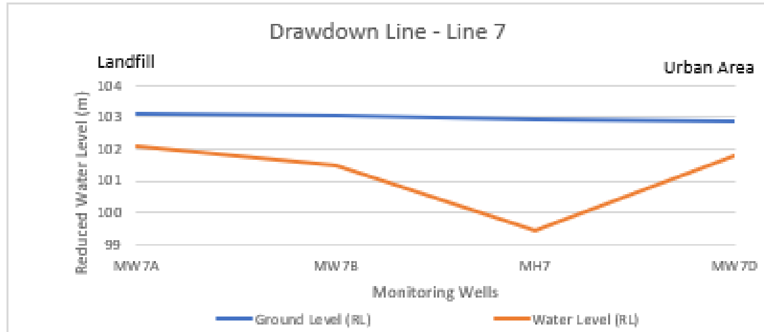

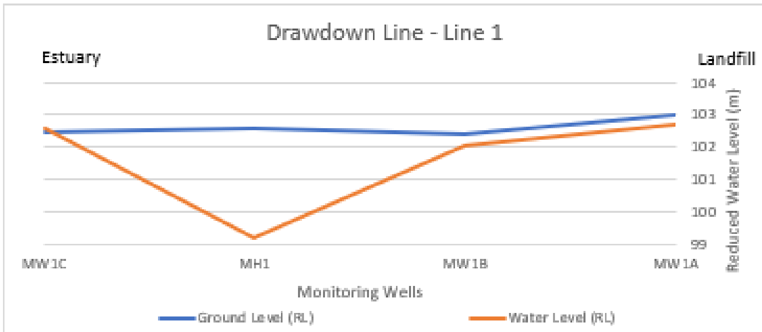

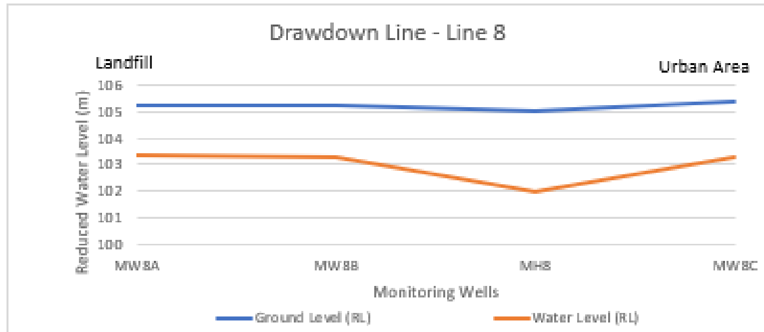

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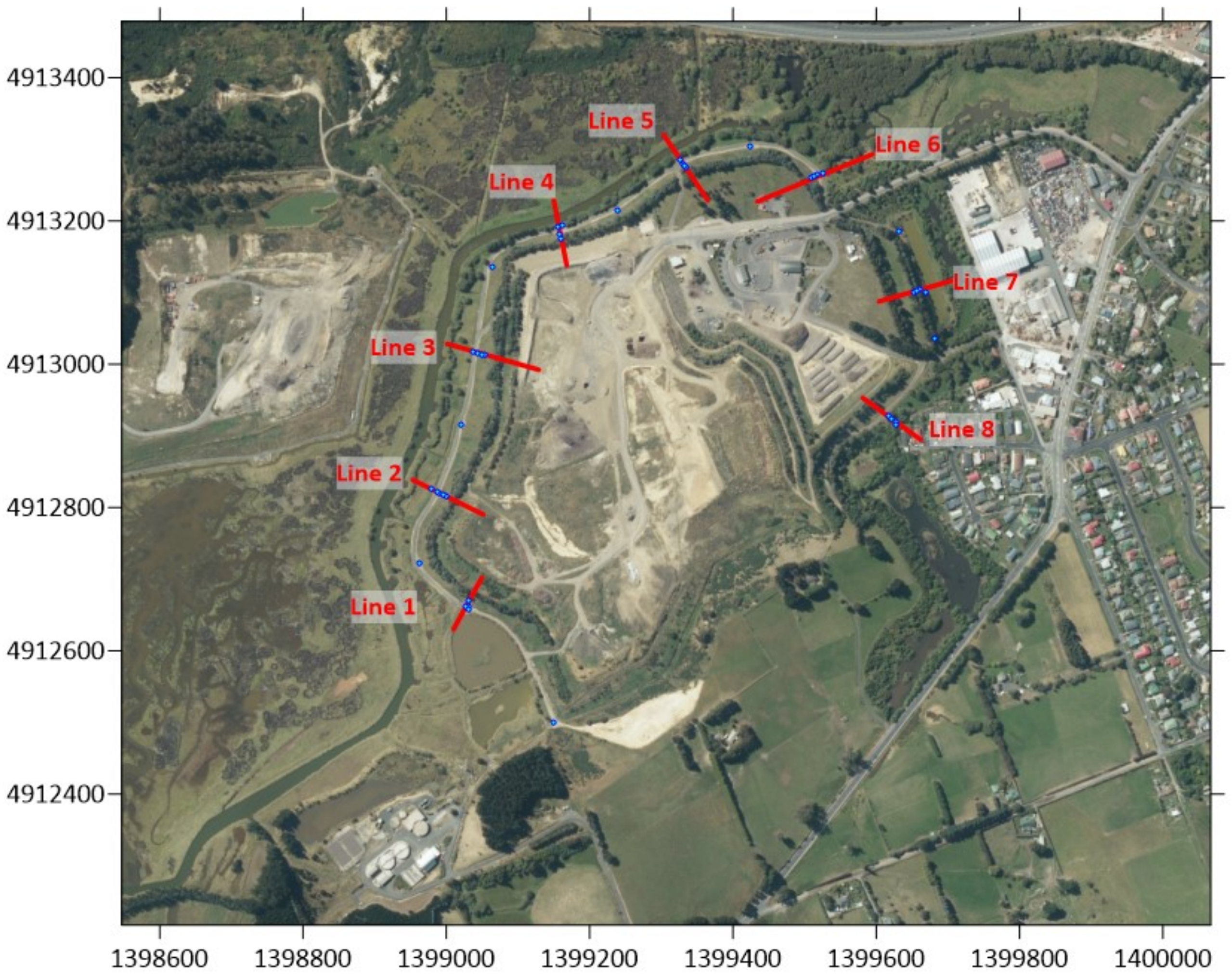
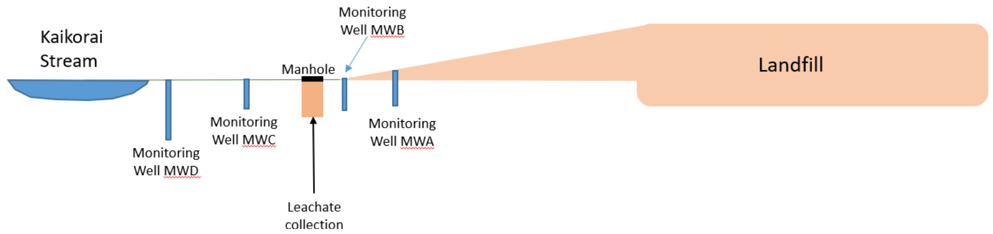
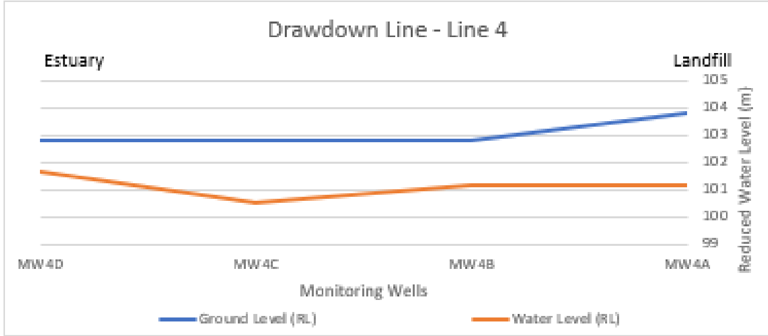
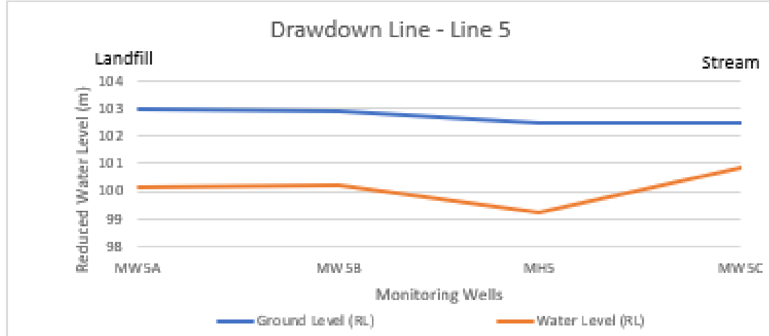
Figure A-5

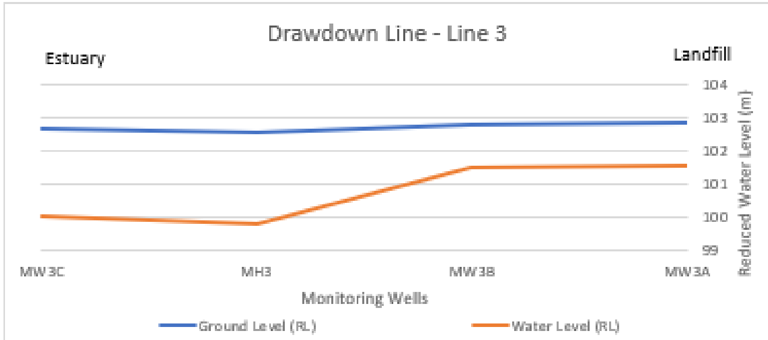
Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

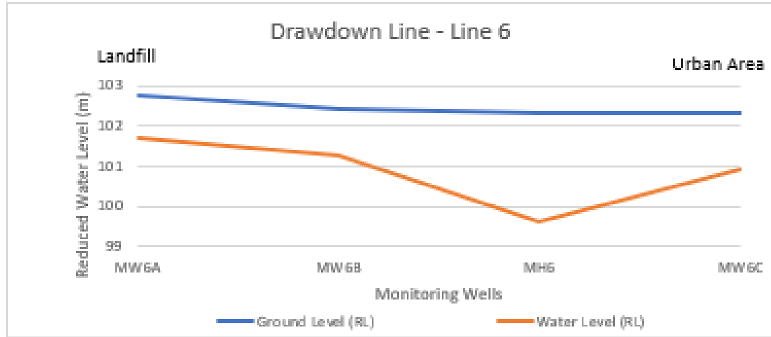


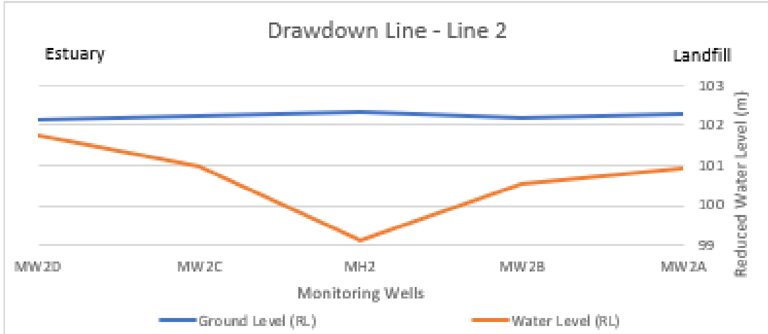


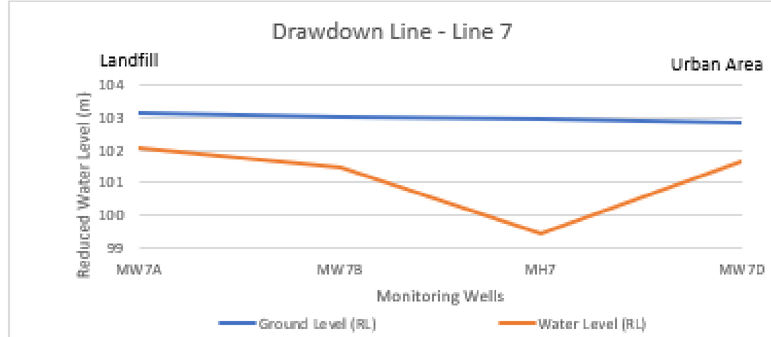


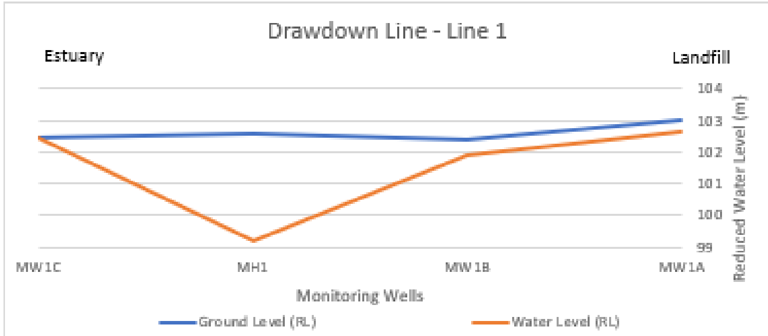


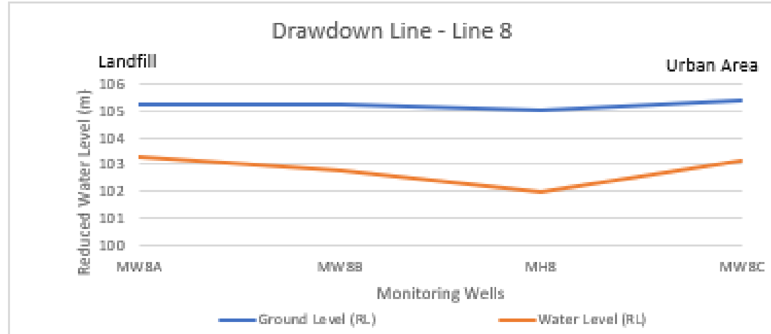












Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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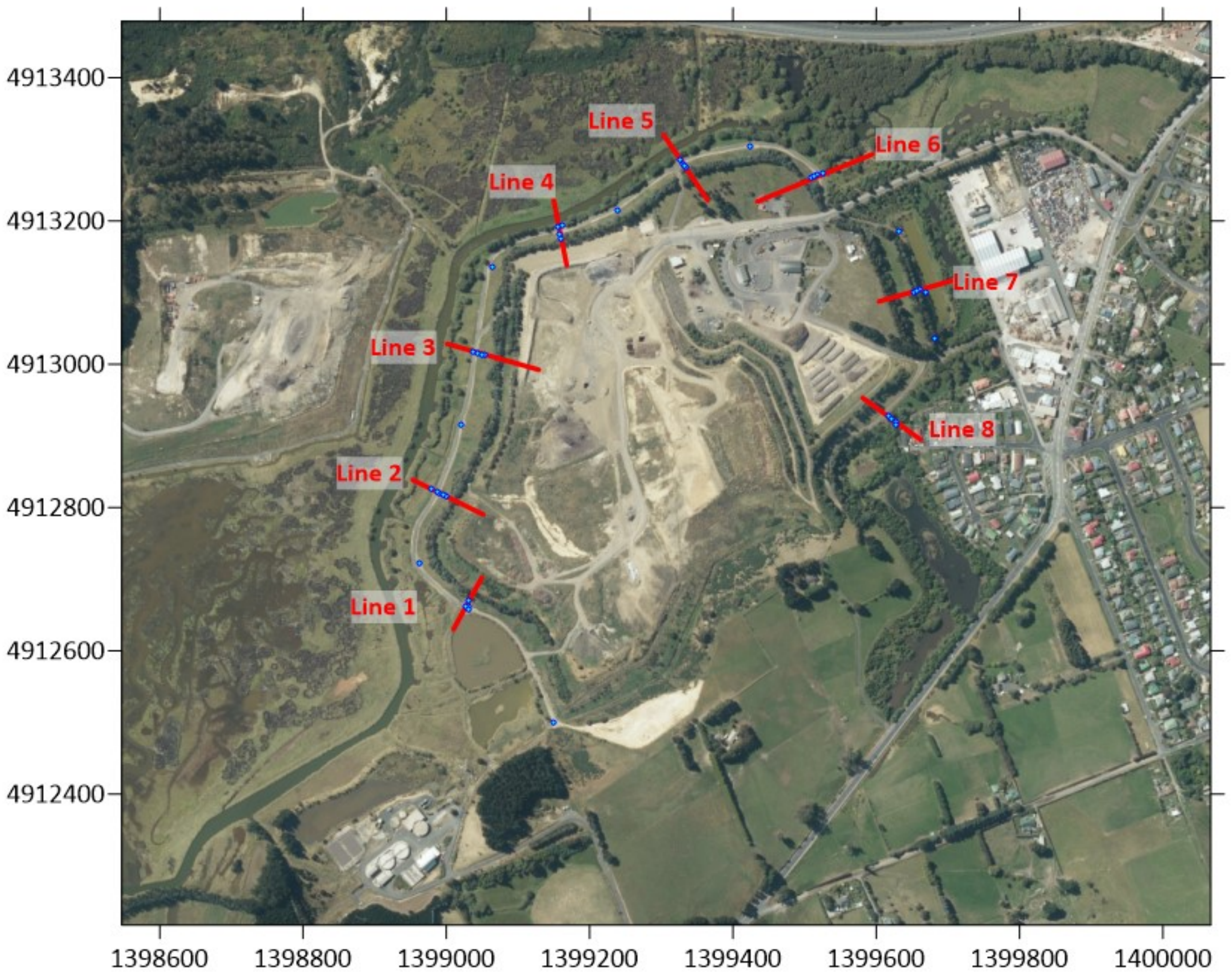

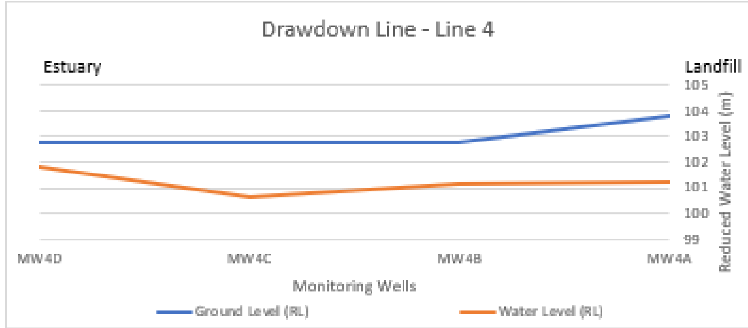

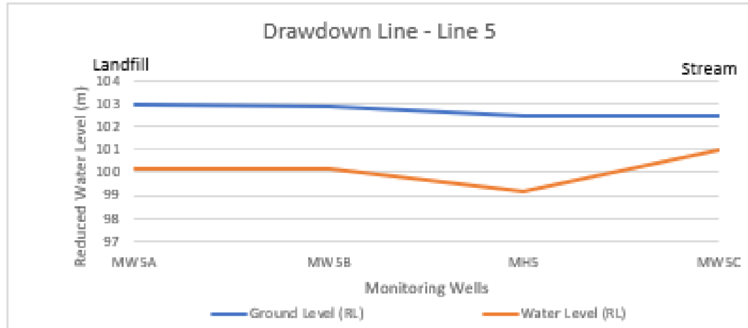

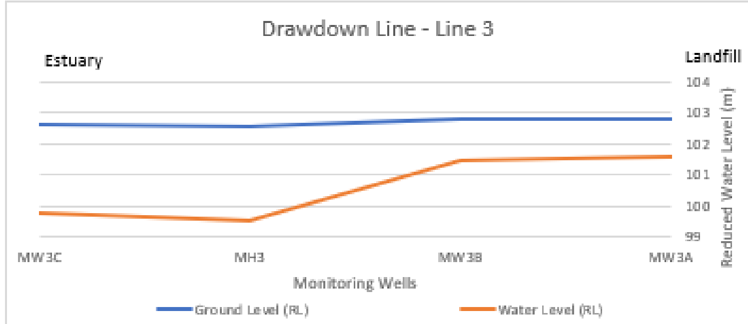

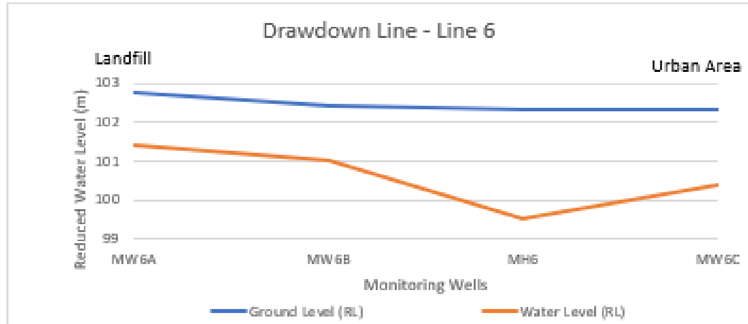

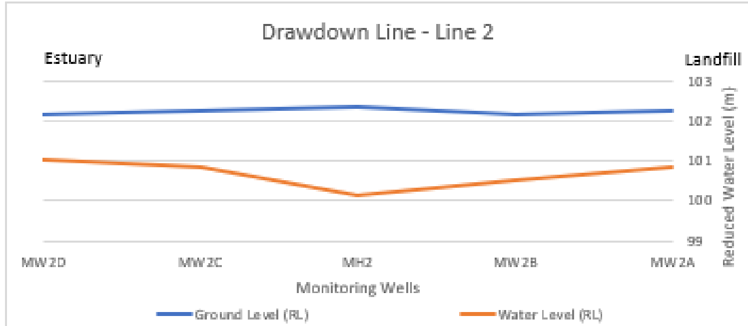

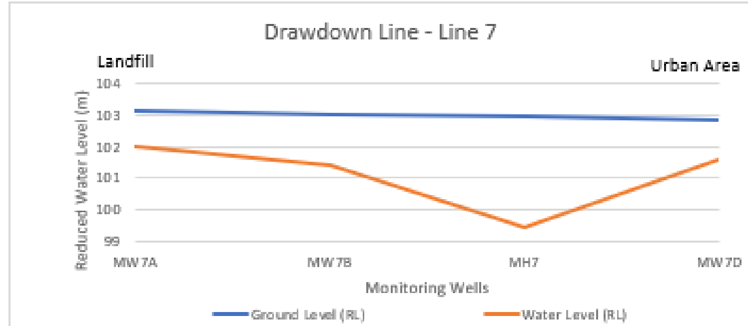

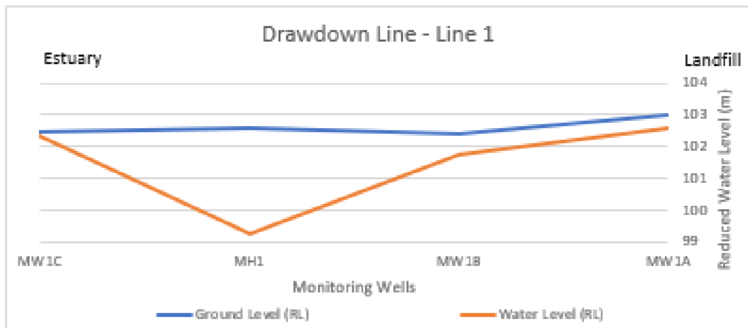

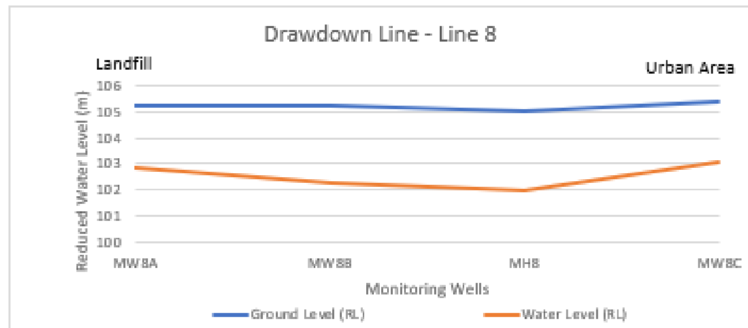

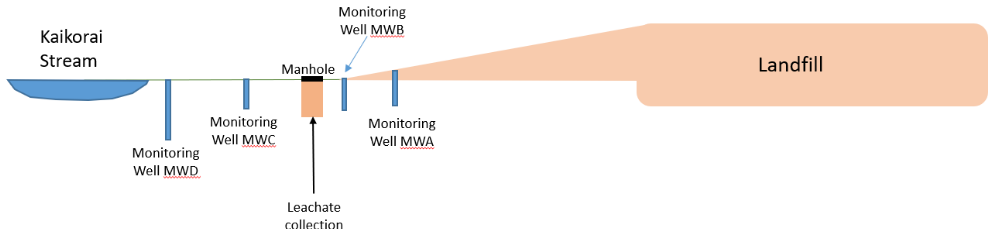

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January 2023

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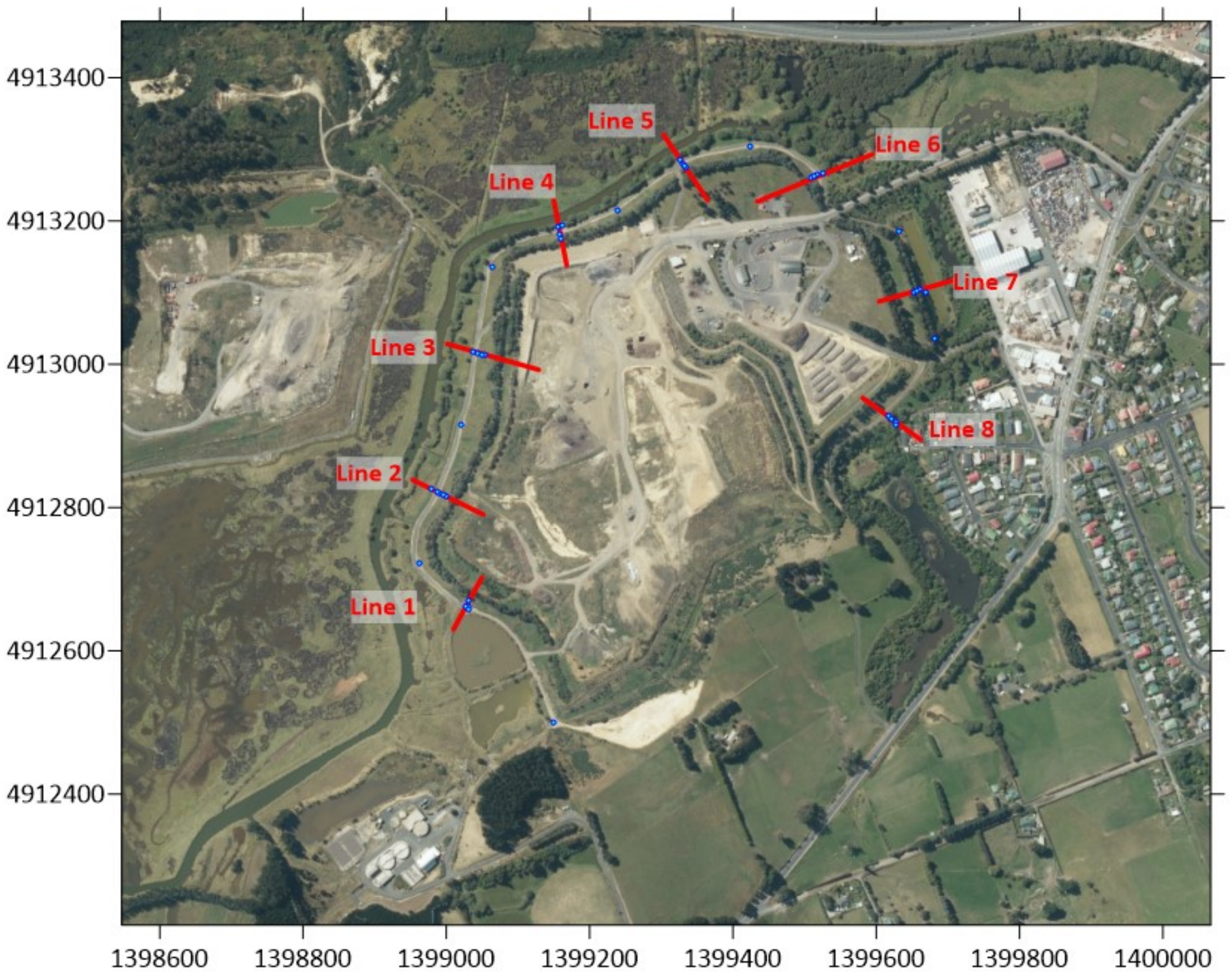
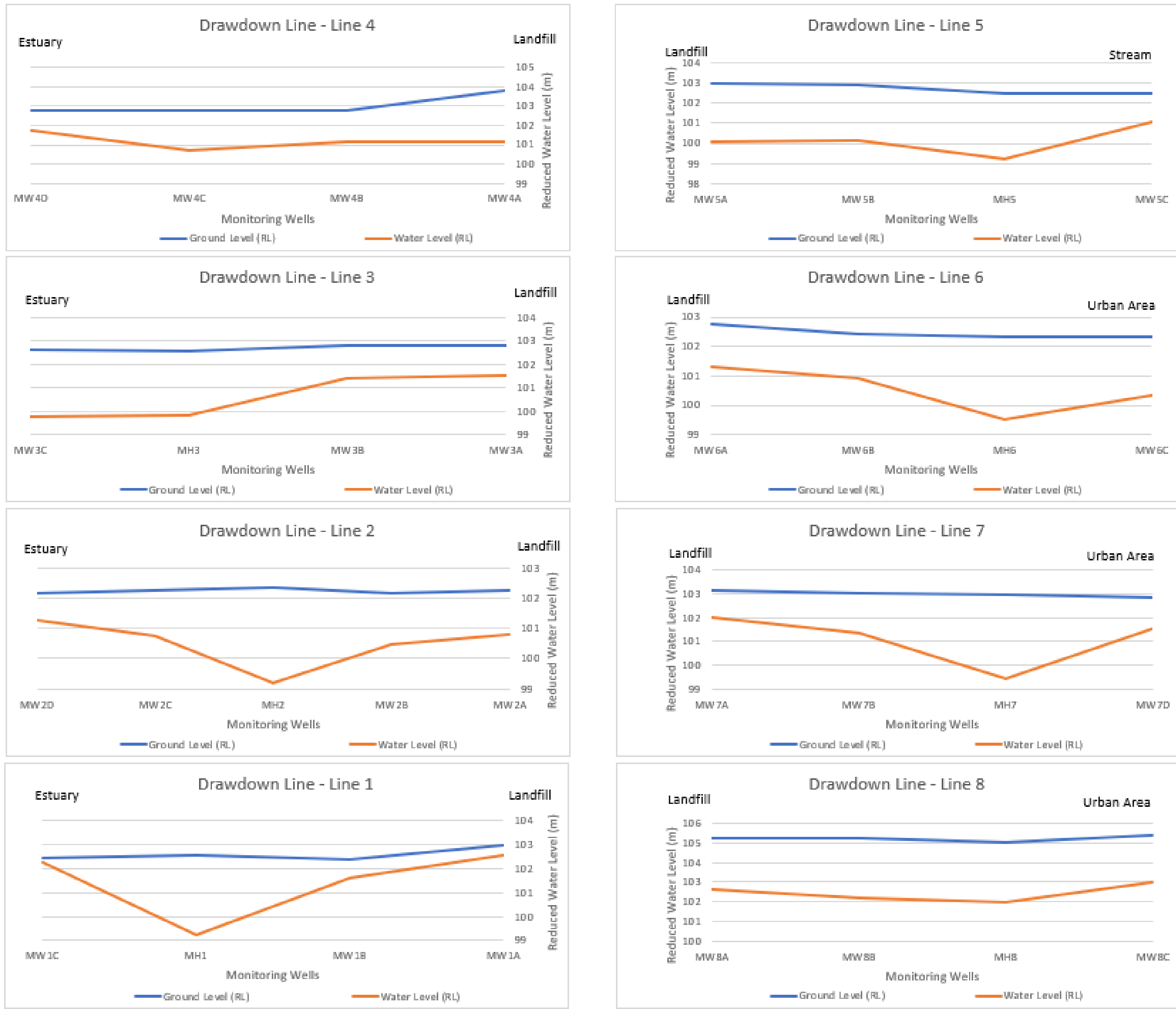
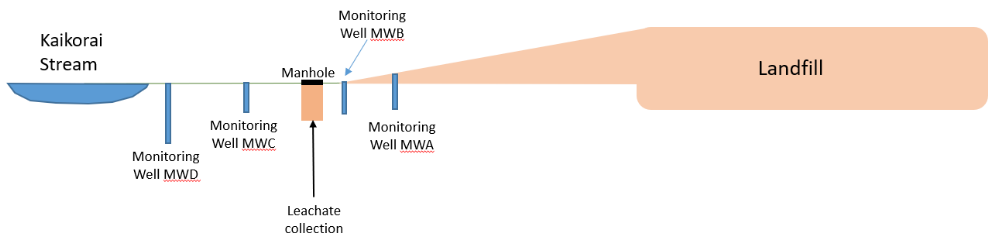
Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx







Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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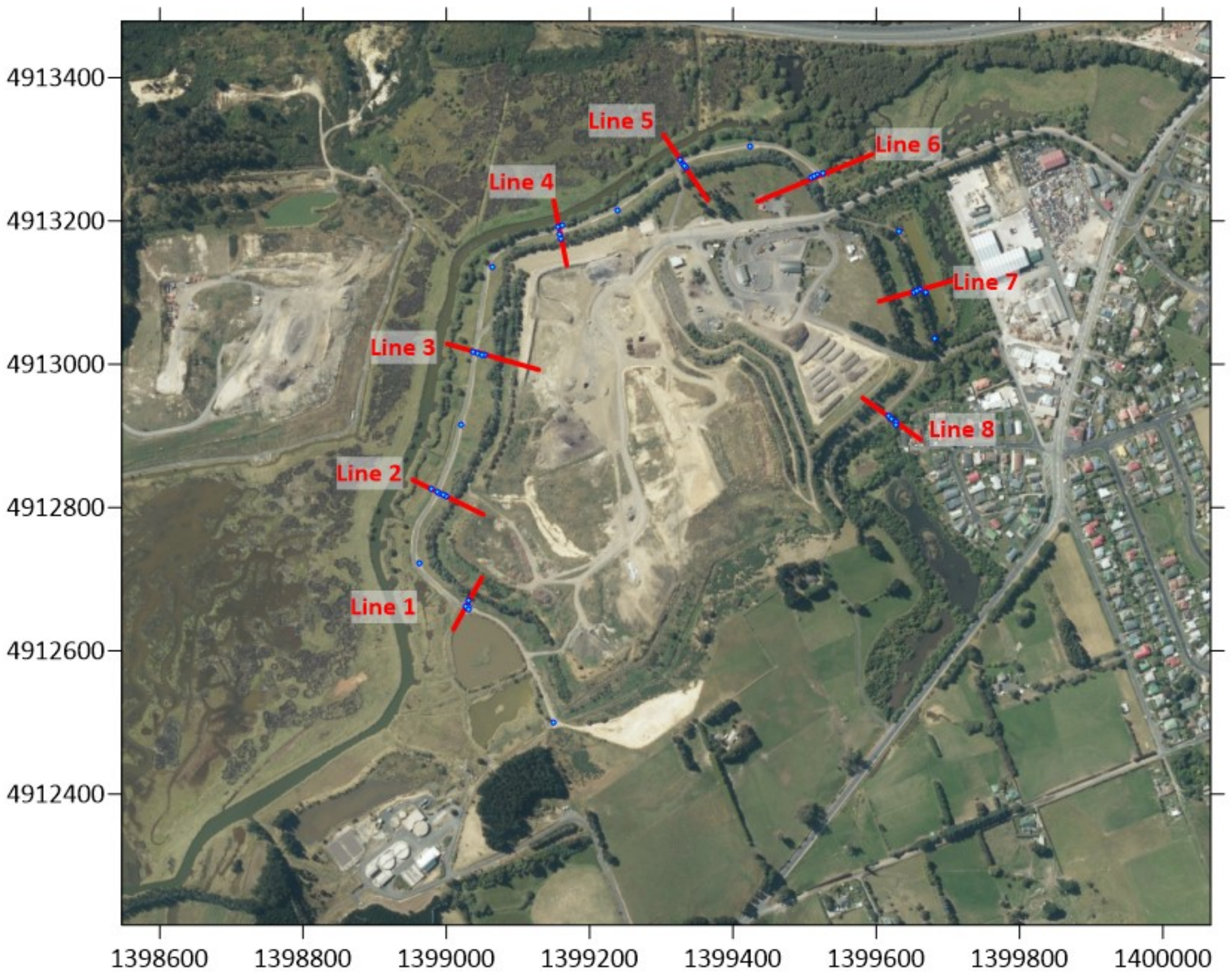

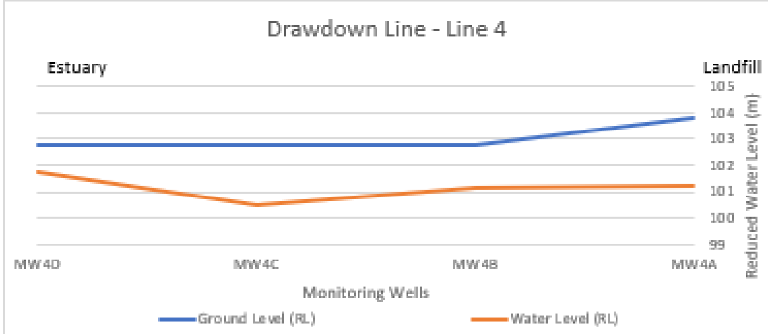

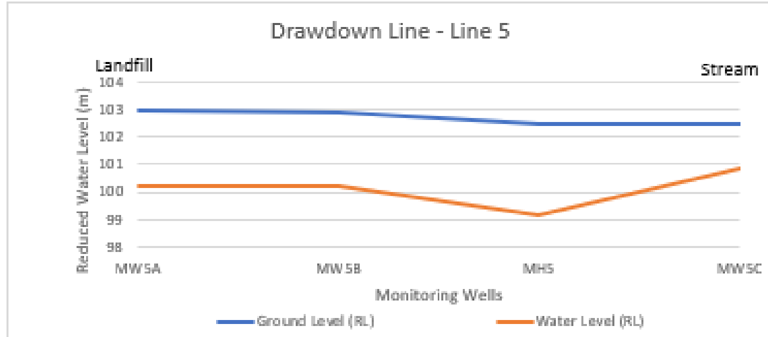

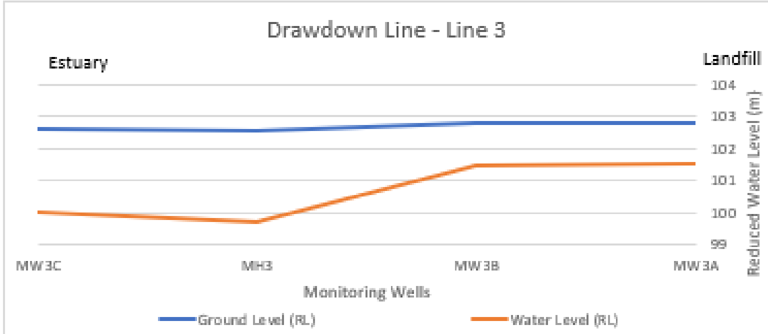

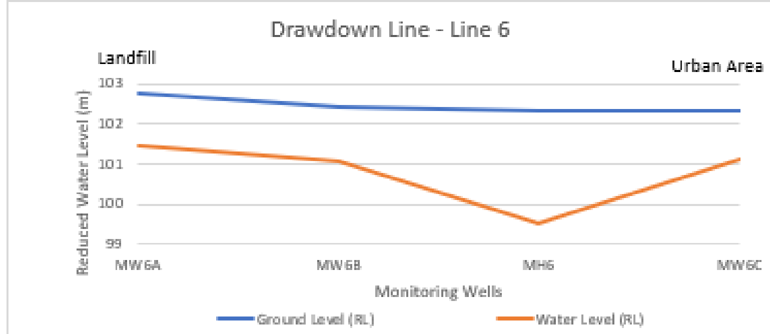

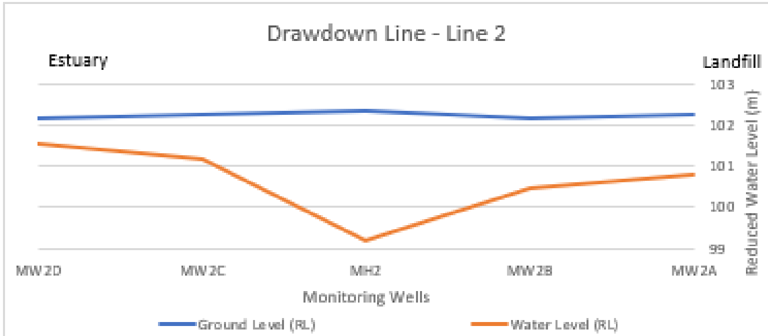

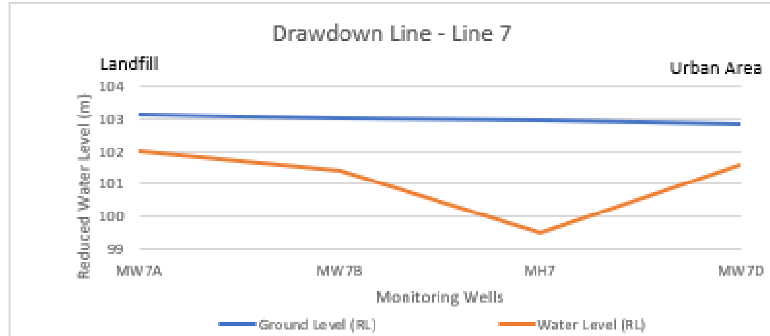

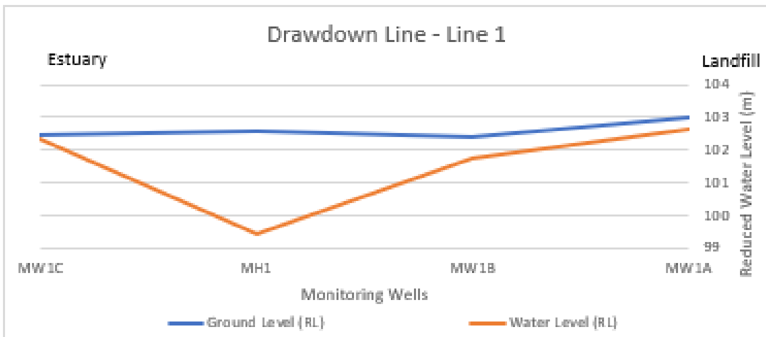

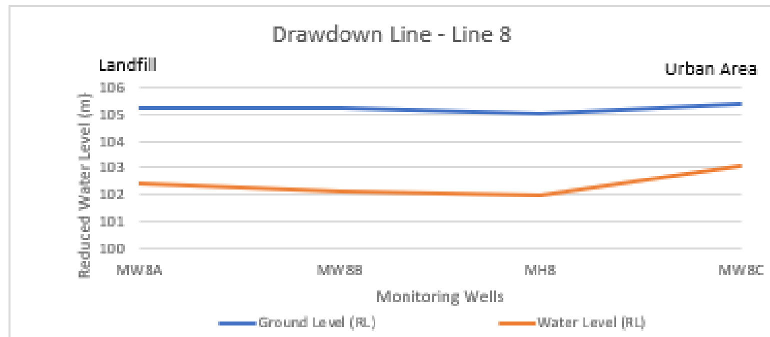

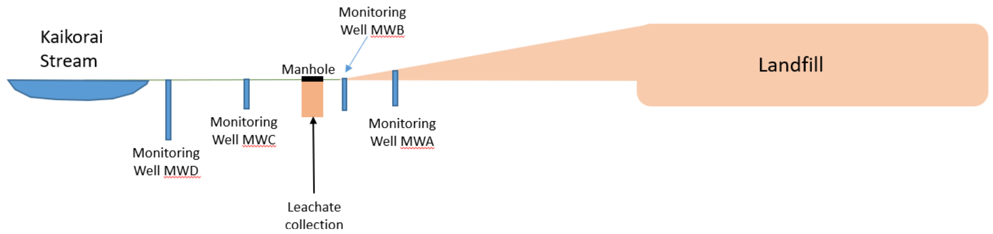

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Figure A-9

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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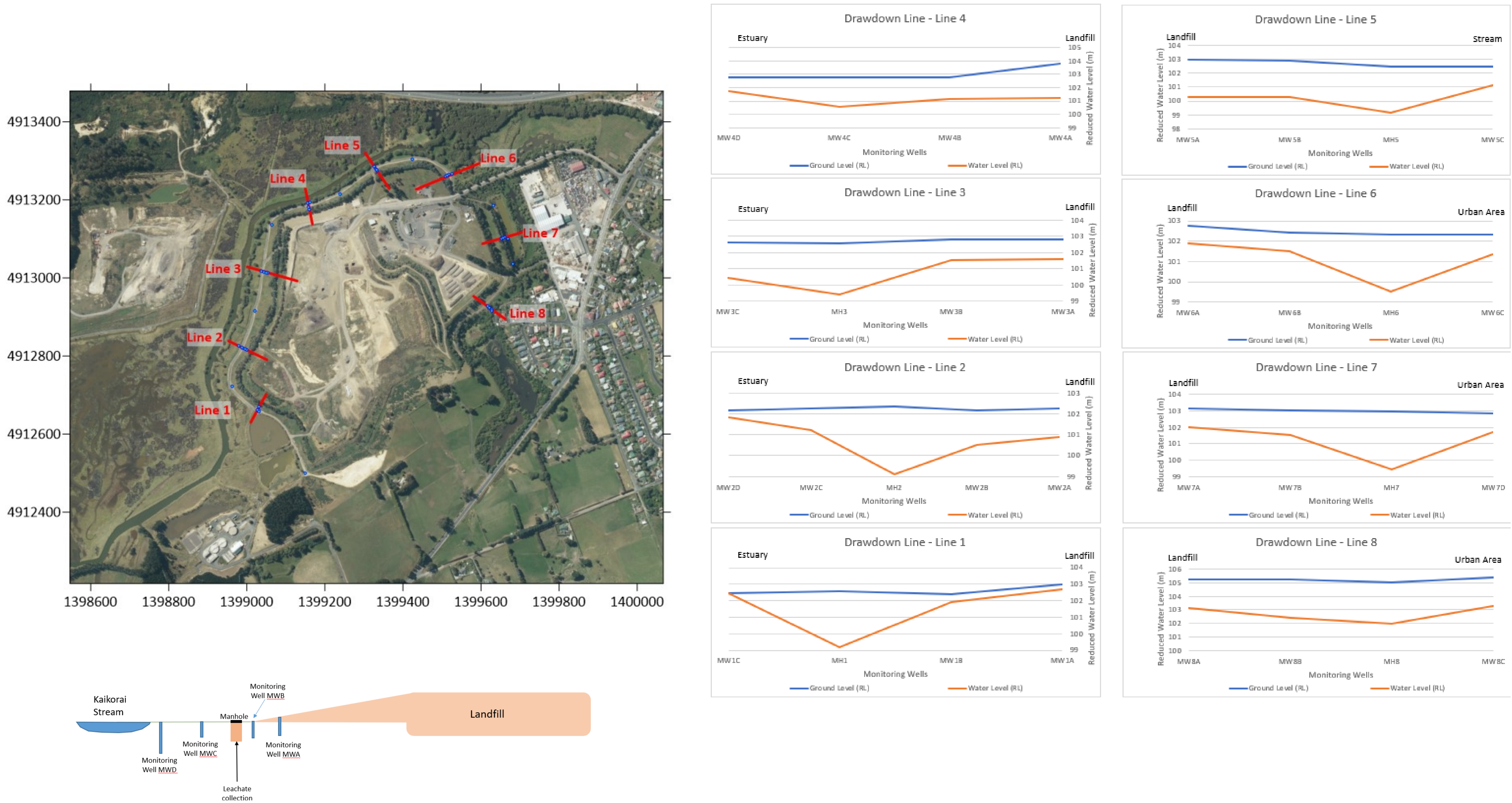

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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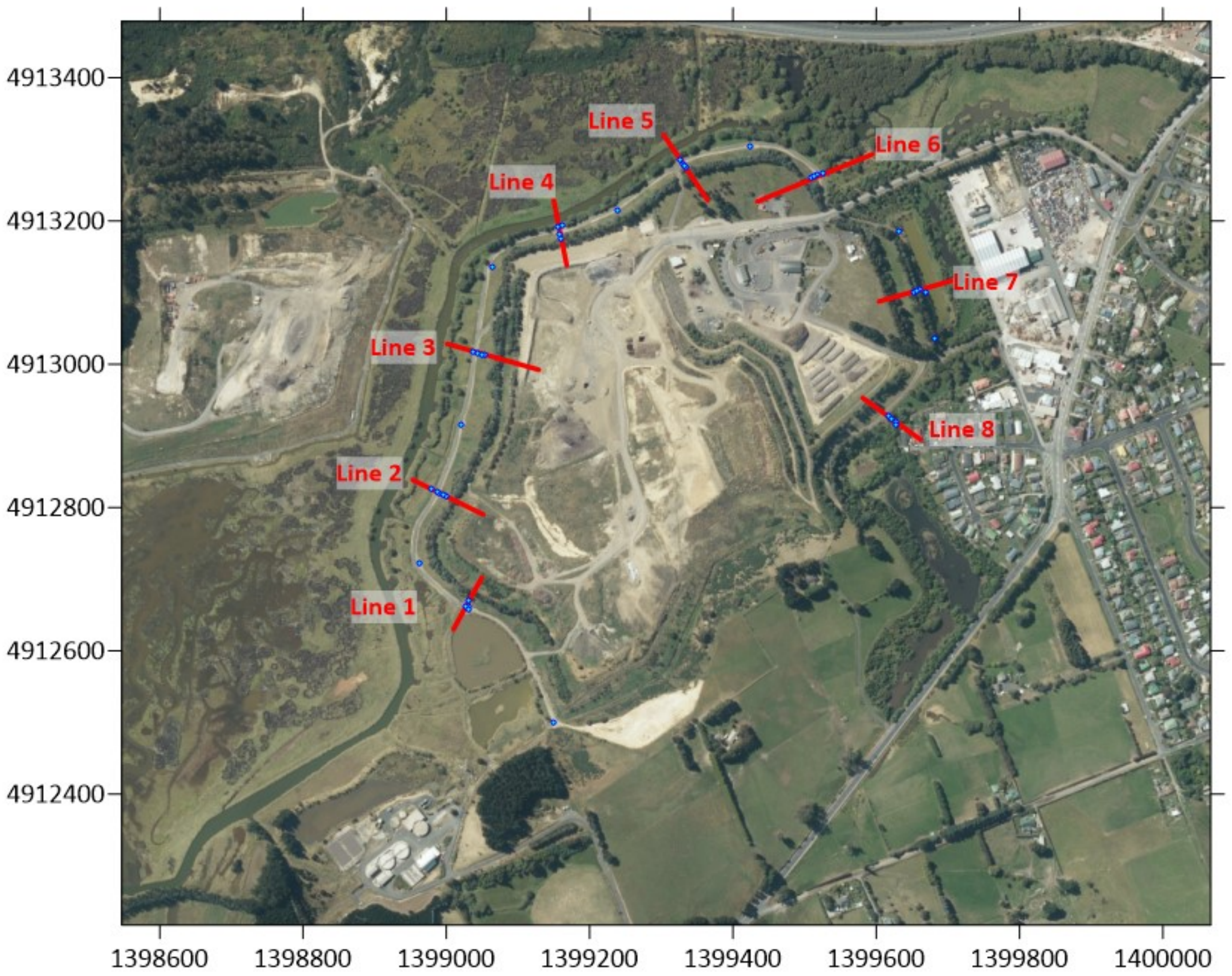
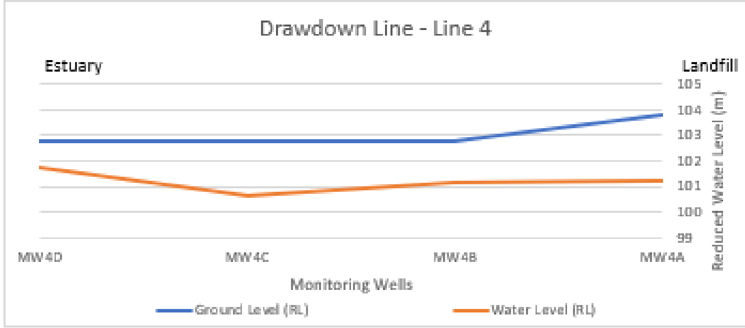
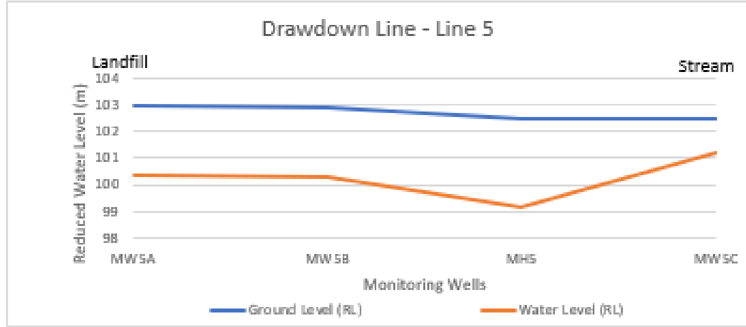
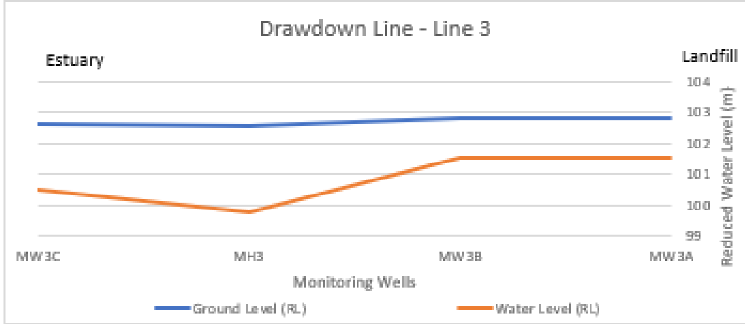
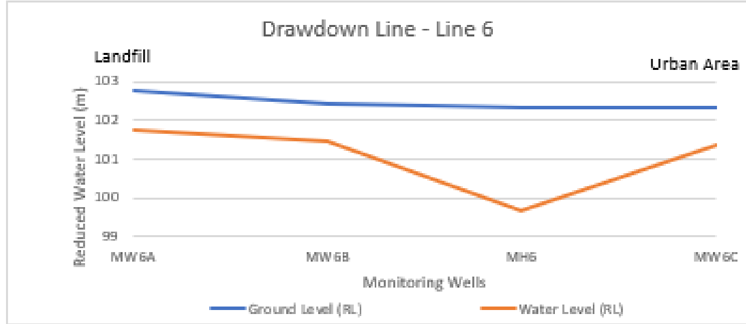
Figure A-10

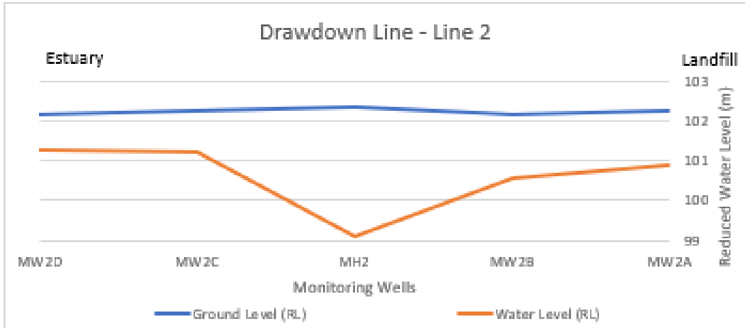


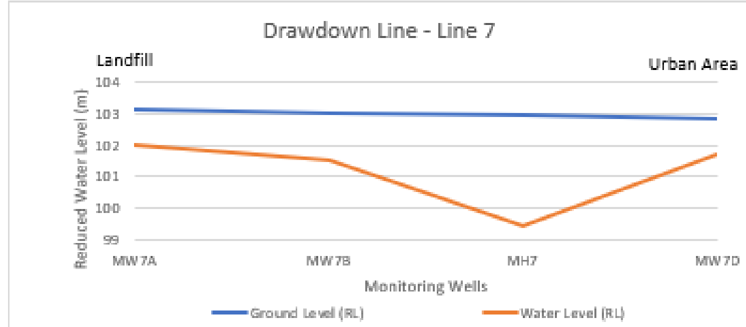


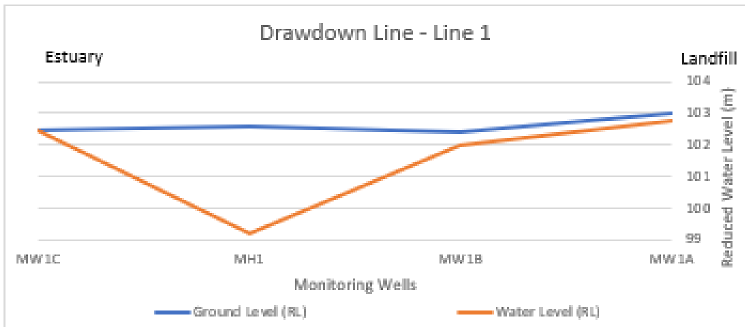


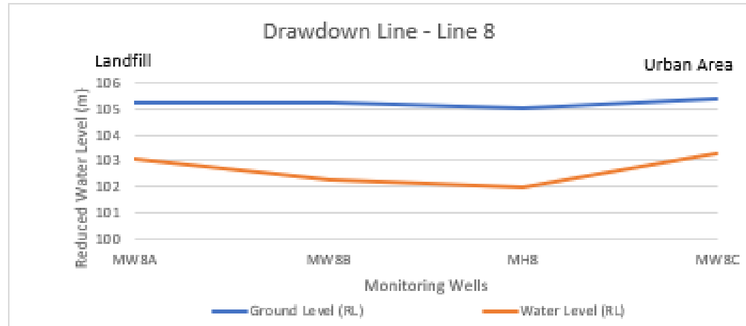


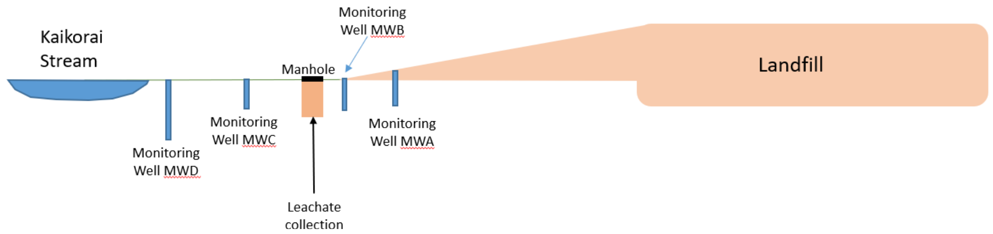












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May 2023

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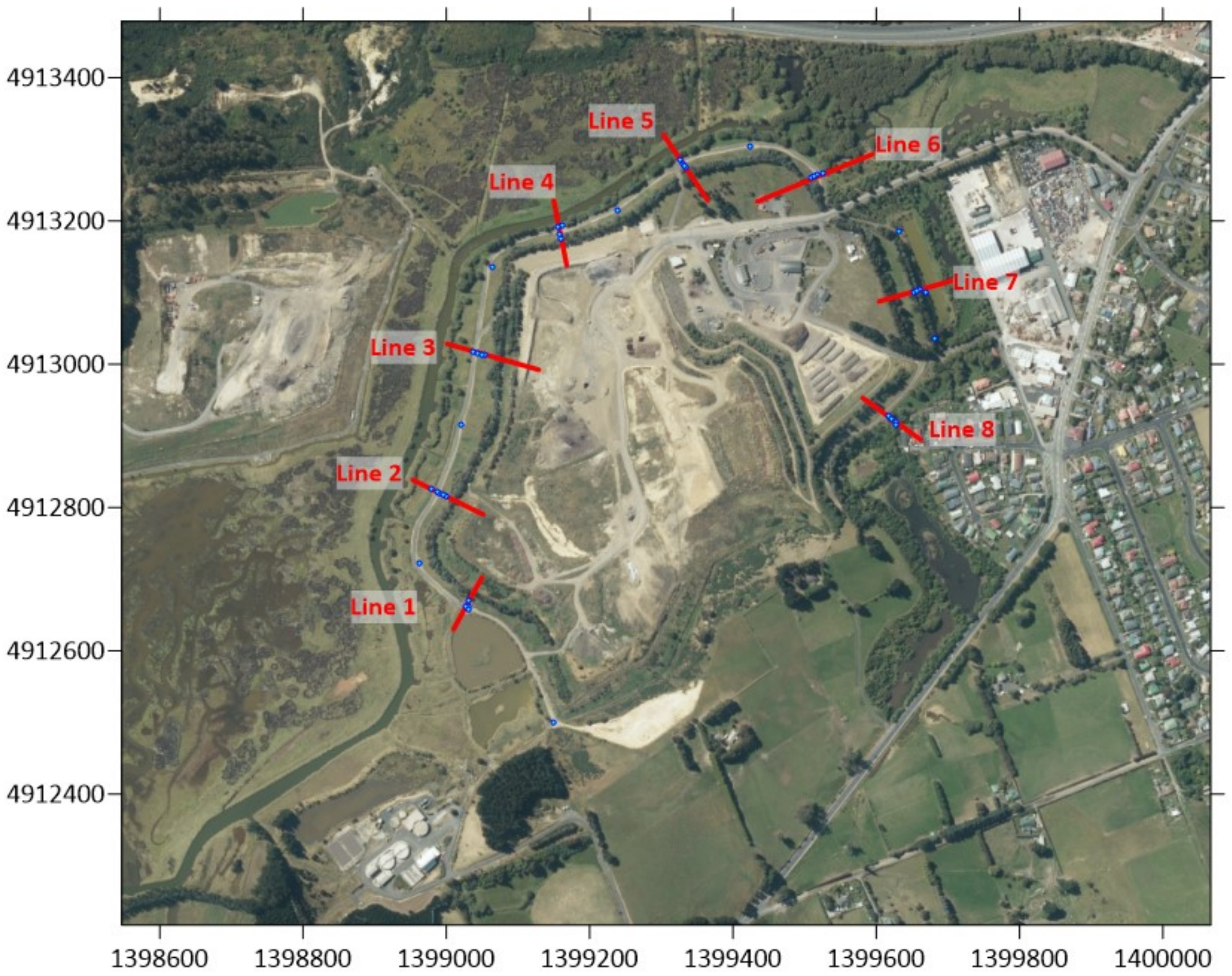
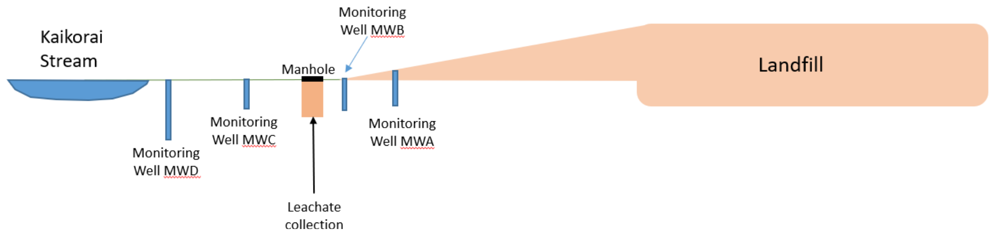
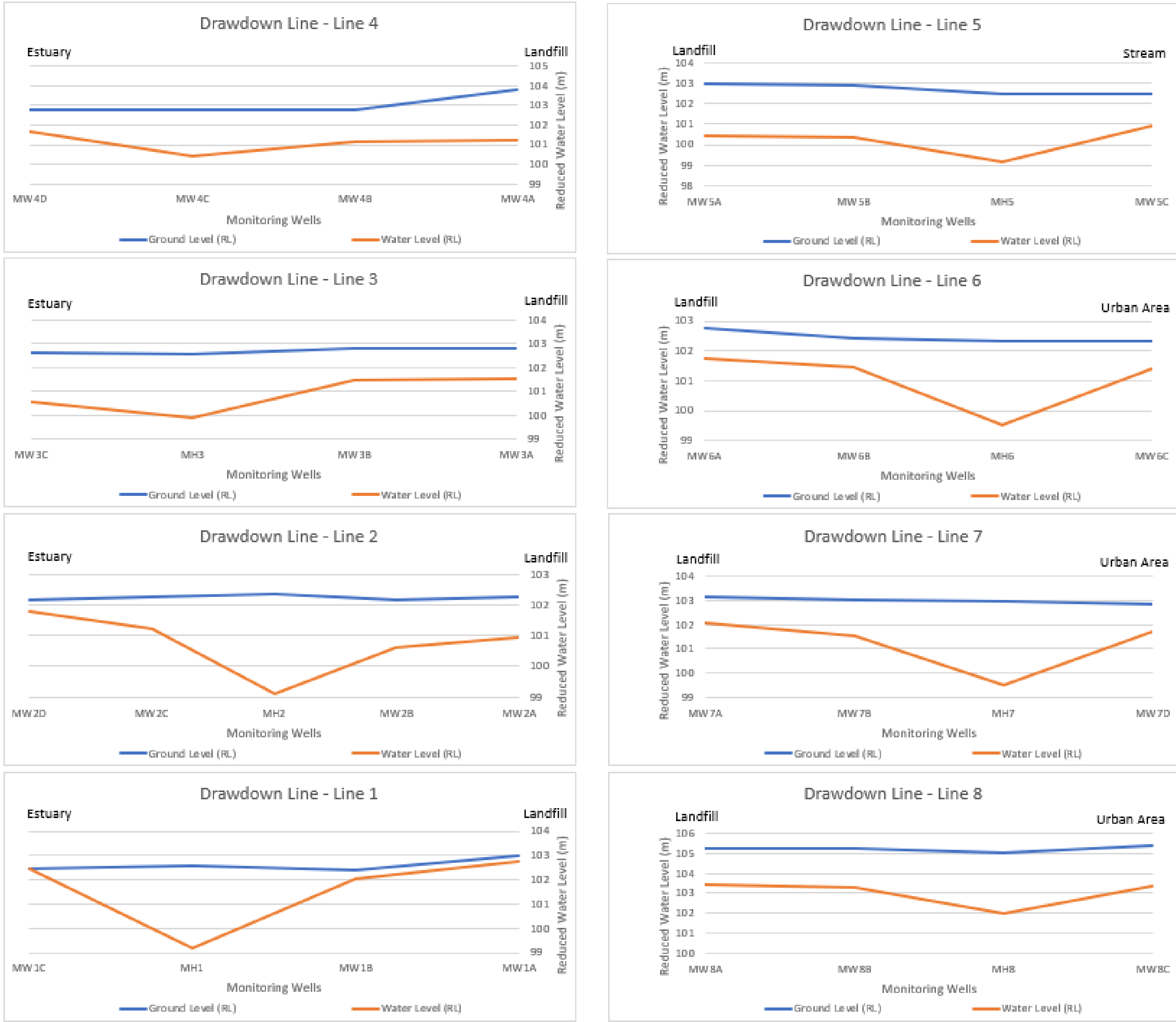
Figure A-11

Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx







Sources: Aerial (LINZ: Aerial Dunedin 0.4m Rural, 2013, NZGD2000) ; Computed using Green_Island_water_levels.xlsb.xlsx

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Figure A-12

Appendix B

Pumps Monitoring Data

Table B1: Green Island Pump Fault Register (July 2022 - June 2023)

This sheet is filled in whenever a pump fault is detected. Faults needing repair should be actioned as soon as possible from the notification of the alarm.

Time of Fault	Date Of Fault	Pump Station Faulting	Cause Of Fault	Time Rectified	Date Rectified	Actions Taken
09.15am	9/07/2022	PS1	High Level	23.12pm	9/07/2022	Checked in morning. Returned to "normal".
11.05M	9/07/2022	PS2	High Level	22.13pm	9/07/2022	Checked in morning. Returned to "normal".
22.14pm	9/07/2022	PS2	High Level	22.21pm	9/07/2022	Checked in morning. Returned to "normal".
15.59pm	12/07/2022	PS2	High Level	23.00pm	13/07/2022	Pump returned to "Normal" after heavy rainfall.
16.11pm	12/07/2022	PS1	High Level	02.03am	17/07/2022	Pump returned to "Normal" after heavy rainfall.
19.45pm	12/07/2022	PS6	High Level	18.28pm	15/07/2022	Pump returned to "Normal" after heavy rainfall.
21.56pm	12/07/2022	PS3	High Level	21.34pm	14/07/2022	Pump returned to "Normal" after heavy rainfall.
22.30pm	12/07/2022	PS5	High Level	06.48am	15/07/2022	Pump returned to "Normal" after heavy rainfall.
00.42am	13/07/2022	PS8	High Level	12.16pm	14/07/2022	Checked in morning. Returned to "normal".
03.39am	13/07/2022	PS4	High Level	05.46am	15/07/2022	Pump returned to "Normal" after heavy rainfall.
10.29am	13/07/2022	PS9	High Level	18.08pm	13/07/2022	Checked in morning. Returned to "normal".
05.00am	26/07/2022	PS1	High Level	13.00pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS2	High Level	13.03pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS3	High Level	13.06pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS4	High Level	13.09pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS5	High Level	13.12pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS6	High Level	13.15pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS7	High Level	13.18pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS8	High Level	13.21pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
05.00am	26/07/2022	PS9	High Level	13.24pm	29/07/2022	Pump returned to "Normal" after heavy rainfall.
10.04am	1/08/2022	PS1	Low Level	10.24am	1/08/2022	Checked in morning. Returned to "normal".
13.11pm	1/08/2022	PS3	Low Level	13.27pm	1/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS1	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS2	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS3	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS4	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS5	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS6	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS7	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS8	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
06.40am	8/08/2022	PS9	Power Outage	06.52am	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS1	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS2	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS3	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS4	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS5	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS6	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS7	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS8	Power Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
17.34pm	8/08/2022	PS9	Powe Outage	18.11pm	8/08/2022	Checked. Returned to "normal".
13.45pm	15/08/2022	PS3	Low Level	13.50pm	15/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS1	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS2	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS3	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS4	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS5	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS6	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS7	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS8	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
06.41am	19/08/2022	PS9	Power Outage	07.04am	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS1	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS2	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS3	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS4	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS5	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS6	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS7	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS8	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
17.35pm	19/08/2022	PS9	Power Outage	17.56pm	19/08/2022	Checked. Returned to "normal".
1:31pm	30/08/2022	PS3	Low Level	1.36pm	30/08/2022	Checked. Returned to "normal".
10.25am	31/08/2022	PS3	Low Level	10.32am	31/08/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS1	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS2	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS3	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS4	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS5	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS6	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS7	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
23.01pm	20/09/2022	PS8	Power Outage	00.33am	21/09/2022	Checked. Returned to "normal".
		PS9				
13.21pm	10/10/2022	PS3	Running Low level	13.36pm	10/10/2022	Checked. Returned to "normal".
09.57am	11/10/2022	PS3	Running Low level	10.24am	11/10/2022	Checked. Returned to "normal".
11.30am	12/10/2022	PS3	Running Low level	11.49am	12/10/2022	Checked. Returned to "normal".
13.21pm	17/10/2022	PS9	High Level	13.25pm	17/10/2022	Checked. Returned to "normal".
10.12am	31/10/2022	PS3	Running Low level	10.19am	31/10/2022	Checked. Returned to "normal".
10.23am	1/11/2022	PS3	Running Low level	10.29am	1/11/2022	Checked. Returned to "normal".
17.03pm	1/11/2022	PS3	Running Low level	17.23pm	1/11/2022	Checked. Returned to "normal".
10.00am	2/11/2022	PS3	Running Low level	10.02am	2/11/2022	Checked. Returned to "normal".
10.57am	22/11/2022	PS3	Running Low level	11.00am	22/11/2022	Checked. Returned to "normal".
09.43am	23/11/2022	PS3	Running Low level	09.45am	23/11/2022	Checked. Returned to "normal".

16.53pm	23/11/2022	PS3	Running Low level	17.00pm	23/11/2022	Checked. Returned to "normal".
14.38pm	25/11/2022	PS3	Running Low level	14.43pm	25/11/2022	Checked. Returned to "normal".
13.12pm	28/11/2022	PS3	Running Low level	13.33pm	28/11/2022	Checked. Returned to "normal".
06.58am	29/11/2022	PS3	Running Low level	13.39pm	29/11/2022	Checked. Returned to "normal".
14.54pm	1/12/2022	PS3	Running Low level	15.21pm	1/12/2022	Checked. Returned to "normal".
14.09pm	5/12/2022	PS1	Running Low level	14.39pm	5/12/2022	Checked. Returned to "normal".
17.28pm	5/12/2022	PS3	Running Low level	18.09pm	5/12/2022	Checked. Returned to "normal".
08.09am	8/12/2022	PS1	Running Low level	08.39am	8/12/2022	Checkd. Returned to "normal".
16.39pm	9/12/2022	PS1	Running Low level	17.10pm	9/12/2022	Checked. Returned to "normal".
09.59am	12/12/2022	PS6	Running Low level	10.43am	13/12/2022	Checked. Returned to "normal".
14.20pm	23/02/2023	PS1	Running Low level	14.35pm	23/02/2023	Checked. Returned to "normal".
9.05am	21/03/2023	PS1	High Level	23.33pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
10.19am	21/03/2023	PS2	High Level	20.44pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
10.52am	21/03/2023	PS2	High Level	20.44pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
10.52am	21/03/2023	PS2	High Level	20.44pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
20.53pm	21/03/2023	PS2	High Level	21.03pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
22.46pm	21/03/2023	PS2	High Level	23.06pm	21/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
00.56am	22/03/2023	PS1	High Level	11.03am	22/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
1.03am	22/03/2023	PS2	High Level	9.42am	22/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
9.48am	22/03/2023	PS2	High Level	9.56am	22/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
13.32pm	22/03/2023	PS1	High Level	14.32pm	22/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
13.42am	22/03/2023	PS2	High Level	13.46pm	22/03/2023	Significant Amount Of Rain. Monitored, "Returned To Normal"
7.55am	23/03/2023	PS3	Running Low level	8.05am	23/03/2023	Checked. Returned to "Normal".
14.12pm	5/04/2023	PS3	Running Low level	14.15pm	5/04/2023	Checked. Returned to "Normal".
14.13pm	21/04/2023	PS3	Running Low Level	14.17pm	21/04/2023	Checked. Returned To "Normal".
16.41pm	21/04/2023	PS3	Running Low level	00.40am	23/04/2023	Checked. Returned To "Normal".
17.24pm	23/04/2023	PS3	Running Low Level	8.09am	24/04/2023	Checked. Returned To "Normal".
14.11pm	7/05/2023	PS3	Running Low level	8.10am	8/05/2023	Checked. Returned To "Normal".
11.57am	8/05/2023	PS6	High Level	12.00pm	8/05/2023	High Level Due To Jetting Of Leachate Lines. "Returned To Norm
13.32pm	8/05/2023	PS3	Running Low level	13.36pm	8/05/2023	Checked. Returned To "Normal".
14.36pm	8/05/2023	PS6	High Level	15.14pm	8/05/2023	High Level Due To Jetting Of Leachate Lines. "Returned To Norm
8.44am	9/05/2023	PS3	Running Low level	8.56am	9/05/2023	Checked. Returned To "Normal".
9.22am	11/05/2023	PS3	Power Failure	9.37am	11/05/2023	SwitchBuild was working on pumpstation which caused power failu
9.38am	11/05/2023	PS3	Power Failure	10.01am	11/05/2023	SwitchBuild was working on pumpstation which caused power failu
17.33pm	14/05/2023	PS1	High Level	20.04pm	14/05/2023	Checked in morning. Returned to "normal".
9.54am	16/05/2023	PS9	Running Low level	10.05am	16/05/2023	SwitchBuild was working on pumpstation causing Low Level.
1.04pm	16/05/2023	PS3	Power Failure	2.16pm	16/05/2023	SwitchBuild was working on pumpstation which caused power failu
10.20am	17/05/2023	PS3	High Level	10.23am	17/05/2023	Checked. Returned To "Normal".
10.24am	17/05/2023	PS3	High Level	10.27am	17/05/2023	Checked. Returned To "Normal".
10.27am	17/05/2023	PS3	High Level	3.01pm	17/05/2023	Checked. Returned To "Normal'.
9.03pm	17/05/2023	PS1	High Level	10.34pm	17/05/2023	Checked in morning. Returned to "normal".
6.03am	18/05/2023	PS3	High Level	11.02am	18/05/2023	Checked. Returned To "Normal".
11.03am	18/05/2023	PS3	High Level	11.23am	18/05/2023	Checked. Returned To "Normal".
11.31am	18/05/2023	PS3	High Level	11.34am	18/05/2023	Checked. Returned To "Normal".
8.57am	19/05/2023	PS3	Running Low level	9.03am	19/05/2023	Checked. Returned To "Normal".
11.32am	19/05/2023	PS3	Running Low level	11.37am	19/05/2023	Checked. Returned To "Normal".
2.09pm	19/05/2023	PS3	Running Low level	2.24pm	19/05/2023	Checked. Returned To "Normal".
3.04pm	19/05/2023	PS3	Running Low level	3.18pm	19/05/2023	Checked. Returned To "Normal".
9.03pm	17/05/2023	PS1	High Level	11.33pm	20/05/2023	Checked. Returned To "Normal".
10.34pm	17/05/2023	PS2	High Level	11.33pm	20/05/2023	Checked. Returned To "Normal".
2.24pm	25/05/2023	PS3	Running Low level	2.40pm	25/05/2023	Checked. Returned To "Normal".
1.54pm	26/05/2023	PS3	Running Low level	2.05pm	26/05/2023	Checked. Returned To "Normal".
9.35am	5/06/2023	PS3	Running Low level	9.40am	5/06/2023	Checked. Returned To "Normal".
11.46am	5/06/2023	PS3	Running Low level	11.52am	5/06/2023	Checked. Returned To "Normal".
2.38pm	5/06/2023	PS3	Running Low level	8.20am	6/06/2023	Checked. Returned To "Normal".
8.34am	19/06/2023	PS1	Running Low level	9.04am	19/06/2023	Checked. Returned To "Normal".
3.04pm	19/06/2023	PS1	Running Low level	3.34pm	19/06/2023	Checked. Returned To "Normal".
8.34am	20/06/2023	PS1	Running Low level	9.34am	20/06/2023	Checked. Returned To "Normal".
11.04am	20/06/2023	PS1	Running Low level	11.34am	20/06/2023	Checked. Returned To "Normal".
8.04am	21/06/2023	PS1	Running Low level	9.34am	21/06/2023	Checked. Returned To "Normal".
12.34pm	22/06/2023	PS1	Running Low level	1.04pm	22/06/2023	Checked. Returned To "Normal".
4.04pm	22/06/2023	PS1	Running Low level	4.35pm	22/06/2023	Checked. Returned To "Normal".
12.34pm	23/06/2023	PS1	Running Low level	1.04pm	23/06/2023	Probe Cable Was Broken. Has Now Been Replaced All Ok.
10.34pm	27/06/2023	PS1	High Level	12.34pm	29/06/2023	High Level Due To Heavy Rainfall. Returned To "Normal".
11.08pm	27/06/2023	PS2	High Level	23.13pm	27/06/2023	High Level Due To Heavy Rainfall. Returned To "Normal".
11.21pm	27/06/2023	PS2	High Level	9.30am	28/06/2023	High Level Due To Heavy Rainfall. Returned To "Normal".
9.30am	28/06/2023	PS2	High Level	12.28pm	29/06/2023	High Level Due To Heavy Rainfall. Returned To "Normal".
10.51am	28/06/2023	PS3	Low Level	10.55am	28/06/2023	Checked Returned To "Normal".

Table B2: Green Island Landfill Leachate - Overflow Events, High Alarm Levels and Pump Faults (July 2022 - June 2023)

Event Number	Dates	Pump Station	Alarm Type	Hi Level Alarm	Return to Normal	Event Duration (hrs)	Rain Day	Daily Rain (mm)	Stream Staff Peak (when avail)	Commentary	Photo Records
2022_19	27 to 29 Jun	Leachate 2	High Level	27/06/2023 23:08	29/06/2023 12:28	37.3	27-Jun	23.8		Moderate 2 day rain event - no issues.	
		Leachate 1	High Level	27/06/2023 22:34	29/06/2023 12:34	38.0	28-Jun	4			
2022_18	25 May to 28 Jun	Leachate 3	Pump Running and Low Level	28/06/2023 10:51	28/06/2023 10:51	0.0				Various similar Pump Low Level alarms. PS1 probe cable was replaced 23 Jun which fixed this recurring false alarm. Recurring foaming of PS3 and false reporting. Inspections undertaken at the individual PS time to confim.	
		Leachate 1	Pump Running and Low Level	23/06/2023 12:34	23/06/2023 13:04	0.5					
		Leachate 1	Pump Running and Low Level	22/06/2023 16:04	22/06/2023 16:35	0.5					
		Leachate 1	Pump Running and Low Level	22/06/2023 12:34	22/06/2023 13:04	0.5					
		Leachate 1	Pump Running and Low Level	21/06/2023 8:04	21/06/2023 9:34	1.5					
		Leachate 1	Pump Running and Low Level	20/06/2023 11:04	20/06/2023 11:34	0.5					
		Leachate 1	Pump Running and Low Level	20/06/2023 8:34	20/06/2023 9:34	1.0					
		Leachate 1	Pump Running and Low Level	19/06/2023 15:04	19/06/2023 15:34	0.5					
		Leachate 1	Pump Running and Low Level	19/06/2023 8:34	19/06/2023 9:04	0.5					
		Leachate 3	Pump Running and Low Level	5/06/2023 14:38	6/06/2023 8:20	17.7					
		Leachate 3	Pump Running and Low Level	5/06/2023 11:46	5/06/2023 11:52	0.1					
		Leachate 3	Pump Running and Low Level	5/06/2023 9:35	5/06/2023 9:40	0.1					
		Leachate 3	Pump Running and Low Level	26/05/2023 13:54	26/05/2023 14:05	0.2					
		Leachate 3	Pump Running and Low Level	25/05/2023 14:24	25/05/2023 14:30	0.1					
2022_17	17 to 20 May	Leachate 3	High Level	18/05/2023 6:03	19/05/2023 15:18	33.3	14-May	23.6		Moderate event. Evreything working as expected given **69.8mm rain** over that 6 day period.	
		Leachate 2	High Level	17/05/2023 22:34	20/05/2023 23:33	73.0	17-May	33.8			
		Leachate 1	High Level	17/05/2023 21:03	20/05/2023 23:33	74.5	18-May	3.4			
		Leachate 3	High Level	17/05/2023 10:20	17/05/2023 15:01	4.7	19-20 May	9			
2022_16	14-May	Leachate 1	High Level	14/05/2023 17:33	14/05/2023 20:04	2.5	4 days prior	11.6		Minor event - Normal response.	
2022_15	11-May & 16 May	Leachate 3	Power Failure	16/05/2023 13:04	16/05/2023 14:16	1.2				Power turned OFF for initital inspeciton and then changing of Flowmeter	
		Leachate 3	Power Failure	11/05/2023 9:22	11/05/2023 10:01	0.6					
2022_14	8-May	Leachate 6	High Level	8/05/2023 14:36	8/05/2023 15:14	0.6				Jetting of Leachate Lines to PS5 were dumped into PS6 causing High Level	
		Leachate 6	High Level	8/05/2023 11:57	8/05/2023 12:00	0.0					
2022_13	23-Mar to 16-May	Leachate 9	Pump Running and Low Level	16/05/2023 9:54	16/05/2023 10:05	0.2				Various similar Pump Low Level alarms. Recurring foaming of PS3 and false reporting. Inspections undertaken at the individual PS time to confim.	
		Leachate 3	Pump Running and Low Level	15/05/2023 11:23	15/05/2023 11:39	0.3					
		Leachate 3	Pump Running and Low Level	9/05/2023 8:44	9/05/2023 8:56	0.2					
		Leachate 3	Pump Running and Low Level	8/05/2023 13:32	8/05/2023 13:36	0.1					
		Leachate 3	Pump Running and Low Level	7/05/2023 14:11	8/05/2023 8:10	18.0					
		Leachate 3	Pump Running and Low Level	23/04/2023 17:24	24/04/2023 8:09	14.8					
		Leachate 3	Pump Running and Low Level	21/04/2023 16:41	23/04/2023 0:40	32.0					
		Leachate 3	Pump Running and Low Level	21/04/2023 14:13	21/04/2023 14:17	0.1					
		Leachate 3	Pump Running and Low Level	5/04/2023 14:12	5/04/2023 14:15	0.0					
		Leachate 3	Pump Running and Low Level	23/03/2023 7:55	23/03/2023 8:05	0.2					
2022_12	21-Mar	Leachate 2	High Level	21/03/2023 10:19	22/03/2023 13:46	27.4	20-Mar	18.2		Moderate event. Normal response.	
		Leachate 1	High Level	21/03/2023 9:05	22/03/2023 14:32	29.5	21-Mar	13			
2022_11	5-Dec to 8-Mar	Leachate 6	Pump Running and Low Level	8/03/2023 14:38	8/03/2023 14:51	0.2				Various similar Pump Low Level alarms. Recurring foaming of PS3 and false reporting. Inspections undertaken at the individual PS time to confim.	
		Leachate 1	Pump Running and Low Level	7/03/2023 9:32	7/03/2023 10:03	0.5					
		Leachate 3	Pump Running and Low Level	27/02/2023 11:16	27/02/2023 11:40	0.4					
		Leachate 6	Pump Running and Low Level	13/12/2022 9:59	13/12/2022 10:43	0.7					
		Leachate 1	Pump Running and Low Level	12/12/2022 8:40	12/12/2022 9:09	0.5					
		Leachate 1	Pump Running and Low Level	9/12/2022 16:39	9/12/2022 17:10	0.5					
		Leachate 1	Pump Running and Low Level	8/12/2022 8:09	8/12/2022 8:39	0.5					
		Leachate 3	Pump Running and Low Level	5/12/2022 17:28	5/12/2022 18:09	0.7					
		Leachate 1	Pump Running and Low Level	5/12/2022 14:09	5/12/2022 14:39	0.5					
2022_10	10-Oct to 1 Dec	Leachate 3	Pump Running and Low Level	1/12/2022 14:54	1/12/2022 15:21	0.5				Recurring Foaming of PS3 and false reporting. Inspections undertaken each time to confim.	
		Leachate 3	Pump Running and Low Level	29/11/2022 6:58	29/11/2022 13:39	6.7					
		Leachate 3	Pump Running and Low Level	28/11/2022 13:12	28/11/2022 13:33	0.3					
		Leachate 3	Pump Running and Low Level	25/11/2022 14:38	25/11/2022 14:43	0.1					
		Leachate 3	Pump Running and Low Level	23/11/2022 16:53	23/11/2022 17:00	0.1					
		Leachate 3	Pump Running and Low Level	23/11/2022 9:43	23/11/2022 9:45	0.0					
		Leachate 3	Pump Running and Low Level	2/11/2022 10:00	2/11/2022 10:02	0.0					
		Leachate 3	Pump Running and Low Level	2/11/2022 17:03	2/11/2022 17:23	0.3					
		Leachate 3	Pump Running and Low Level	2/11/2022 10:23	2/11/2022 10:29	0.1					
		Leachate 3	Pump Running and Low Level	10/12/2022 11:38	10/12/2022 11:49	0.2					
		Leachate 3	Pump Running and Low Level	10/11/2022 9:57	10/11/2022 10:24	0.4					
		Leachate 3	Pump Running and Low Level	10/10/2022 13:21	10/10/2022 13:36	0.2					
2022_9	17-Oct	Leachate 9	High Level	17/10/2022 13:21	17/10/2022 13:25	0.1	N/A			Inspected - no issues	
2022_8	20-Sep	Leachate 5	Power Failure	20/09/2022 23:17	21/09/2022 0:48	1.5				UNPLANNED POWER OUTGAGE. All pumpstations came back on as expected. Walkover undertaken, all systems OK	
		Leachate 2	Power Failure	20/09/2022 23:08	21/09/2022 0:38	1.5					
		Leachate 3	Power Failure	20/09/2022 23:08	21/09/2022 0:38	1.5					
		Leachate 1	Power Failure	20/09/2022 23:04	21/09/2022 0:34	1.5					
		Leachate 7	Power Failure	20/09/2022 23:03	21/09/2022 0:33	1.5					
		Leachate 6	Power Failure	20/09/2022 23:02	21/09/2022 0:41	1.7					
		Leachate 8	Power Failure	20/09/2022 23:01	21/09/2022 0:34	1.5					
		Leachate 4	Power Failure	20/09/2022 23:01	21/09/2022 0:33	1.5					
2022_7	30-Aug to 12-Sep	Leachate 3	Pump Running and Low Level	12/09/2022 4:32	12/09/2022 11:57	7.4				Inspections followed, foaming in PS, operating as per normal.	
		Leachate 3	Pump Running and Low Level	31/08/2022 10:25	31/08/2022 10:32	0.1					
		Leachate 3	Pump Running and Low Level	30/08/2022 13:31	30/08/2022 13:36	0.1					
2022_6	19-Aug	Leachate 2	Power Failure	19/08/2022 17:38	19/08/2022 17:56	0.3				PLANNED POWER OUTGAGE. Temporary generator was set up on site to power pump stations during this period.	
		Leachate 9	Power Failure	19/08/2022 17:35	19/08/2022 17:40	0.1					
		Leachate 4	Power Failure	19/08/2022 6:54	19/08/2022 17:35	10.7					
		Leachate 8	Power Failure	19/08/2022 6:39	19/08/2022 7:04	0.4					
		Leachate 6	Power Failure	19/08/2022 6:39	19/08/2022 17:35	10.9					
		Leachate 3	Power Failure	19/08/2022 6:39	19/08/2022 17:35	10.9					
		Leachate 5	Power Failure	19/08/2022 6:39	19/08/2022 17:35	10.9					
2022_5	8-Aug	Leachate 7	Power Failure	8/08/2022 17:33	8/08/2022 17:33	0.0				PLANNED POWER OUTGAGE. Temporary generator was set up on site to power pump stations during this period.	
		Leachate 8	Power Failure	8/08/2022 6:54	8/08/2022 7:03	0.1					
		Leachate 6	Power Failure	8/08/2022 6:41	8/08/2022 18:11	11.5					
		Leachate 2	Power Failure	8/08/2022 6:39	8/08/2022 18:09	11.5					
		Leachate 4	Power Failure	8/08/2022 6:39	8/08/2022 18:09	11.5					
		Leachate 9	Power Failure	8/08/2022 6:39	8/08/2022 17:41	11.0					
		Leachate 3	Power Failure	8/08/2022 6:39	8/08/2022 17:57	11.3					
2022_4	1-Aug	Leachate 3	Pump Running and Low Level	1/08/2022 13:11	1/08/2022 13:27	0.3				Inspections followed - no issues	
		Leachate 1	Pump Running and Low Level	1/08/2022 10:04	1/08/2022 11:33	1.5					
		Leachate 1	Pump Running and Low Level	1/08/2022 8:33	1/08/2022 9:03	0.5					
2022_3	26 Jul to 30 July	Leachate 4	High Level	26/07/2022 22:43	30/07/2022 2:24	75.7	25-Jul	21.2		**MAJOR OTAGO EVENT. 97.0mm RAI**N. PS3 -PS6 inundated by Kaikorai Stream for a period late on 26th. 13th. All systems operating continuously for 2 days to 4.5 days	YES
		Leachate 8	High Level	26/07/2022 22:41	28/07/2022 23:04	48.4	26-Jul	52.2			
		Leachate 3	High Level	26/07/2022 16:11	29/07/2022 13:24	69.2	27-Jul	21.2			
		Leachate 5	High Level	26/07/2022 15:08	29/07/2022 7:21	64.2	28-Jul	1.8			
		Leachate 6	High Level	26/07/2022 8:07	29/07/2022 23:33	87.4	29-Jul	0.6			
		Leachate 2	High Level	26/07/2022 6:22	30/07/2022 18:38	108.3					
		Leachate 1	High Level	26/07/2022 5:03	30/07/2022 19:03	110.0					
2022_2	12 Jul to 17 Jul	Leachate 4	High Level	13/07/2022 3:39	15/07/2022 5:46	50.1	11-Jul	1.4		**MAJOR OTAGO EVENT. 102.4mm RAIN.** PS3 -PS6 inundated by Kaikorai Stream for a period late on 12th, early 13th. All systems operating continuously for 2 days to 4.5 days	YES
		Leachate 8	High Level	13/07/2022 0:42	14/07/2022 12:16	35.6	12-Jul	65.6			
		Leachate 5	High Level	12/07/2022 22:30	15/07/2022 6:57	56.4	13-Jul	32.0			
		Leachate 3	High Level	12/07/2022 21:56	14/07/2022 22:09	48.2	14-Jul	2.2			
		Leachate 6	High Level	12/07/2022 19:45	15/07/2022 18:28	70.7	15-Jul	1.2			
		Leachate 1	High Level	12/07/2022 16:11	17/07/2022 2:03	105.9					
		Leachate 2	High Level	12/07/2022 15:59	17/07/2022 1:48	105.8					
2022_1	9 Jul	Leachate 2	High Level	9/07/2022 11:05	9/07/2022 22:21	11.3	3 day total	23.6		Minor event - Normal response	
		Leachate 1	High Level	9/07/2022 9:15	9/07/2022 23:12	13.9					

Site Name: Green Island Landfill

Table B3-1: Pump Stations Cumulative Net Flow Data

Cumulative Net Flow from 30 June 2022 (M3)																									
Date	30-Jun-22	12-Jul-22	29-Jul-22	1-Aug-22	9-Aug-22	15-Aug-22	23-Aug-22	29-Aug-22	12-Sep-22	19-Sep-22	26-Sep-22	3-Oct-22	10-Oct-22	17-Oct-22	23-Oct-22	1-Nov-22	7-Nov-22	16-Nov-22	21-Nov-22	28-Nov-22	7-Dec-22	12-Dec-22	23-Dec-22	29-Dec-22	5-Jan-23
Station No																									
PS1	6202	639	3958	5075	6415	7136	7733	8023	8380	9169	9377	9626	10428	10897	11224	11719	11915	12071	12244	12405	12630	12775	13069	13247	13395
PS2	8935	1283	2817	4100	4141	4141	4145	4145	4146	4164	4188	4217	4565	4605	4606	4606	4606	4606	4606	4606	4606	4606	4607	4607	4607
PS3	3175	215	2160	2418	2702	2873	3035	3124	3495	3543	3605	3679	3781	3848	3914	4035	4085	4168	4220	4295	4360	4388	4461	4503	4550
PS4	3809	159	1483	1788	2009	2148	2305	2394	2581	2700	2815	2919	3028	3138	3220	3330	3414	3511	3561	3627	3699	3749	3847	3906	3967
PS5	9965	583	2927	3267	3794	4054	4316	4510	4863	5065	5213	5384	5812	5988	6313	6746	7041	7346	7514	7737	8002	8167	8326	8428	8524
PS6	7295	216	1734	2039	2502	2796	3118	3319	3741	3933	4112	4288	4470	4651	4653	4669	4675	4675	4692	4693	4698	4704	4876	4984	5088
PS7	7766	187	2047	2279	2640	2831	3045	3180	3460	3589	3706	3819	3946	4068	4159	4300	4396	4524	4601	4701	4813	4872	4988	5063	5130
PS8	4144	144	2257	2510	2819	3011	3223	3360	3648	3779	3903	4019	4146	4257	4342	4470	4546	4648	4702	4773	4856	4900	4987	5043	5095
PS9	2.46	0	30	34	38	40	43	45	48	49	51	52	54	55	55	56	57	58	59	60	61	61	62	62	63
Total	51293.46	3426.00	19413.00	23510.00	27060.00	29030.00	30963.00	32100.00	34362.00	35991.00	36970.00	38003.00	40230.00	41507.00	42486.00	43931.00	44735.00	45607.00	46199.00	46897.00	47725.00	48222.00	49223.00	49843.00	50419.00

Cumulative Net Flow from 30 June 2022 (M3)																								
Date	12-Jan-23	16-Jan-23	25-Jan-23	31-Jan-23	7-Feb-23	13-Feb-23	21-Feb-23	27-Feb-23	8-Mar-23	13-Mar-23	24-Mar-23	27-Mar-23	4-Apr-23	11-Apr-23	17-Apr-23	28-Apr-23	1-May-23	9-May-23	17-May-23	22-May-23	31-May-23	15-Jun-23	23-Jun-23	29-Jun-23
Station No																								
PS1	13642	13743	14002	14083	14154	14213	14273	14625	14960	15087	16487	16700	17574	17781	18240	18907	19033	19302	20470	22880	24094	24954	25398	26494
PS2	4607	4607	4607	4607	4607	4609	4623	4650	4676	4689	5588	5588	5591	5591	5591	5591	5591	5601	5678	7116	7116	7116	7116	7922
PS3	4605	4621	4679	4725	4773	4805	4846	4913	4955	4993	4999	5039	5615	6358	6498	6949	7325	7702	8000	540	726	942	1029	1234
PS4	4029	4067	4148	4202	4270	4322	4401	4467	4552	4598	4819	4870	4975	5053	5130	5241	5277	5357	5456	5691	5851	6022	6117	6213
PS5	8646	8699	8822	8912	9013	9093	9196	9360	9539	9628	10079	10288	10531	10685	10885	11210	11280	11444	11880	12578	13016	13427	13612	13913
PS6	5196	5251	5378	5468	5572	5654	5758	5856	5991	6054	6262	6316	6454	6564	6676	6899	6976	7161	7343	7600	7909	8305	8487	8652
PS7	5203	5239	5317	5370	5429	5481	5548	5657	5748	5796	6088	6150	6270	6364	6473	6644	6688	6792	6922	7175	7377	7640	7767	7893
PS8	5149	5177	5240	5281	5326	5362	5407	5482	5568	5617	6095	6160	6276	6350	6427	6557	6594	6678	6808	7211	7378	7628	7750	7908
PS9	64	64	65	65	65	66	67	67	68	68	69	69	70	71	71	74	74	74						
Total	51141.00	51468.00	52258.00	52713.00	53209.00	53605.00	54119.00	55077.00	56057.00	56530.00	60486.00	61180.00	63356.00	64817.00	65991.00	68072.00	68838.00	70111.00	72557.00	70791.00	73467.00	76034.00	77276.00	80229.00

Table B3-2: Pump Stations Net Flow Between Readings

Net Flow Between Readings from 30 June 2022 (M3)																									
Date	30-Jun-22	12-Jul-22	29-Jul-22	1-Aug-22	9-Aug-22	15-Aug-22	23-Aug-22	29-Aug-22	12-Sep-22	19-Sep-22	26-Sep-22	3-Oct-22	10-Oct-22	17-Oct-22	23-Oct-22	1-Nov-22	7-Nov-22	16-Nov-22	21-Nov-22	28-Nov-22	7-Dec-22	12-Dec-22	23-Dec-22	29-Dec-22	5-Jan-23
PS1	360	639	3319	1117	1340	721	597	290	357	789	208	249	802	469	327	495	196	156	173	161	225	145	294	178	148
PS2	36	1283	1534	1283	41	0	4	0	1	18	24	29	348	40	1	0	0	0	0	0	0	0	1	0	0
PS3	77	215	1945	258	284	171	162	89	371	48	62	74	102	67	66	121	50	83	52	75	65	28	73	42	47
PS4	102	159	1324	305	221	139	157	89	187	119	115	104	109	110	82	110	84	97	50	66	72	50	98	59	61
PS5	232	583	2344	340	527	260	262	194	353	202	148	171	428	176	325	433	295	305	168	223	265	165	159	102	96
PS6	138	216	1518	305	463	294	322	201	422	192	179	176	182	181	2	16	6	0	17	1	5	6	172	108	104
PS7	111	187	1860	232	361	191	214	135	280	129	117	113	127	122	91	141	96	128	77	100	112	59	116	75	67
PS8	92	144	2113	253	309	192	212	137	288	131	124	116	127	111	85	128	76	102	54	71	83	44	87	56	52
PS9	0	0	30	4	4	2	3	2	3	1	2	1	2	1	0	1	1	1	1	1	1	0	1	0	1
Total	1148	3426	15987	4097	3550	1970	1933	1137	2262	1629	979	1033	2227	1277	979	1445	804	872	592	698	828	497	1001	620	576

Net Flow Between Readings from 30 June 2022 (M3)																								
Date	12-Jan-23	16-Jan-23	25-Jan-23	31-Jan-23	7-Feb-23	13-Feb-23	21-Feb-23	27-Feb-23	8-Mar-23	13-Mar-23	24-Mar-23	27-Mar-23	4-Apr-23	11-Apr-23	17-Apr-23	28-Apr-23	1-May-23	9-May-23	17-May-23	22-May-23	31-May-23	15-Jun-23	23-Jun-23	29-Jun-23
PS1	247	101	259	81	71	59	60	352	335	127	1400	213	874	207	459	667	126	269	1168	2410	1214	860	444	1096
PS2	0	0	0	0	0	2	14	27	26	13	899	0	3	0	0	0	0	10	77	1438	0	0	0	806
PS3	55	16	58	46	48	32	41	67	42	38	6	40	576	743	140	451	376	377	298	540	186	216	87	205
PS4	62	38	81	54	68	52	79	66	85	46	221	51	105	78	77	111	36	80	99	235	160	171	95	96
PS5	122	53	123	90	101	80	103	164	179	89	451	209	243	154	200	325	70	164	436	698	438	411	185	301
PS6	108	55	127	90	104	82	104	98	135	63	208	54	138	110	112	223	77	185	182	257	309	396	182	165
PS7	73	36	78	53	59	52	67	109	91	48	292	62	120	94	109	171	44	104	130	253	202	263	127	126
PS8	54	28	63	41	45	36	45	75	86	49	478	65	116	74	77	130	37	84	130	403	167	250	122	158
PS9	1	0	1	0	0	1	1	0	1	0	1	0	1	1	0	3	0	0	0	0	0	0	0	0
Total	722	327	790	455	496	396	514	958	980	473	3956	694	2176	1461	1174	2081	766	1273	2520	6234	2676	2567	1242	2953

Table B3-3: Pump Stations Flow Rate Between Readings

Flow Rate Between Readings from 30 June 2022 (Litres/second)																									
Date	30-Jun-22	12-Jul-22	29-Jul-22	1-Aug-22	9-Aug-22	15-Aug-22	22-Aug-22	29-Aug-22	12-Sep-22	19-Sep-22	26-Sep-22	3-Oct-22	10-Oct-22	17-Oct-22	23-Oct-22	1-Nov-22	7-Nov-22	16-Nov-22	21-Nov-22	28-Nov-22	7-Dec-22	12-Dec-22	23-Dec-22	29-Dec-22	5-Jan-23
PS1	0.417	0.616	2.260	4.309	1.939	1.391	0.864	0.559	0.295	1.305	0.344	0.412	1.326	0.775	0.631	0.637	0.378	0.201	0.400	0.266	0.289	0.336	0.309	0.343	0.245
PS2	0.042	1.237	1.044	4.950	0.059	0.000	0.006	0.000	0.001	0.030	0.040	0.048	0.575	0.066	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
PS3	0.089	0.207	1.324	0.995	0.411	0.330	0.234	0.172	0.307	0.079	0.103	0.122	0.169	0.111	0.127	0.156	0.096	0.107	0.120	0.124	0.084	0.065	0.077	0.081	0.078
PS4	0.118	0.153	0.901	1.177	0.320	0.268	0.227	0.172	0.155	0.197	0.190	0.172	0.180	0.182	0.158	0.141	0.162	0.125	0.116	0.109	0.093	0.116	0.103	0.114	0.101
PS5	0.269	0.562	1.596	1.312	0.762	0.502	0.379	0.374	0.292	0.334	0.245	0.283	0.708	0.291	0.627	0.557	0.569	0.392	0.389	0.369	0.341	0.382	0.167	0.197	0.159
PS6	0.160	0.208	1.033	1.177	0.670	0.567	0.466	0.388	0.349	0.317	0.296	0.291	0.301	0.299	0.004	0.021	0.012	0.000	0.039	0.002	0.006	0.014	0.181	0.208	0.172
PS7	0.128	0.180	1.266	0.895	0.522	0.368	0.310	0.260	0.231	0.213	0.193	0.187	0.210	0.202	0.176	0.181	0.185	0.165	0.178	0.165	0.144	0.137	0.122	0.145	0.111
PS8	0.106	0.139	1.439	0.976	0.447	0.370	0.307	0.264	0.238	0.217	0.205	0.192	0.210	0.184	0.164	0.165	0.147	0.131	0.125	0.117	0.107	0.102	0.092	0.108	0.086
PS9	0.000	0.000	0.020	0.015	0.006	0.004	0.004	0.004	0.002	0.002	0.003	0.002	0.003	0.002	0.000	0.001	0.002	0.001	0.002	0.002	0.001	0.000	0.001	0.000	0.002
Total	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42

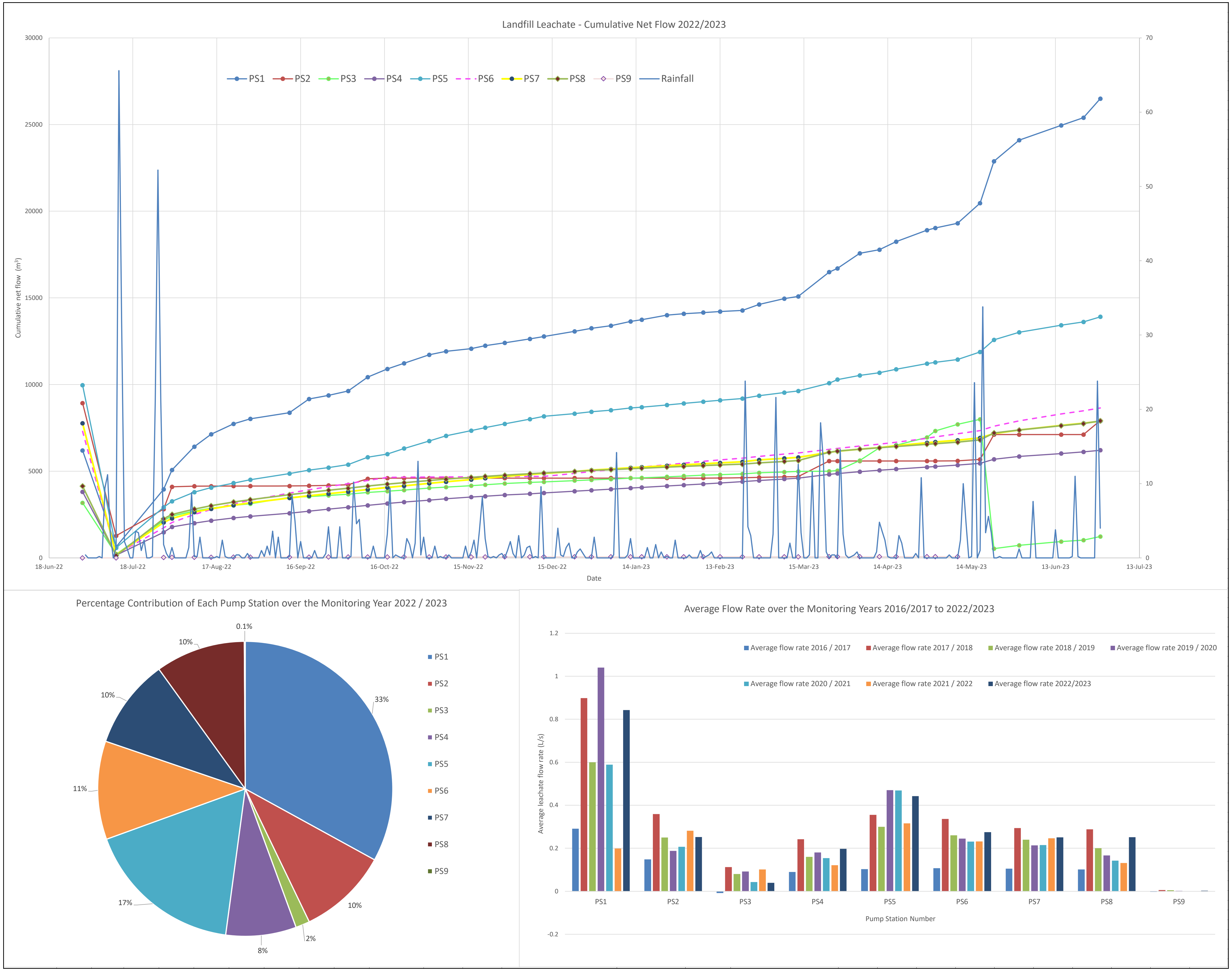
Flow Rate Between Readings from 30 June 2022 (Litres/second)																								
Date	12-Jan-23	16-Jan-23	25-Jan-23	31-Jan-23	7-Feb-23	13-Feb-23	21-Feb-23	27-Feb-23	8-Mar-23	13-Mar-23	24-Mar-23	27-Mar-23	4-Apr-23	11-Apr-23	17-Apr-23	28-Apr-23	1-May-23	9-May-23	17-May-23	22-May-23	31-May-23	15-Jun-23	23-Jun-23	29-Jun-23
PS1	0.408	0.292	0.333	0.156	0.117	0.114	0.087	0.679	0.431	0.294	1.473	0.822	1.264	0.342	0.885	0.702	0.486	0.389	1.690	5.579	1.561	0.664	0.642	2.114
PS2	0.000	0.000	0.000	0.000	0.000	0.004	0.020	0.052	0.033	0.030	0.946	0.000	0.004	0.000	0.000	0.000	0.000	0.014	0.111	3.329	0.000	0.000	0.000	1.555
PS3	0.091	0.046	0.075	0.089	0.079	0.062	0.059	0.129	0.054	0.088	0.006	0.154	0.833	1.229	0.270	0.475	1.451	0.545	0.431	1.250	0.239	0.167	0.126	0.395
PS4	0.103	0.110	0.104	0.104	0.112	0.100	0.114	0.127	0.109	0.106	0.233	0.197	0.152	0.129	0.149	0.117	0.139	0.116	0.143	0.544	0.206	0.132	0.137	0.185
PS5	0.202	0.153	0.158	0.174	0.167	0.154	0.149	0.316	0.230	0.206	0.475	0.806	0.352	0.255	0.386	0.342	0.270	0.237	0.631	1.616	0.563	0.317	0.268	0.581
PS6	0.179	0.159	0.163	0.174	0.172	0.158	0.150	0.189	0.174	0.146	0.219	0.208	0.200	0.182	0.216	0.235	0.297	0.268	0.263	0.595	0.397	0.306	0.263	0.318
PS7	0.121	0.104	0.100	0.102	0.098	0.100	0.097	0.210	0.117	0.111	0.307	0.239	0.174	0.155	0.210	0.180	0.170	0.150	0.188	0.586	0.260	0.203	0.184	0.243
PS8	0.089	0.081	0.081	0.079	0.074	0.069	0.065	0.145	0.111	0.113	0.503	0.251	0.168	0.122	0.149	0.137	0.143	0.122	0.188	0.933	0.215	0.193	0.177	0.305
PS9	0.002	0.000	0.001	0.000	0.000	0.002	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.002	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42

Table B3-4: Pump Stations Cumulative Pump Time

Cumulative Pump Time from from 30 June 2022 (Hours)																									
Date	**30-Jun-22**	**12-Jul-22**	**29-Jul-22**	**1-Aug-22**	**9-Aug-22**	**15-Aug-22**	**22-Aug-22**	**29-Aug-22**	**12-Sep-22**	**19-Sep-22**	**26-Sep-22**	**3-Oct-22**	**10-Oct-22**	**17-Oct-22**	**23-Oct-22**	**1-Nov-22**	**7-Nov-22**	**16-Nov-22**	**21-Nov-22**	**28-Nov-22**	**7-Dec-22**	**12-Dec-22**	**23-Dec-22**	**29-Dec-22**	**5-Jan-23**
PS1	57718.00	57797.00	58152.00	58217.00	58274.00	58305.00	58330.00	58342.00	58375.00	58390.00	58399.00	58410.00	58445.00	58465.00	58478.00	58499.00	58508.00	58514.00	58521.00	58528.00	58537.00	58543.00	58555.00	58562.00	58568.00
PS2	19438.00	19493.00	19709.00	19723.00	19745.00	19761.00	19761.00	19761.00	19761.00	19761.00	19763.00	19764.00	19775.00	19779.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00
PS3	15231.00	15244.00	15413.00	15428.00	15442.00	15450.00	15457.00	15461.00	15690.00	15692.00	15695.00	15698.00	15703.00	15706.00	15709.00	15714.00	15717.00	15720.00	15723.00	15726.00	15735.00	15736.00	15740.00	15741.00	15743.00
PS4	34093.00	34101.00	34257.00	34284.00	34295.00	34302.00	34309.00	34313.00	34322.00	34327.00	34332.00	34337.00	34342.00	34347.00	34350.00	34355.00	34359.00	34363.00	34365.00	34368.00	34371.00	34373.00	34377.00	34379.00	34382.00
PS5	13438.00	13455.00	13623.00	13642.00	13661.00	13666.00	13674.00	13679.00	13691.00	13694.00	13698.00	13702.00	13720.00	13725.00	13731.00	13742.00	13746.00	13751.00	13759.00	13763.00	13770.00	13774.00	13779.00	13782.00	13793.00
PS6	19671.00	19687.00	19871.00	19903.00	19937.00	19957.00	19980.00	19994.00	20150.00	20163.00	20175.00	20188.00	20202.00	20288.00	20288.00	20289.00	20289.00	20290.00	20291.00	20291.00	20291.00	20291.00	20303.00	20310.00	20317.00
PS7	13389.00	13399.00	13529.00	13542.00	13561.00	13571.00	13582.00	13589.00	13603.00	13609.00	13615.00	13620.00	13627.00	13633.00	13637.00	13644.00	13648.00	13655.00	13658.00	13663.00	13669.00	13671.00	13677.00	13681.00	13684.00
PS8	29588.00	29598.00	29753.00	29770.00	29791.00	29803.00	29817.00	29827.00	29846.00	29855.00	29863.00	29871.00	29879.00	29887.00	29893.00	29901.00	29907.00	29914.00	29918.00	29922.00	29928.00	29931.00	29938.00	29941.00	29945.00
PS9	3768.00	3768.00	3769.00	3769.00	3769.00	3769.00	3769.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00
Total	**206334.00**	**206542.00**	**208076.00**	**208278.00**	**208475.00**	**208584.00**	**208679.00**	**208736.00**	**209208.00**	**209261.00**	**209310.00**	**209360.00**	**209463.00**	**209600.00**	**209636.00**	**209694.00**	**209724.00**	**209757.00**	**209785.00**	**209811.00**	**209851.00**	**209869.00**	**209919.00**	**209946.00**	**209982.00**

Cumulative Pump Time from from 30 June 2022 (Hours)																								
Date	**12-Jan-23**	**16-Jan-23**	**25-Jan-23**	**31-Jan-23**	**7-Feb-23**	**13-Feb-23**	**21-Feb-23**	**27-Feb-23**	**8-Mar-23**	**13-Mar-23**	**24-Mar-23**	**27-Mar-23**	**4-Apr-23**	**11-Apr-23**	**17-Apr-23**	**28-Apr-23**	**1-May-23**	**9-May-23**	**17-May-23**	**22-May-23**	**31-May-23**	**15-Jun-23**	**23-Jun-23**	**29-Jun-23**
PS1	58578.00	58582.00	58592.00	58595.00	58598.00	58600.00	58603.00	58617.00	58629.00	58634.00	58693.00	58701.00	58733.00	58740.00	58757.00	58782.00	58786.00	58796.00	58840.00	58947.00	58997.00	59032.00	59050.00	59099.00
PS2	19780.00	19780.00	19780.00	19780.00	19780.00	19780.00	19781.00	19782.00	19783.00	19784.00	19829.00	19829.00	19829.00	19829.00	19829.00	19829.00	19829.00	19830.00	19834.00	19911.00	19911.00	19911.00	19911.00	19951.00
PS3	15746.00	15746.00	15749.00	15751.00	15753.00	15754.00	15756.00	15760.00	15763.00	15765.00	15776.00	15778.00	15784.00	15786.00	15789.00	15839.00	15840.00	15861.00	15866.00	15900.00	15907.00	15932.00	15935.00	15947.00
PS4	34384.00	34386.00	34389.00	34392.00	34394.00	34397.00	34400.00	34403.00	34406.00	34408.00	34421.00	34423.00	34428.00	34431.00	34434.00	34439.00	34441.00	34444.00	34448.00	34468.00	34475.00	34483.00	34487.00	34492.00
PS5	13785.00	13787.00	13790.00	13792.00	13795.00	13795.00	13796.00	13802.00	13805.00	13807.00	13819.00	13823.00	13834.00	13841.00	13849.00	13862.00	13864.00	13866.00	13875.00	13879.00	13890.00	13906.00	13911.00	13928.00
PS6	20325.00	20328.00	20337.00	20342.00	20349.00	20355.00	20361.00	20368.00	20376.00	20380.00	20395.00	20399.00	20407.00	20414.00	20421.00	20435.00	20440.00	20468.00	20480.00	20504.00	20524.00	20569.00	20580.00	20594.00
PS7	13687.00	13689.00	13693.00	13695.00	13698.00	13700.00	13704.00	13709.00	13713.00	13715.00	13731.00	13734.00	13740.00	13744.00	13750.00	13758.00	13760.00	13765.00	13771.00	13787.00	13796.00	13809.00	13815.00	13822.00
PS8	29949.00	29951.00	29956.00	29959.00	29962.00	29965.00	29968.00	29974.00	29980.00	29984.00	30021.00	30026.00	30035.00	30040.00	30046.00	30055.00	30058.00	30064.00	30074.00	30108.00	30120.00	30139.00	30148.00	30160.00
PS9	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3770.00	3772.00	3772.00	3772.00	3772.00	3772.00	3772.00	3772.00	3772.00	3772.00
Total	**210004.00**	**210019.00**	**210056.00**	**210076.00**	**210099.00**	**210116.00**	**210139.00**	**210185.00**	**210225.00**	**210247.00**	**210455.00**	**210483.00**	**210560.00**	**210595.00**	**210645.00**	**210771.00**	**210790.00**	**210866.00**	**210960.00**	**211276.00**	**211392.00**	**211553.00**	**211609.00**	**211765.00**

Green Island Landfill Leachate Collection - Figure B1 - Leachate Flow Charts



Project number: 12587765

Appendix C

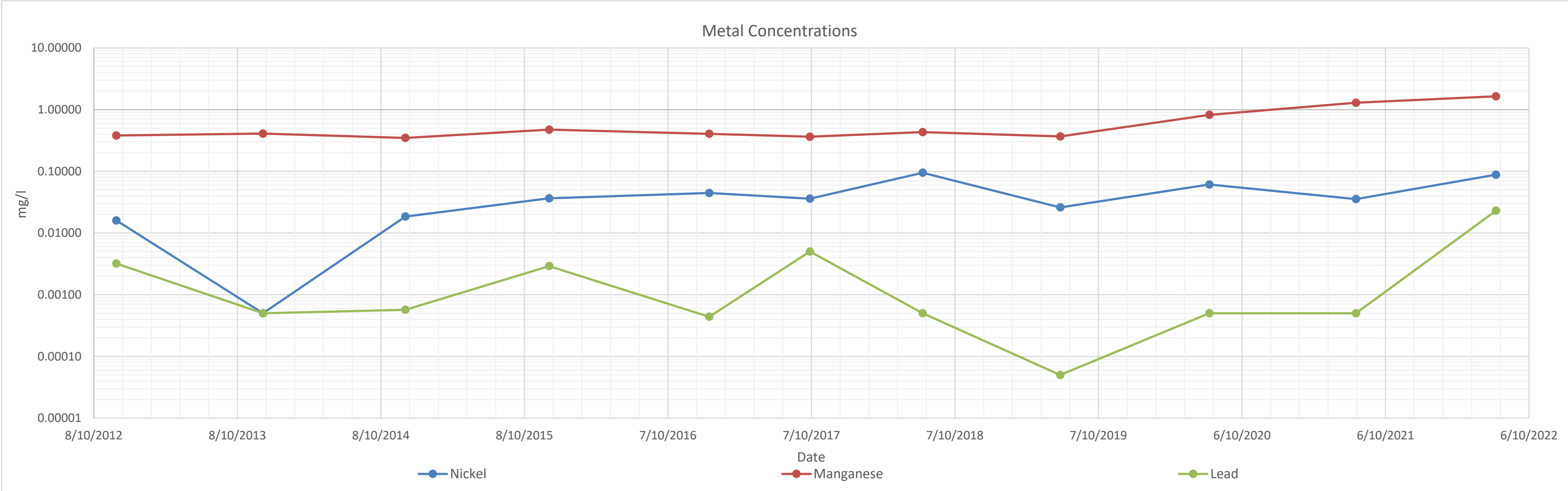
Water Chemistry Monitoring

			Table C1: July 2022 - Leachate Analytical Results		
			Location	PS3	**DCC TRADE WASTE GUIDELINE**
			Sample Date	14/07/2022	
Analyte		**Units**	**LOR**		
	Thermotolerant (Faecal) Coliforms	orgs/100mL	2	>16,000	-
	Total Organic Carbon	µg/L	0.5	290,000	-
	Volatile Fatty Acids (as Acetic Acid)	µg/L	5	35,000	-
Water - Aggregates/Nutrients					
	Electrical conductivity (lab)	µS/cm	-	5,240	-
Field Parameters					
	DO (%S) (Field)	%S	-	13.4	-
	Dissolved Oxygen (Field)	mg/L	-	1.46	-
	Electrical conductivity (field)	µS/cm	-	3,113	-
	Temperature (Field)	°C	-	10.2	-
	Redox (Field)	mV	-	26.2	-
	pH (Field)	pH units	-	6.75	6.0-9.0
Metals					
	Acid Soluble Aluminium	mg/L	0.003	0.76	100
	Acid Soluble Arsenic	mg/L	-	0.024	5
	Acid Soluble Barium	mg/L	0.005	0.112	10
	Acid Soluble Boron	mg/L	0.005	2.1	25
	Acid Soluble Cadmium	mg/L	0.002	0.00037	0.5
	Acid Soluble Chromium (III+VI)	mg/L	0.0005	0.0199	-
	Acid Soluble Copper	mg/L	0.0005	0.064	10
	Acid Soluble Iron	mg/L	0.02	8.5	100
	Acid Soluble Lead	mg/L	0.0001	0.023	10
	Acid Soluble Manganese	mg/L	0.0005	1.64	20
	Mercury (total)	mg/L	0.00008	0.0001	0.05
	Acid Soluble Nickel	mg/L	0.0005	0.088	10
	Acid Soluble Zinc	mg/L	-	0.162	10
Inorganics					
	BOD	mg/L	2	330	600
	COD	mg/L	25	930	-
	Cyanide (Total)	mg/L	0.02	<0.02	5
	Sulfide	mg/L	0.5	<0.05	5
Nutrients					
	Ammonia as N (Filtered)	mg/L	0.01	**165**	50
	Reactive Phosphorus as P (Filtered)	mg/L	0.004	0.031	10
	Nitrate (as N)	mg/L	0.001	90	-
Alkalinity					
	Alkalinity (total as CaCO3)	mg/L	1	1210	-
	Alkalinity (Bicarbonate as CaCO3)	mg/L	1	1470	-
Major Ions					
	Sum of Anions	meq/L	0.07	55	-
	Calcium (Filtered)	mg/L	1	300	-
	Chloride (Filtered)	mg/L	0.5	460	-
	Sum of Cations	meq/L	0.07	56	-
	Magnesium (Filtered)	mg/L	0.02	101	-
	Potassium (Filtered)	mg/L	0.05	116	-
	Sodium (Filtered)	mg/L	0.02	420	-
	Sulfate (Filtered)	mg/L	0.5	540	500
BTEX & MAH (All other analytes were reported below the LOR - Full lab reports in Appendices)					
	1,2,4-trimethylbenzene	µg/L	3	12	-
	1,3,5-Trimethylbenzene	µg/L	3	4	-
	Ethylbenzene	µg/L	3	14	-
	Toluene	µg/L	3	30	-
	Xylene (o)	µg/L	3	10	-
	Xylene (m & p)	µg/L	3	19	-
	4-Isopropyltoluene (p-Cymene)	µg/L	3	9	-
Phenols (All other analytes were reported below the LOR - Full lab reports in Appendices)					
	Phenol	µg/L	20	68	-
	3,4-Methylphenol (m,p-cresol)	µg/L	20	11	-
PAH in Water (All analytes were reported below the LOR - Full lab reports in Appendices)					
OCP in Water (All analytes were reported below the LOR - Full lab reports in Appendices)					
OC Pesticides (All analytes were reported below the LOR - Full lab reports in Appendices)					
SVOCs (All other analytes were reported below the LOR - Full lab reports in Appendices)					
PCBs (All analytes were reported below the LOR - Full lab reports in Appendices)					
Phthalates (All other analytes were reported below the LOR - Full lab reports in Appendices)					
Chlorinated Hydrocarbons (All analytes were reported below the LOR - Full lab reports in Appendices)					
Other (All analytes were reported below the LOR - Full lab reports in Appendices)					
Halogenated Hydrocarbons (All analytes were reported below the LOR - Full lab reports in Appendices)					

Notes:
LOR - Limit of Reporting
Shaded pink and bold: Indicates that the value exceeds the Dunedin City Council Trade Waste guideline value

Table C2: Leachate - Historical and Current Analytical Results

			Location	TRADE WASTE GUIDELINE	Combined Leachate Pump Collection Points					PS3	PS3	PS3	PS3	PS3	PS3	Statistical Summary of Historical Data		
			Sample Date		4-Dec-12	12-Dec-13	9-Dec-14	10-Dec-15	20-Jan-17	3-Oct-17	17-Jul-18	2-Jul-19	15-Jul-20	23-Jul-21	14-Jul-22	Minimum Concentrations	Maximum Concenrtations	Average Concentrations
Analytes		Units	LOR															
	Faecal Coliforms	cfu/100ml	1	-	500	310	100	200	95	64	20	10	12,000	4,000	**>16,000**	10	12000	1729.9
	Total Organic Carbon	µg/L	500	-	160,000	150,000	144,000	200,000	198,000	111,000	111,000	150,000	150,000	291,000	290,000	111,000	291000	166500
	Volatile Fatty Acids	µg/L	50,000	-	<10,000	<50,000	<50000	<50,000	<50,000	<50,000	<10,000	<10,000	142,000	164,000	35,000	142000	164000	153000
Water - Aggregates/Nutrients																**Water - Aggregates / Nutrients**		
	Electrical Conductivity	µS/cm	0.2	-	10,000	10,000	10,000	13,000	12,000	10,250	8,460	12,310	6,870	5,890	*5,240*	5890	13000	9878
Field Parameters																**Field Parameters**		
	Dissolved Oxygen (% saturated) (Field)	%S	-	-	-	-	-	-	-	46	6.5	29.4	8.7	17.6	13.4	6.5	46	21.6
	Dissolved Oxygen (mg/L) (Field)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	1.46	0	0	
	Electrical Conductivity (Field)	µS/cm	-	-	10,000	10,000	10,000	13,000	12,000	10,550	8,246	7,682	7,953	6,161	*3,113*	6161	13000	9559.2
	Temp (Field)	°C	-	-	-	-	-	-	-	10.2	11.4	12.5	10.9	11	10.2	10.2	12.5	11.2
	Redox	mV	-	-	-	-	-	-	-	-88	120	21.7	-40.1	-19.9	26.2	-88	120	-1.3
	pH (Field)	pH Units	-	6.0-9.0	7.15	7.24	7.19	7.58	7.15	6.93	6.80	6.82	7.03	6.91	*6.75*	6.8	7.58	7.1
Metals																**Metals**		
	Aluminium (Acid soluble)	mg/L	0.03	100	0.035	1.15	0.01	0.055	0.204	<0.1	<0.01	0.012	<0.03	<0.03	0.76	0.01	1.15	0.244
	Arsenic (Acid soluble)	mg/L	0.005	5	<0.005	<0.001	0.004	0.004	0.005	<0.05	<0.005	0.003	<0.005	<0.005	**0.024**	0.003	0.005	0.004
	Barium (Acid soluble)	mg/L	0.0001	10	0.350	2.920	0.240	0.225	0.169	0.162	0.212	0.171	0.148	0.113	*0.112*	0.113	2.92	0.471
	Boron (Acid soluble)	mg/L	0.005	25	5.900	63.100	6.438	4.920	4.320	5.140	5.410	5.030	4.240	4.14	*2.1*	4.14	63.1	10.864
	Cadmium (Acid soluble)	mg/L	0.0002	0.5	<0.0003	<0.0001	0.00011	0.0001	0.00005	<0.001	<0.0001	<0.00001	<0.0002	0.00032	**0.00037**	0.00005	0.00032	0.000
	Chromium (III+VI) (Acid soluble)	mg/L	0.0002	-	0.015	<0.0001	0.010	0.026	0.029	-	0.016	0.019	0.022	0.015	0.0199	0.0099	0.0291	0.019
	Copper (Acid soluble)	mg/L	0.002	10	<0.003	0.002	0.008	0.007	0.002	<0.02	0.004	0.004	<0.002	<0.002	**0.064**	0.0018	0.008	0.004
	Iron (Acid soluble)	mg/L	0.005	100	15.5	0.47	0.241	5.2	0.884	<5	0.42	0.767	1.58	3.87	8.5	0.241	15.5	3.215
	Lead (Acid soluble)	mg/L	0.0005	10	0.00320	<0.0005	0.00057	0.00291	0.00044	<0.005	<0.0005	<0.00005	<0.0005	<0.0005	**0.023**	0.00044	0.0032	0.002
	Manganese (Acid soluble)	mg/L	0.0005	20	0.380	0.409	0.348	0.474	0.405	0.363	0.432	0.367	0.823	1.290	**1.64**	0.3476	1.29	0.529
	Mercury (Acid soluble)	mg/L	0.001	0.05	<0.00008	0.00008	0.00008	0.00008	0.00008	<0.0001	<0.0001	<0.001	<0.001	<0.001	**0.0001**	0.00008	0.00008	0.000
	Nickel (Acid soluble)	mg/L	0.0002	10	0.016	0.001	0.019	0.037	0.045	0.036	0.095	0.026	0.061	0.0355	0.088	0.0005	0.095	0.037
	Zinc (Acid soluble)	mg/L	0.001	10	0.018	0.846	0.011	0.071	0.002	<0.1	<0.01	0.021	0.108	0.028	0.162	0.002	0.846	0.138
Inorganics																**Inorganics**		
	BOD_5	mg/L	1	600	91	80	51	79	170	36.5	22.5	20.6	66.9	422	330	20.6	422	104.0
	COD	mg/L	10	-	490	380	530	830	800	1,081	454	491	538	938	930	380	1081	675.3
	Cyanide (Total)	mg/L	0.005	5	0.078	0.1	0.094	0.037	0.037	0.05	0.082	0.078	0.023	0.056	*<0.02*	0.023	0.1	0.1
	Sulphide	mg/L	0.1	-	-	-	<0.04	3.6	0.4	<0.1	<0.1	<0.1	0.9	1.9	*<0.05*	<0.04	3.6	
	Sulphide (Filtered)	mg/L	0.1	5	-	-	-	-	-	-	<0.1	<0.1	0.9	-	-	<0.1	0.9	0.9
	pH (Final)	pH_Units	1	6.0-9.0	7.15	7.24	7.19	7.58	7.15	7.4	7.3	7.2	7.3	7.4	7.3	7.15	7.58	7.3
Nutrients																**Nutrients**		
	Ammoniacal Nitrogen (Filtered)	mg/L	0.01	50	292	276	302	415	424	419	288	292	167	208	*165*	167	424	323.38
	Phosphorus (Filtered)	mg/L	0.04	10	<0.05	<0.05	<0.025	0.152	0.088	3.2	<0.04	0.044	<0.02	<0.02	*0.031*	0.044	3.2	0.87
	Nitrate (as NO3-) (Filtered)	mg/L	5	-	<0.02	<0.02	0.967	1.97	0.395	<5	<0.02	0.0689	<0.02	<0.02	**90**	0.0689	1.97	0.85
Alkalinity																**Alkalinity**		
	Alkalinity (Total) as CaCO3	mg/L	1	-	2,800	2,700	2,700	3,300	3,300	3,340	<1	3,467	1,828	1,882	*1,210*	1828	3467	2813.0
	Bicarbonate (Filtered)	mg/L	1	-	3,400	3,200	3,300	4,000	4,000	3,329	<1	3,462	1,824	1,877	1470	1824	4000	3154.7
	Carbonate (Filtered)	mg/L	1	-	3	3	3	9	3	10.9	<1	4.8	3.7	4.5	-	3	10.9	5.2
Major Ions																**Major Ions**		
	Sum of Anions	meq/L	0.01	-	102.9	108.4	103.5	135.9	126.4	117.4	39.62	116.3	65.85	59.23	*55*	59.23	135.9	108.75
	Calcium (Filtered)	mg/L	0.05	-	140	98.7	144	147	141	140	140	144	153	160	300	98.7	160	139.34
	Chloride (Filtered)	mg/L	0.5	-	1,640	1,930	1,720	2,400	2,100	1,760	1,380	1,620	957	743	*460*	743	2400	1699.22
	Sum of Cations	meq/L	0.01	-	110.2	107.2	103.4	142.8	129.2	116.4	91.17	100.8	79.97	64.64	*56*	64.64	142.8	107.31
	Magnesium (Filtered)	mg/L	0.01	-	200	234	11.9	244	229	181	173	186	150	115	101	11.9	244	175.11
	Potassium (Filtered)	mg/L	0.05	-	210	83.5	247	327	326	315	160	202	209	128	116	83.5	327	222.06
	Sodium (Filtered)	mg/L	0.01	-	1,400	1,480	1,630	1,890	1,600	1,300	1,040	1,200	980	664	*420*	664	1890	1356.00
	Zinc (Total)	mg/L	0.001	10	-	-	-	-	-	-	0.019	-	0.105	0.017	-	0.017	0.019	0.02
	Manganese (Total)	mg/L	0.0005	20	-	-	-	-	-	-	0.533	-	1.11	3.87	-	0.533	3.87	2.20
	Iron (Total)	mg/L	0.005	100	-	-	-	-	-	-	3.09	-	1.12	1.57	-	1.57	3.09	2.33
	Sulphate (Filtered)	mg/L	0.15	500	42	71	40	109	76	42	30	56.9	105	24.1	**540**	24.1	109	59.60
BTEX & MAH (All other analytes were reported below the LOR - Full lab reports in Appendices)																**BTEX & MAH (All other analytes were reported below the LOR - Full lab reports in Appendices)**		
	1,2,4-trimethylbenzene	µg/L	1	-	-	-	-	-	-	1	2	<1	2	4.6	**12**	1	4.6	2.4
	1,3,5-trimethylbenzene	µg/L	1	-	-	-	-	-	-	-	<1	<1	<1.2	1.1	**4**	1.1	1.1	1.1
	Ethylbenzene	µg/L	1	-	-	-	-	-	-	<1	<1	<1	2	4.5	**14**	2	4.5	3.25
	Toluene	µg/L	1	-	-	-	-	-	-	<1	<1	<1	2	5.3	**30**	2	5.3	3.65
	Xylene (o)	µg/L	1	-	-	-	-	-	-	<1	<1	<1	2	3.8	**10**	2	3.8	2.9
	Xylene (m & p)	µg/L	1	-	-	-	-	-	-	1	2	<1	3	6.7	**19**	1	6.7	3.175
	p-isopropyltoluene	µg/L	1	-	-	-	-	-	-	-	<1	<1	<1.2	1.3	**9**	1.3	1.3	1.3
Phenols (All other analytes were reported below the LOR - Full lab reports in Appendices)																**Phenols (All other analytes were reported below the LOR - Full lab reports in Appendices)**		
	Phenol	µg/L	0.3	-	0.04	0.052	0.06	0.15	0.02	0.3	<0.3	<2	<2	150	68	0.02	150	21.51742857
	3,4-Methylphenol (m,p-cresol)	µg/L	0.3	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-



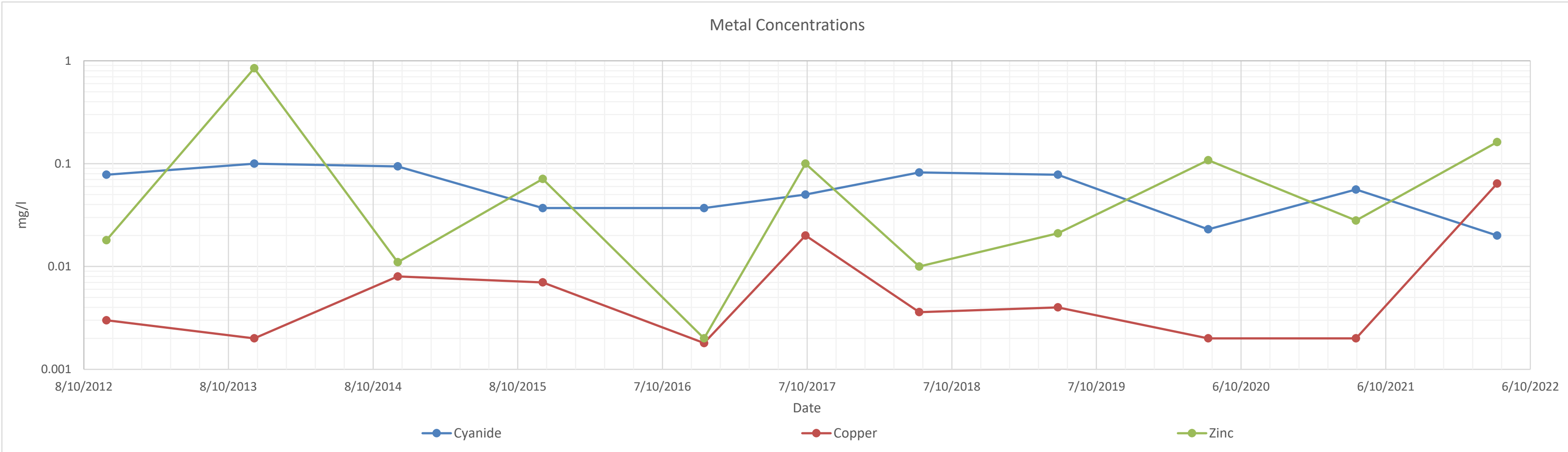


Figure C1-1: Green Island Landfill Leachate - Chemistry Data

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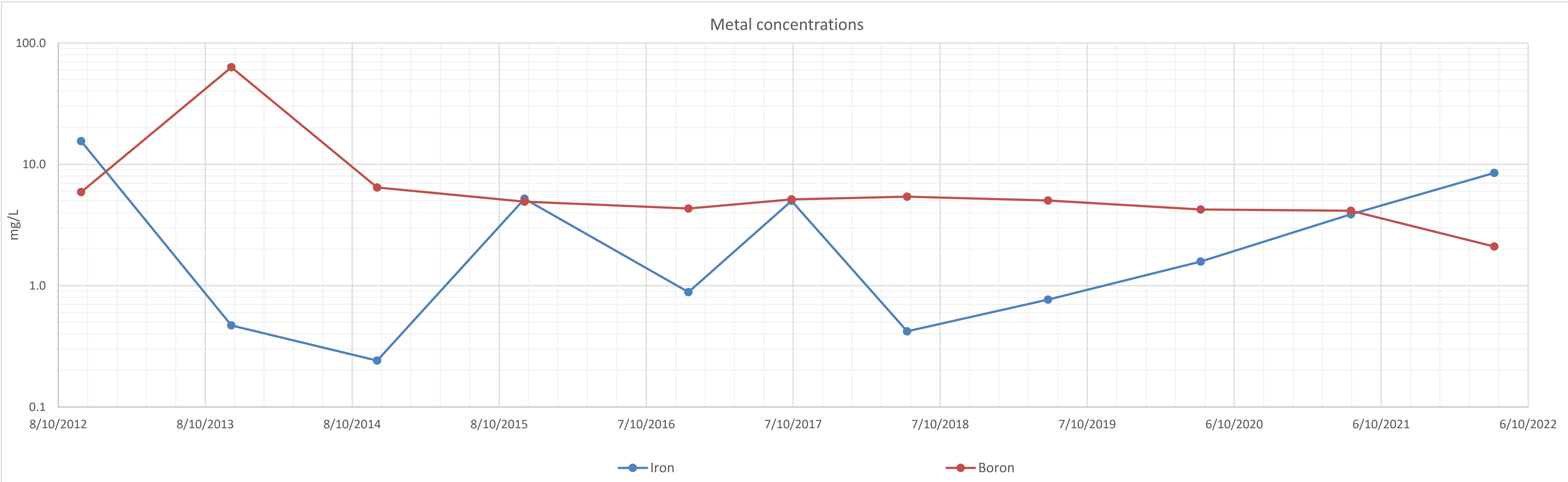

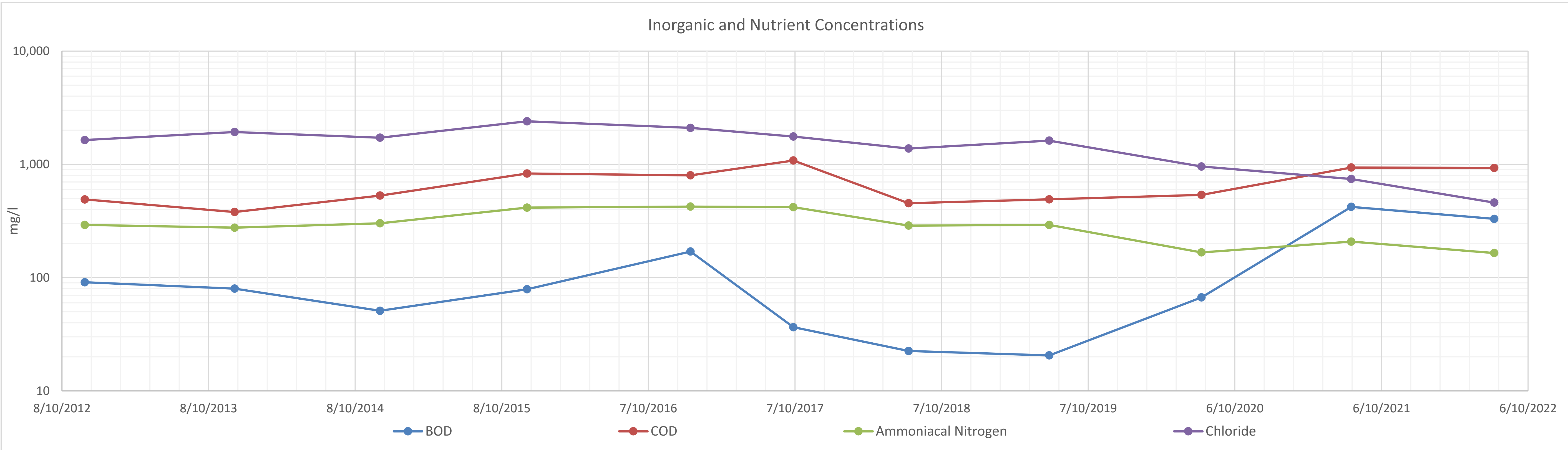

Figure C1-2: Green Island Landfill Leachate - Chemistry Data

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		Anion/Cation Suite													Elements in Water (soluble)	Water - Aggregate/Nutrients		Field Parameters				
		Ammonia as N (Filtered)	Ammonia (Corrected for pH and temperature)	Iron (Filtered)	Nitrate (as N) (Filtered)	Zinc (Filtered)	Calcium (Filtered)	Chloride (Filtered)	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulfate (Filtered)	Anions Total	Cations Total	Lead (Filtered)	Biochemical Oxygen Demand (BOD)	Total Organic Carbon	Dissolved Oxygen (%S) (Field)	Dissolved Oxygen (mg/L) (Field)	Electrical conductivity (field)	Temperature	pH (Field)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L	mg/L	µg/L	%S	mg/L	µS/cm	^{0}C	pH Units
LOR		0.01	-	0.02	0.1	0.1	0.05	0.5	0.02	0.05	0.02	5	0.07	0.05	0.01	2	0.5	-	-	-		-
ANZG (2018) Freshwater 95% Toxicant Default Guideline Values		-	0.9	<u>ID</u>	<u>0.7</u>	0.008	-	-	-	-	-	-	-	-	0.0034	-	-	<u>99 - 103</u>	-	-	-	<u>7.3-8</u>
ANZG (2018) Marine Water 95% Toxicant Default Guideline Values		-	0.91	-	-	0.008	-	-	-	-	-	-	-	-	0.0044	-	-	-	-	-	-	
National Policy Statement for Freshwater Management (2020)		-	0.24 and 0.40 #1	-	2.4 and 3.5 #2	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0 and 5.0#3	-	-	-
Sample Location	**Sample Date**																					
MW2D	13/07/2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.5	0.65	**30,187**	9.5	6.98
	11/10/2022	22	0.787	**111**	<0.1	**1.68**	810	11,500	730	69	4,700	<5	330	310	<0.01	**11**	**52,000**	5.8	0.58	27,430	9.4	6.89
	17/01/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.6	0.96	**30,483**	19.5	6.96
	12/04/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	0.76	**30,123**	13.5	6.98
Historical Statistical Summary																						
Minimum Concentration		14.2	-	43.9	<0.002	<0.001	780	10,774	689	65.5	4,470	<0.5	308.4	295.9	<0.00005	2.4	34,000	1.5	0.15	93	-	6.2
Maximum Concentration		23	-	76.1	0.51	<1	879	11,600	780	71.4	4,800	<15	330.0	319.8	<0.05	10.3	47,100	48	4.22	29,970	-	7.77
Average Concentration		20	-	65	0.17	0.081	820	11,160	743	68	4,571	4	319	305	0.0041	6.1	38,875	14	1.4	21,304	-	6.9
Sample Location	**Sample Date**																					
MW4D	13/07/2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	0.66	**25,608**	9.4	6.56
	11/10/2022	**11.1**	0.163	**97**	0.13	<0.1	830	**9,500**	590	57	3,900	<5	270	260	<0.01	**8**	**38,000**	6.6	0.65	22,737	9.5	6.5
	17/01/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.2	0.65	**25,839**	17.1	6.57
	12/04/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9	0.56	**25,607**	14.5	***6.41***
Historical Statistical Summary																						
Minimum Concentration		0.84	-	0.51	<0.002	<0.001	750	9,080	458	51	3,010	<0.5	260.9	213.4	<0.00005	2.3	21,000	1.1	0.29	8,419	-	6.46
Maximum Concentration		10.5	-	71	<5	<1	888	9,410	630	57.1	3,900	<15	270.1	265.3	<0.05	6.7	33,400	62.8	3.43	25,560	-	7.21
Average Concentration		7.8	-	31	0.63	0.082	829	9,268	579	55	3,631	5.4	266	251	0.0041	4	26,375	14	1.1	18,917	-	6.7
Sample Location	**Sample Date**																					
MW7D	13/07/2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7	0.67	12,633	12.3	6.42
	12/10/2022	<0.01	0.0002	13	0.38	<0.1	440	**6,200**	360	55	2,800	**680**	**197**	175	<0.01	3	***2,400*** #4	23.1	2.37	15,894	10.9	6.85
	18/01/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.7	0.75	**17,416**	14.0	6.54
	13/04/2023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	0.62	**17,898**	14.5	6.42
Historical Statistical Summary																						
Minimum Concentration		0.13	-	0.321	<0.002	0.0014	19.3	122	7.5	9.6	63.7	51.3	5.01	4.63	<0.00005	<1	3,000	2.4	0.29	17.6	-	5.98
Maximum Concentration		1.3	-	50	1.06	<0.1	510	5,800	380	55	2,800	624	185.0	180.0	<0.005	<4	14,200	119.1	3.58	17,260	-	9.12
Average Concentration		0.87	-	29	0.35	0.013	408	4,753	299	46	2,195	491	152	143	0.00056	1.5	8,225	23	1.2	7,108	-	6.8

Table C3: Green Island Landfill - Deep Well Analytical Results 2022 / 2023

Notes:
LOR - Limit of Detection
Underlined values have been adopted from the ANZECC 95% (freshwater and marine water protection values). Australian and New Zealand Environment and Conservation Council
Values shaded grey exceed both the ANZG 2018 Freshwater and Marine Default Guideline Values for zinc
Red and Bold: Value exceeds the Historical Maximum Concentration
Blue, Italic and Bold : Value is less than the Historical Minimum Concentration
< - Less than the LOR
Values shaded grey represent concentrations lower than LOR
A hyphen (-) indicates that a parameter or criterion is not available
ID: Insufficient data to derive a reliable trigger value (ANZECC, 2000)
Half the LOR value was used in the calculation for the corrected ammonia concentration where original concentration reported as <LOR

References and Comments:
ANZG (2018) Freshwater 95% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for fresh water protection values. Australian and New Zealand Environment and Conservation Council (2018).
ANZG (2018) Marine water 95% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for Marine water protection values. Australian and New Zealand Environment and Conservation Council (2018).
National Policy Statement for Freshwater Management (2020). Values taken from Appendix 2A - Attributes requiring limits on resource use.
#1: 95% species protection level: Starts impacting occasionally on the 5% most sensitive species. The national bottom line guideline values were adopted: the annual median (0.24 mg/L) and the annual maximum (0.40 mg/L).
#2: Some growth effect on up to 5% of species. The national bottom line guideline values were adopted: the annual median (2.4 mg/L) and the annual maximum (3.5 mg/L).
#3: 11-day minimum (4.0 mg/L) (lowest daily minimum across the whole summer period) and 7-day mean minimum (5.0 mg/L) (mean value of seven consecutive daily minimum values). Values presented not directly comparable to NPS attribute value.
#4: Laboratory Analyst's Comment: (Sample 10 - MW7D) Please note that the level of Uncertainty of Measurement (UOM) for the Total Organic Carbon result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

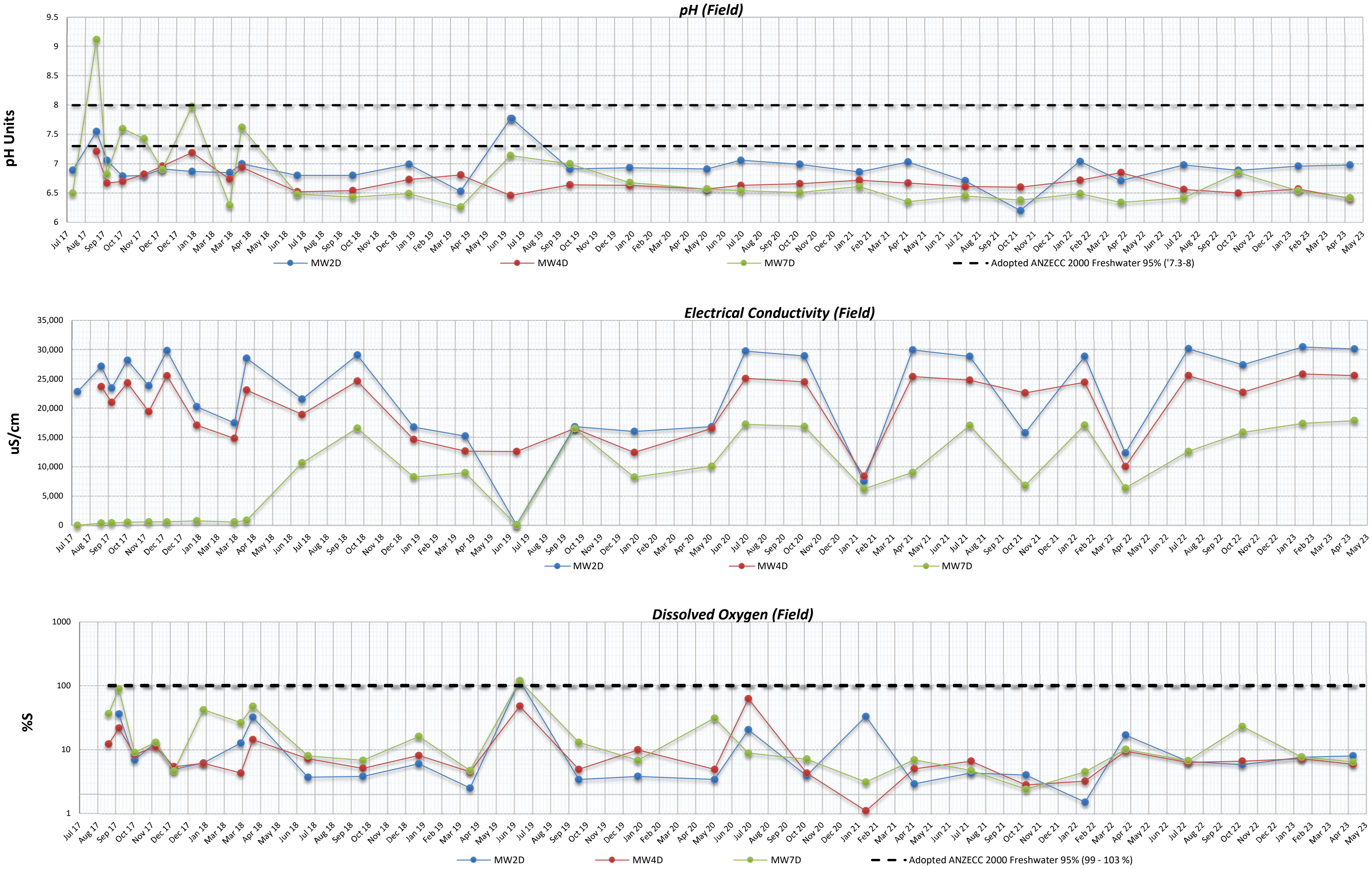
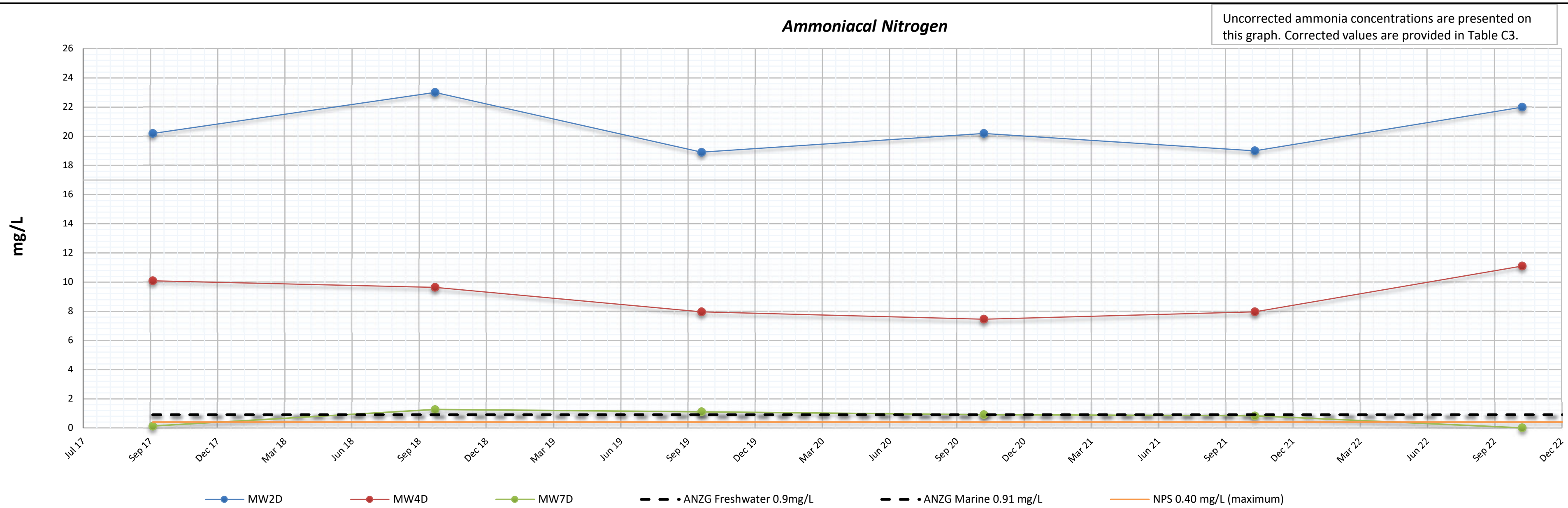


Figure C2-1: Green Island Landfill Deep Wells - Chemistry Data	**Date:** Aug 23	
	Drawn: HE	**Reviewer:** CG
DCC Landfill All Data	**Project Number:** 12587765	



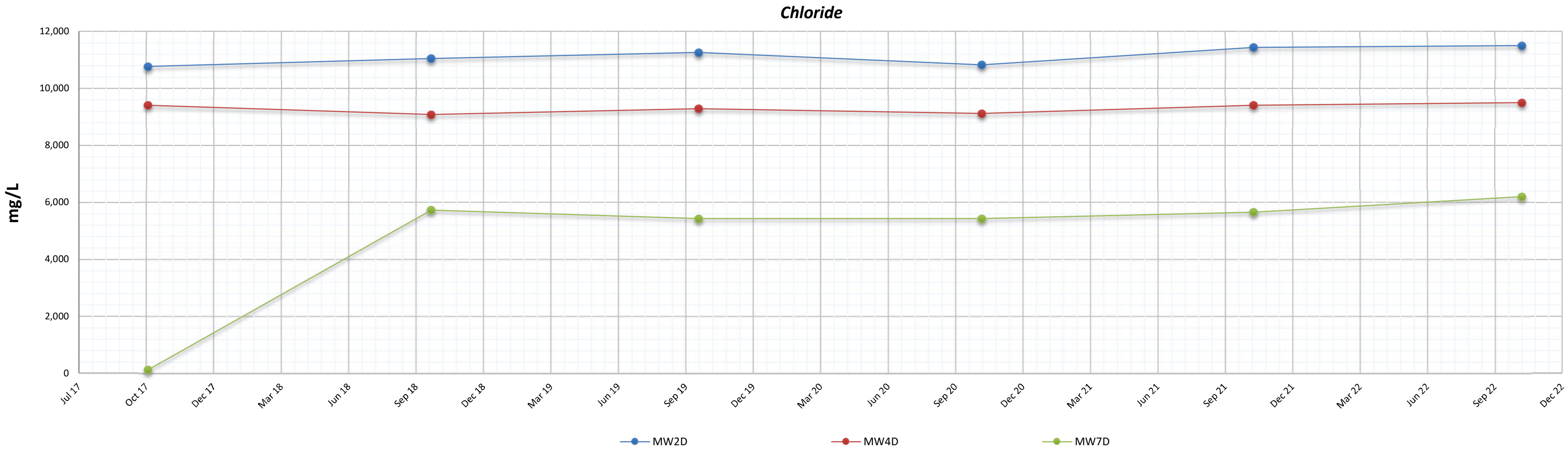


Figure C2-2: Green Island Landfill Deep Wells - Chemistry Data

DCC Landfill All Data

Date: Aug 23	
Drawn: HE	Reviewer: CG
Project Number: 12587765	

Table C4: Monitoring wells and manholes - 2022 - 2023 Field Data

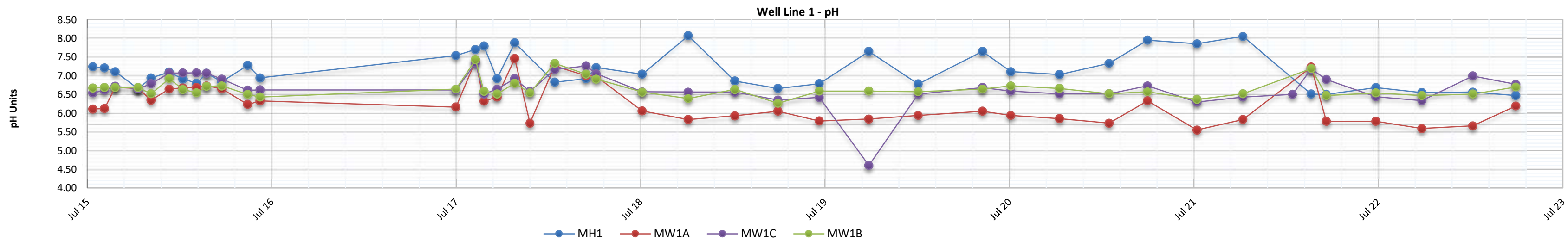
	Location	Sample Date	Redox (Field)	Dissolved Oxygen (% saturated) (Field)	Electrical Conductivity (Field)	pH (Field)
			mV	%S	µS/cm	pH Units
Well Line 0	MW0C	8/07/2022	229.6	13.7	2,583	6.76
		7/10/2022	72.3	29.8	2,660	6.60
		16/01/2023	21.0	17.4	2,710	6.36
		11/04/2023	190.8	45.7	2,649	6.59
Well Line 1	MH1	8/07/2022	-59.4	11.4	25,582	6.68
		7/10/2022	-43.3	5.7	24,230	6.55
		16/01/2023	-65.3	9.9	25,569	6.56
		11/04/2023	123.7	79.9	19,505	6.47
	MW1A	8/07/2022	225.6	14.5	30,034	5.78
		7/10/2022	115.4	21.5	29,074	5.59
		16/01/2023	76.7	9.7	30,579	5.66
		11/04/2023	137.5	73.1	30,332	6.19
	MW1B	8/07/2022	28.1	79.3	21,841	6.54
		7/10/2022	68.0	11.2	32,216	6.47
		16/01/2023	26.3	19.8	32,865	6.51
		11/04/2023	106.5	61.3	32,716	6.70
	MW1C	8/07/2022	-66.6	45.1	27,865	6.44
		7/10/2022	-42.6	9.4	27,215	6.34
		16/01/2023	87.8	46.8	28,317	6.99
		11/04/2023	59.8	37.0	27,266	6.77
Pump Station 1		8/07/2022	178.5	87.2	5,515	7.87
		7/10/2022	76.2	83.9	4,366	7.66
		16/01/2023	114.7	70.7	5,739	7.76
		11/04/2023	155.9	77.2	6,313	7.75
Well Line 2	MH2	8/07/2022	-115.4	54.2	27,530	6.50
		7/10/2022	-76.6	8.3	21,666	6.53
		16/01/2023	-124.6	11.0	29,046	6.52
		11/04/2023	-127.0	12.3	28,980	6.59
	MW2A	8/07/2022	-123.6	20.3	28,029	7.58
		7/10/2022	-180.5	6.6	27,656	7.39
		16/01/2023	-134.9	12.5	28,541	7.24
		11/04/2023	-188.6	9.3	28,296	7.50
	MW2B	8/07/2022	-146.8	20.6	27,763	7.41
		7/10/2022	-120.5	80.7	27,377	7.43
		16/01/2023	-160.8	8.5	28,042	7.41
		11/04/2023	-107.6	27.9	27,807	7.42
	MW2C	8/07/2022	-85.5	21.4	29,931	6.74
		7/10/2022	-94.0	74.4	28,947	6.83
		16/01/2023	-100.4	7.3	30,058	6.70
		11/04/2023	-61.0	13.7	29,797	6.65
	MW2D	8/07/2022	-131.0	11.2	30,186	7.01
		7/10/2022	-115.6	11.1	29,441	6.98
		16/01/2023	-95.7	12.0	30,681	6.71
		11/04/2023	-95.2	13.3	30,213	6.75

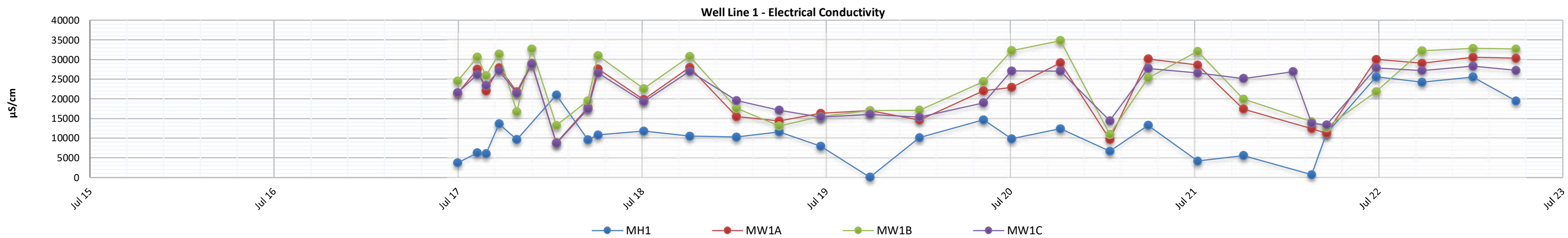
	Location	Sample Date	Redox (Field)	Dissolved Oxygen (% saturated) (Field)	Electrical Conductivity (Field)	pH (Field)
			mV	%S	µS/cm	pH Units
Pump Station 2		8/07/2022	-52.4	11.3	11,833	6.88
		7/10/2022	-35.0	12.2	7,055	6.82
		16/01/2023	106.2	19.7	15,228	6.78
		11/04/2023	42.2	27.8	13,299	6.67
Well Line 3	MH3	8/07/2022	-99.3	13.8	22,144	6.88
		7/10/2022	-157.2	18.2	20,706	6.93
		16/01/2023	-121.2	12.1	16,267	7.38
		11/04/2023	-283.0	18.0	11,023	7.16
	MW3A	8/07/2022	-11.6	37.9	14,024	7.84
		7/10/2022	-115.9	68.4	13,982	7.51
		16/01/2023	-134.4	28.4	14,304	7.45
		11/04/2023	-207.8	8.6	13,747	7.43
	MW3B	8/07/2022	-6.2	19.1	11,669	7.79
		7/10/2022	-106.4	22.6	12,064	7.41
		16/01/2023	-138.8	12.6	12,301	7.31
		11/04/2023	-207.7	16.0	11,040	7.30
	MW3C	8/07/2022	-69.2	86.1	1,754	7.65
		7/10/2022	-112.0	57.5	1,541	7.39
		16/01/2023	-48.4	19.9	1,459	6.90
		11/04/2023	-55.0	28.2	2,467	6.56
Pump Station 3		8/07/2022	-29.8	54.3	9,002	7.26
		7/10/2022	66.1	68.1	10,935	7.41
		16/01/2023	-54.4	12.8	16,687	7.40
		11/04/2023	-152.9	9.1	14,235	7.37
Well Line 4	MW4A	8/07/2022	-10.4	13.1	3,121	7.05
		7/10/2022	-87.8	6.1	3,261	7.94
		16/01/2023	-44.6	15.2	3,351	7.54
		11/04/2023	-356.0	11.6	5,277	7.48
	MW4B	8/07/2022	-14.6	10.8	3,218	7.52
		7/10/2022	-47.3	9.5	3,823	7.20
		16/01/2023	-84.7	9.3	3,922	7.05
		11/04/2023	-162.0	6.7	4,274	7.01
	MW4C	8/07/2022	16.6	13.0	20,560	6.94
		7/10/2022	-51.9	17.4	19,988	6.84
		16/01/2023	-56.3	8.6	21,095	6.78
		11/04/2023	-98.7	10.9	20,749	6.89
	MW4D	8/07/2022	-65.0	12.8	25,610	6.63
		7/10/2022	-73.7	7.8	24,632	6.55
		16/01/2023	-11.5	18.7	25,910	6.46
		11/04/2023	-67.9	5.5	25,609	6.36
Pump Station 4		8/07/2022	-98.5	19.0	11,829	6.94
		7/10/2022	95.8	11.6	9,726	6.87
		16/01/2023	-98.6	11.9	14,079	6.96
		11/04/2023	-170.5	77.2	12,926	6.98

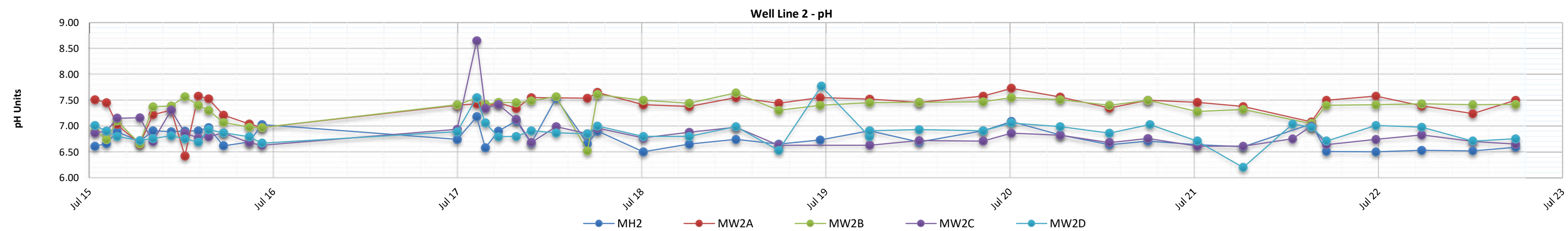
Table C4: Monitoring wells and manholes - 2022 - 2023 Field Data

	Location	Sample Date	Redox (Field)	Dissolved Oxygen (% saturated) (Field)	Electrical Conductivity (Field)	pH (Field)
			mV	%S	µS/cm	pH Units
Well Line 5	MH5	8/07/2022	-138.8	10.7	10,180	6.90
		7/10/2022	-1.8	10.0	4,898	6.86
		16/01/2023	-25.0	10.4	7,024	6.76
		11/04/2023	-61.3	6.5	5,479	6.87
	MW5A	8/07/2022	-89.8	13.9	6,537	7.01
		7/10/2022	-61.4	27.9	1,951	7.40
		16/01/2023	-27.0	18.0	2,103	7.50
		11/04/2023	-33.2	9.6	2,719	6.92
	MW5B	8/07/2022	-67.0	18.6	4,406	7.60
		7/10/2022	-22.3	8.0	4,846	7.73
		16/01/2023	-2.3	22.9	4,962	7.36
		11/04/2023	-51.4	10.4	4,955	7.16
	MW5C	8/07/2022	-82.2	23.6	7,053	7.51
		7/10/2022	-88.4	9.6	7,699	7.11
		16/01/2023	-140.4	9.3	7,991	7.12
		11/04/2023	-161.4	5.6	3,979	7.30
Pump Station 5		8/07/2022	-31.3	40.7	2,259	7.04
		7/10/2022	-71.6	26.8	4,924	7.08
		16/01/2023	-103.4	13.2	10,840	7.00
		11/04/2023	-108.5	9.6	8,604	6.99
Well Line 6	MH6	8/07/2022	-44.1	25.3	5,715	6.38
		7/10/2022	-33.0	13.6	5,001	6.87
		16/01/2023	-9.2	7.0	5,953	6.81
		11/04/2023	-33.3	27.1	4,604	7.00
	MW6A	8/07/2022	-79.6	60.5	4,888	6.93
		7/10/2022	-89.2	8.2	4,794	6.92
		16/01/2023	99.9	12.4	4,813	6.87
		11/04/2023	-7.1	5.1	4,662	7.19
	MW6B	8/07/2022	-66.9	102.8	1,902	7.56
		7/10/2022	-61.9	40.3	2,017	7.07
		16/01/2023	-40.0	8.0	2,080	6.88
		11/04/2023	-7.1	53.6	2,096	7.19
	MW6C	8/07/2022	-43.0	38.6	6,232	6.67
		7/10/2022	-50.4	57.8	1,234	7.22
		16/01/2023	-54.3	17.3	1,308	6.60
		11/04/2023	-5.5	62.5	1,327	6.90
Pump Station 6		8/07/2022	-52.1	185.8	6,070	6.97
		7/10/2022	-60.2	46.9	5,199	6.95
		16/01/2023	-87.3	11.8	6,292	6.81
		11/04/2023	-55.9	12.4	45,878	6.84
Well Line 7	MH7	8/07/2022	91.0	10.8	11,532	6.62
		7/10/2022	-6.0	8.5	7,371	6.75
		16/01/2023	-12.2	11.6	9,390	6.65
		11/04/2023	53.4	13.5	10,384	6.69
	MW7A	8/07/2022	-21.3	12.3	1,719	7.57
		7/10/2022	-87.9	55.2	1,777	7.85
		16/01/2023	-143.8	12.3	1,830	7.49
		11/04/2023	-135.1	9.7	1,803	7.28
	MW7B	8/07/2022	-21.4	55.8	1,678	7.27
		7/10/2022	-55.5	59.0	1,850	7.47
		16/01/2023	-64.7	31.7	1,943	7.05
		11/04/2023	21.6	17.2	1,930	6.96
	MW7D	8/07/2022	101.5	80.7	14,731	7.21
		7/10/2022	3.3	35.3	16,181	6.83
		16/01/2023	-10.8	11.3	17,063	6.55
		11/04/2023	32.6	49.8	16,924	6.90
Pump Station 7		8/07/2022	-43.3	42.9	3,543	6.90
		7/10/2022	-54.8	53.2	1,834	6.81
		16/01/2023	-65.4	26.5	4,379	6.89
		11/04/2023	-82.9	34.5	4,024	6.83
Well Line 8	MH8	8/07/2022	69.6	58.5	891	7.03
		7/10/2022	3.1	27.4	954	6.59
		16/01/2023	-14.7	8.7	1,166	7.76
		11/04/2023	-37.8	27.0	1,213	6.95
	MW8A	8/07/2022	99.9	16.2	1,365	7.43
		7/10/2022	-22.6	103.7	1,473	6.99
		16/01/2023	109.1	15.9	1,552	7.05
		11/04/2023	-27.1	86.9	1,497	6.99
	MW8B	8/07/2022	123.3	88.3	1,167	7.00
		7/10/2022	-22.0	76.0	1,301	7.44
		16/01/2023	-63.2	14.8	1,320	7.12
		11/04/2023	-67.8	23.8	1,296	7.01
	MW8C	8/07/2022	65.6	64.8	1,039	7.02
		7/10/2022	5.8	69.7	928	7.16
		16/01/2023	-17.6	12.8	948	6.57
		11/04/2023	75.5	11.7	879	6.18
Pump Station 8		8/07/2022	83.4	18.4	2,600	6.55
		7/10/2022	13.1	10.9	4,481	6.79
		16/01/2023	-0.6	17.8	5,586	6.84
		11/04/2023	1.4	63.8	3,137	6.62
Pump Station 9		8/07/2022	-16.7	30.3		6.23
		7/10/2022	76.5	110.4	5,188	5.77
		16/01/2023	-	-	-	-
		11/04/2023	-4.7	44.1	602	6.09

Notes:
A hyphen (-) indicates that field parameters are not avaliable.







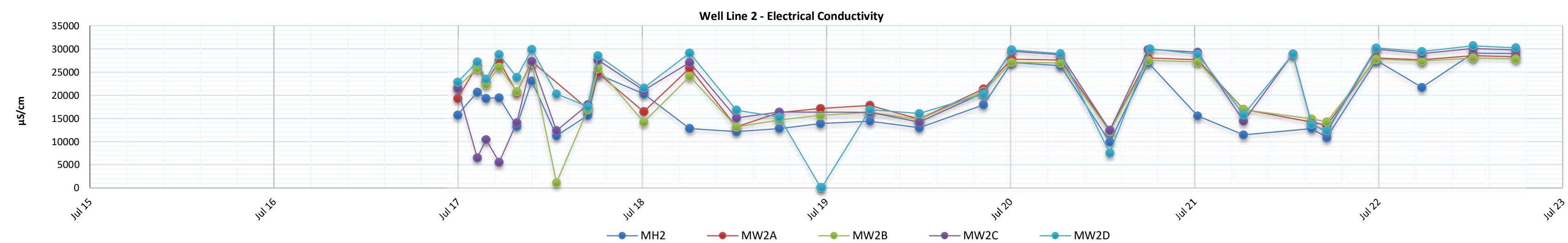
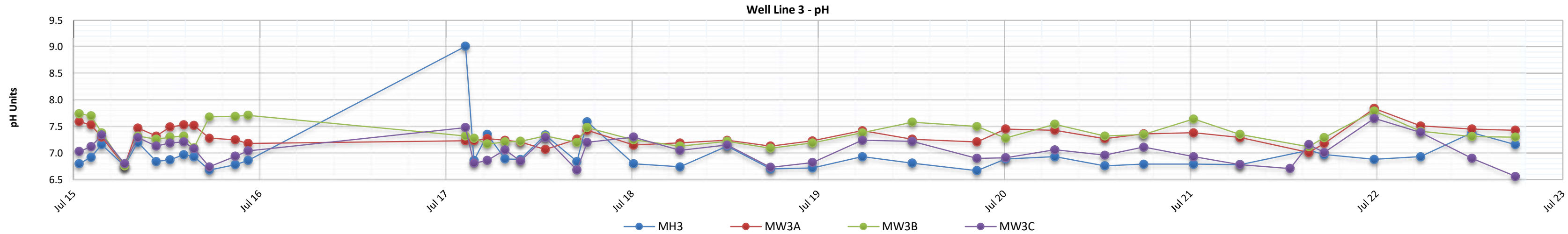
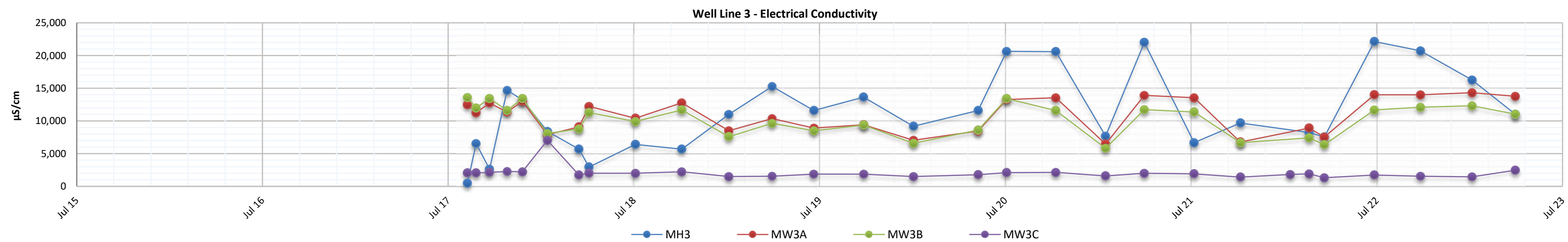
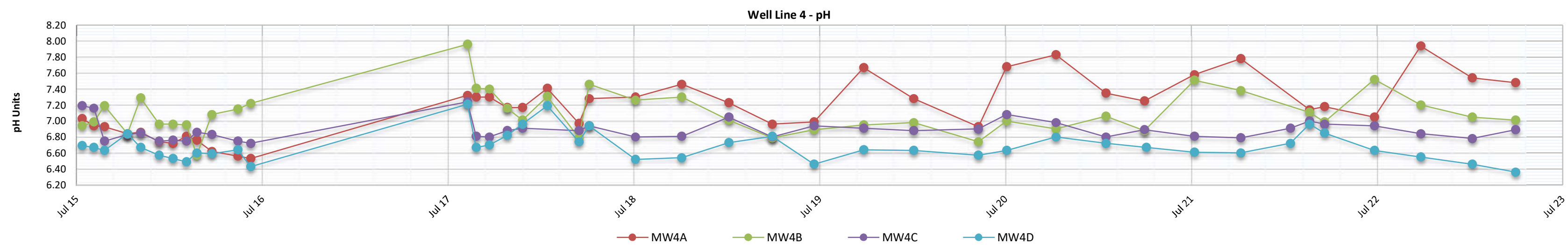


Figure C3-1: Green Island Landfill - Manhole, Shallow Monitoring Wells and Pump Station pH and EC Data	Date: Aug-23	Page 1	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		







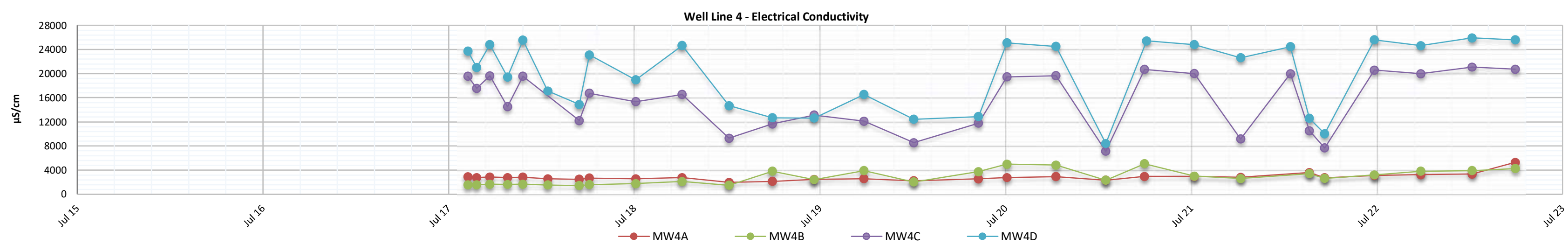


Figure C3-2: Green Island Landfill - Manhole, Shallow Monitoring Wells and Pump Station pH and EC Data

DCC Landfill All Data

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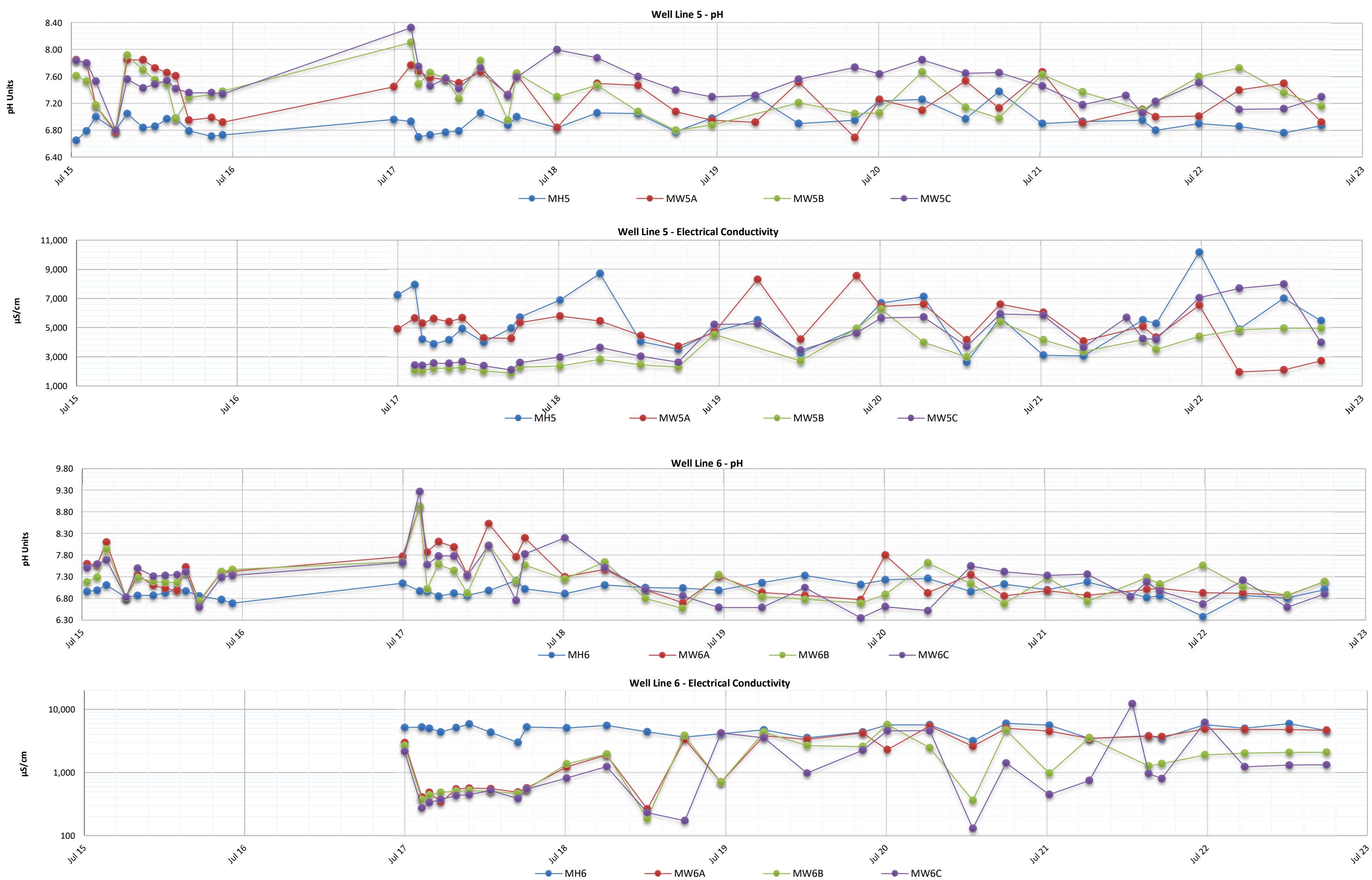


Figure C3-3: Green Island Landfill - Manhole, Shallow Monitoring Wells and Pump Station pH and EC Data	Date: Aug-23	Page 3	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		

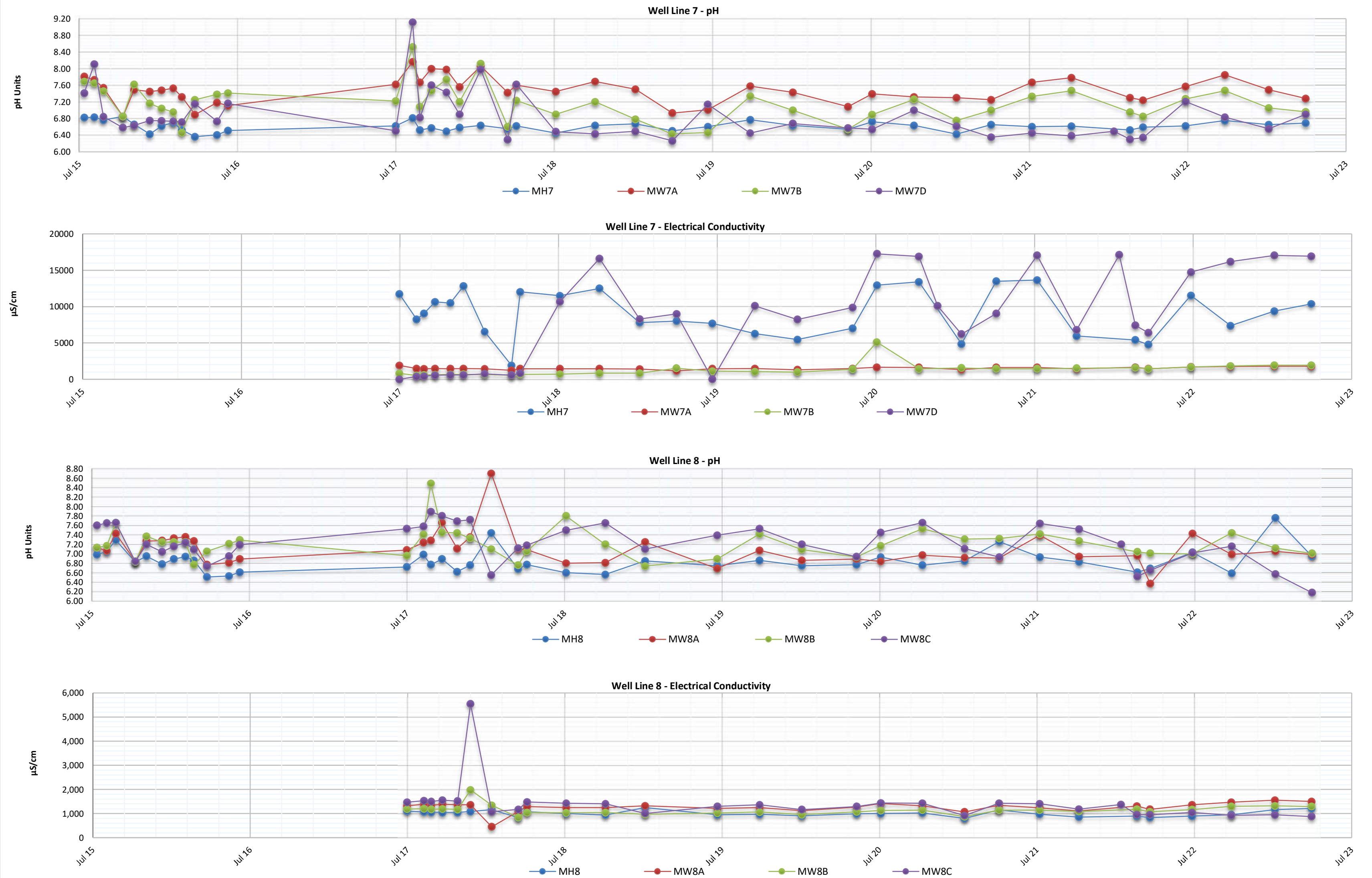
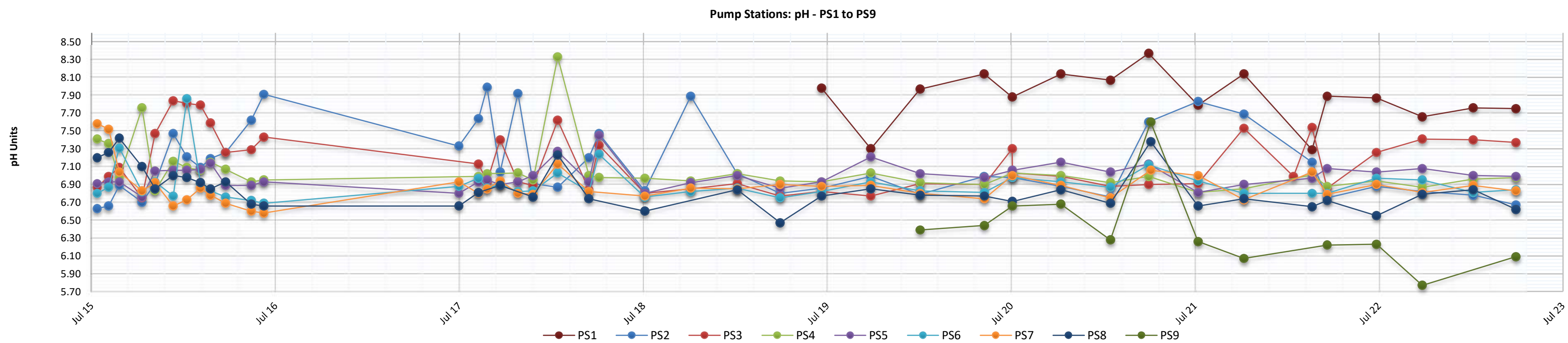
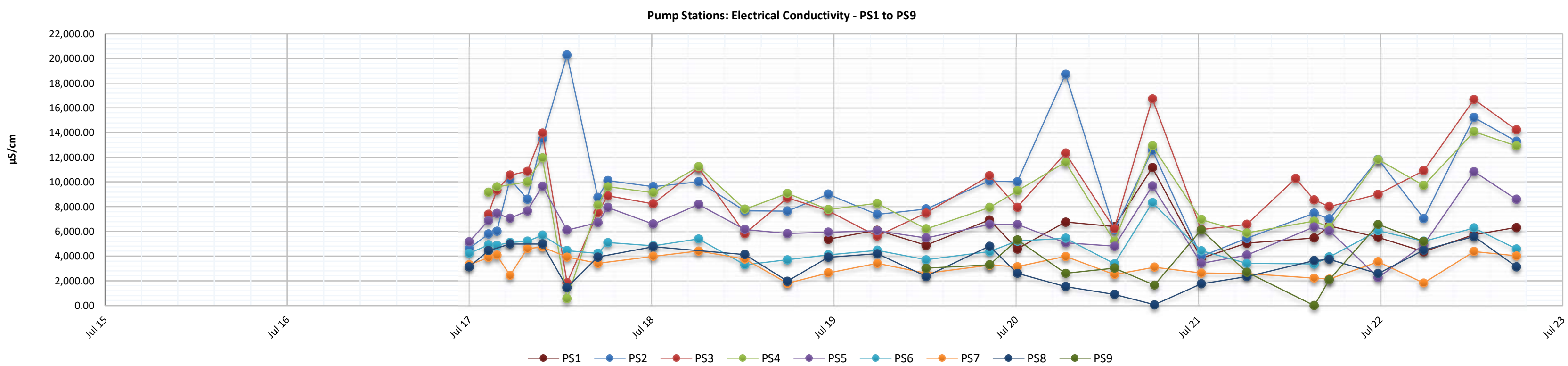


Figure C3-4: Green Island Landfill - Manhole, Shallow Monitoring Wells and Pump Station pH and EC Data	Date: Aug-23	Page 4
	Drawn: HE	Reviewer: CG
DCC Landfill All Data	Project Number: 12587765	





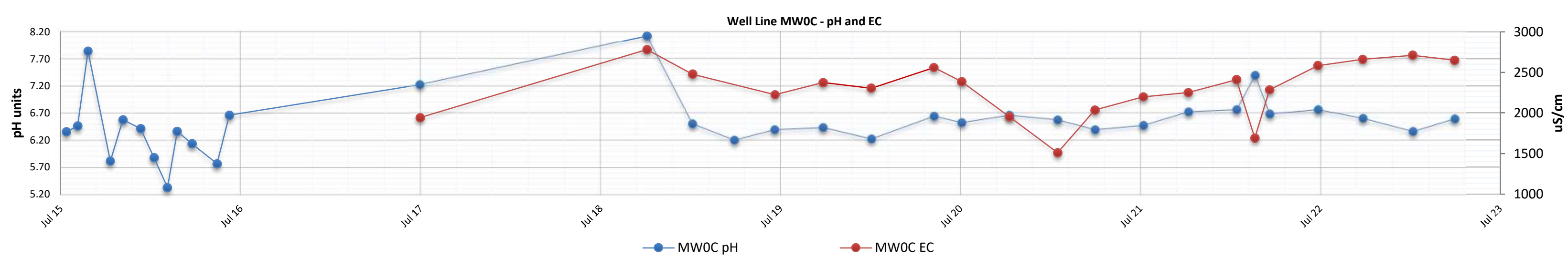


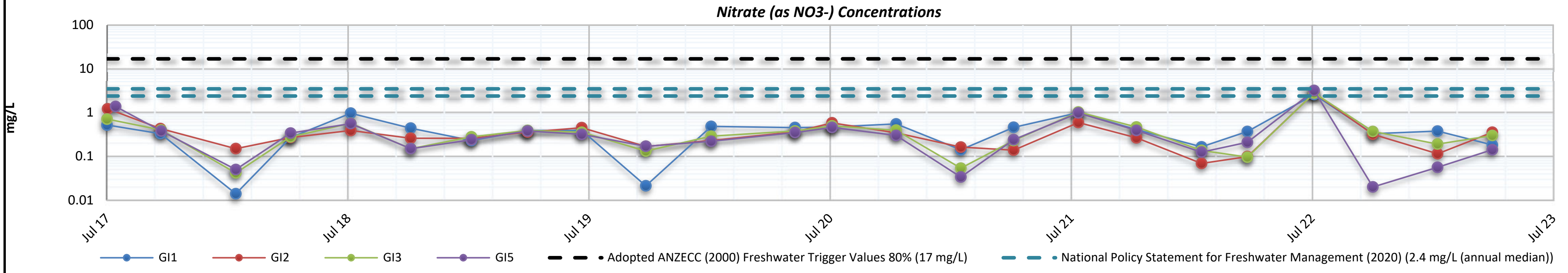
Figure C3-5: Green Island Landfill - Manhole, Shallow Monitoring Wells and Pump Station pH and EC Data	Date: Aug-23	Page 5	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		

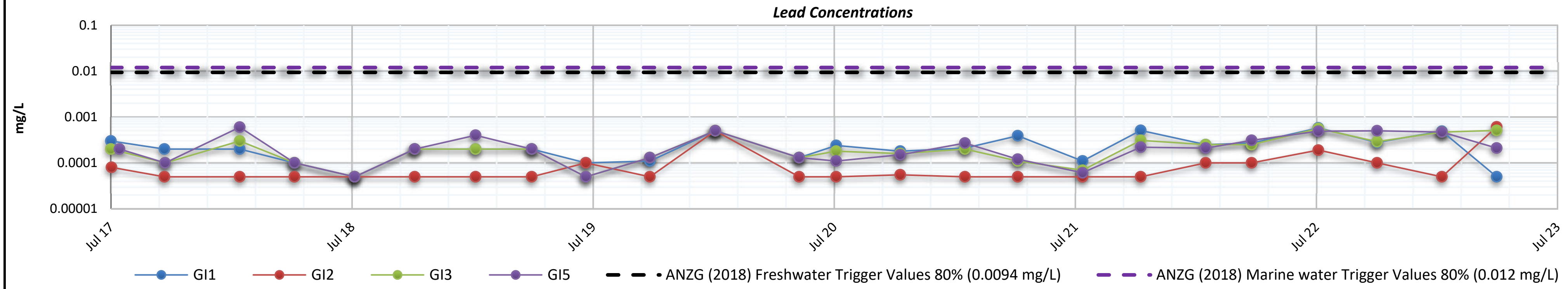
Table C5: Green Island Landfill - Kaikorai Stream Analytical Results 2022 / 2023

		Elements in Water (soluble)						Field Parameters					Water - Aggregates/Nutrients					
		Aluminium (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Copper (Filtered)	Lead (Filtered)	Nickel (Filtered)	Dissolved Oxygen (%S) (Field)	Dissolved Oxygen (mg/L) (Field)	Electrical conductivity (Field)	Temperature	pH (Field)	Ammonia as N (Filtered)	Ammonia (Corrected for pH and Temperature)	Cyanide (Total)	Nitrate (as N)	Total Organic Carbon	Chloride (Filtered)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%S	mg/L	µS/cm	°C	pH Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR[#1]		0.003	0.00005	0.0005	0.0005	0.0001	0.0005	-	-	-		-	0.01	-	0.002	0.02	0.5	0.5
ANZG (2018) Freshwater 80% Toxicant Default Guideline Values		0.15	0.0008	0.04	0.0025	0.0094	0.017	98 - 105	-	-	-	7.2-7.8	-	2.3	0.018	17	-	-
ANZG (2018) Marine Water 80% Toxicant Default Guideline Values		-	0.036	0.0085	0.008	0.012	0.56	-	-	-	-	-	-	1.7	0.014	-	-	-
National Policy Statement for Freshwater Management (2020)		-	-	-	-	-	-	-	4.0 and 5.0[#5]	-	-	-	-	0.24 and 0.40 [#3]	-	2.4 and 3.5* [#4]	-	-
Sample Location	**Sample Date**																	
GI1	15/07/2022	**0.31**	<0.00005	0.0007	0.0027	**0.00058**	0.0014	101.9	12.56	223.1	6.0	7.37	0.108	0.009	<0.002	**2.6**	**10.4**	23
	12/10/2022	0.069	<0.00005	<0.0005	0.0022	0.00028	0.001	115.3	**13.32**	209.2	9.3	8.77	<0.01	0.012	<0.002	0.33	5	18.7
	18/01/2023	0.082	<0.00002	0.00079	0.0038	0.00049	0.0011	97.1	9.7	***194***	15.6	7.97	0.02	0.014	0.05	0.378	6	17
	11/04/2023	0.144	0.0002	<0.0002	0.0018	<0.00005	0.017	64.5	***6.63***	575	13.2	6.28	0.12	0.009	<0.02	0.182	3.2	**32.6**
Historical Statistical Summary																		
Minimum Concentration		0.01	<0.00001	<0.0002	0.001	<0.00005	0.0005	29.5	7.67	108.4	-	5.96	<0.005	-	<0.001	0.014	1.9	10.3
Maximum Concentration		0.301	0.00028	<0.002	0.004	0.00051	0.0238	158.2	12.83	5,004	-	9.02	0.38	-	0.083	0.998	9	29.9
Average Concentration		0.048	0.000028	0.0003	0.0019	0.00021	0.002	125	10	480	-	8.1	0.033	-	0.0056	0.4	4.715	18
Sample Location	**Sample Date**																	
GI2	15/07/2022	**0.53**	0.00011	0.0007	0.0023	0.00019	0.0082	86.5	10.69	309.6	6.0	6.29	0.089	0.001	<0.002	**2.8**	**13**	30
	12/10/2022	0.055	0.00012	<0.0005	0.0014	<0.0001	0.0128	65	7.6	420.1	9.2	6.47	0.142	0.002	<0.002	0.32	***3.4***	29
	18/01/2023	0.024	0.000085	<0.0002	0.00093	<0.00005	0.0091	***7.3***	***0.71***	1,980	16.4	7.01	0.12	0.010	0.03	0.115	***2.1***	24.3
	11/04/2023	0.117	<0.00002	0.00044	**0.0029**	**0.00061**	0.0007	91.2	9.24	1,228	18.9	7.91	<0.005	0.002	<0.02	0.355	***4.1***	***12.2***
Historical Statistical Summary																		
Minimum Concentration		0.0027	<0.00001	<0.0002	0.00048	<0.00005	0.00054	54.9	5.73	110.5	-	6.03	0.006	-	<0.001	0.069	8.9	14.7
Maximum Concentration		0.148	<0.0002	<0.002	0.0028	<0.0005	0.0173	142.7	11.54	21,530	-	9.58	0.26	-	0.024	1.22	11.4	37.1
Average Concentration		0.035	0.000075	0.00019	0.0012	0.000047	0.008	121	8.1	1,425	-	7.1	0.12	-	0.0035	0.34	4.505	24
Sample Location	**Sample Date**																	
GI3	15/07/2022	**0.38**	<0.00005	0.0012	0.0029	**0.00056**	0.0024	88.6	10.94	312.4	6.1	7.2	0.173	0.010	<0.002	**2.8**	**13.7**	36
	12/10/2022	**0.111**	<0.00005	<0.0005	0.0026	0.00029	0.0023	77.7	8.86	603.9	10.0	7.08	0.027	0.002	<0.002	0.37	6	98
	18/01/2023	0.036	<0.00002	0.00028	0.0029	0.00047	0.0016	68	6.57	330.1	17.0	7.55	0.04	0.012	0.02	0.191	4.8	38.7
	11/04/2023	**0.108**	<0.00002	0.00058	0.0026	**0.00051**	0.002	59.5	5.75	11,538	14.2	***6.82***	0.09	0.004	<0.02	0.3	4.1	339
Historical Statistical Summary																		
Minimum Concentration		0.009	<0.00001	<0.0002	0.00075	<0.00005	0.0009	6.1	4.94	183.4	-	6.84	<0.01	-	<0.001	0.042	2.1	13.5
Maximum Concentration		0.064	<0.0002	<0.002	0.0029	<0.0005	0.003	97.7	11.33	26,900	-	8.25	0.57	-	<0.005	1.03	9.2	2,330
Average Concentration		0.028	0.000019	0.00029	0.0015	0.00017	0.0021	83	7	4,816	-	7.4	0.19	-	0.0018	0.34	5.44	272
Sample Location	**Sample Date**																	
GI5	15/07/2022	**0.42**	<0.00005	0.0011	0.0031	0.00049	0.0036	14.1	***1.72***	550.4	5.9	7.34	0.38	0.029	<0.002	**3.2**	12.6	75
	12/10/2022	0.091	<0.00005	0.0013	0.0022	0.0005	0.0018	33.5	***3.7***	1,753	10.9	***6.49***	0.024	0.0004	<0.002	<0.02	21	320
	18/01/2023	0.028	<0.00002	0.00036	0.0011	0.00047	0.0017	57.7	***5.35***	719	19.0	7.53	0.18	0.058	<0.02	0.0563	4.4	131
	11/04/2023	0.02	<0.00002	0.00021	0.0011	0.00021	0.0014	30.5	***2.35***	677	16.4	6.86	***0.008***	0.0005	<0.02	0.142	5	1,030
Historical Statistical Summary																		
Minimum Concentration		0.0094	<0.00001	<0.0002	0.00072	<0.00005	0.0011	2.8	6.28	197.4	-	6.67	<0.01	-	<0.001	0.0337	2.1	24.2
Maximum Concentration		0.203	<0.0002	<0.002	0.0037	0.0008	0.014	149.6	10.98	25,270	-	8.81	2.44	-	0.07	2.75	24.4	1,850
Average Concentration		0.035	0.000026	0.00036	0.0017	0.00022	0.003	88	8.3	2,969	-	7.6	0.28	-	0.0048	0.48	6.252	392

Notes:
LOR - Laboratory Limit of Reporting
Underlined values have been adopted from the ANZECC 80% (freshwater and marine water protection values). Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Red and Bold: Value exceeds the Historical Maximum Concentration
Blue, Italic and Bold : Value is less than the Historical Minimum Concentration
Values shaded grey represent concentrations lower than LOR
A hyphen (-) indicates that a parameter or criterion is not available
< - Less than the LOR

References and Comments:
ANZG (2018) Freshwater 80% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for fresh water protection values. Australian and New Zealand Environment and Conservation Council (2018).
ANZG (2018) Marine water 80% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for marine water protection values. Australian and New Zealand Environment and Conservation Council (2018).
National Policy Statement for Freshwater Management (2020). Values taken from Appendix 2A - Attributes requiring limits on resource use.
#1: LOR in table represents the LOR for Hills Laboratory which analysed samples in July and October 2022. For the LOR for the January and April 2023 analysis, please see the associated laboratory reports.
#2: 1-day minimum (lowest daily minimum across the whole summer period) and 7-day mean minimum (mean value of seven consecutive daily minimum values). Values presented not directly comparable to NPS attribute value and as such are not shaded.
#3: 95% species protection level: Starts impacting occasionally on the 5% most sensitive species. The national bottom line guideline values were adopted: the annual median (0.24 mg/L) and the annual maximum (0.40 mg/L)
#4:Some growth effect on up to 5% of species. The national bottom line guideline values were adopted: the annual median (2.4 mg/L) and the annual maximum (3.5 mg/L)
#5: 11-day minimum (4.0 mg/L) (lowest daily minimum across the whole summer period) and 7-day mean minimum (5.0 mg/L) (mean value of seven consecutive daily minimum values). Values presented not directly comparable to NPS attribute value.





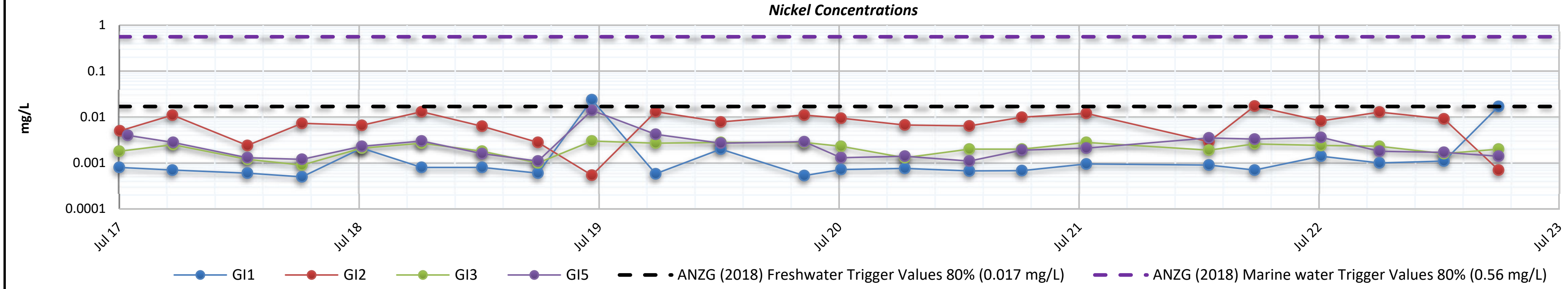


Figure C4-1: Green Island Landfill Surface Water - Chemistry Data	Date: Aug 23	Page 1	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		

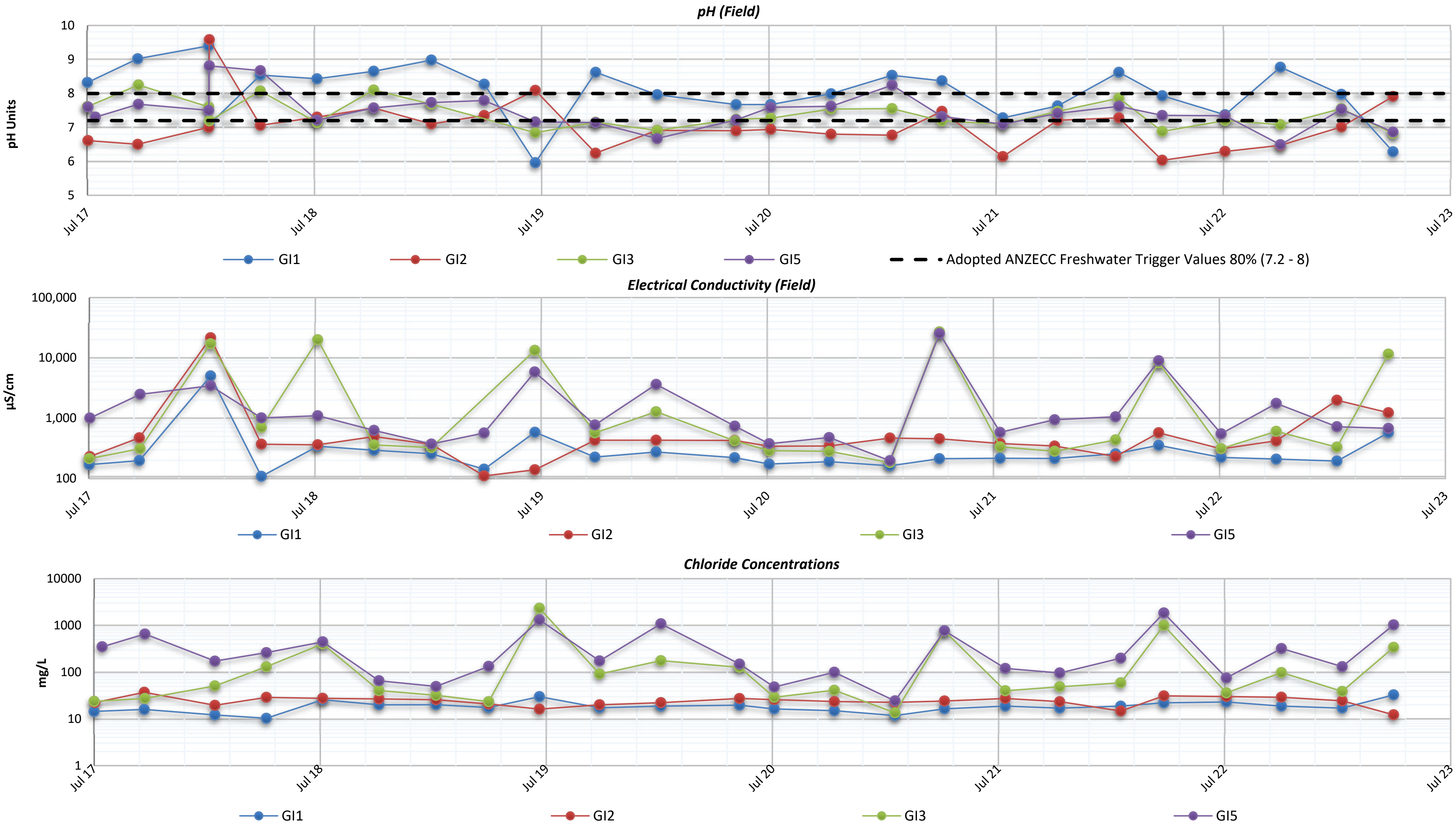
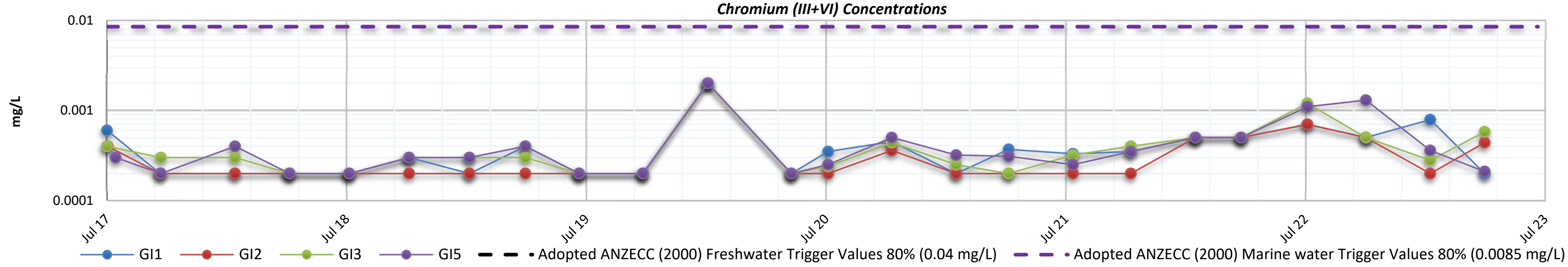
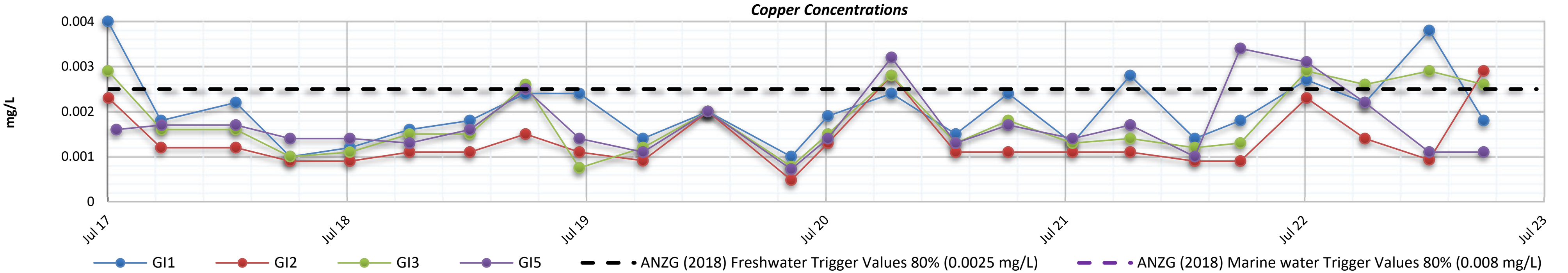


Figure C4-2: Green Island Landfill Surface Water - Chemistry Data	Date: Aug 23	Page 2
	Drawn: HE	Reviewer: CG
DCC Landfill All Data	Project Number: 12587765	





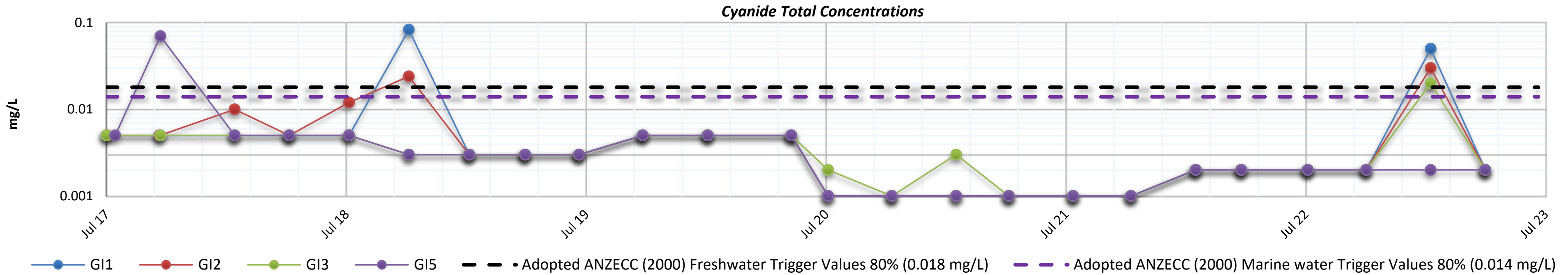


Figure C4-3: Green Island Landfill Surface Water - Chemistry Data	Date: Aug 23	Page 3	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		

Uncorrected ammonia concentrations are presented on this graph. Corrected values are provided in Table C5.

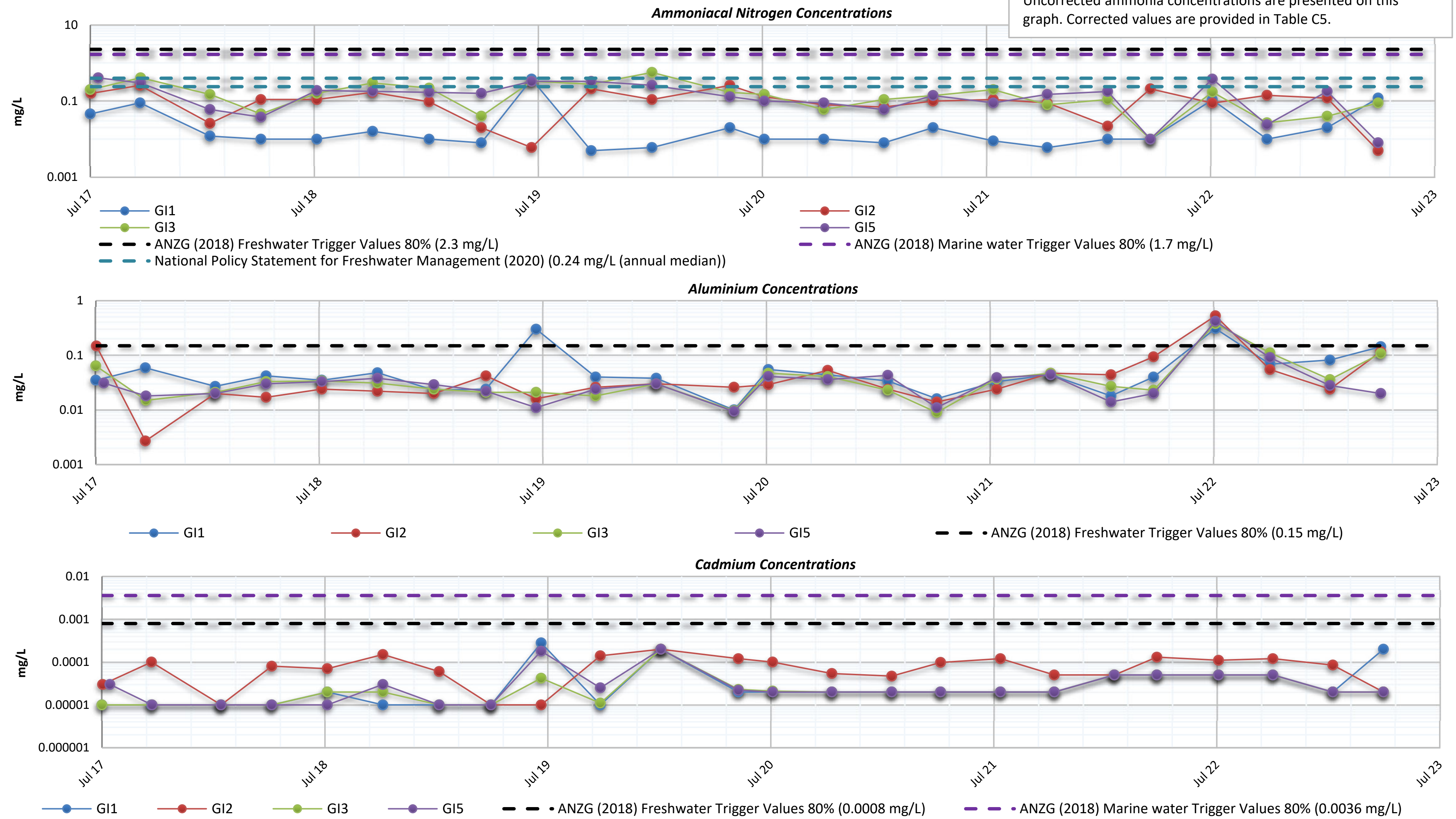


Figure C4-4: Green Island Landfill Surface Water - Chemistry Data

DCC Landfill All Data

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Drawn: HE	Reviewer: CG
Project Number: 12587765	

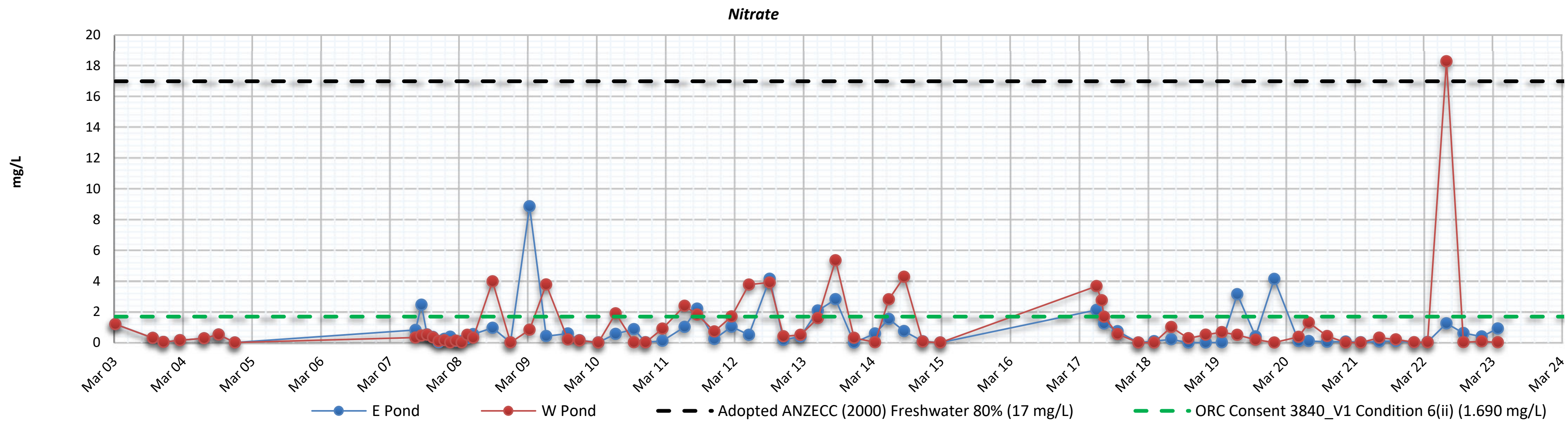
GHD

Table C6: Green Island Landfill - Sedimentation Ponds Analytical Results 2022 / 2023

		Elements in Water (soluble)					Major Ions		Field Parameters					Nutrients			Total Alkalinity	Organic Indicators
		Chromium (III+VI) (Filtered)	Copper (Filtered)	Lead (Filtered)	Nickel (Filtered)	Zinc (Filtered)	Potassium	Chloride (Filtered)	Dissolved Oxygen (%S) (Field)	Dissolved Oxygen (mg/L) (Field)	Electrical conductivity (field)	Temperature	pH (Field)	Ammonia as N (Filtered)	Ammonia (Corrected for pH and temperature)	Nitrate (as N)	Alkalinity (total as CaCO3)	Total Organic Carbon
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%S	mg/L	µS/cm		pH Units	mg/L	mg/L	mg/L	mg/L	mg/L
LOR [#1]		0.0005	0.0005	0.0001	0.0005	0.001	0.05	0.5	-	-	-		-	0.01	-	0.001	1	0.5
ANZG (2018) Freshwater 80% Toxicant Default Guideline Values		0.04	0.0025	0.0094	0.017	0.031	-	<u>0.013</u>	<u>98 - 105</u>	-	-	-	<u>7.2 - 7.8</u>	-	2.3	<u>17</u>	-	-
ANZG (2018) Marine Water 80% Toxicant Default Guideline Values		0.085	0.008	0.012	0.56	0.021	-	-	-	-	-	-	-	-	1.7	-	-	-
ORC Consent 3840_V1 Condition 6(ii)		0.008	0.0068	0.0008	0.0106	0.029	217	2,068	-	-	-	-	-	-	17.33	1.690	560	78.3
Sample Location	**Sample Date**																	
Eastern Pond	14/07/2022	0.0016	0.0037	0.00133	0.0019	0.0146	11.3	46	41.6	4.95	579.3	7.2	7.37	0.53	0.048	1.25	58	18.2
	12/10/2022	0.0006	0.0038	0.00044	0.0047	0.0018	26	150	67	7.41	1,052	11.3	8.17	0.113	0.087	0.62	240	31
	17/01/2023	0.0014	0.0015	0.0013	0.0074	0.043	45.1	494	252.2	**20.54**	2,147	25.7	9.36	***<0.005***	0.0380	0.394	242	86
	12/04/2023	0.0011	***0.00026***	0.00024	0.0043	0.0039	33.8	202	16.1	1.66	1,214	13.6	7.65	***<0.005***	0.0007	0.915	193	34.6
Historical Statistical Summary																		
Minimum Concentration		0.0002	0.00028	<0.00005	<0.0005	<0.001	0.06	6.93	1.2	0.93	120	-	7.33	<0.01	-	<0.001	12	7
Maximum Concentration		1,050	4.3	0.016	0.04	1.22	310	950	336.8	10.58	3,600	-	9.38	15.4	-	8.86	560	163
Average Concentration		50	0.16	0.0015	0.0082	0.04	36	219	57	5.3	1,461	-	8.2	4.1	-	0.66	302	46
Sample Location	**Sample Date**																	
Western Pond	14/07/2022	0.001	0.0048	0.00027	0.0025	0.0098	36	1,240	66.1	7.91	4,605	6.6	7.46	1.7	0.180	**18.3**	112	29
	12/10/2022	<0.005	<0.005	<0.001	<0.005	<0.01	44	2,000	52.4	5.48	6,205	12.9	7.45	0.097	0.016	0.03	132	13.6
	17/01/2023	0.0018	0.00056	0.00021	0.0025	0.0028	63.6	2,210	75.7	6.15	7,676	24.7	8.04	0.65	0.983	0.0787	221	31.2
	13/04/2023	0.0019	0.0012	0.000078	0.0018	0.0028	53.3	1,840	30.7	3.02	6,535	14.6	7.61	4.05	1.130	0.0172	239	29
Historical Statistical Summary																		
Minimum Concentration		0.00047	0.00042	<0.00005	<0.0005	<0.001	0.06	6.93	26.3	2.6	740	-	7.22	<0.005	-	0.0008	12	7
Maximum Concentration		1,050	4.3	0.016	0.041	1.22	97.9	2,880	271.6	9.62	18,100	-	9.09	55.4	-	5.35	810	186
Average Concentration		50	0.16	0.0011	0.0094	0.039	52	815	78	6.7	3,839	-	8.2	7.7	-	0.9	346	53

Notes:
LOR - Laboratory Limit of Reporting
Underlined values have been adopted from the ANZECC 95% (fresh water protection values). Australian and New Zealand Environment and Conservation Council (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
Red and Bold: Value exceeds the Historical Maximum Concentration
Blue, Italic and Bold : Value is less than the Historical Minimum Concentration
< - Less than the LOR
Values in grey text represent concentrations lower than LOR
A hyphen (-) indicates that a parameter or criterion is not available
Half the LOR value was used in the calculation for the corrected ammonia concentration where original concentration reported as <LOR

Comments and References:
ANZG (2018) Freshwater 80% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for fresh water protection values. Australian and New Zealand Environment and Conservation Council (2018).
ANZG (2018) Marine water 80% Toxicant Default Guideline Value - Values taken from the Default Guideline Values for Marine water protection values. Australian and New Zealand Environment and Conservation Council (2018).
ORC Consent 3840_V1 Condition 6(ii)
#1: LOR in table represents the LOR for Hills Laboratory which analysed samples in July and October 2022. For the LOR for the January and April 2023 analysis, please see the associated laboratory reports.



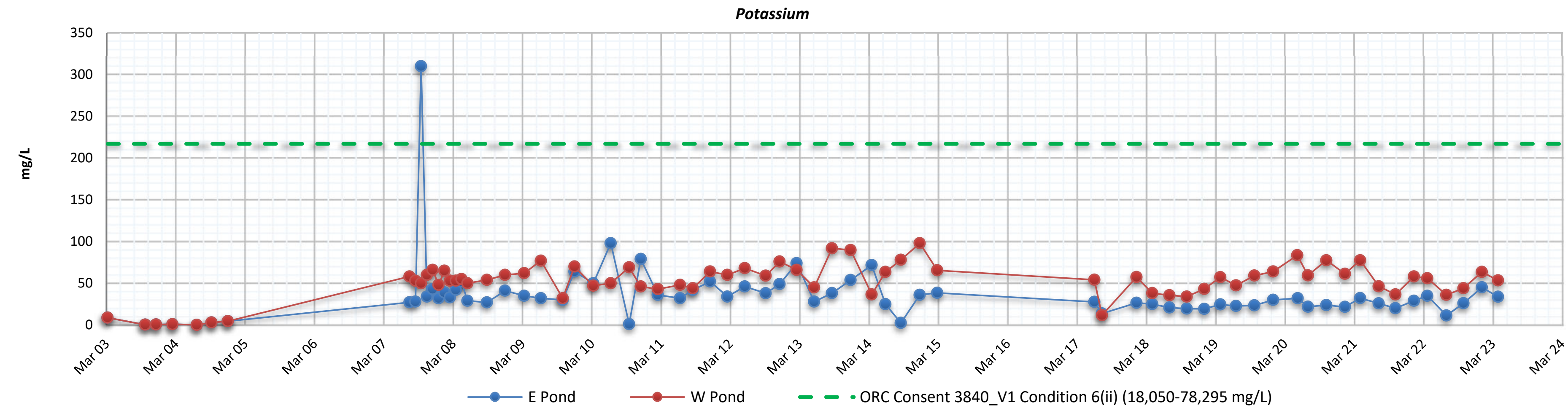
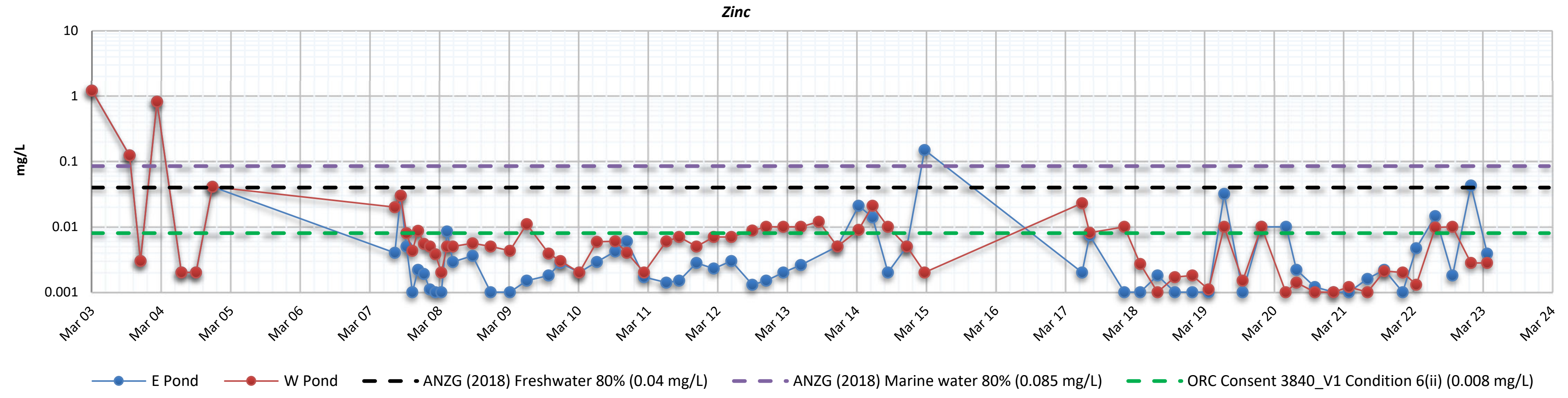


Figure C5-1: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data	**Date:** Aug 23	**Page 1**	GHD
	Drawn: HE	**Reviewer:** CG	
DCC Landfill All Data	**Project Number:** 12587765		



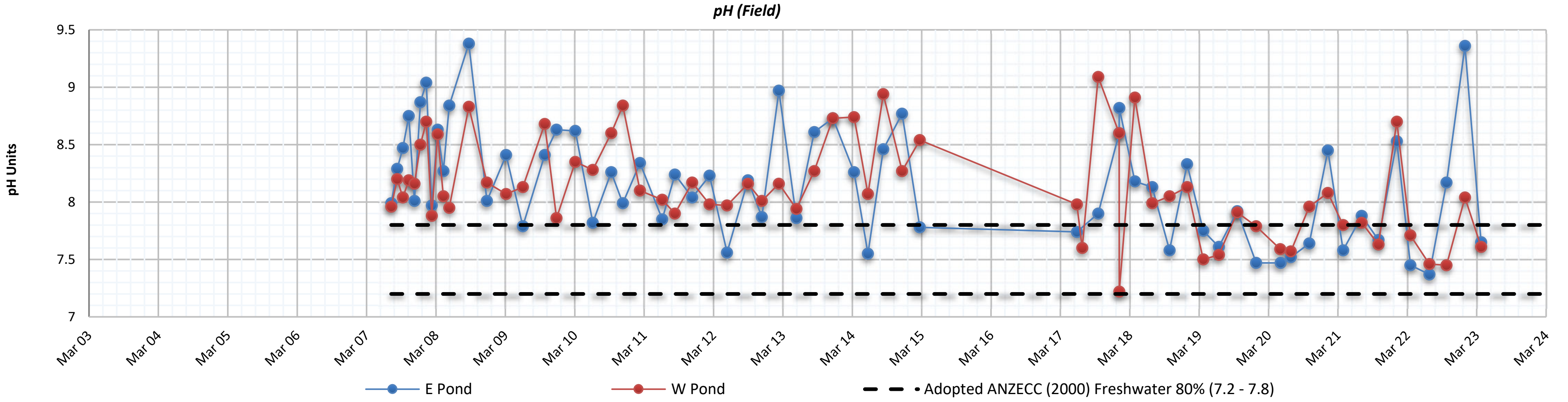
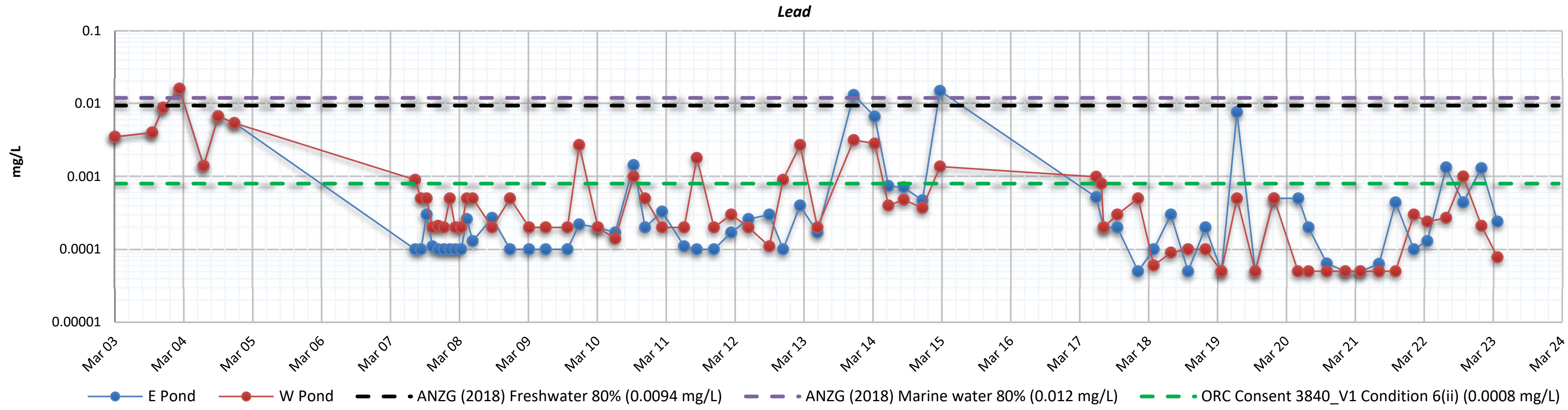


Figure C5-2: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data	Date: Aug 23	Page 2	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		



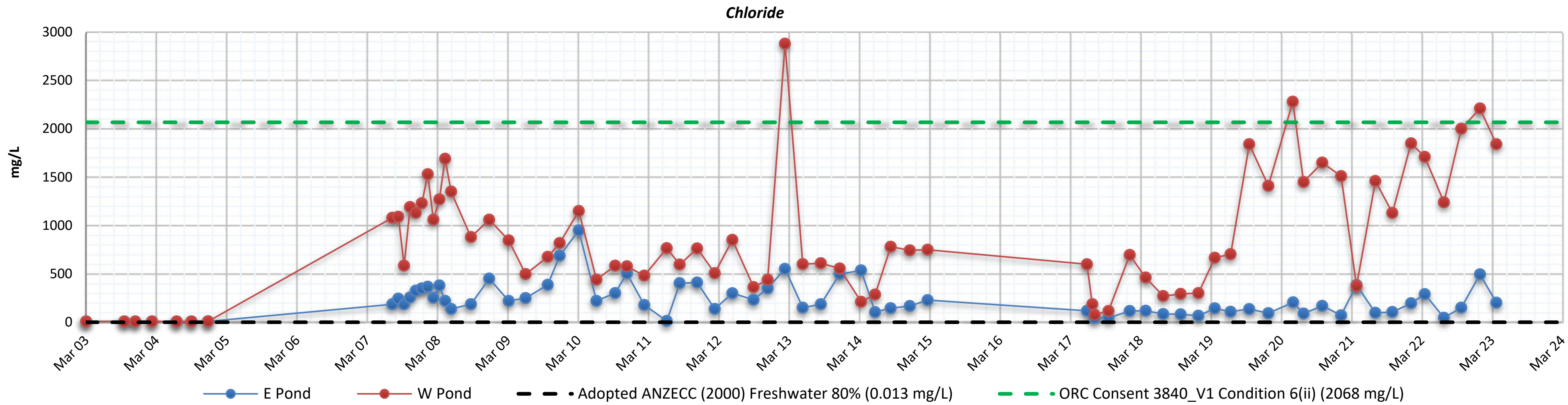


Figure C5-3: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data

DCC Landfill All Data

Date: Aug 23	Page 3
Drawn: HE	Reviewer: CG
Project Number: 12587765	

GHD

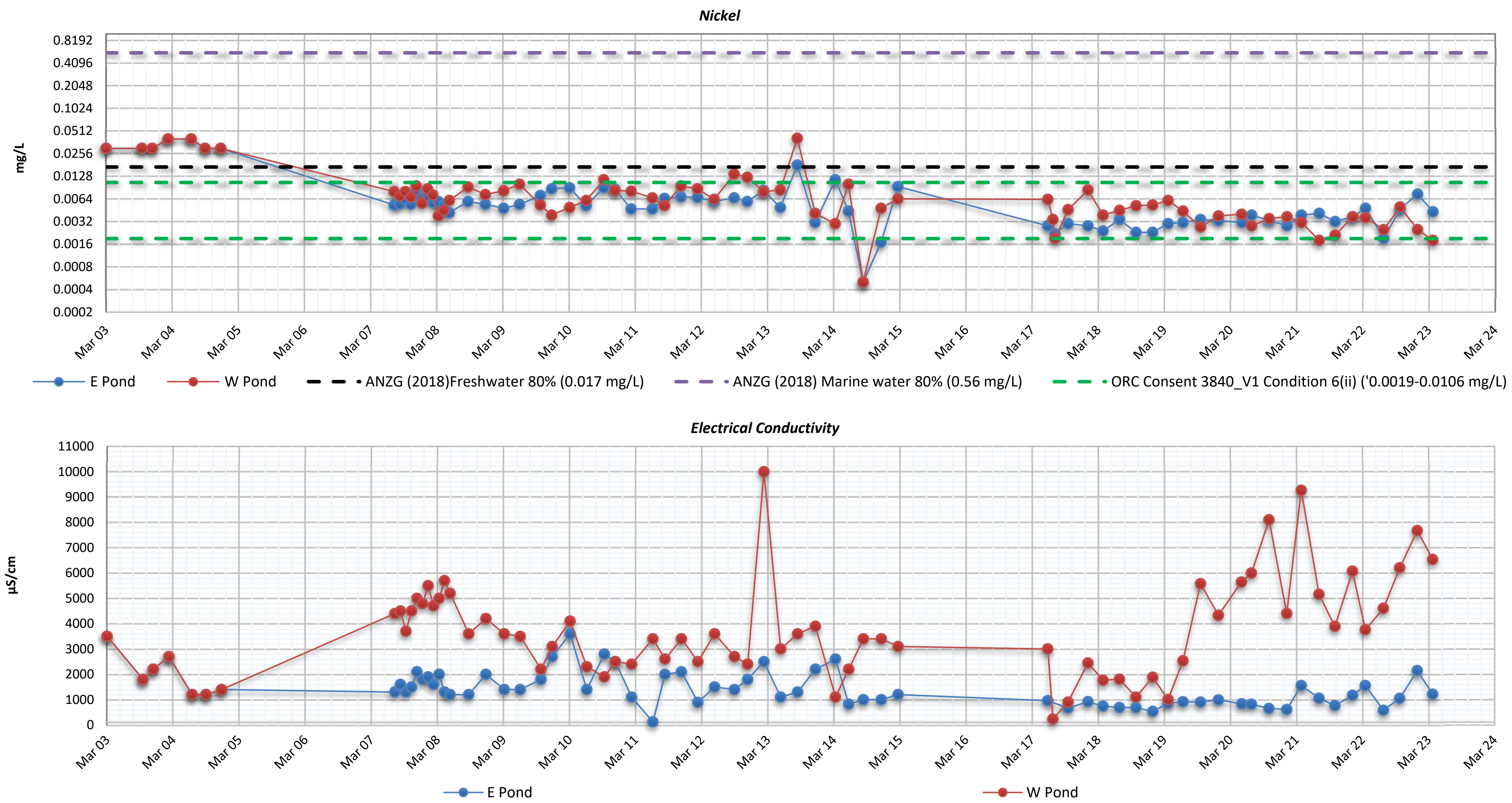
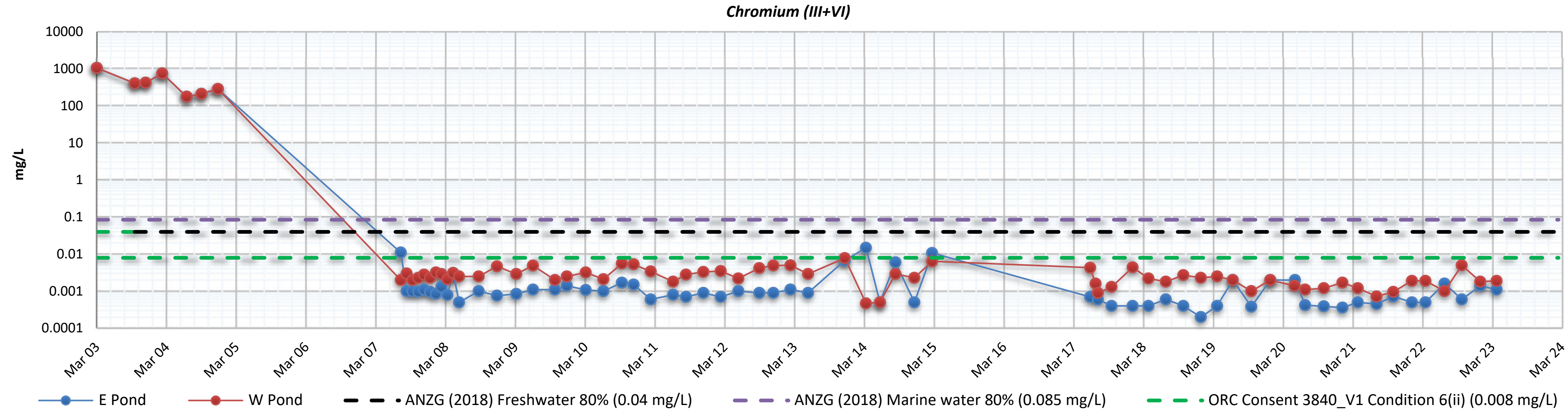


Figure C5-4: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data

DCC Landfill All Data

Date: Aug 23	Page 4
Drawn: HE	Reviewer: CG
Project Number: 12587765	

GHD



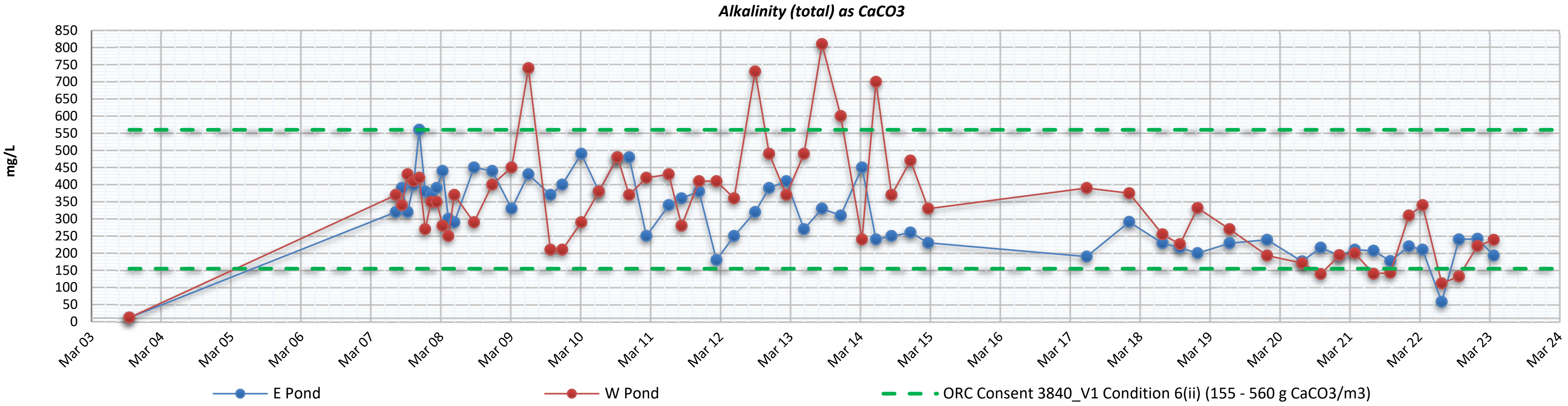
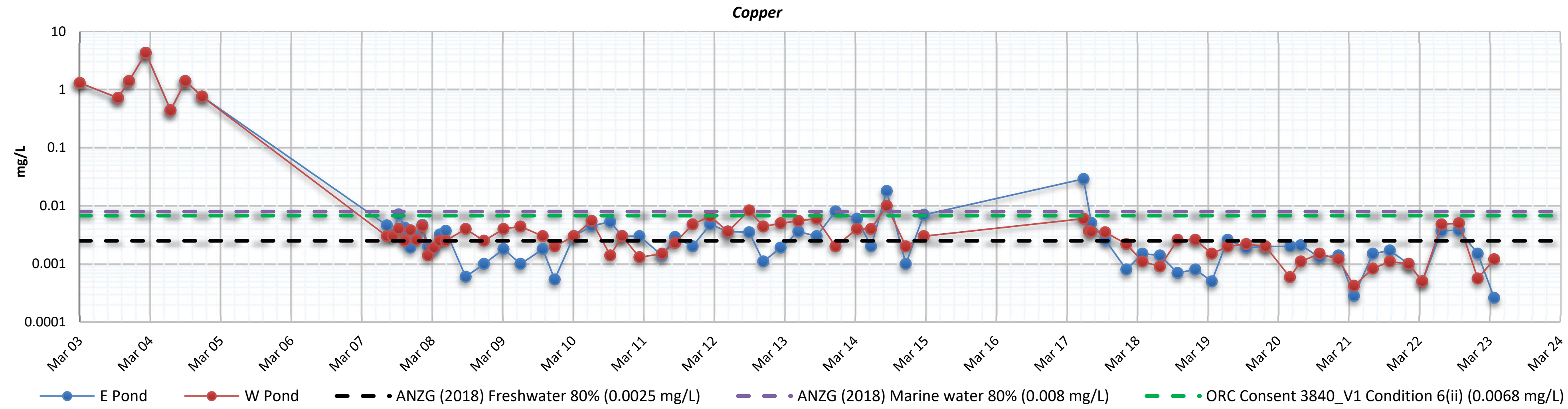


Figure C5-5: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data	Date: Aug 23	Page 5	GHD
	Drawn: HE	Reviewer: CG	
DCC Landfill All Data	Project Number: 12587765		



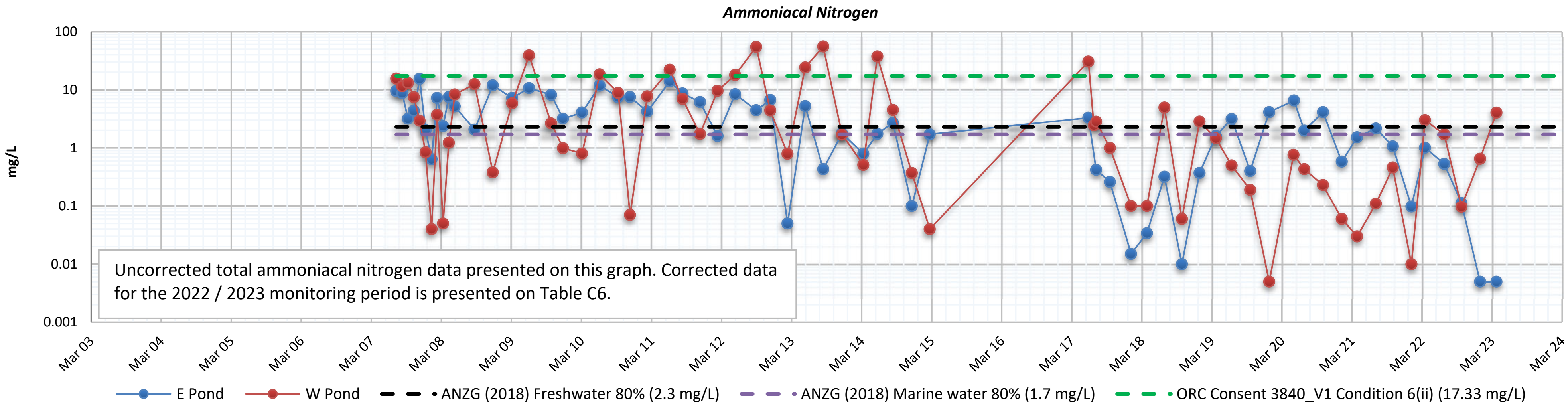


Figure C5-6: Green Island Landfill Western and Eastern Sedimentation Ponds - Analytical Data

DCC Landfill All Data

Date: Aug 23	**Page 6**	GHD
Drawn: HE	**Reviewer:** CG	
Project Number: 12587765		

Green Island Landfill - Northern Sedimentation Pond
Sediment Analytical Results
Table C7-1: Heavy Metals and Semi-volatile organic compounds (SVOCs)

Lab Reference		23-05039-1	NES SCSs for Protection of Human Health based on a Recreational land use (mg/kg) [1 & 2]	NES SCSs for Protection of Human Health based on a Commercial/Industrial land use (mg/kg) [1 & 2]	ANZG DGV (mg/kg) [3]	Background Soil Concentrations[4,6,7] (mg/kg)
Sample Depth	m bgl	0.1 - 0.2				
GHD Sample Name		N_Sed_Pond				
Sample Date		20-Feb-23				
Heavy Metals						
Arsenic	mg/kg	7.4	**80 [1]**	**70 [1]**	**20**	**11.7**
Boron	mg/kg	11	**>10,000**	**>10,000**	-	-
Cadmium	mg/kg	0.042	**400 [1]**	**1,300 [1]**	**1.5**	**0.34**
Chromium [5]	mg/kg	25	**2700 [1]**	**6,300 [1]**	**80**	**80.15**
Copper	mg/kg	13.3	**>10,000 [1]**	**>10,000 [1]**	**65**	**60.85**
Lead	mg/kg	15.4	**880 [1]**	**3,300 [1]**	**50**	**44.34**
Mercury	mg/kg	0.039	**1,800 [1]**	**4,200 [1]**	**0.15**	-
Nickel	mg/kg	16	**1,200 [2]**	**6,000 [2]**	**21**	**44.96**
Zinc	mg/kg	59.3	**30,000 [2]**	**400,000 [2]**	**200**	**182.8**
Semi volatile organic compounds (SVOCs)						
Acenaphthene	mg/kg	<0.10	-	-	**0.016 [8]**	**0.055**
Acenaphthylene	mg/kg	<0.10	-	-	**0.044 [8]**	**0.069**
Anthracene	mg/kg	<0.10	-	-	**0.085 [8]**	**0.113**
Benz[a]anthracene	mg/kg	<0.10	#	#	**0.261 [8]**	**0.47**
Benzo[a]pyrene	mg/kg	<0.10	#	#	**0.43 [8]**	**0.595**
Benzo[b]&[j] fluoranthene	mg/kg	<0.10	#	#	-	**0.947**
Benzo[g,h,i]perylene	mg/kg	<0.10	-	-	-	**0.459**
Benzo[k]fluoranthene	mg/kg	<0.10	#	#	-	**0.296**
Chrysene	mg/kg	<0.10	#	#	**0.384 [8]**	**0.539**
Dibenz(a,h)anthracene	mg/kg	<0.10	#	#	**0.063 [8]**	**0.112**
Fluoranthene	mg/kg	<0.10	#	#	**0.6 [8]**	**1.345**
Fluorene	mg/kg	<0.10	-	-	**0.019 [8]**	**0.06**
Indeno(1,2,3-cd)pyrene	mg/kg	<0.10	#	#	-	**0.385**
Naphthalene	mg/kg	<0.10	-	-	**0.16 [8]**	**0.029**
Phenanthrene	mg/kg	<0.10	-	-	**0.24 [8]**	**0.703**
Pyrene	mg/kg	<0.20	-	-	**0.665 [8]**	**1.362**
Benzo[a]pyrene TEQ (LOR)	mg/kg	0.2	**40**	**35**	-	**0.922**
Total PAHs	mg/kg	<LOR	-	-	**10**	-
4,4'-DDD	mg/kg	<0.30	-	-	**0.0035**	**0.00471 [6]**
4,4'-DDE	mg/kg	<0.30	-	-	**0.0014**	**0.0229 [6]**
4,4'-DDT	mg/kg	<0.50	**400**	**1,000**	-	**0.0236 [6]**

Notes:
mg/kg - miligrams per kilogram
m bgl - metres below ground level

References

1. Ministry for the Environment (2011). Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS).
2. National Environment Protection Council (1999, revised 2013) National Environment Protection (Assessment of Site Contamination) Measure. Table 1A. (NEPM)
3. Australian Government Initiative (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines (ANZG). Default Guideline Values (DGV) Sediment Quality Guideline values, Table 3.5.1
4. Landcare Research Limited (2006) PBC - Predicted Background Soil Concentrations, New Zealand - fill material (the highest value for each metal form the dominant soil groups surrounding Green Island Landfill) Dunedin , New Zealand
5. NES SCS criteria presented are for Chromium (VI)
6. Ministry for the Environment (1998). Ambient concentrations of selected organochlorines in soils. Table F3 - mean values.
7. Environment Canterbury (2007) Background concentrations of polycyclic aromatic hydrocarbons in Christchurch urban soils. Report No R07/19. Table 9.
8. Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) Interim sediment quality guideline values (ISQG-Low) values, Table 3.5.1

Green Island Landfill - Northern Sedimentation Pond
Table C7-2: Sediment -BTEX and Total Petroleum Hydrocarbons (TPH)

			Guidelines for Hydrocarbon Contamination - Residential - All Pathways - Sand (<1m) (mg/kg) [1]	Guidelines for Hydrocarbon Contamination - Commercial/industrial - All Pathways - Sand (<1m) (mg/kg) [2]
Sample ID		23-05039-1		
Sample Depth	m bgl	0.1 - 0.2		
Sample Name		N_Sed_Pond		
Soil Type		Sediment		
Sample Date		20-Feb-23		
BTEX				
Benzene	mg/kg	<0.050	**1.1** (v)	**3.0** (m)
Toluene	mg/kg	<0.10	**(68)** (4,v)	**(94)** (4,m)
Ethylbenzene	mg/kg	<0.050	**(53)** (4,v)	**(180)** (4,v)
m,p-Xylene	mg/kg	<0.10	**(48)** (4,v)	**(150)** (4,m)
o-Xylene		<0.050	**(48)** (4,v)	**(150)** (4,m)
Total Petroleum Hydrocarbons (TPH)				
C7-C9	mg/kg	<10	**120** (m)	**120** (m)
C10-C14	mg/kg	<15	**(470)** (3, x)	**(1,500)** (3, x)
C15-C36	mg/kg	207	**NA**	**NA**
C7-C36 (Total)	mg/kg	207	-	-

Notes:

All units are in mg/kg

m bgl - metres below ground level

A hyphen (-) indicates criterion not available or sample not anlaysed for this analyte

< - reported at a concentration less than the laboratory limit of reporting (LOR)

(m) = Maintenance/Excavation , (3) and (4)= Brackets denote values exceed threshold likely to correspond to formation of residual separate phase hydrocarbons, (x) = PAH surrogate, (v) volatilisation

NA - indicates estimated criterion exceeds 20,000 mg/kg. At 20,000 mg/kg residual separate phase is expected to have formed in soil matrix

References

1. Ministry for the Environment (2011) Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Module 4 - Tier 1 Soil screening criteria. Table 4.13. Residential land use.
2. Ministry for the Environment (2011) Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Module 4 - Tier 1 Soil screening criteria. Table 4.13. Residential land use.

Project Name: Green Island Landfill - Northern Sedimentation Pond
Table C7-3: Stormwater Analytical Results

GHD Sample Name		N_Sed_Pond_SW	ANZG Freshwater - 80% species protection Default Guideline Values (DGV) (g/m^3)	ANZG Freshwater - 90% species protection Default Guideline Values (DGV) (g/m3) [1]	ANZG Freshwater - 95% species protection Default Guideline Values (DGV) (g/m3) [2]
Laboratory Sample Number		23-06742			
Date of Sampling	***Laboratory Detection limit***	6-Mar-23			
Physiochemical Parameters (Field measured)					
pH	-	7.29	7.2-7.8	7.2 -7.8	7.2 - 7.8
Dissolved Oxygen (%)	-	120.9	98-102	98-105	98-105
Temperature (^{0}C)	-	22.6	-	-	-
Electrical Conductivity (µS/cm)	-	768	-	-	-
Nutrients					
Ammonia as N (mg/L)	0.005	0.13	-	-	-
Corrected Ammonia (mg/L)	-	0.032	2.3	1.43	0.9
Heavy Metals - Soluble (mg/l)					
Arsenic	0.0005	0.00085	0.36	0.024	0.013
Boron	0.01	0.15	2.5	1.5	0.94
Cadmium	0.00002	<0.000020	0.0008	0.0004	0.0002
Chromium[3]	0.0002	0.00026	0.04	0.006	0.001
Copper	0.0002	0.0046	0.0025	0.0018	0.0014
Lead	0.00005	0.000066	0.0094	0.0056	0.0034
Mercury	0.00008	0.000092	0.0054	0.0019	0.0006
Nickel	0.0002	0.0034	0.017	0.013	0.011
Zinc	0.001	0.0036	0.031	0.015	0.008
Heavy Metals - Total (mg/l)					
Arsenic	0.0005	0.0015	0.36	0.024	0.013
Boron	0.005	0.17	2.5	1.5	0.94
Cadmium	0.00002	0.000043	0.0008	0.0004	0.0002
Chromium[3]	0.0002	0.0014	0.04	0.006	0.001
Copper	0.0002	0.0065	0.0025	0.0018	0.0014
Lead	0.00005	0.0025	0.0094	0.0056	0.0034
Mercury	0.0001	<0.00010	0.0054	0.0019	0.0006
Nickel	0.0002	0.0043	0.017	0.013	0.011
Zinc	0.003	0.014	0.031	0.015	0.008

Notes:

Blue shaded: Indicates value exceeds the trigger value for 95% Level of Protection (% species) for freshwater
Peach shaded: Indicates value exceeds the trigger value for 90% Level of Protection (% species) for freshwater
Green shaded: Indicates value exceeds the trigger value for 80% Level of Protection (% species) for freshwater
mg/l - Miligrams per litre
µS/cm- MicroSiemems / cm
A hyphen (-) indicates criterion not available or sample not anlaysed for this analyte
ID - Insufficient data to derive a reliable trigger value
A hyphen (-) indicates that either criterion is not available or a sample not analysed for this analyte
< indicates values less than the laboratory limit of reporting
The m-Xylene ANZG 2018 guideline value was taken as a conservative approach
All semi-volatile organic compounds were reported as being below the laboratory limit of reporting

References:

1: Australian and New Zealand Guidelines for fresh and marine water quality: Toxicant default guideline values for protecting aquatic ecosystems (90% species protection)
2: Australian and New Zealand Guidelines for fresh and marine water quality: Toxicant default guideline values for protecting aquatic ecosystems (95% species protection)
3. Guideline Value is for Chromium (CrVI)

Appendix D

Field Notes and Equipment Calibration Documents

Green Island Landfill
Groundwater Parameter Results - July 2022

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	8/07/2022	10:26	0.0	1.488	ND	11.2	13.7	1.43	2583	6.76	229.6	No Well Cap (NWC)
PS1	8/07/2022	10:31	0.1	3.600	ND	6.9	87.2	10.29	5515	7.87	178.5	Slight leachate odour
MW1 A	8/07/2022	10:36	0.0	1.435	ND	10.4	14.5	1.39	30034	5.78	225.6	NWC
MW1 B	8/07/2022	10:40	0.0	1.322	ND	10.1	79.3	7.69	21841	6.54	28.1	NWC
MH 1	8/07/2022	10:43	0.0	3.391	ND	11.8	11.4	1.10	25582	6.68	-59.4	NWC
MW1 C	8/07/2022	10:47	0.0	1.211	ND	8.6	45.1	4.53	27865	6.44	-66.6	NWC
PS2	8/07/2022	10:54	0.0	3.265	ND	11.6	11.3	1.17	11833	6.88	-52.4	-
MW2 A	8/07/2022	10:58	0.0	2.806	ND	14.0	20.3	1.67	28029	7.58	-123.6	NWC
MW2 B	8/07/2022	11:00	0.0	2.323	ND	13.3	20.6	1.70	27763	7.41	-146.8	NWC
MH2	8/07/2022	11:03	0.0	3.130	ND	12.5	54.2	5.14	27530	6.50	-115.4	-
MW2 C	8/07/2022	11:07	0.0	1.216	ND	11.0	21.4	1.70	29931	6.74	-85.5	NWC, iron staining within well
MW2 D	8/07/2022	11:10	0.0	0.500	ND	9.5	11.2	1.06	30186	7.01	-131.0	NWC, metallic scum on water
PS3	8/07/2022	11:17	1.3	3.020	ND	13.5	54.3	5.40	9002	7.26	-29.8	-
MW3 A	8/07/2022	11:22	0.0	1.292	ND	12.0	37.9	3.79	14024	7.84	-11.6	NWC
MW3 B	8/07/2022	11:25	0.0	1.380	ND	11.2	19.1	1.95	11669	7.79	-6.2	NWC
MH3	8/07/2022	11:29	0.0	3.142	ND	12.6	13.8	1.34	22144	6.88	-99.3	-
MW3 C	8/07/2022	11:31	0.0	2.242	ND	10.8	86.1	9.31	1754	7.65	-69.2	NWC
PS4	8/07/2022	11:36	0.0	3.210	ND	12.5	19.0	1.91	11829	6.94	-98.5	-
MW4 A	8/07/2022	11:41	0.0	2.789	ND	15.5	13.1	1.27	3121	7.05	-10.4	NWC
MW4 B	8/07/2022	11:43	0.0	1.886	ND	13.3	10.8	1.08	3218	7.52	-14.6	NWC
MW4 C	8/07/2022	11:46	0.0	2.205	ND	12.3	13.0	1.24	20560	6.94	16.6	NWC
MW4 D	8/07/2022	11:51	0.0	1.880	ND	9.4	12.8	1.29	25610	6.63	-65.0	NWC
PS5	8/07/2022	11:57	0.2	3.196	ND	9.2	40.7	4.60	2259	7.04	-31.3	-
MW5 A	8/07/2022	12:02	0.0	2.983	ND	13.6	13.9	1.33	6537	7.01	-89.8	NWC, leaf litter around well head.
MW5 B	8/07/2022	12:05	0.0	2.854	ND	12.6	18.6	1.75	4406	7.60	-67.0	NWC, well sign damaged
MH5	8/07/2022	12:08	0.0	3.206	ND	11.4	10.7	1.11	10180	6.90	-138.8	-
MW5 C	8/07/2022	12:11	0.0	1.772	ND	10.3	23.6	2.36	7053	7.51	-82.2	NWC
PS6	8/07/2022	12:16	0.0	3.874	ND	12.1	185.8	18.73	6070	6.97	-52.1	-
MW6 A	8/07/2022	12:23	0.0	0.748	ND	11.4	60.5	5.81	4888	6.93	-79.6	NWC, scum on water
MW6 B	8/07/2022	12:26	0.0	1.164	ND	9.5	102.8	11.38	1902	7.56	-66.9	NWC
MH6	8/07/2022	12:29	0.0	3.125	ND	10.6	25.3	2.65	5715	6.38	-44.1	-
MW6 C	8/07/2022	12:32	0.0	1.173	ND	10.8	38.6	4.09	6232	6.67	-43.0	NWC
PS7	8/07/2022	12:40	0.0	3.913	ND	11.0	42.9	4.59	3543	6.90	-43.3	-
MW7 A	8/07/2022	12:47	0.0	1.254	ND	12.9	12.3	1.26	1719	7.57	-21.3	NWC
MW7 B	8/07/2022	12:50	0.0	1.848	ND	13.1	55.8	5.68	1678	7.27	-21.4	NWC
MH7	8/07/2022	12:54	0.0	3.528	ND	12.9	10.8	1.04	11532	6.62	91.0	-
MW7 D	8/07/2022	12:56	0.0	1.562	ND	12.3	80.7	8.01	14731	7.21	101.5	NWC, unstable concrete base
PS8	8/07/2022	13:02	0.0	4.056	ND	11.7	18.4	1.92	2600	6.55	83.4	-
MW8 A	8/07/2022	13:14	0.0	3.482	ND	12.2	16.2	1.66	1365	7.43	99.9	Pot being used as a well cap
MW8 B	8/07/2022	13:17	0.0	3.191	ND	13.1	88.3	9.11	1167	7.00	123.3	Well cover does not sit flush with piezo. Opens/closes with wind gusts.
MH8	8/07/2022	13:21	0.0	3.912	ND	10.9	58.5	6.32	891	7.03	69.6	-
MW8 C	8/07/2022	13:23	0.0	2.296	ND	11.7	64.8	6.75	1039	7.02	65.6	NWC
PS9	8/07/2022	13:32	0.0	5.892	ND	11.3	30.3	3.20	6569	6.23	-16.7	-

Notes:
m btoc - metres below top of casing
ND - Not determined
 - No information

Green Island Landfill Groundwater Parameter Results - October 2022

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	7/10/2022	8:45	0.0	0.468	3.835	9.7	29.8	3.42	2,660	6.60	72.3	Slight scum on water, no well cap.
PS1	7/10/2022	9:11	0.1	3.410	ND	5.8	83.9	10.42	4,366	7.66	76.2	Static water level unstable due to foam, pump operational during testing.
MW1A	7/10/2022	9:17	0.0	1.372	6.241	9.7	21.5	2.15	29,074	5.59	115.4	No well cap.
MW1B	7/10/2022	9:21	0.0	1.180	5.181	9.3	11.2	1.12	32,216	6.47	68.0	Slight scum on water, no well cap.
MH1	7/10/2022	9:24	0.0	3.396	4.526	10.1	5.7	0.58	24,230	6.55	-43.3	
MW1C	7/10/2022	9:28	0.0	1.133	5.705	8.7	9.4	0.98	27,215	6.34	-42.6	No well cap.
PS2	7/10/2022	9:33	0.0	3.153	ND	9.6	12.2	1.24	7,055	6.82	-35.0	
MW2A	7/10/2022	9:37	0.0	2.694	6.221	11.7	6.6	0.61	27,656	7.39	-180.5	No well cap
MW2B	7/10/2022	9:45	0.0	2.156	5.209	11.6	80.7	8.09	27,377	7.43	-120.5	No well cap.
MH2	7/10/2022	9:49	0.0	3.905	4.789	10.9	8.3	0.85	21,666	6.53	-76.6	Sediment in base of manhole, no well cap.
MW2C	7/10/2022	10:02	0.0	1.701	5.109	10.4	74.4	7.50	28,947	6.83	-94.0	No well cap.
MW2D	7/10/2022	10:07	0.0	0.550	11.666	9.4	11.1	1.07	29,441	6.98	-115.6	Water has metallic sheen on surface, no well cap.
PS3	7/10/2022	10:16	4.5	2.530	ND	12.8	68.1	7.06	10,935	7.41	66.1	Very foamy water.
MW3A	7/10/2022	10:19	0.0	1.201	3.799	11.1	68.4	7.30	13,982	7.51	-115.9	Sediment in base of well.
MW3B	7/10/2022	10:22	0.0	1.357	5.089	10.7	22.6	1.91	12,064	7.41	-106.4	No well cap.
MH3	7/10/2022	10:24	0.0	2.658	4.456	11.2	18.2	1.92	20,706	6.93	-157.2	
MW3C	7/10/2022	10:26	0.0	2.280	4.090	9.7	57.5	6.50	1,541	7.39	-112.0	No well cap.
PS4	7/10/2022	10:31	0.0	3.204	ND	11.2	11.6	1.35	9,726	6.87	95.8	
MW4A	7/10/2022	10:35	0.0	2.286	5.570	13.9	6.1	0.56	3,261	7.94	-87.8	No well cap.
MW4B	7/10/2022	10:38	0.0	1.913	4.104	12.1	9.5	0.85	3,823	7.20	-47.3	No well cap.
MW4C	7/10/2022	10:41	0.0	2.138	4.860	10.5	17.4	1.33	19,988	6.84	-51.9	No well cap.
MW4D	7/10/2022	10:43	0.0	1.928	12.212	9.5	7.8	0.81	24,632	6.55	-73.7	No well cap.
PS5	7/10/2022	10:48	1.7	3.166	ND	9.7	26.8	3.03	4,924	7.08	-71.6	
MW5A	7/10/2022	10:51	0.0	2.896	4.340	12.2	27.9	2.93	1,951	7.40	-61.4	Sediment in base of well.
MW5B	7/10/2022	10:54	0.1	2.867	4.976	11.2	8.0	0.79	4,846	7.73	-22.3	No well cap.
MH5	7/10/2022	10:57	0.0	3.297	4.431	10.2	10.0	1.12	4,898	6.86	-1.8	Sediment in base of well.
MW5C	7/10/2022	11:01	0.0	1.695	4.822	9.5	9.6	0.98	7,699	7.11	-88.4	No well cap.
PS6	7/10/2022	11:05	0.1	3.620	ND	11.2	46.9	5.13	5,199	6.95	-60.2	
MW6A	7/10/2022	11:09	0.0	0.818	3.789	10.9	8.2	0.92	4,794	6.92	-89.2	No well cap.
MW6B	7/10/2022	11:12	0.0	1.211	3.850	10.1	40.3	4.52	2,017	7.07	-61.9	No well cap.
MH6	7/10/2022	11:13	0.1	3.158	4.256	10.6	13.6	1.47	5,001	6.87	-33.0	
MW6C	7/10/2022	11:15	0.0	1.031	5.043	9.0	57.8	6.69	1,234	7.22	-50.4	No well cap.
PS7	7/10/2022	11:25	1.5	3.675	ND	10.4	53.2	5.93	1,834	6.81	-54.8	
MW7A	7/10/2022	11:28	0.0	1.134	3.316	11.3	55.2	6.12	1,777	7.85	-87.9	Sediment in base of well, no well cap.
MW7B	7/10/2022	11:32	0.0	1.784	5.179	11.9	59.0	6.41	1,850	7.47	-55.5	No well cap.
MH7	7/10/2022	11:35	0.0	3.519	4.557	11.6	8.5	0.95	7,371	6.75	-6.0	
MW7D	7/10/2022	11:38	0.0	1.463	5.226	10.9	35.3	3.73	16,181	6.83	3.3	No well cap, unstable concrete base.
PS8	7/10/2022	12:01	0.0	4.010	ND	11.1	10.9	1.14	4,481	6.79	13.1	
MW8A	7/10/2022	12:08	0.1	2.008	4.324	10.6	103.7	9.42	1,473	6.99	-22.6	Sediment in base, no well cap.
MW8B	7/10/2022	12:12	0.0	2.164	5.117	11.5	76.0	8.35	1,301	7.44	-22.0	Sediment in base, no well cap, lid does not site flush with well.
MH8	7/10/2022	12:14	0.0	3.030	4.028	10.6	27.4	2.98	954	6.59	3.1	
MW8C	7/10/2022	12:16	0.0	2.163	3.933	10.3	69.7	7.85	928	7.16	5.8	Sediment in base, no well cap.
PS9	7/10/2022	12:36	0.0	5.741	ND	11.2	110.4	10.63	5,188	5.77	76.5	

Notes:

ND - Not Determined

Green Island Landfill
Groundwater Parameter Results - January 2023

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	16/01/2023	9:25	0.0	1.367	3.852	12.5	17.4	1.82	2,710	6.36	21.0	Clear, trace particulates, odourless.
PS1	16/01/2023	9:30	0.2	3.490	-	14.3	70.7	7.16	5,739	7.76	114.7	-
MW1A	16/01/2023	9:52	0.9	1.419	-	12.3	9.7	0.93	30,579	5.66	76.7	-
MW1B	16/01/2023	9:39	0.0	1.369	-	15.9	19.8	1.74	32,865	6.51	26.3	-
MH1	16/01/2023	9:45	0.0	3.336	-	12.6	9.9	0.95	25,569	6.56	-65.3	-
MW1C	16/01/2023	9:36	8.1	0.313	5.716	19.1	46.8	3.93	28,317	6.99	87.8	Slightly cloudy, trace particulates, odourless.
PS2	16/01/2023	10:00	0.3	3.096	-	12.7	19.7	1.96	15,228	6.78	106.2	-
MW2A	16/01/2023	10:07	0.0	2.763	-	14.7	12.5	1.14	28,541	7.24	-134.9	-
MW2B	16/01/2023	10:10	0.1	2.272	-	14.4	8.5	0.79	28,042	7.41	-160.8	-
MH2	16/01/2023	10:17	0.0	3.126	-	13.7	11.0	1.02	29,046	6.52	-124.6	-
MW2C	16/01/2023	10:24	0.3	1.588	5.104	14.0	7.3	0.67	30,058	6.70	-100.4	Brown, minor odour, trace particulates.
MW2D	16/01/2023	10:30	8.0	0.531	10.664	19.5	12.0	0.97	30,681	6.71	-95.7	Trace particulates, cloudy, odourless.
PS3	16/01/2023	10:34	0.1	2.599	-	16.9	12.8	1.17	16,687	7.40	-54.4	Brown, strong odour, minor particulates.
MW3A	16/01/2023	10:37	2.5	1.206	-	18.2	28.4	2.54	14,304	7.45	-134.4	-
MW3B	16/01/2023	10:43	0.0	1.364	-	15.5	12.6	1.15	12,301	7.31	-138.8	-
MH3	16/01/2023	10:45	0.0	2.366	-	13.8	12.1	1.16	16,267	7.38	-121.2	-
MW3C	16/01/2023	10:47	0.0	3.054	4.086	12.8	19.9	2.12	1,459	6.90	-48.4	Transparent, no particulates, odourless.
PS4	16/01/2023	10:50	0.0	3.164	-	13.4	11.9	1.18	14,079	6.96	-98.6	-
MW4A	16/01/2023	10:55	0.0	2.726	-	14.9	15.2	1.52	3,351	7.54	-44.6	-
MW4B	16/01/2023	10:59	0.0	1.786	-	14.3	9.3	0.93	3,922	7.05	-84.7	-
MW4C	16/01/2023	11:02	0.0	2.492	4.895	12.7	8.6	0.84	210,995	6.78	-56.3	Slightly cloudy, trace particulates, odourless.
MW4D	16/01/2023	11:04	0.0	2.424	12.206	17.1	18.7	1.64	25,910	6.46	-11.5	Trace particulates, cloudy, odourless.
PS5	16/01/2023	11:09	0.9	3.199	-	14.7	13.2	1.29	10,840	7.00	-103.4	-
MW5A	16/01/2023	11:15	0.0	2.909	-	13.4	18.0	1.85	2,103	7.50	-27.0	-
MW5B	16/01/2023	11:19	0.0	2.870	-	14.1	22.9	2.35	4,962	7.36	-2.3	-
MH5	16/01/2023	11:21	0.0	3.264	-	13.5	10.4	1.05	7,024	6.76	-25.0	-
MW5C	16/01/2023	11:23	0.0	2.351	4.79	14.0	9.3	0.98	7,991	7.12	-140.4	Slightly cloudy, no particulates, odourless.
PS6	16/01/2023	11:26	0.0	3.419	-	13.8	11.8	1.20	6,292	6.81	-87.3	-
MW6A	16/01/2023	11:31	0.0	1.188	-	14.1	12.4	1.23	4,813	6.87	99.9	-
MW6B	16/01/2023	11:34	0.0	1.539	-	15.5	8.0	0.80	2,080	6.88	-40.0	-
MH6	16/01/2023	11:37	0.0	3.151	-	12.6	7.0	0.74	5,953	6.81	-9.2	Slightly cloudy, trace particulates, odourless.
MW6C	16/01/2023	11:40	0.0	2.152	5.031	11.6	17.3	1.89	1,308	6.60	-54.3	-
PS7	16/01/2023	11:46	0.8	3.651	-	13.5	26.5	2.84	4,379	6.89	-65.4	-
MW7A	16/01/2023	11:52	0.0	1.121	-	13.2	12.3	1.29	1,830	7.49	-143.8	-
MW7B	16/01/2023	11:55	0.0	1.765	-	12.7	31.7	3.37	1,943	7.05	-64.7	-
MH7	16/01/2023	11:57	0.0	3.501	-	12.9	11.6	1.18	9,390	6.65	-12.2	-
MW7D	16/01/2023	12:00	0.0	1.663	5.216	14.0	11.3	1.09	17,063	6.55	-10.8	Slightly cloudy, trace particulates, slight odour.
PS8	16/01/2023	12:02	0.1	4.004	-	12.2	17.8	1.89	5,586	6.84	-0.6	-
MW8A	16/01/2023	12:10	0.7	2.325	-	13.5	15.9	1.66	1,552	7.05	109.1	-
MW8B	16/01/2023	12:14	0.0	3.144	-	12.9	14.8	1.57	1,320	7.12	-63.2	-
MH8	16/01/2023	12:26	0.7	3.026	-	12.6	8.7	0.93	1,166	7.76	-14.7	-
MW8C	16/01/2023	12:20	3.3	2.362	3.994	12.3	12.8	1.38	948	6.57	-17.6	Minor particulates, brown and cloudy, slight odour.
PS9	16/01/2023	12:30	0.0	5.691	-	-	-	-	-	-	-	Unable to meausre water parameters due to water depth.

- No data

Green Island Landfill Groundwater Parameter Results - April 2023

Site	Date	Time	PID Reading (ppm)	Water Level (m btoc)	Borehole Depth (m)	Temp (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
MW0C	11/04/2023	9:43	0.0	0.884	3.856	14.7	45.7	4.59	2,649	6.59	190.8	-
PS1	11/04/2023	9:48	0.0	4.543	ND	13.6	77.2	7.68	6,313	7.75	155.9	-
MW1A	11/04/2023	9:52	0.0	1.300	6.259	13.3	73.1	6.72	30,332	6.19	137.5	-
MW1B	11/04/2023	9:59	0.0	1.244	5.180	13.5	61.3	5.50	32,716	6.70	106.5	-
MH1	11/04/2023	10:04	0.0	3.368	ND	13.9	79.9	7.54	19,505	6.47	123.7	-
MW1C	11/04/2023	10:05	0.0	1.211	5.719	14.0	37.0	3.35	27,266	6.77	59.8	-
PS2	11/04/2023	10:09	0.0	3.126	ND	14.3	27.8	2.69	13,299	6.67	42.2	-
MW2A	11/04/2023	10:14	0.0	2.748	6.224	16.1	9.3	0.80	28,296	7.50	-188.6	-
MW2B	11/04/2023	10:17	0.0	2.244	5.202	15.9	27.9	2.45	27,807	7.42	-107.6	-
MH2	11/04/2023	10:20	0.0	3.970	ND	14.8	12.3	1.10	28,980	6.59	-127.0	-
MW2C	11/04/2023	10:22	0.0	2.801	5.115	15.0	13.7	1.19	29,797	6.65	-61.0	-
MW2D	11/04/2023	10:25	0.0	0.605	10.664	13.5	13.3	1.21	30,213	6.75	-95.2	-
PS3	11/04/2023	10:41	0.0	2.757	ND	12.2	9.1	0.80	14,235	7.37	-152.9	-
MW3A	11/04/2023	10:44	0.0	1.223	3.806	15.4	8.6	0.80	13,747	7.43	-207.8	-
MW3B	11/04/2023	10:45	0.0	1.328	5.088	15.0	16.0	1.49	11,040	7.30	-207.7	-
MH3	11/04/2023	10:49	0.0	2.739	ND	15.1	18.0	1.67	11,023	7.16	-283.0	-
MW3C	11/04/2023	10:53	0.0	2.498	4.101	14.6	28.2	2.80	2,467	6.56	-55.0	-
PS4	11/04/2023	10:57	0.0	2.165	ND	14.8	77.2	7.51	12,926	6.98	-170.5	-
MW4A	11/04/2023	11:05	0.0	2.512	6.558	16.5	11.6	1.08	5,277	7.48	-356.0	-
MW4B	11/04/2023	11:07	0.0	1.771	4.102	15.3	6.7	0.64	4,274	7.01	-162.0	-
MW4C	11/04/2023	11:10	0.0	2.224	4.902	14.6	10.9	1.00	20,749	6.89	-98.7	-
MW4D	11/04/2023	11:12	0.0	2.460	12.178	14.5	5.5	0.51	25,609	6.36	-67.9	Iron staining on base of the well.
PS5	11/04/2023	11:20	0.0	3.198	ND	15.4	9.6	0.87	8,604	6.99	-108.5	-
MW5A	11/04/2023	11:30	0.0	2.678	4.313	14.3	9.6	0.79	2,719	6.92	-33.2	Sludge in bottom of the well, green coloured sludge.
MW5B	11/04/2023	11:32	0.0	1.528	4.920	15.4	10.4	0.93	4,955	7.16	-51.4	-
MH5	11/04/2023	11:35	0.0	3.294	ND	14.7	6.5	0.62	5,479	6.87	-61.3	-
MW5C	11/04/2023	11:40	0.0	1.794	5.829	13.4	5.6	0.52	3,979	7.30	-161.4	-
PS6	11/04/2023	11:47	0.0	4.690	ND	14.8	12.4	0.95	45,878	6.84	-55.9	Iron staining in base of the well.
MW6A	11/04/2023	11:53	0.0	0.779	4.798	15.2	5.1	0.49	4,662	7.19	-7.1	No well cap
MW6B	11/04/2023	11:56	0.0	1.209	3.848	15.0	53.6	5.30	2,096	7.19	-7.1	-
MH6	11/04/2023	12:00	0.0	3.106	ND	14.6	27.1	2.59	4,604	7.00	-33.3	-
MW6C	11/04/2023	12:05	0.0	0.976	5.009	13.1	62.5	6.38	1,327	6.90	-5.5	-
PS7	11/04/2023	12:16	0.0	3.899	ND	14.1	34.5	3.36	4,024	6.83	-82.9	-
MW7A	11/04/2023	12:23	0.0	1.241	3.303	13.7	9.7	0.94	1,803	7.28	-135.1	-
MW7B	11/04/2023	12:27	0.0	1.796	5.773	13.6	17.2	1.67	1,930	6.96	21.6	-
MH7	11/04/2023	12:31	0.0	3.618	ND	13.8	13.5	1.34	10,384	6.69	53.4	-
MW7D	11/04/2023	12:36	0.0	1.502	5.233	14.5	49.8	4.67	16,924	6.90	32.6	-
PS8	11/04/2023	12:40	0.0	3.850	ND	13.8	63.8	0.47	3,137	6.62	1.4	-
MW8A	11/04/2023	12:50	0.0	2.112	4.310	15.1	86.9	1.66	1,497	6.99	-27.1	-
MW8B	11/04/2023	12:52	0.0	2.109	5.103	14.0	23.8	2.05	1,296	7.01	-67.8	Green/ grey coloured sludge in base of the well.
MH8	11/04/2023	12:54	0.0	3.478	ND	13.4	27.0	2.68	1,213	6.95	-37.8	-
MW8C	11/04/2023	12:58	0.0	2.156	4.982	13.5	11.7	1.18	879	6.18	75.5	-
PS9	11/04/2023	13:04	0.0	5.794	ND	12.7	44.1	4.50	602	6.09	-4.7	-

Notes:
- No Comment.
ND - Not Determined
PID - Photoionisation detector (Measuring the presence of VOCs).

Green Island Landfill
Surface Water Parameter Results - July 2022

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	15/07/2022	9:54	6.0	101.9	12.56	223.1	7.37	31.8	Slightly cloudy, trace particulates, no odour.
GI2	15/07/2022	10:13	6.0	86.5	10.69	309.6	6.29	64.1	No odour, slight cloudy, trace particulates, minor sediment content.
GI3	15/07/2022	9:14	6.1	88.6	10.94	312.4	7.20	48.4	Slight brownish tinge, no odour, trace particulates.
GI5	15/07/2022	8:52	5.9	14.1	1.72	550.4	7.34	42.3	Slight brownish tinge, no visible particulates, no odour.
Eastern Pond	14/07/2022	10:45	7.2	41.6	4.95	579.3	7.37	38.5	Moderate to high sediment content no odour, no visible particulates, brownish tinge.
Western Pond	14/07/2022	9:54	6.6	66.1	7.91	4605.0	7.46	44.6	Slightly cloudy, trace particulates, slight brownish tinge, minor sediment content.

Notes:

Heavy rainfall over 48 hours prior to sampling

m btoc - metres below top of casing

Green Island Landfill
Surface Water Parameter Results - October 2022

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	12/10/2022	12:06	9.3	115.3	13.32	209.2	8.77	16.0	Trace particulates, no odour, transparent.
GI2	12/10/2022	12:30	9.2	65.0	7.60	420.1	6.47	44.1	Transparent colour, no odour, no particulates.
GI3	12/10/2022	12:52	10.0	77.7	8.86	603.9	7.08	55.3	Trace to no particulates, no odour, transparent.
GI5	12/10/2022	13:12	10.9	33.5	3.70	1753.0	6.49	77.6	Trace to minor particles, slightly cloudy, slight organic odour.
Eastern Pond	12/10/2022	10:02	11.3	67.0	7.41	1052.0	8.17	-4.0	Cloudy, minor particulates, no odour.
Western Pond	12/10/2022	13:22	12.9	52.4	5.48	6205.0	7.45	94.0	Slight yellow colour, transparent, no particulates, slight odour.

Green Island Landfill
Surface Water Parameter Results - January 2023

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	18/01/2023	9:42	15.6	97.1	9.70	194	7.97	3.2	Transparent, no particulates, odourless.
GI2	18/01/2023	9:59	16.4	7.3	0.71	1,980	7.01	-157.8	Slightly cloudy, trace particulates, odourless.
GI3	18/01/2023	8:50	17	68	6.57	330.1	7.55	7.4	Slightly cloudy, trace particulates, odourless.
GI5	18/01/2023	8:35	19	57.7	5.35	719	7.53	24.7	Slightly cloudy, trace particulates, odourless.
Eastern Pond	17/01/2023	15:19	25.7	252.2	20.54	2,147	9.36	-54.30	Very high sediment content, brown, odourless.
Western Pond	17/01/2023	14:58	24.7	75.7	6.15	7,676	8.04	-44.2	Cloudy, minor particulates, odourless.

Green Island Landfill
Surface Water Parameter Results - April 2023

Site	Date	Time	Temperature (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Electrical Conductivity (uS/cm)	pH	Redox (mV)	Comments
GI1	11.04.2023	15:40	13.2	64.5	6.63	515	6.28	131.0	Cloudy, brown coloured water, strong odour, minor particulates.
GI2	11.04.2023	14:39	18.9	91.2	9.24	1,228	7.91	-19.7	Cloudy, no odour, trace particulates.
GI3	11.04.2023	15:17	14.2	59.5	5.75	11,538	6.82	-18.2	Minor dark particulates, coudy, dark coloured water, no odour.
GI5	11.04.2023	14:52	16.4	30.5	2.35	677	6.86	-58.1	Cloudy, minor particulates, slight odour.
Eastern Pond	13.04.2023	9:41	13.6	16.1	1.66	1,214	7.65	-126.4	Minor particulates, no odour, cloudy and yellow coloured water.
Western Pond	12.04.2023	9:41	14.6	30.7	3.02	6,535	7.61	-182.0	Sheen on surface, strong odour, minor particulates,dark coloured water, rubbish in water

VAN WALT
Monitoring your needs

INWARDS CHECKLIST

YSIPRO Checklist and Spot Check

Date Received 18/7/22
YSI Number and Serial Number YSI 3
Overall Condition OK

Hayden Erasmus
GHD

	Reading	Last Calibration Date	Lot No:
pH7 Buffer	7.03	6/7/22	21C1
pH4 Buffer	4.00		21G1
Conductivity 1413 µS/cm	1390		21L
Redox 250mV Solution {Target: 262.1 }	268.8		20H6
DO (fresh air)	96.1%		N/A
Temperature °C	15.4	Ref: 15.8	N/A

This post rental check gives and indication of the status of the probes in the condition they were returned. For each parameter the probes are submerged in the applicable solution and the reading recorded. It is not a full calibration or proof that the probes are in good condition.

Notes:

Checklist

Comments

- [x] YSI PRO meter
- [x] 4 Meter Meter Cable Assy
- [x] Probe Guard
- [x] Calibration Cup
- [x] Manual CD
- [x] Quick Start Guide
- [x] Hard Case
- [x] Flow Cell (including 2 o-rings)
- [x] 2 x RS138-379 Flow Cell Nipples (sent w/flow cell)
- [x] 2 x RS138-385 Flow Cell Nipples (sent w/flow cell)
- [x] 2 x Spare 'C' Type Batteries
- [x] Spare DO Membrane and Electrolyte
- [x] Tamper sticker intact
- [x] Base Plate for Flow Cell
- [x] Calibration solutions - if used mark: pH7, pH4, CSKCL, ORP

Name: Mitch   Signed: [signature]   Date: 18/7/22

VAN WALT
Monitoring your needs

INWARDS CHECKLIST

YSIPRO Checklist and Spot Check

Date Received: 18.10.'22 from Hayden
YSI Number and Serial Number: YSI 8
Overall Condition: ok

	Reading	Last Calibration Date	Lot No:
pH7 Buffer	7.08	4/10/22	21F1
pH4 Buffer	4.00	↓	21L1
Conductivity 1413 µS/cm	1597		22B1
Redox 250mV Solution {Target: 257.9}	259.5		20H1
DO (fresh air)	88.1		N/A
Temperature °C	18.4	Ref: 19.1	N/A

This post rental check gives and indication of the status of the probes in the condition they were returned. For each parameter the probes are submerged in the applicable solution and the reading recorded. It is not a full calibration or proof that the probes are in good condition.

Notes: Cond/Temp sensor seemed loose upon receival

Checklist	Comments
☑ YSI PRO meter	
☑ 4 Meter Meter Cable Assy	
☑ Probe Guard	
☑ Calibration Cup	
☑ Manual ~~CD~~	
☑ Quick Start Guide	
☑ Hard Case	
☑ Flow Cell (including 2 o-rings)	
☑ 2 x RS138-379 Flow Cell Nipples (sent w/flow cell)	
☑ 2 x RS138-385 Flow Cell Nipples (sent w/flow cell)	
☑ 2 x Spare 'C' Type Batteries	used
☐ Spare DO Membrane and Electrolyte	
☑ Tamper sticker intact	
☑ Base Plate for Flow Cell	
☐ Calibration solutions - if used mark: pH7	
pH4	
CSKCL	
ORP	

Name: Andrea Signed: A. Basler Date: 18.10.'22

VAN WALT
Monitoring your needs

INWARDS CHECKLIST

YSI Pro DSS Checklist and Spot Check

Date Received 31/1/23
YSI DSS Number and Serial Number DSS 5
Overall Condition ~~Q~~ ~~Not~~ OK

	Reading	Last Calibration Date	Lot No:
pH7 Buffer	7.14		21J1
pH4 Buffer	4.15		21D1
Conductivity 1413 µS/cm	1425		22B1
Redox 250mV Solution {Target: 234.0}	233.8		21J1
DO (fresh air)	103.1%		N/A
Temperature °C	26.4	Ref: 26.0	N/A
Turbidity NTU - 0 126			N/A

This post rental check gives and indication of the status of the probes in the condition they were returned. For each parameter the probes are submerged in the applicable solution and the reading recorded. It is not a full calibration or proof that the probes are in good condition.

Notes: Not registering cable. Cable has died.

Checklist

- [x] YSI DSS meter
- [x] 4 Meter Cable Assy
- [x] Probe Guard & Calibration Cup
- [x] Manual KOR USB Key
- [x] Quick Start Guide
- [x] Hard Case
- [x] Flow Cell (including 2 o-rings)
- [x] Tamper sticker intact
- [x] 2 x 122004 Flow Cell Nipples Small
- [x] 2 x 122013 Flow Cell Nipples Large
- [x] USB Lead, Charger & Plug
- [x] Base Plate for Flow Cell
- [ ] Put handset on charge
- [x] Calibration solutions - if used mark:

Comments

pH7
pH4
CSKCL
ORP

Name: Mitch
Signed:
Date: 31/1/23

VAN WALT
Monitoring your needs

OUTWARDS CHECKLIST

YSIPRO Checklist and Calibration

YSI Number and Serial Number: YSI 8
Rental Customer and Company: Paige Wills GHD

	Reading	Target	Acceptable	Pass	Lot No:
Temp	19.2	Ref: 19.1	± 1°C	✓	N/A
pH7mv	-25.3	0.0	0 ± 50	✓	Z1L1
pH4mv	147.0	177	177 ± 50	✓	22E1
pH Slope	172.3	177	162 - 180	✓	N/A
Cond. Cell Constant	5.0	5	4.6 - 5.4	✓	22D1
Redox Offset	24.9	0.0	±50.0	✓	21J1
DO Gain	Pass or fail determined by the meter			✓	N/A

*Calibrated to manufacturers standards. All parameters were within acceptable range on the day of calibration; however we do recommend that the instrument is calibrated daily to ensure accurate readings.

Checklist | **Comments**

- [x] YSI PRO meter
- [x] 4 Meter Quatro Cable Assy
- [x] Probe Guard
- [x] Calibration Cup
- [ ] Manual/Data Manager key
- [x] Quick Start Guide
- [x] Hard Case
- [x] Flow Cell (including 2 o-rings)
- [x] 2 x RS138-379 Flow Cell Nipples (sent w/flow cell)
- [x] 2 x RS138-385 Flow Cell Nipples (sent w/flow cell)
- [x] 2 x Spare 'C' Type Batteries
- [ ] Spare DO Membrane and Electrolyte
- [ ] Calibration solutions in date & sealed (charged if used)
- [x] Tamper sticker intact
- [x] Base Plate for Flow Cell
- [x] Record battery level — 85%

Signed: [signature]

Name: Mitch

Date: 5/4/23

Cross Checked Initials:

VAN WALT
Monitoring your needs

OUTWARDS CHECKLIST

Geocontrol Pro

Geocontrol Pro Number and Serial Number NZ Pro 1
Rental Customer and Company Paige Wills GHD

Checklist | Comments

- [x] Geocontrol Pro controller
- [x] Power lead
- [x] Portable battery
- [x] Battery charger
- [x] Car Cigarette Adaptor with clip attachment
- [x] Manual and quick start guide
- [x] Hard case

Maintenance Checks

- [x] Discharge and Fill controllers operate
- [x] Air tube connector operates
- [x] Controller reaches 100 psi of pressure
- [x] Battery Voltage is correct
- [x] PAT test date on battery charger
- [x] Power lead and clips are not broken

Signed: [signature]

Date: 5/4/23

Name: Mitch

VAN WALT
Monitoring your needs

OUTWARDS CHECKLIST

42mm Bladder Pump

42mm Bladder Pump Number #422
Rental Customer and Company Paige Wills GHD

Checklist | Comments

- [x] Bladder pump 42mm
- [x] PE bladder (fitted)
- [x] Spare o-ring set (2 large & 2 small)

Maintenance Checks

- [x] O-rings intact
- [x] Pump tested for air leaks @ 100psi
- [x] Both checkvalves in place

Signed: [signature]

Date: 5/4/23

Name: [signature]

VAN WALT
Monitoring your needs

Outwards CHECKLIST

MicroClip XL Checklist

Microclip Number & Serial number MC1
Rental Customer and Company Paige Wills · GHD

- [x] Passed calibration
- [x] Record gas Lot number W0311087-6

The Microclip was calibrated to manufacturers standards and was within acceptable range on the day of calibration.

Calibrated (DD/MM/YY)	Calibration due (DD/MM/YY)
	2/5/23

Checklist **Comments**

- [x] Microclip XL
- [x] Charging adapter
- [ ] Flow plate with tubing
- [ ] Quad gas 'bump' mix bottle (log expiry date)
- [ ] Gas flow regulator
- [x] Safety Data Sheet
- [x] Quick Start Guide
- [x] Bump test pass

Sign: [signature]

Date: 5/4/23

RO097V5_13/05/2019_JI

VAN WALT
Monitoring your needs

OUTWARDS CHECKLIST

PID Lite Checklist and Calibration

PID Number: MR 4
Serial Number: 595-005046
Rental Customer and Company: Paige Wills GHD

	Reading	Target	Acceptable	Pass	Lot no / Expiry date
100ppm Isobutylene gas	98.6	100	± 10% *	✓	A008829
Fresh Air	0.4	0.0	± 10% *	✓	—

This PID was calibrated to manufacturers standards and was within acceptable range on the day of calibration. The MiniRAE Lite can keep calibration for up to 30 days. * On bump test after calibration

Maintenance Checks

- [x] PID Turns on/off
- [x] Internal pump functioning
- [x] PAT test date on charger
- [x] Pump stall test

Comments

Checklist

- [x] MiniRAE Lite
- [x] 100ppm Isobutylene cylinder (log expiry date)
- [x] Gas Regulator
- [x] Charcoal Filter Trap Zeroing Kit Qty 1
- [x] Charging Adaptor
- [x] Alkaline Battery Pack / Allen key / Spare batteries
- [x] ~~Manual~~ and Quick Start Guide
- [x] Use of PID Information sheet
- [x] Hard Case
- [x] Water Trap x 2
- [x] Tamper sticker intact
- [x] Water trap additional Qty

Comments

Signed: [signature] Name: Mitch Date:

VAN WALT
Monitoring your needs

OUTWARDS CHECKLIST

Peristaltic Pump

Peristaltic Pump Number & Serial Number: EP 1
Rental Customer and Company: Paige Wills GHD

Checklist | Comments

- [x] Eijkelkamp Peristaltic Pump
- [x] Battery Charger
- [x] Manual and Quick Start
- [x] Car Cigarette Adaptor
- [x] Charging Port Cap is attached and in place

Maintenance Checks

- [x] Pump turns on
- [x] Pump turns forwards and backwards
- [x] Pump Speeds up and down
- [x] Battery last tested on
- [x] All rollers on pump head move freely
- [x] Pump case is intact with no cracks
- [x] Silicone tube clamp screws up and down freely
- [x] PAT test date on charger
- [x] External battery lead tested

Signed: [signature]

Date: 5/4/23

Name: MAch

Appendix E

Laboratory Reports

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	GHD Limited	**Lab No:**	3034727 SPv1
Contact:	Cecilia Gately	**Date Received:**	15-Jul-2022
	C/- GHD Limited	**Date Reported:**	27-Jul-2022
	PO Box 13468	**Quote No:**	115579
	Armagh	**Order No:**	12587765
	Christchurch 8141	**Client Reference:**	12587765
		Submitted By:	Hayden Erasmus

Sample Type: Aqueous

Sample Name:		E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
Lab Number:		3034727.1	3034727.2	3034727.3
Individual Tests				
Sum of Anions	meq/L	-	-	55
Sum of Cations	meq/L	-	-	56
pH	pH Units	-	-	7.3
Total Alkalinity	g/m^3 as $CaCO_3$	58	112	1,210
Bicarbonate	g/m^3 at 25°C	-	-	1,470
Total Hardness	g/m^3 as $CaCO_3$	-	-	1,170
Electrical Conductivity (EC)	mS/m	34.7	461	524
Acid Soluble Aluminium	g/m^3	-	-	0.76
Acid Soluble Barium	g/m^3	-	-	0.112
Acid Soluble Boron	g/m^3	-	-	2.1
Dissolved Calcium	g/m^3	-	-	300
Dissolved Chromium	g/m^3	0.0016	0.0010	-
Dissolved Copper	g/m^3	0.0037	0.0048	-
Acid Soluble Iron	g/m^3	-	-	8.5
Dissolved Lead	g/m^3	0.00133	0.00027	-
Dissolved Magnesium	g/m^3	-	-	101
Acid Soluble Manganese	g/m^3	-	-	1.64
Total Mercury	g/m^3	-	-	0.00010
Dissolved Nickel	g/m^3	0.0019	0.0025	-
Dissolved Potassium	g/m^3	-	-	116
Total Potassium	g/m^3	11.3	36	-
Dissolved Sodium	g/m^3	-	-	420
Dissolved Zinc	g/m^3	0.0146	0.0098	-
Total Cyanide	g/m^3	-	-	< 0.02
Chloride	g/m^3	46	1,240	460
Total Ammoniacal-N	g/m^3	0.53	1.70	165
Nitrite-N	g/m^3	0.025	0.28	3.9
Nitrate-N	g/m^3	1.25	18.3	90
Nitrate-N + Nitrite-N	g/m^3	1.28	18.6	93
Dissolved Reactive Phosphorus	g/m^3	-	-	0.031
Total Sulphide	g/m^3	-	-	< 0.05
Sulphate	g/m^3	-	-	540
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m^3	-	-	330
Chemical Oxygen Demand (COD)	g O_2/m^3	-	-	930
Total Organic Carbon (TOC)	g/m^3	18.2	29	290
Total Phenols	g/m^3	-	-	0.15
Faecal Coliforms	MPN / 100mL	-	-	> 16,000 [#1]

Sample Type: Aqueous				
	Sample Name:	E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
	Lab Number:	3034727.1	3034727.2	3034727.3
Heavy metals, acid sol, trace As,Cd,Cr,Cu,Ni,Pb,Zn				
Acid Soluble Arsenic	g/m^3	-	-	0.024
Acid Soluble Cadmium	g/m^3	-	-	0.00037
Acid Soluble Chromium	g/m^3	-	-	0.0199
Acid Soluble Copper	g/m^3	-	-	0.064
Acid Soluble Lead	g/m^3	-	-	0.023
Acid Soluble Nickel	g/m^3	-	-	0.088
Acid Soluble Zinc	g/m^3	-	-	0.162
Volatile Fatty Acid Profile				
Volatile Fatty Acids (VFA), Total	g/m^3 as acetic acid	-	-	35
Formic Acid	g/m^3	-	-	< 5
Acetic Acid	g/m^3	-	-	< 5
Propionic Acid	g/m^3	-	-	< 5
Butyric Acid	g/m^3	-	-	42
Organochlorine Pesticides Screening in Water, By Liq/Liq				
Aldrin	g/m^3	-	-	< 0.00010
alpha-BHC	g/m^3	-	-	< 0.0002
beta-BHC	g/m^3	-	-	< 0.0002
delta-BHC	g/m^3	-	-	< 0.0002
gamma-BHC (Lindane)	g/m^3	-	-	< 0.0002
cis-Chlordane	g/m^3	-	-	< 0.00010
trans-Chlordane	g/m^3	-	-	< 0.00010
2,4'-DDD	g/m^3	-	-	< 0.0002
4,4'-DDD	g/m^3	-	-	< 0.0002
2,4'-DDE	g/m^3	-	-	< 0.0002
4,4'-DDE	g/m^3	-	-	< 0.0002
2,4'-DDT	g/m^3	-	-	< 0.0002
4,4'-DDT	g/m^3	-	-	< 0.0002
Dieldrin	g/m^3	-	-	< 0.00010
Endosulfan I	g/m^3	-	-	< 0.0002
Endosulfan II	g/m^3	-	-	< 0.0002
Endosulfan sulphate	g/m^3	-	-	< 0.0002
Endrin	g/m^3	-	-	< 0.00010
Endrin aldehyde	g/m^3	-	-	< 0.00010
Endrin ketone	g/m^3	-	-	< 0.0002
Heptachlor	g/m^3	-	-	< 0.00010
Heptachlor epoxide	g/m^3	-	-	< 0.00010
Hexachlorobenzene	g/m^3	-	-	< 0.0008
Methoxychlor	g/m^3	-	-	< 0.00010
Polychlorinated Biphenyls Screening in Water, By Liq/Liq				
PCB-18	g/m^3	-	-	< 0.00010
PCB-28	g/m^3	-	-	< 0.00010
PCB-31	g/m^3	-	-	< 0.00010
PCB-44	g/m^3	-	-	< 0.00010
PCB-49	g/m^3	-	-	< 0.00010
PCB-52	g/m^3	-	-	< 0.00010
PCB-60	g/m^3	-	-	< 0.00010
PCB-77	g/m^3	-	-	< 0.00010
PCB-81	g/m^3	-	-	< 0.00010
PCB-86	g/m^3	-	-	< 0.00010
PCB-101	g/m^3	-	-	< 0.00010
PCB-105	g/m^3	-	-	< 0.00010
PCB-110	g/m^3	-	-	< 0.00010
PCB-114	g/m^3	-	-	< 0.00010
PCB-118	g/m^3	-	-	< 0.00010

Sample Type: Aqueous				
Sample Name:		E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
Lab Number:		3034727.1	3034727.2	3034727.3
Polychlorinated Biphenyls Screening in Water, By Liq/Liq				
PCB-121	g/m³	-	-	< 0.00010
PCB-123	g/m³	-	-	< 0.00010
PCB-126	g/m³	-	-	< 0.00010
PCB-128	g/m³	-	-	< 0.00010
PCB-138	g/m³	-	-	< 0.00010
PCB-141	g/m³	-	-	< 0.00010
PCB-149	g/m³	-	-	< 0.00010
PCB-151	g/m³	-	-	< 0.00010
PCB-153	g/m³	-	-	< 0.00010
PCB-156	g/m³	-	-	< 0.00010
PCB-157	g/m³	-	-	< 0.00010
PCB-159	g/m³	-	-	< 0.00010
PCB-167	g/m³	-	-	< 0.00010
PCB-169	g/m³	-	-	< 0.00010
PCB-170	g/m³	-	-	< 0.00010
PCB-180	g/m³	-	-	< 0.00010
PCB-189	g/m³	-	-	< 0.00010
PCB-194	g/m³	-	-	< 0.00010
PCB-206	g/m³	-	-	< 0.00010
PCB-209	g/m³	-	-	< 0.00010
Total PCB (Sum of 35 congeners)	g/m³	-	-	< 0.005
Haloethers in SVOC Water Samples by GC-MS				
Bis(2-chloroethoxy) methane	g/m³	-	-	< 0.005
Bis(2-chloroethyl)ether	g/m³	-	-	< 0.005
Bis(2-chloroisopropyl)ether	g/m³	-	-	< 0.005
4-Bromophenyl phenyl ether	g/m³	-	-	< 0.005
4-Chlorophenyl phenyl ether	g/m³	-	-	< 0.005
Nitrogen containing compounds in SVOC Water Samples by GC-MS*				
2,4-Dinitrotoluene	g/m³	-	-	< 0.010
2,6-Dinitrotoluene	g/m³	-	-	< 0.010
Nitrobenzene	g/m³	-	-	< 0.005
N-Nitrosodi-n-propylamine	g/m³	-	-	< 0.010
N-Nitrosodiphenylamine + Diphenylamine*	g/m³	-	-	< 0.010
Organochlorine Pesticides in SVOC Water Samples by GC-MS				
Aldrin	g/m³	-	-	< 0.005
alpha-BHC	g/m³	-	-	< 0.005
beta-BHC	g/m³	-	-	< 0.005
delta-BHC	g/m³	-	-	< 0.005
gamma-BHC (Lindane)	g/m³	-	-	< 0.005
4,4'-DDD	g/m³	-	-	< 0.005
4,4'-DDE	g/m³	-	-	< 0.005
4,4'-DDT	g/m³	-	-	< 0.010
Dieldrin	g/m³	-	-	< 0.005
Endosulfan I	g/m³	-	-	< 0.010
Endosulfan II	g/m³	-	-	< 0.010
Endosulfan sulphate	g/m³	-	-	< 0.010
Endrin	g/m³	-	-	< 0.010
Endrin ketone	g/m³	-	-	< 0.010
Heptachlor	g/m³	-	-	< 0.005
Heptachlor epoxide	g/m³	-	-	< 0.005
Hexachlorobenzene	g/m³	-	-	< 0.005
Polycyclic Aromatic Hydrocarbons in SVOC Water Samples by GC-MS*				
Acenaphthene	g/m³	-	-	< 0.003
Acenaphthylene	g/m³	-	-	< 0.003

Sample Type: Aqueous				
Sample Name:		E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
Lab Number:		3034727.1	3034727.2	3034727.3
Polycyclic Aromatic Hydrocarbons in SVOC Water Samples by GC-MS*				
Anthracene	g/m^3	-	-	< 0.003
Benzo[a]anthracene	g/m^3	-	-	< 0.003
Benzo[a]pyrene (BAP)	g/m^3	-	-	< 0.003
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	-	-	< 0.003
Benzo[g,h,i]perylene	g/m^3	-	-	< 0.003
Benzo[k]fluoranthene	g/m^3	-	-	< 0.003
1&2-Chloronaphthalene	g/m^3	-	-	< 0.003
Chrysene	g/m^3	-	-	< 0.003
Dibenzo[a,h]anthracene	g/m^3	-	-	< 0.003
Fluoranthene	g/m^3	-	-	< 0.003
Fluorene	g/m^3	-	-	< 0.003
Indeno(1,2,3-c,d)pyrene	g/m^3	-	-	< 0.003
2-Methylnaphthalene	g/m^3	-	-	< 0.003
Naphthalene	g/m^3	-	-	< 0.003
Phenanthrene	g/m^3	-	-	< 0.003
Pyrene	g/m^3	-	-	< 0.003
Benzo[a]pyrene Toxic Equivalence (TEF)*	g/m^3	-	-	< 0.008
Phenols in SVOC Water Samples by GC-MS				
4-Chloro-3-methylphenol	g/m^3	-	-	< 0.010
2-Chlorophenol	g/m^3	-	-	< 0.005
2,4-Dichlorophenol	g/m^3	-	-	< 0.005
2,4-Dimethylphenol	g/m^3	-	-	< 0.005
3 & 4-Methylphenol (m- + p-cresol)	g/m^3	-	-	0.011
2-Methylphenol (o-Cresol)	g/m^3	-	-	< 0.005
2-Nitrophenol	g/m^3	-	-	< 0.010
Pentachlorophenol (PCP)	g/m^3	-	-	< 0.10
Phenol	g/m^3	-	-	0.068
2,4,5-Trichlorophenol	g/m^3	-	-	< 0.010
2,4,6-Trichlorophenol	g/m^3	-	-	< 0.010
Plasticisers in SVOC Water Samples by GC-MS				
Bis(2-ethylhexyl)phthalate	g/m^3	-	-	< 0.03
Butylbenzylphthalate	g/m^3	-	-	< 0.010
Di(2-ethylhexyl)adipate	g/m^3	-	-	< 0.005
Diethylphthalate	g/m^3	-	-	< 0.010
Dimethylphthalate	g/m^3	-	-	< 0.010
Di-n-butylphthalate	g/m^3	-	-	< 0.010
Di-n-octylphthalate	g/m^3	-	-	< 0.010
Other Halogenated compounds in SVOC Water Samples by GC-MS				
1,2-Dichlorobenzene	g/m^3	-	-	< 0.010
1,3-Dichlorobenzene	g/m^3	-	-	< 0.010
1,4-Dichlorobenzene	g/m^3	-	-	< 0.010
Hexachlorobutadiene	g/m^3	-	-	< 0.010
Hexachloroethane	g/m^3	-	-	< 0.010
1,2,4-Trichlorobenzene	g/m^3	-	-	< 0.005
Other compounds in SVOC Water Samples by GC-MS				
Benzyl alcohol	g/m^3	-	-	< 0.05
Carbazole	g/m^3	-	-	< 0.005
Dibenzofuran	g/m^3	-	-	< 0.005
Isophorone	g/m^3	-	-	< 0.005
BTEX in VOC Water by Headspace GC-MS				
Benzene	g/m^3	-	-	< 0.003
Ethylbenzene	g/m^3	-	-	0.014
Toluene	g/m^3	-	-	0.030
m&p-Xylene	g/m^3	-	-	0.019

Sample Type: Aqueous				
Sample Name:		E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
Lab Number:		3034727.1	3034727.2	3034727.3
BTEX in VOC Water by Headspace GC-MS				
o-Xylene	g/m^3	-	-	0.010
Halogenated Aliphatics in VOC Water by Headspace GC-MS				
Bromomethane (Methyl Bromide)	g/m^3	-	-	< 0.003
Carbon tetrachloride	g/m^3	-	-	< 0.003
Chloroethane	g/m^3	-	-	< 0.003
Chloromethane	g/m^3	-	-	< 0.003
1,2-Dibromo-3-chloropropane	g/m^3	-	-	< 0.003
1,2-Dibromoethane (ethylene dibromide, EDB)	g/m^3	-	-	< 0.003
Dibromomethane	g/m^3	-	-	< 0.003
Dichlorodifluoromethane	g/m^3	-	-	< 0.003
1,1-Dichloroethane	g/m^3	-	-	< 0.003
1,2-Dichloroethane	g/m^3	-	-	< 0.003
1,1-Dichloroethene	g/m^3	-	-	< 0.003
cis-1,2-Dichloroethene	g/m^3	-	-	< 0.003
trans-1,2-Dichloroethene	g/m^3	-	-	< 0.003
Dichloromethane (methylene chloride)	g/m^3	-	-	< 0.10
1,2-Dichloropropane	g/m^3	-	-	< 0.003
1,3-Dichloropropane	g/m^3	-	-	< 0.003
1,1-Dichloropropene	g/m^3	-	-	< 0.003
cis-1,3-Dichloropropene	g/m^3	-	-	< 0.005
trans-1,3-Dichloropropene	g/m^3	-	-	< 0.005
Hexachlorobutadiene	g/m^3	-	-	< 0.003
1,1,1,2-Tetrachloroethane	g/m^3	-	-	< 0.003
1,1,2,2-Tetrachloroethane	g/m^3	-	-	< 0.003
Tetrachloroethene (tetrachloroethylene)	g/m^3	-	-	< 0.003
1,1,1-Trichloroethane	g/m^3	-	-	< 0.003
1,1,2-Trichloroethane	g/m^3	-	-	< 0.003
Trichloroethene (trichloroethylene)	g/m^3	-	-	< 0.003
Trichlorofluoromethane	g/m^3	-	-	< 0.003
1,2,3-Trichloropropane	g/m^3	-	-	< 0.003
1,1,2-Trichlorotrifluoroethane (Freon 113)	g/m^3	-	-	< 0.003
Vinyl chloride	g/m^3	-	-	< 0.003
Haloaromatics in VOC Water by Headspace GC-MS				
Bromobenzene	g/m^3	-	-	< 0.003
Chlorobenzene (monochlorobenzene)	g/m^3	-	-	< 0.003
2-Chlorotoluene	g/m^3	-	-	< 0.003
1,2-Dichlorobenzene	g/m^3	-	-	< 0.003
1,3-Dichlorobenzene	g/m^3	-	-	< 0.003
1,4-Dichlorobenzene	g/m^3	-	-	< 0.003
4-Chlorotoluene	g/m^3	-	-	< 0.003
1,2,3-Trichlorobenzene	g/m^3	-	-	< 0.003
1,2,4-Trichlorobenzene	g/m^3	-	-	< 0.003
1,3,5-Trichlorobenzene	g/m^3	-	-	< 0.003
Monoaromatic Hydrocarbons in VOC Water by Headspace GC-MS				
n-Butylbenzene	g/m^3	-	-	< 0.005
tert-Butylbenzene	g/m^3	-	-	< 0.003
4-Isopropyltoluene (p-Cymene)	g/m^3	-	-	0.009
Isopropylbenzene (Cumene)	g/m^3	-	-	< 0.003
n-Propylbenzene	g/m^3	-	-	< 0.005
sec-Butylbenzene	g/m^3	-	-	< 0.003
Styrene	g/m^3	-	-	< 0.005
1,2,4-Trimethylbenzene	g/m^3	-	-	0.012
1,3,5-Trimethylbenzene	g/m^3	-	-	0.004

Sample Type: Aqueous				
Sample Name:		E Pond 14-Jul-2022	W Pond 14-Jul-2022	PS3 14-Jul-2022 10:00 am
Lab Number:		3034727.1	3034727.2	3034727.3
Ketones in VOC Water by Headspace GC-MS				
Acetone	g/m^3	-	-	< 0.5
2-Butanone (MEK)	g/m^3	-	-	< 0.5
Methyl tert-butylether (MTBE)	g/m^3	-	-	< 0.003
4-Methylpentan-2-one (MIBK)	g/m^3	-	-	< 0.10
Trihalomethanes in VOC Water by Headspace GC-MS				
Bromodichloromethane	g/m^3	-	-	< 0.003
Bromoform (tribromomethane)	g/m^3	-	-	< 0.003
Chloroform (Trichloromethane)	g/m^3	-	-	< 0.003
Dibromochloromethane	g/m^3	-	-	< 0.003
Other VOC in Water by Headspace GC-MS				
Carbon disulphide	g/m^3	-	-	< 0.005
Naphthalene	g/m^3	-	-	< 0.005

Analyst's Comments

[#1] Please interpret this microbiological result with caution as the sample was > 24 hours old at the time of testing in the laboratory. The sample is required to reach the laboratory with sufficient time to allow testing to commence within 24 hours of sampling.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-3
Acid Soluble Extraction Filtered	Nitric acid extraction (pH1.65-1.85, 16 hours). US EPA 200.1.	-	3
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	3
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	3
pH	pH meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	1-3
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m^3 at 25°C	3
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	3
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1-3
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	3
Acid Soluble Aluminium	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.003 g/m^3	3

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Acid Soluble Barium	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m^3	3
Acid Soluble Boron	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m^3	3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m^3	3
Dissolved Chromium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-2
Acid Soluble Iron	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	3
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	3
Acid Soluble Manganese	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	3
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	3
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m^3	3
Total Potassium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.053 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	3
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-2
Total Cyanide Screen	On-line distillation, colorimetry, screen level. ISO 14403:2012(E) (modified).	0.02 g/m^3	3
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m^3	1-3
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-3
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-3
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-3
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	3
Total Sulphide Screen	In-line distillation, segmented flow colorimetry. APHA 4500-S^{2-} E (modified) 23rd ed. 2017.	0.05 g/m^3	3
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m^3	3
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, seeded. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m^3	3
Chemical Oxygen Demand (COD), screen level	Dichromate/sulphuric acid digestion, colorimetry. Screen Level method. APHA 5220 D 23rd ed. 2017.	25 g O_2/m^3	3
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 23rd ed. 2017.	0.5 g/m^3	1-3
Total Phenols	In-line distillation, segmented flow colorimetry. NB: Does not detect 4-methylphenol. APHA 5530 B & D (modified) 23rd ed. 2017 & Skalar Method I497-001 (modified).	0.02 g/m^3	3

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Faecal Coliforms	MPN count in LT Broth at 35°C for 48 hours, EC Broth at 44.5° C for 24 hours Analysed at Hill Laboratories - Microbiology; 101c Waterloo Road, Hornby, Christchurch. APHA 9221 E 23rd ed. 2017.	2 MPN / 100mL	3
Heavy metals, acid sol, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Dilute nitric acid extraction, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00005 - 0.0010 g/m^3	3
Organochlorine Pesticides Screening in Water, By Liq/Liq	Liquid / liquid extraction, GC-ECD analysis. In-house based on US EPA 8081.	0.00010 - 0.0008 g/m^3	3
Polychlorinated Biphenyls Screening in Water, By Liq/Liq	Liquid / liquid extraction, GC-MS analysis. In-house based on US EPA 8270.	0.00010 - 0.005 g/m^3	3
Semivolatile Organic Compounds Screening in Water by GC-MS	Liquid / liquid extraction, GC-MS analysis. In-house based on US EPA 8270.	0.00005 - 0.10 g/m^3	3
Volatile Organic Compounds Screening in Water by Headspace GC-MS	Headspace GC-MS analysis. In-house based on US EPA 8260 and 5021.	0.003 - 0.5 g/m^3	3
Volatile Fatty Acid Profile			
Volatile Fatty Acids (VFA), Total	Ion Chromatography. Sum of Formic, Acetic, Propionic and Butyric acids only, expressed as acetic acid. In-house calculation.	5 g/m^3 as acetic acid	3
Formic Acid	Ion Chromatography. In-house.	0.5 g/m^3	3
Acetic Acid	Ion Chromatography. In-house.	0.5 g/m^3	3
Propionic Acid	Ion Chromatography. In-house.	0.5 g/m^3	3
Butyric Acid	Ion Chromatography. In-house.	0.5 g/m^3	3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 16-Jul-2022 and 27-Jul-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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Certificate of Analysis

SPv1

Client:	GHD Limited	**Lab No:**	3035296
Contact:	Cecilia Gately	**Date Received:**	16-Jul-2022
	C/- GHD Limited	**Date Reported:**	25-Jul-2022
	PO Box 13468	**Quote No:**	115579
	Armagh	**Order No:**	12587765
	Christchurch 8141	**Client Reference:**	12587765
		Submitted By:	Hayden Erasmus

Sample Type: Aqueous

Sample Name:		GI1 15-Jul-2022	GI2 15-Jul-2022	GI3 15-Jul-2022	GI5 15-Jul-2022
Lab Number:		3035296.1	3035296.2	3035296.3	3035296.4
Individual Tests					
Dissolved Aluminium	g/m^3	0.31	0.53	0.38	0.42
Total Cyanide	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002
Chloride	g/m^3	23	30	36	75
Total Ammoniacal-N	g/m^3	0.108	0.089	0.173	0.38
Nitrite-N	g/m^3	0.009	0.009	0.014	0.060
Nitrate-N	g/m^3	2.6	2.8	2.8	3.2
Nitrate-N + Nitrite-N	g/m^3	2.6	2.8	2.8	3.3
Total Biochemical Oxygen Demand ($TBOD_5$)	$g\ O_2/m^3$	< 2 #1	< 2 #1	< 2 #1	< 2 #1
Total Organic Carbon (TOC)	g/m^3	10.4	13.0	13.7	12.6
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Dissolved Cadmium	g/m^3	< 0.00005	0.00011	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0007	0.0007	0.0012	0.0011
Dissolved Copper	g/m^3	0.0027	0.0023	0.0029	0.0031
Dissolved Lead	g/m^3	0.00058	0.00019	0.00056	0.00049
Dissolved Nickel	g/m^3	0.0014	0.0082	0.0024	0.0036
Dissolved Zinc	g/m^3	0.026	0.047	0.028	0.028

Analyst's Comments

#1 The BOD5 result for this sample may be biased slightly low as evidenced by quality control samples analysed with these samples.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00005 - 0.0010 g/m^3	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-4
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.003 g/m^3	1-4
Total Cyanide Trace	On-line distillation, colorimetry, trace level. ISO 14403:2012(E) (modified).	0.002 g/m^3	1-4
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m^3	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-4
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-4
Total Biochemical Oxygen Demand ($TBOD_5$)	Incubation 5 days, DO meter, no nitrification inhibitor added, seeded. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m^3	1-4
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 23rd ed. 2017.	0.5 g/m^3	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 19-Jul-2022 and 22-Jul-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

Client:	GHD Limited	**Lab No:**	3095310 SPv1
Contact:	Cecilia Gately	**Date Received:**	13-Oct-2022
	C/- GHD Limited	**Date Reported:**	21-Oct-2022
	PO Box 13468	**Quote No:**	115579
	Armagh	**Order No:**	12587765
	Christchurch 8141	**Client Reference:**	12587765
		Add. Client Ref:	Quarterly Monitoring
		Submitted By:	Hayden Erasmus

Sample Type: Aqueous

	Sample Name:	GI1 12-Oct-2022	GI2 12-Oct-2022	GI3 12-Oct-2022	GI5 12-Oct-2022	E Pond 12-Oct-2022
	Lab Number:	3095310.1	3095310.2	3095310.3	3095310.4	3095310.5
Individual Tests						
pH	pH Units	8.3	7.1	7.6	7.4	8.4
Total Alkalinity	g/m³ as $CaCO_3$	-	-	-	-	240
Electrical Conductivity (EC)	mS/m	21.6	42.9	51.2	131.5	104.9
Dissolved Aluminium	g/m³	0.069	0.055	0.111	0.091	-
Dissolved Chromium	g/m³	-	-	-	-	0.0006
Dissolved Copper	g/m³	-	-	-	-	0.0038
Dissolved Iron	g/m³	0.27	0.64	0.35	0.59	0.20
Dissolved Lead	g/m³	-	-	-	-	0.00044
Dissolved Nickel	g/m³	-	-	-	-	0.0047
Total Potassium	g/m³	-	-	-	-	26
Dissolved Zinc	g/m³	-	-	-	-	0.0018
Total Cyanide	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	-
Chloride	g/m³	18.7	29	98	320	150
Total Ammoniacal-N	g/m³	< 0.010	0.142	0.027	0.024	0.113
Nitrite-N	g/m³	0.005	0.002	0.006	< 0.02 #2	0.026
Nitrate-N	g/m³	0.33	0.32	0.37	< 0.02	0.62
Nitrate-N + Nitrite-N	g/m³	0.34	0.32	0.38	< 0.02 #2	0.64
Total Biochemical Oxygen Demand ($TBOD_5$)	g O_2/m³	< 2 #1	< 2 #1	< 2 #1	5 #1	-
Total Organic Carbon (TOC)	g/m³	5.0	3.4	6.0	21	31
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	< 0.0010	< 0.0010	< 0.0010	0.0014	-
Dissolved Cadmium	g/m³	< 0.00005	0.00012	< 0.00005	< 0.00005	-
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	< 0.0005	0.0013	-
Dissolved Copper	g/m³	0.0022	0.0014	0.0026	0.0022	-
Dissolved Lead	g/m³	0.00028	< 0.00010	0.00029	0.00050	-
Dissolved Nickel	g/m³	0.0010	0.0128	0.0023	0.0018	-
Dissolved Zinc	g/m³	0.0083	0.052	0.0198	0.152	-

	Sample Name:	W Pond 12-Oct-2022	PS3 11-Oct-2022	MW2D 11-Oct-2022	MW4D 11-Oct-2022	MW7D 12-Oct-2022
	Lab Number:	3095310.6	3095310.7	3095310.8	3095310.9	3095310.10
Individual Tests						
Sum of Anions	meq/L	-	-	330	270	197
Sum of Cations	meq/L	-	-	310	260	175
pH	pH Units	8.0	-	7.0	7.0	7.7
Total Alkalinity	g/m³ as $CaCO_3$	132	-	196	240	410
Carbonate	g/m³ at 25°C	-	-	< 1.0	< 1.0	1.3

Sample Type: Aqueous						
	Sample Name:	W Pond 12-Oct-2022	PS3 11-Oct-2022	MW2D 11-Oct-2022	MW4D 11-Oct-2022	MW7D 12-Oct-2022
	Lab Number:	3095310.6	3095310.7	3095310.8	3095310.9	3095310.10
Individual Tests						
Bicarbonate	g/m^3 at 25°C	-	-	240	290	500
Total Hardness	g/m^3 as $CaCO_3$	-	-	5,000	4,500	2,600
Electrical Conductivity (EC)	mS/m	635	-	2,650	2,280	1,545
Total Suspended Solids	g/m^3	-	60	-	-	-
Dissolved Calcium	g/m^3	-	-	810	830	440
Dissolved Chromium	g/m^3	< 0.005	-	-	-	-
Dissolved Copper	g/m^3	< 0.005	-	-	-	-
Dissolved Iron	g/m^3	< 0.2	-	111	97	13
Dissolved Lead	g/m^3	< 0.0010	-	< 0.010	< 0.010	< 0.010
Dissolved Magnesium	g/m^3	-	-	730	590	360
Dissolved Nickel	g/m^3	< 0.005	-	-	-	-
Dissolved Potassium	g/m^3	-	-	69	57	55
Total Potassium	g/m^3	44	-	-	-	-
Dissolved Sodium	g/m^3	-	-	4,700	3,900	2,800
Dissolved Zinc	g/m^3	< 0.010	-	1.68	< 0.10	< 0.10
Chloride	g/m^3	2,000	-	11,500	9,500	6,200
Total Ammoniacal-N	g/m^3	0.097	410	22	11.1	< 0.010
Nitrite-N	g/m^3	0.008	-	< 0.10 [#2]	< 0.10 [#2]	< 0.002
Nitrate-N	g/m^3	0.030	-	< 0.10	0.13	0.38
Nitrate-N + Nitrite-N	g/m^3	0.038	-	< 0.10 [#2]	0.13 [#2]	0.38
Sulphate	g/m^3	-	-	< 5 [#3]	< 5 [#3]	680
Total Biochemical Oxygen Demand ($TBOD_5$)	g O_2/m^3	-	43 [#1]	11 [#1]	8 [#1]	3 [#1]
Total Organic Carbon (TOC)	g/m^3	13.6	-	52	38	2.4

Analyst's Comments

[#1] The TBOD5 result may be biased slightly low as evidenced by quality control samples analysed with this sample. This result should be interpreted with caution.

[#2] Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NOxN /NO2N analysis.

[#3] Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the SO4 analysis.

Sample 10 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00005 - 0.0010 g/m^3	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-10
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	5-6
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	8-10
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	8-10

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
pH	pH meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1-6, 8-10
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	5-6, 8-10
Carbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m^3 at 25°C	8-10
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m^3 at 25°C	8-10
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	8-10
Electrical Conductivity (EC)	Conductivity meter, 25°C. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1-6, 8-10
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	7
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.003 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m^3	8-10
Dissolved Chromium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	5-6
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	5-6
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	1-6, 8-10
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	5-6, 8-10
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	8-10
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	5-6
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m^3	8-10
Total Potassium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.053 g/m^3	5-6
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m^3	8-10
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	5-6, 8-10
Total Cyanide Trace	On-line distillation, colorimetry, trace level. ISO 14403:2012(E) (modified).	0.002 g/m^3	1-4
Chloride	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m^3	1-6, 8-10
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-10
Nitrite-N	Filtered sample from Christchurch. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-6, 8-10
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-6, 8-10
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-6, 8-10
Sulphate	Filtered sample from Christchurch. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m^3	8-10
Total Biochemical Oxygen Demand ($TBOD_5$)	Incubation 5 days, DO meter, no nitrification inhibitor added, seeded. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m^3	1-4, 7-10

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 23rd ed. 2017.	0.5 g/m^3	1-6, 8-10

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 17-Oct-2022 and 21-Oct-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Kim Harrison MSc
Client Services Manager - Environmental

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Certificate of Analysis

GHD Dunedin

Attention: Cecilia Gately
Phone: 0272699123
Email: cecilia.gately@ghd.com

Lab Reference: 23-01371
Submitted by: Hayden Erasmus
Date Received: 02/02/2023
Testing Initiated: 2/02/2023
Date Completed: 15/02/2023
Order Number: 12587765
Reference: 12587765

Sampling Site: Green Island

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Reporting limit of PFBA, PFPeA and HFPO-DA is raised due to the presence of interferences and low recovery of ISTD.

Water Aggregate Properties

	Client Sample ID		W Pond	E Pond
	Date Sampled		18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2
Electrical Conductivity	µS/cm	*0.2*	8,170	2,030
Total Alkalinity (CaCO3)	g $CaCO_3/m^3$	*1*	221	242
Conductivity of Water (mS/m)	mS/m	*0.02*	817	203

Inorganic Nutrients and Nutrient Species in Water

	Client Sample ID		W Pond	E Pond	PS3
	Date Sampled		18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2	23-01371-3
Ammonia as N	g/m^3	*0.005*	0.65	<0.005	370
Nitrate-N	g/m^3	*0.002*	0.0787	0.394	

Anions in Water

	Client Sample ID		W Pond	E Pond
	Date Sampled		18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2
Chloride	g/m^3	*0.5*	2,210	494

Elements in Water (Total Recoverable)

		Client Sample ID	W Pond	E Pond
		Date Sampled	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2
Potassium	g/m^3	*0.05*	63.6	45.1

Carbon in Water

		Client Sample ID	W Pond	E Pond
		Date Sampled	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2
Total Organic Carbon	g/m^3	*0.5*	31.2	86.0

Elements in Water (Soluble)

		Client Sample ID	W Pond	E Pond
		Date Sampled	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01371-1	23-01371-2
Chromium	g/m^3	*0.0002*	0.0018	0.0014
Copper	g/m^3	*0.0002*	0.00056	0.0015
Lead	g/m^3	*0.00005*	0.00021	0.0013
Nickel	g/m^3	*0.0002*	0.0025	0.0074
Zinc	g/m^3	*0.001*	0.0028	0.043

Solids in Water

		Client Sample ID	[redacted]
		Date Sampled	[redacted]
Analyte	Unit	*Reporting Limit*	[redacted]
Total Suspended Solids	g/m^3	*3*	[redacted]

Biochemical Oxygen Demand

		Client Sample ID	[redacted]
		Date Sampled	[redacted]
Analyte	Unit	*Reporting Limit*	[redacted]
Total Biochemical Oxygen Demand	g/m^3	*1*	[redacted]

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Method Summary

Electrical Conductivity	Samples analysed as received using a conventional conductivity electrode. (APHA 2510 B - Modified - Auto-titrator - Online edition).
Total Alkalinity ($CaCO_3$)	Samples analysed as received by potentiometric titration. (APHA 2320 B Online edition).
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
Chloride	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
Recoverable Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following an acid digestion. In house procedure based on US EPA method 200.8.
Total Organic Carbon	Samples analysed as received by combustion analysis at 850°C. Organic carbon is calculated through subtraction of inorganic carbon from total carbon (APHA 5310 B - Online edition)
Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45μm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Total Suspended Solids	Measured gravimetrically following filtration through glass micro-fibre filters. (APHA 2540 D - Modified - Online edition).
BOD	Dissolved oxygen measured using a dissolved oxygen electrode after a 5 day incubation period. (APHA 5210 B - Online edition).

Method Summary

[redacted]

Sharelle Frank, B.Sc. (Tech)
Technologist

Sandra Mathews, B.Eng.
Technologist

Jarred Wilson, DipSci
Trace Elements Team Leader

Derek Yang, B.Sc.(Tech)
Senior Technologist

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Certificate of Analysis

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Dunedin 9016

Attention: Cecilia Gately
Phone: 0272699123
Email: cecilia.gately@ghd.com

Lab Reference: 23-01714
Submitted by: Hayden Erasmus
Date Received: 02/02/2023
Testing Initiated: 2/02/2023
Date Completed: 15/02/2023
Order Number: 12547621
Reference: 12547621

Sampling Site: Green Island

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

AMENDED REPORT. This report replaces in full a previous version R00 sent on 15/02/2023. Reference updated for PFAS results only.

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Nitrate-N	g/m^3	*0.002*	0.378	0.115	0.191	0.0563
Ammonia as N	g/m^3	*0.005*	0.02	0.12	0.04	0.18

Anions in Water

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Chloride	g/m^3	*0.5*	17.0	24.3	38.7	131

Elements in Water (Soluble)

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Aluminium	g/m^3	*0.003*	0.082	0.024	0.036	0.028
Cadmium	g/m^3	*0.00002*	<0.000020	0.000085	<0.000020	<0.000020
Chromium	g/m^3	*0.0002*	0.00079	<0.00020	0.00028	0.00036
Copper	g/m^3	*0.0002*	0.0038	0.00093	0.0029	0.0011
Lead	g/m^3	*0.00005*	0.00049	<0.000050	0.00047	0.00047

Elements in Water (Soluble)

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Nickel	g/m^3	*0.0002*	0.0011	0.0091	0.0016	0.0017
Zinc	g/m^3	*0.001*	0.013	0.027	0.011	0.0054

Carbon in Water

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Total Organic Carbon	g/m^3	*0.5*	6.0	2.1	4.8	4.4

Cyanide in Water (Subcontracted - Hill Labs)

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Custom Job			0.05	0.03	0.02	<0.02

Custom Job

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Custom Job			<0.02	<0.02	<0.02	<0.02

Biochemical Oxygen Demand

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	18/01/2023	18/01/2023	18/01/2023	18/01/2023
Analyte	Unit	*Reporting Limit*	23-01714-1	23-01714-2	23-01714-3	23-01714-4
Total Biochemical Oxygen Demand	g/m^3	*1*	<1.0	<1.0	<1.0	<1.0

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Method Summary

NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
Chloride	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Total Organic Carbon	Samples analysed as received by combustion analysis at 850°C. Organic carbon is calculated through subtraction of inorganic carbon from total carbon (APHA 5310 B - Online edition)
BOD	Dissolved oxygen measured using a dissolved oxygen electrode after a 5 day incubation period. (APHA 5210 B - Online edition).

Method Summary

[redacted]

Short-hand Name	Full name
[redacted]	[redacted]

Sharelle Frank, B.Sc. (Tech)
Technologist

Jarred Wilson, DipSci
Trace Elements Team Leader

Amaria Reweti, BA
Technician

Derek Yang, B.Sc.(Tech)
Senior Technologist

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Dunedin 9016

Attention: Hayden Erasmus
Phone: 03 479 9494
Email: hayden.erasmus@ghd.com

Lab Reference: 23-10977
Submitted by: Hayden Erasmus
Date Received: 13/04/2023
Testing Initiated: 13/04/2023
Date Completed: 18/07/2023
Order Number: 12587765
Reference: 12587765

Sampling Site: Green Island

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

AMENDED REPORT. This report replaces in full a previous version [R00] sent on 29/05/2023. Nickel results and sampling date added.

Elements in Water (Soluble)

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	13/04/2023	13/04/2023	13/04/2023	13/04/2023
Analyte	Unit	*Reporting Limit*	23-10977-1	23-10977-2	23-10977-3	23-10977-4
Aluminium	g/m^3	*0.003*	0.144	0.117	0.108	0.020
Chromium	g/m^3	*0.0002*	<0.00020	0.00044	0.00058	0.00021
Copper	g/m^3	*0.0002*	0.0018	0.0029	0.0026	0.0011
Lead	g/m^3	*0.00005*	<0.000050	0.00061	0.00051	0.00021
Zinc	g/m^3	*0.001*	0.077	0.016	0.028	0.014
Cadmium	g/m^3	*0.00002*	0.00020	<0.000020	<0.000020	<0.000020
Nickel	g/m^3	*0.0002*	0.017	0.00070	0.0020	0.0014

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	GI1	GI2	GI3	GI5
		Date Sampled	13/04/2023	13/04/2023	13/04/2023	13/04/2023
Analyte	Unit	*Reporting Limit*	23-10977-1	23-10977-2	23-10977-3	23-10977-4
Ammonia as N	g/m^3	*0.005*	0.12	<0.005	0.09	0.008
Nitrate-N	g/m^3	*0.002*	0.182	0.355	0.300	0.142

Anions in Water

Client Sample ID			GI1	GI2	GI3	GI5
Date Sampled			13/04/2023	13/04/2023	13/04/2023	13/04/2023
Analyte	Unit	*Reporting Limit*	23-10977-1	23-10977-2	23-10977-3	23-10977-4
Chloride	g/m^3	*0.5*	32.6	12.2	339	1,030

Cyanide in Water (Subcontracted - Hill Labs)

Client Sample ID			GI1	GI2	GI3	GI5
Date Sampled			13/04/2023	13/04/2023	13/04/2023	13/04/2023
Analyte	Unit	*Reporting Limit*	23-10977-1	23-10977-2	23-10977-3	23-10977-4
Total Cyanide (Hills)	g/m^3	*0.02*	<0.02	<0.02	<0.02	<0.02

Carbon in Water

Client Sample ID			GI1	GI2	GI3	GI5
Date Sampled			13/04/2023	13/04/2023	13/04/2023	13/04/2023
Analyte	Unit	*Reporting Limit*	23-10977-1	23-10977-2	23-10977-3	23-10977-4
Total Organic Carbon	g/m^3	*0.5*	3.2	4.1	4.1	5.0

Method Summary

Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
Chloride	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
Total Cyanide Screen (Hills)	Subcontracted to Hill Laboratories - On-line distillation, colorimetry, screen level. ISO 14403:2012(E)(modified).
Total Organic Carbon	Samples analysed as received by combustion analysis at 850°C. Organic carbon is calculated through subtraction of inorganic carbon from total carbon (APHA 5310 B - Online edition)

Sharelle Frank, B.Sc. (Tech)
Technologist

Sandra Mathews, B.Eng.
Technologist

Matthew Counsell, B.Sc.
Inorganics Team Leader

Ashley Emery
Lab. Technician

ANALYTICA LABORATORIES

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Certificate of Analysis

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Attention: Cecilia Gately
Phone: 03 479 9494
Email: hayden.erasmus@ghd.com

Sampling Site: Green Island

Lab Reference: 23-11603
Submitted by: Paige Wills
Date Received: 01/05/2023
Testing Initiated: 18/04/2023
Date Completed: 10/05/2023
Order Number: 12587765
Reference: 12587765

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Water Aggregate Properties

		Client Sample ID	E Pond
		Date Sampled	12/04/2023
Analyte	Unit	*Reporting Limit*	23-11603-1
Total Alkalinity (CaCO3)	g $CaCO_3/m^3$	*1*	193

Anions in Water

		Client Sample ID	E Pond
		Date Sampled	12/04/2023
Analyte	Unit	*Reporting Limit*	23-11603-1
Chloride	g/m^3	*0.5*	202

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	E Pond
		Date Sampled	12/04/2023
Analyte	Unit	*Reporting Limit*	23-11603-1
Ammonia as N	g/m^3	*0.005*	<0.005
Nitrate-N	g/m^3	*0.002*	0.915

Elements in Water (Soluble)

		Client Sample ID	E Pond
		Date Sampled	12/04/2023
Analyte	Unit	*Reporting Limit*	23-11603-1
Chromium	g/m^3	*0.0002*	0.0011
Copper	g/m^3	*0.0002*	0.00026
Lead	g/m^3	*0.00005*	0.00024
Nickel	g/m^3	*0.0002*	0.0043
Zinc	g/m^3	*0.001*	0.0039
Potassium	g/m^3	*0.05*	33.8

Carbon in Water

		Client Sample ID	E Pond
		Date Sampled	12/04/2023
Analyte	Unit	*Reporting Limit*	23-11603-1
Total Organic Carbon	g/m^3	*0.5*	34.6

Method Summary

Total Alkalinity ($CaCO_3$)	Samples analysed as received by potentiometric titration. (APHA 2320 B Online edition).
Chloride	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Total Organic Carbon	Samples analysed as received by combustion analysis at 850°C. Organic carbon is calculated through subtraction of inorganic carbon from total carbon (APHA 5310 B - Online edition)

Sandra Mathews, B.Eng.
Technologist

Sharelle Frank, B.Sc. (Tech)
Technologist

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Attention: Cecilia Gately
Phone: 0273393506
Email: paige.wills@ghd.com

Lab Reference: 23-11202
Submitted by: Paige Wills
Date Received: 14/04/2023
Testing Initiated: 17/04/2023
Date Completed: 12/05/2023
Order Number: 12547621
Reference: 12547621

Sampling Site: Green Island

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Please note reporting limits for total recoverable cadmium, lead and arsenic for fractions 2, 3, 4, 6, 7, 10 and 11 are elevated as the sample matrix required an additional dilution prior to analysis.

Anion/Cation Suite

[redacted]

Anion/Cation Suite

		Client Sample ID	[redacted]	[redacted]	Western Pond	[redacted]	[redacted]
		Date Sampled	[redacted]	[redacted]	12/04/2023	[redacted]	[redacted]
Analyte	Unit	*Reporting Limit*	[redacted]	[redacted]	23-11202-8	[redacted]	[redacted]
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Total Alkalinity (CaCO3)	g $CaCO_3/m^3$	*1*	899	174	239	53.9	82.5
Chloride	g/m^3	*0.5*	6,600	8,830	1,840	1,360	6,480
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Nitrate-N	g/m^3	*0.002*	0.0085	5.14	0.0172	0.107	<0.0020
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Ammonia as N	g/m^3	*0.005*	9.07	2.96	4.05	0.13	0.1
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Potassium	g/m^3	*0.05*	103	56.7	53.3	33.6	150
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Elements in Water (Soluble)

[redacted]

Elements in Water (Soluble)

[redacted]

Elements in Water (Soluble)

[redacted]

Elements in Water (Total Recoverable)

[redacted]

Elements in Water (Total Recoverable)

[redacted]

Elements in Water (Total Recoverable)

		Client Sample ID	[redacted]		Western Pond	[redacted]	
		Date Sampled	[redacted]		12/04/2023	[redacted]	
Analyte	Unit	*Reporting Limit*	[redacted]		23-11202-8	[redacted]	
[redacted]							
Chromium	g/m³	*0.0002*	0.0012	0.00044	0.0068	0.00049	0.00033
Copper	g/m³	*0.0002*	0.00079	0.0024	0.0028	0.0013	0.0014
Lead	g/m³	*0.00005*	0.00057	0.00084	0.00505	0.00038	<0.0005
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Nickel	g/m³	*0.0002*	0.0011	0.0041	0.0034	0.0021	0.0015
Zinc	g/m³	*0.003*	0.0074	0.076	0.013	0.011	<0.0030

Elements in Water (Total Recoverable)

[redacted]

[redacted]

[redacted]

Method Summary

pH	Samples measured as received using a conventional pH electrode. (APHA 4500 H^+ B. Online edition).
Electrical Conductivity	Samples analysed as received using a conventional conductivity electrode. (APHA 2510 B - Modified - Auto-titrator - Online edition).
Total Alkalinity ($CaCO_3$)	Samples analysed as received by potentiometric titration. (APHA 2320 B Online edition).
Chloride	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
Sulfate	Analysis by Ion exchange chromatography following sample filtration. (APHA 4110B - Online edition).
NO3-N	Calculated from oxidised nitrogen and Nitrite-N, measured colourimetrically by flow injection analysis. (APHA NO_{3-} I. Online edition)
Dissolved Reactive Phosphorus	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-P G - Modified - Online edition)
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).
Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Sum of Anions	Sum of milliequivalents/Litre of measured Anions.
Sum of Cations	Sum of milliequivalents/Litre of measured Cations.
Recoverable Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following an acid digestion. In house procedure based on US EPA method 200.8.
Total Cyanide Screen (Hills)	Subcontracted to Hill Laboratories - On-line distillation, colorimetry, screen level. ISO 14403:2012(E)(modified).

Method Summary

Total Organic Carbon	Samples analysed as received by combustion analysis at 850°C. Organic carbon is calculated through subtraction of inorganic carbon from total carbon (APHA 5310 B - Online edition)

Sharelle Frank, B.Sc. (Tech)
Technologist

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Certificate of Analysis

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Attention:
Phone: 0272699123
Email: hayden.erasmus@ghd.com

Sampling Site: Green Island

Lab Reference: 23-05039
Submitted by: Hayden Erasmus
Date Received: 22/02/2023
Testing Initiated: 22/02/2023
Date Completed: 27/02/2023
Order Number:
Reference: 12547621

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

9 Heavy Metals in Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Analyte	Unit	*Reporting Limit*	23-05039-1
Arsenic	mg/kg dry wt	*0.125*	7.4
Boron	mg/kg dry wt	*1.25*	11
Cadmium	mg/kg dry wt	*0.005*	0.042
Chromium	mg/kg dry wt	*0.125*	25.0
Copper	mg/kg dry wt	*0.075*	13.3
Lead	mg/kg dry wt	*0.25*	15.4
Mercury	mg/kg dry wt	*0.025*	0.039
Nickel	mg/kg dry wt	*0.05*	16.0
Zinc	mg/kg dry wt	*0.05*	59.3

BTEX in Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Analyte	Unit	*Reporting Limit*	23-05039-1
Benzene	mg/kg dry wt	*0.05*	<0.050
Toluene	mg/kg dry wt	*0.10*	<0.10
Ethylbenzene	mg/kg dry wt	*0.05*	<0.050
m,p-Xylene	mg/kg dry wt	*0.10*	<0.10
o-Xylene	mg/kg dry wt	*0.05*	<0.050
Toluene-d8 (Surrogate)	%	*1*	100

BTEX in Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
p-Bromofluorobenzene (Surrogate)	%	*1*	82

Semivolatile Organic Compounds - Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Analyte	Unit	*Reporting Limit*	23-05039-1
Phenol	mg/kg dry wt	*0.3*	<0.30
2-Chlorophenol	mg/kg dry wt	*0.3*	<0.30
2-Methylphenol	mg/kg dry wt	*0.3*	<0.30
2-Nitrophenol	mg/kg dry wt	*1.0*	<1.0
2,4-Dimethylphenol	mg/kg dry wt	*0.3*	<0.30
2,4-Dichlorophenol	mg/kg dry wt	*0.3*	<0.30
2,6-Dichlorophenol	mg/kg dry wt	*0.3*	<0.30
4-Chloro-3-methylphenol	mg/kg dry wt	*0.3*	<0.30
2,4,5-Trichlorophenol	mg/kg dry wt	*5*	<5.0
2,4,6-Trichlorophenol	mg/kg dry wt	*5*	<5.0
2,3,4,6-Tetrachlorophenol	mg/kg dry wt	*5*	<5.0
4-Methylphenol	mg/kg dry wt	*0.3*	<0.30
Naphthalene	mg/kg dry wt	*0.1*	<0.10
2-Methylnaphthalene	mg/kg dry wt	*0.1*	<0.10
2-Chloronaphthalene	mg/kg dry wt	*0.3*	<0.30
Acenaphthene	mg/kg dry wt	*0.1*	<0.10
Acenaphthylene	mg/kg dry wt	*0.1*	<0.10
Fluorene	mg/kg dry wt	*0.1*	<0.10
Phenanthrene	mg/kg dry wt	*0.1*	<0.10
Anthracene	mg/kg dry wt	*0.1*	<0.10
2-Phenylphenol	mg/kg dry wt	*0.5*	<0.50
Fluoranthene	mg/kg dry wt	*0.1*	<0.10
Benzo[a]anthracene	mg/kg dry wt	*0.1*	<0.10
Chrysene	mg/kg dry wt	*0.1*	<0.10
Bis(2-ethylhexyl) adipate	mg/kg dry wt	*0.5*	<0.50
Benzo[b and j]fluoranthene	mg/kg dry wt	*0.1*	<0.10
Benzo[k]fluoranthene	mg/kg dry wt	*0.1*	<0.10
Benzo[a]pyrene	mg/kg dry wt	*0.1*	<0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	*0.1*	<0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	*0.1*	<0.10
Benzo[g,h,i]perylene	mg/kg dry wt	*0.1*	<0.10
Pyrene	mg/kg dry wt	*0.2*	<0.20
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.2*	0.20
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.1*	<0.10
4,4'-DDD	mg/kg dry wt	*0.3*	<0.30
4,4'-DDE	mg/kg dry wt	*0.3*	<0.30
4,4'-DDT	mg/kg dry wt	*0.5*	<0.50
alpha-BHC	mg/kg dry wt	*0.3*	<0.30
beta-BHC	mg/kg dry wt	*0.3*	<0.30
gamma-BHC (Lindane)	mg/kg dry wt	*0.3*	<0.30
delta-BHC	mg/kg dry wt	*0.3*	<0.30

Semivolatile Organic Compounds - Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Aldrin	mg/kg dry wt	*0.3*	<0.30
cis-Chlordane	mg/kg dry wt	*0.3*	<0.30
trans-Chlordane	mg/kg dry wt	*0.3*	<0.30
Dieldrin	mg/kg dry wt	*0.5*	<0.50
Endosulfan I	mg/kg dry wt	*0.3*	<0.30
Endosulfan II	mg/kg dry wt	*0.5*	<0.50
Endosulfan sulfate	mg/kg dry wt	*0.5*	<0.50
Endrin	mg/kg dry wt	*0.5*	<0.50
Endrin aldehyde	mg/kg dry wt	*0.5*	<0.50
Endrin ketone	mg/kg dry wt	*0.5*	<0.50
Hexachlorobenzene	mg/kg dry wt	*0.3*	<0.30
Heptachlor	mg/kg dry wt	*0.3*	<0.30
Heptachlor epoxide	mg/kg dry wt	*0.3*	<0.30
Methoxychlor	mg/kg dry wt	*0.5*	<0.50
Bis(2-ethylhexyl) phthalate	mg/kg dry wt	*0.5*	<0.50
Butyl benzyl phthalate	mg/kg dry wt	*0.5*	<0.50
Di-n-butyl phthalate	mg/kg dry wt	*1*	<1.0
Di-n-octyl phthalate	mg/kg dry wt	*0.5*	<0.50
Diethyl phthalate	mg/kg dry wt	*0.3*	<0.30
Dimethyl phthalate	mg/kg dry wt	*0.3*	<0.30
N-Nitrosodiphenylamine	mg/kg dry wt	*0.3*	<0.30
N-Nitrosodi-n-propylamine	mg/kg dry wt	*0.3*	<0.30
2,4-Dinitrotoluene	mg/kg dry wt	*0.3*	<0.30
2,6-Dinitrotoluene	mg/kg dry wt	*0.3*	<0.30
Azobenzene	mg/kg dry wt	*0.5*	<0.50
Isophorone	mg/kg dry wt	*0.5*	<0.50
Nitrobenzene	mg/kg dry wt	*0.3*	<0.30
4-Bromophenyl phenyl ether	mg/kg dry wt	*0.3*	<0.30
4-Chlorophenyl phenyl ether	mg/kg dry wt	*0.3*	<0.30
Bis(2-Chloroethyl) ether	mg/kg dry wt	*0.3*	<0.30
Bis(2-Chloro-1-methylethyl) ether	mg/kg dry wt	*0.3*	<0.30
Bis(2-Chloroethoxy) methane	mg/kg dry wt	*0.3*	<0.30
1,2-Dichlorobenzene	mg/kg dry wt	*0.3*	<0.30
1,3-Dichlorobenzene	mg/kg dry wt	*0.3*	<0.30
1,4-Dichlorobenzene	mg/kg dry wt	*0.3*	<0.30
Hexachlorobutadiene	mg/kg dry wt	*0.3*	<0.30
Hexachlorocylopentadiene	mg/kg dry wt	*0.3*	<0.30
Hexachloroethane	mg/kg dry wt	*0.3*	<0.30
4-Chloroaniline	mg/kg dry wt	*1.0*	<1.0
2-Nitroaniline	mg/kg dry wt	*0.3*	<0.30
3-Nitroaniline	mg/kg dry wt	*0.5*	<0.50
Aniline	mg/kg dry wt	*1.0*	<1.0
3,3'-Dichlorobenzidine	mg/kg dry wt	*0.5*	<0.50
Dibenzofuran	mg/kg dry wt	*0.3*	<0.30
Methyl methanesulfonate	mg/kg dry wt	*1.0*	<1.0
Ethyl methanesulfonate	mg/kg dry wt	*1*	<1.0
Benzyl alcohol	mg/kg dry wt	*1*	<1.0
Phenol-d5 (Surrogate)	%	*1*	57

Semivolatile Organic Compounds - Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
2-Fluorophenol (Surrogate)	%	*1*	68
2-Fluorobiphenyl (Surrogate)	%	*1*	99
2,4,6-Tribromophenol (Surrogate)	%	*1*	48
p-Terphenyl-d14 (Surrogate)	%	*1*	100
Nitrobenzene-d5 (Surrogate)	%	*1*	80

Total Petroleum Hydrocarbons - Soil

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Analyte	Unit	*Reporting Limit*	23-05039-1
C7-C9	mg/kg dry wt	*10*	<10
C10-C14	mg/kg dry wt	*15*	<15
C15-C36	mg/kg dry wt	*25*	207
C7-C36 (Total)	mg/kg dry wt	*50*	207

Moisture Content

		Client Sample ID	N_Sed_Pond 0.1-0.2
		Date Sampled	20/02/2023
Analyte	Unit	*Reporting Limit*	23-05039-1
Moisture Content	%	*1*	36

Method Summary

Elements in Soil Samples dried and passed through a 2 mm sieve followed by acid digestion and analysis by ICP-MS. In accordance with in-house procedure based on US EPA method 200.8.

VOC in Soil Methanol extraction in accordance with US-EPA 5030A, analysis via GCMS with headspace sample introduction. (In-house procedure based on US EPA Method 5021).

SVOC in Soil Solvent extraction, followed by GC-MS analysis.(In-house based on US EPA 8270).

TPH in Soil Solvent extraction, silica cleanup, followed by GC-FID analysis. (C7-C36). (In accordance with in-house procedure based on US EPA 8015).

Moisture Moisture content is determined gravimetrically by drying at 103 °C.

Jarred Wilson, DipSci
Trace Elements Team Leader

Yuri Zubenko, Ph.D.
Senior Technologist

Prianshu Chawla, B.Tech
Technologist

Astra Southerwood,
Sample Preparation Team Leader

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Certificate of Analysis

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Attention: Hayden Erasmus
Phone: 0272699123
Email: hayden.erasmus@ghd.com

Sampling Site: Green Island

Lab Reference: 23-06742
Submitted by: Hayden Erasmus
Date Received: 07/03/2023
Testing Initiated: 7/03/2023
Date Completed: 10/03/2023
Order Number:
Reference: 12547621

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Elements in Water (Total Recoverable)

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
Arsenic	g/m^3	*0.0005*	0.0015
Boron	g/m^3	*0.005*	0.17
Cadmium	g/m^3	*0.00002*	0.000043
Chromium	g/m^3	*0.0002*	0.0014
Copper	g/m^3	*0.0002*	0.0065
Lead	g/m^3	*0.00005*	0.0025
Mercury	g/m^3	*0.0001*	<0.00010
Nickel	g/m^3	*0.0002*	0.0043
Zinc	g/m^3	*0.003*	0.014

Elements in Water (Soluble)

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
Arsenic	g/m^3	*0.0005*	0.00085
Boron	g/m^3	*0.01*	0.15
Cadmium	g/m^3	*0.00002*	<0.000020
Chromium	g/m^3	*0.0002*	0.00026
Copper	g/m^3	*0.0002*	0.0046
Lead	g/m^3	*0.00005*	0.000066
Mercury	g/m^3	*0.00008*	0.000092

Elements in Water (Soluble)

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Nickel	g/m^3	*0.0002*	0.0034
Zinc	g/m^3	*0.001*	0.0036

Inorganic Nutrients and Nutrient Species in Water

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
Ammonia as N	g/m^3	*0.005*	0.13

BTEX in Water

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
Benzene	g/m^3	*0.001*	<0.0010
Toluene	g/m^3	*0.001*	<0.0010
Ethylbenzene	g/m^3	*0.001*	<0.0010
m,p-Xylene	g/m^3	*0.001*	<0.0010
o-Xylene	g/m^3	*0.001*	<0.0010
Toluene-d8 (Surrogate)	%	*1*	97
p-Bromofluorobenzene (Surrogate)	%	*1*	100

Semivolatile Organic Compounds - Water

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
Phenol	g/m^3	*0.002*	<0.0020
2-Chlorophenol	g/m^3	*0.0003*	<0.00030
2-Methylphenol (o-Cresol)	g/m^3	*0.0003*	<0.00030
2-Nitrophenol	g/m^3	*0.0005*	<0.00050
2,4-Dimethylphenol	g/m^3	*0.0010*	<0.0010
2,4-Dichlorophenol	g/m^3	*0.0003*	<0.00030
2,6-Dichlorophenol	g/m^3	*0.0003*	<0.00030
4-Chloro-3-methylphenol	g/m^3	*0.0003*	<0.00030
2,4,5-Trichlorophenol	g/m^3	*0.0005*	<0.00050
2,4,6-Trichlorophenol	g/m^3	*0.0005*	<0.00050
2,3,4,6-Tetrachlorophenol	g/m^3	*0.0003*	<0.00030
4-Methylphenol	g/m^3	*0.0003*	<0.00030
4-Nitrophenol	g/m^3	*0.0010*	<0.0010
Naphthalene	g/m^3	*0.0003*	<0.00030
2-Methylnaphthalene	g/m^3	*0.0003*	<0.00030
2-Chloronaphthalene	g/m^3	*0.0003*	<0.00030
Acenaphthylene	g/m^3	*0.0003*	<0.00030
Acenaphthene	g/m^3	*0.0003*	<0.00030
Fluorene	g/m^3	*0.0003*	<0.00030

Semivolatile Organic Compounds - Water

Client Sample ID			N_Sed_Pond_SW
Date Sampled			06/03/2023
Phenanthrene	g/m^3	*0.0003*	<0.00030
Anthracene	g/m^3	*0.0003*	<0.00030
2-Phenylphenol	g/m^3	*0.005*	<0.0050
Fluoranthene	g/m^3	*0.0003*	<0.00030
Benzo[a]anthracene	g/m^3	*0.0003*	<0.00030
Chrysene	g/m^3	*0.0003*	<0.00030
Bis(2-ethylhexyl) adipate	g/m^3	*0.005*	<0.0050
Benzo[b and J]fluoranthene	g/m^3	*0.0005*	<0.00050
Benzo[k]fluoranthene	g/m^3	*0.0005*	<0.00050
Benzo[a]pyrene	g/m^3	*0.0003*	<0.00030
Indeno(1,2,3-c,d)pyrene	g/m^3	*0.0003*	<0.00030
Dibenzo[a,h]anthracene	g/m^3	*0.0003*	<0.00030
Benzo[g,h,i]perylene	g/m^3	*0.0003*	<0.00030
Pyrene	g/m^3	*0.0003*	<0.00030
Benzo[a]pyrene TEQ (LOR)	g/m^3	*0.0008*	0.00080
Benzo[a]pyrene TEQ (Zero)	g/m^3	*0.0003*	<0.00030
4,4'-DDD	g/m^3	*0.0005*	<0.00050
4,4'-DDE	g/m^3	*0.0003*	<0.00030
4,4'-DDT	g/m^3	*0.0010*	<0.0010
alpha-BHC	g/m^3	*0.0003*	<0.00030
beta-BHC	g/m^3	*0.0003*	<0.00030
gamma-BHC (Lindane)	g/m^3	*0.0003*	<0.00030
delta-BHC	g/m^3	*0.0003*	<0.00030
Aldrin	g/m^3	*0.0005*	<0.00050
cis-Chlordane	g/m^3	*0.0003*	<0.00030
trans-Chlordane	g/m^3	*0.0005*	<0.00050
Dieldrin	g/m^3	*0.0005*	<0.00050
Endosulfan I	g/m^3	*0.0010*	<0.0010
Endosulfan II	g/m^3	*0.0010*	<0.0010
Endosulfan sulfate	g/m^3	*0.0005*	<0.00050
Endrin	g/m^3	*0.0010*	<0.0010
Endrin aldehyde	g/m^3	*0.0003*	<0.00030
Endrin ketone	g/m^3	*0.0003*	<0.00030
Hexachlorobenzene	g/m^3	*0.0003*	<0.00030
Heptachlor	g/m^3	*0.0003*	<0.00030
Heptachlor epoxide	g/m^3	*0.0003*	<0.00030
Methoxychlor	g/m^3	*0.0003*	<0.00030
Bis(2-ethylhexyl) phthalate	g/m^3	*0.00625*	<0.0063
Butyl benzyl phthalate	g/m^3	*0.0010*	<0.0010
Di-n-butyl phthalate	g/m^3	*0.010*	<0.010
Di-n-octyl phthalate	g/m^3	*0.0005*	<0.00050
Diethyl phthalate	g/m^3	*0.0020*	<0.0020
Dimethyl phthalate	g/m^3	*0.0003*	<0.00030
N-Nitrosodiphenylamine	g/m^3	*0.0003*	<0.00030
N-Nitrosodi-n-propylamine	g/m^3	*0.0003*	<0.00030
2,4-Dinitrotoluene	g/m^3	*0.0010*	<0.0010
2,6-Dinitrotoluene	g/m^3	*0.0010*	<0.0010
Azobenzene	g/m^3	*0.0003*	<0.00030
Isophorone	g/m^3	*0.0003*	<0.00030
Nitrobenzene	g/m^3	*0.0003*	<0.00030

Semivolatile Organic Compounds - Water

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
4-Bromophenyl phenyl ether	g/m^3	*0.0003*	<0.00030
4-Chlorophenyl phenyl ether	g/m^3	*0.0003*	<0.00030
Bis(2-Chloroethyl) ether	g/m^3	*0.0003*	<0.00030
Bis(2-Chloro-1-methylethyl) ether	g/m^3	*0.0003*	<0.00030
Bis(2-Chloroethoxy) methane	g/m^3	*0.0003*	<0.00030
1,2-Dichlorobenzene	g/m^3	*0.0003*	<0.00030
1,3-Dichlorobenzene	g/m^3	*0.0003*	<0.00030
1,4-Dichlorobenzene	g/m^3	*0.0003*	<0.00030
Hexachlorobutadiene	g/m^3	*0.0003*	<0.00030
Hexachlorocylopenta diene	g/m^3	*0.0003*	<0.00030
Hexachloroethane	g/m^3	*0.0003*	<0.00030
4-Chloroaniline	g/m^3	*0.0005*	<0.00050
2-Nitroaniline	g/m^3	*0.0005*	<0.00050
3-Nitroaniline	g/m^3	*0.0003*	<0.00030
3,3'-Dichlorobenzidine	g/m^3	*0.0005*	<0.00050
Dibenzofuran	g/m^3	*0.0003*	<0.00030
Methyl methanesulfonate	g/m^3	*0.0003*	<0.00030
Ethyl methanesulfonate	g/m^3	*0.010*	<0.010
Benzyl alcohol	g/m^3	*0.0003*	<0.00030
Phenol-d5 (Surrogate)	%	*1*	69
2-Fluorophenol (Surrogate)	%	*1*	82
2-Fluorobiphenyl (Surrogate)	%	*1*	89
2,4,6-Tribromophenol (Surrogate)	%	*1*	160
p-Terphenyl-d14 (Surrogate)	%	*1*	150
Nitrobenzene-d5 (Surrogate)	%	*1*	99

Total Petroleum Hydrocarbons - Water

		Client Sample ID	N_Sed_Pond_SW
		Date Sampled	06/03/2023
Analyte	Unit	*Reporting Limit*	23-06742-1
C7-C9	g/m^3	*0.2*	<0.2
C10-C14	g/m^3	*0.2*	<0.2
C15-C36	g/m^3	*0.3*	<0.3
C7-C36 (Total)	g/m^3	*0.5*	<0.5

Method Summary

Recoverable Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following an acid digestion. In house procedure based on US EPA method 200.8.
Soluble Trace Elements	Samples were analysed as received by the laboratory using ICP-MS following a 0.45µm membrane filtration (except when field filtered). In house procedure based on US EPA 200.8.
Ammonia-N	Samples filtered and measured colourimetrically by flow injection analysis. (APHA 4500-NH_3 H - Modified - Online edition).

Method Summary

VOC in Water	GCMS analysis with headspace sample introduction (In accordance with US EPA Method 5021).
SVOC in Water	Dichloromethane extraction followed by GC-MS analysis. (In-house method based on US-EPA 8270).
TPH in Water	Solvent extraction, followed by GC-FID analysis (C7-C36). MFE Petroleum Industry Guidelines. (In accordance with in-house procedure based on US EPA 8015).

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Appendix F

Green Island Interpretative Isotope Report

Green Island Landfill

Interpretative Report Isotopes 2022 - 2023

Dunedin City Council

11 October 2023

→ **The Power of Commitment**

Project name	DCC Landfills 2023						
Document title	Green Island Landfill | Interpretative Report Isotopes 2022 - 2023						
Project number	12587765						
File name	12587765_Isotope_Interpretative_Report_2022-2023						
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S3	Draft A	Hayden Erasmus and Cecilia Gately	Cecilia Gately		Stephen Douglass		29 September 2023
S4	Rev 0	Cecilia Gately	Cecilia Gately	Cecilia Gately	Stephen Douglass	PP Cecilia Gately	11 October 2023

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The Power of Commitment

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1. Introduction

1.1 Purpose

This interpretative isotope report has been prepared by GHD Limited (GHD) in conjunction with the Green Island Landfill Annual Monitoring Report for the monitoring year 1st July 2022 – 30th June 2022[1] on behalf of Dunedin City Council (DCC).

The Otago Regional Council (ORC) has granted several resource consents to DCC to regulate, manage and monitor the various discharges from the Green Island Landfill (the Site). The collection of samples from leachate, groundwater, and surface water for isotopic analysis is required to comply with consent 3839A_v1; all relevant consent conditions are further detailed in Section 1.3.

1.2 Setting and Location

The 'Site' is a municipal sanitary landfill facility situated to the west of Brighton Road, approximately 8 km southwest of central Dunedin. Waste Management Ltd. currently manages this facility on behalf of DCC.

The landfill was established in 1954 in a wetland area in the Kaikorai Estuary with the Kaikorai Stream forming the northern and western limits of the landfill. In 1981, the Site came under the management of DCC. At the time, there was no leachate or landfill gas collection system in place.

The area receives an average annual rainfall of between 515 mm and 926 mm (Statistics New Zealand, 2000-2019 dataset), with 871.8 mm recorded over the 1 July 2022 to 30 June 2023 period.

As Figure 1 shows, the geological map of the area indicates that the Site is situated in marine alluvial material with varying proportions of silt, sand and gravel which is underlain by sandstone, siltstone and claystone of the Abbotsford Formation (ab) that may provide sandstone, siltstone and claystone and dependent on the weathering of the deposit, potential clay layers[2].

Figure 1 Geology of the Green Island landfill area (Bishop and Turnbull, 1996).

[1] GHD (2022) Green Island Landfill – Annual monitoring report 2022 – 2023. Dated 10 October 2023. Project reference 12587765
[2] BISHOP, D. G. & TURNBULL, I. M. 1996. Geology of the Dunedin Area. Lower Hutt, NZ: GNS.

1.3 Monitoring requirements

ORC issued resource consent 3839A_V1 to DCC in March 1994 and renewed it in July 2007. This consent provides conditions “to discharge landfill and composting leachate to land in a manner that may enter water”. Certain consent conditions require that samples be collected and analysis to be undertaken on those samples for the isotopes specified. This consent expires on 1st October 2023.

1.3.1 Leachate

In accordance with condition 9 (A) (b) of the consent, a sample of the combined leachate / groundwater was collected on a quarterly basis over the monitoring year from one of the leachate collection pump stations. Historically, a sample of groundwater/leachate was collected from all of the accessible leachate pump stations and combined to provide a representative sample of the leachate. However, due to health and safety concerns, a combined collection tap was fitted to pump station 3 (PS3) in October 2017 and the leachate sample has been collected from there since that time.

To determine isotopic enrichment / depletion, condition 9 (A) (b) of consent 3839A_V1 requires that the following isotopic analysis be undertaken on the samples collected from PS3 (combined leachate / groundwater):

- Oxygen-18 in water from leachate (δ18O-H2O), relative to Vienna standard mean ocean water.
- Hydrogen-2 in water from leachate (δD- H2O), relative to Vienna standard mean ocean water.
- Carbon-13 in dissolved inorganic carbon from leachate (δ13C- DIC), relative to Vienna Pee Dee Belemite.
- Nitrogen-15 in ammonium from leachate (δ15N-NH4+), relative to atmospheric nitrogen.

1.3.2 Groundwater and surface water

In accordance with consent condition 9 (B) (d), a groundwater sample is to be collected from the deep monitoring wells (MW2D, MW4D and MW9D) on a quarterly basis for isotopic analysis. However, monitoring well MW9D was lost during landfilling activities in 2015 and MW7D has been monitored in its place since.

An assessment was undertaken by GHD to understand the risks involved in installing a replacement monitoring well within the waste mass. The risk posed both to the health and safety of drilling staff from landfill gasses and exposure to waste and also to the environment should the well become damaged or shear off due to movement within the waste mass providing a preferential flow pathway to the underlying aquifer, was considered too high. It was recommended to DCC that the well not be replaced.

In addition, in accordance with consent condition 10 (c), four surface water samples were collected from the Kaikorai Stream and its tributary, Abbots Creek, at monitoring locations GI1, GI2, GI3 and GI5 (as identified in Figure 2), on a quarterly basis for isotopic analysis.

In addition to those isotopes listed above in Section 1.3.1, consent condition 9 (B) (d) requires that the deep groundwater wells and surface water samples also be analysed for:

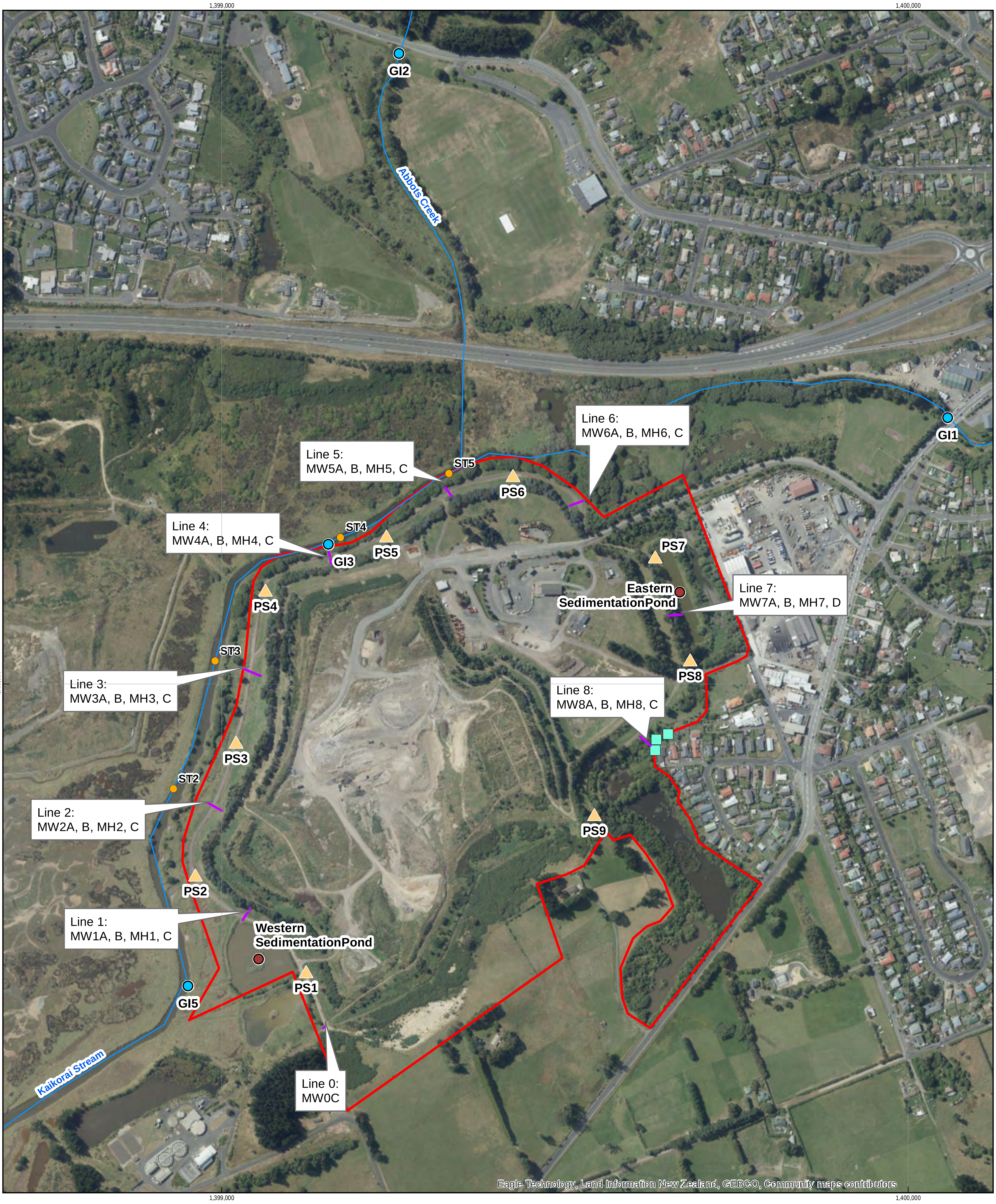
- Nitrogen-15 in nitrate from leachate (δ15N-NO3-), relative to atmospheric nitrogen.

1.3.3 Sampling frequency and analysis summary

The consent required isotope monitoring and analysis regime is summarised in Table 1.

Table 1 Isotope Sampling Frequency

Sample Type	Sample Location	Analytes	Frequency
Surface Water	GI1, GI2, GI3, GI5	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+, ^{15}N-NO_3^-	Quarterly
Groundwater	MW2D, MW4D, MW9D (MW7D monitored in its place)	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+, ^{15}N-NO_3^-	Quarterly
Leachate	PS3 (Representative location)	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+	Quarterly



Legend

	Site Boundary		Pump Station		Sedimentation Pond		River
	Staff Gauge		Surface Water		Landfill Gas Monitoring Well Locations		Monitoring Array

Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Dunedin City Council
Green Island Landfill 2023

Green Island Landfill
Monitoring Locations

Job Number 12587765
Revision A
Date 07 Jun 2023

Figure 2

G:\51\12587765\GIS\Maps\Deliverables\Green Island\12587765_GI_Figure3_samplingLocation.mxd

Level 3 138 Victoria Street Christchurch 8141 New Zealand **T** 64 3 378 0900 **F** 64 3 377 8575 **E** chcmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro; Imagery as at April 2019, DCC; GHD_DCC_Urban_Imagery_2013, Data (SIte_Boundary_GHD_20230531, GILF_Stream_GHD_20180818, GILF_Location_from_esdat_GHD_20180818, GILF_Location, GILF_location_monitoringArray_Polyline, Landfill_Gas_Monitoring_Locations). Created by:herasmus

Historically, only analysis of ^{18}O, ^{2}H and ^{13}C were undertaken. However, in November 2018 it was agreed with GHD and DCC that analysis for ^{15}N would also be undertaken. An assessment was undertaken by GHD of all the available isotopic data in 2021[3] and it was recommended that analysis of $^{15}N\text{-}NO_3$ no longer be undertaken as it does not provide useful scientific information. It was further recommended that analysis of the ^{15}N species, $^{15}N\text{-}NH_4^+$, be continued as it provides a better indication of the presence or absence of leachate in the environment. As such, monitoring (sampling locations and frequency) was undertaken as required by the consent, but the analysis suite was reduced with analysis of the $^{15}N\text{-}NO_3$ isotope not being undertaken over 2022 / 2023 monitoring year.

Further details of other recommendations for changes to the monitoring suite and frequency are provided in the GHD isotopes analysis assessment report.

1.4 Background

A study was undertaken by J. North between August 2000 and May 2001 as part of an MSc. thesis[4] to determine whether stable isotope analysis could be used as indicators of landfill leachate and its impact on environmental receptors at the Green Island Landfill in Dunedin.

During this study water and leachate samples were collected and analysed for ^{13}C and ^{15}N of their nitrate and ammonium components. Results are expressed as a ratio of the heavier to lighter isotope in a sample compared with that same ratio in a suitable standard. This is referred to as a δ (delta) value and uses units of per mil (‰).

The study indicated that there was a general trend of enriched $\delta^{15}N\text{-}NH_4^+$ and depleted $\delta^{15}N\text{-}NO_3^-$ for landfill leachate, and depleted $\delta^{15}N\text{-}NH_4^+$ and enriched $\delta^{15}N\text{-}NO_3^-$ for the stream sites. Downstream monitoring locations appeared to have $\delta^{15}N$ characteristics approaching those of leachate, with higher $\delta^{15}N\text{-}NH_4^+$ and lower $\delta^{15}N\text{-}NO_3^-$ values than upstream sites. Typical values for the various sites are presented in the table below.

Table 2 Isotopic values for the different monitoring sites over the 2000-2001 period

Site	Average $\delta^{15}N\text{-}NO_3^-$ (‰)	Average $\delta^{15}N\text{-}NH_4^+$ (‰)	Average $\delta^{13}C\text{-}CO_2$ (‰)
Upstream	2.14 ± 3.44	-2.71 ± 2.93	-15.09 ± 0.02
Downstream	-4.87 ± 2.42	7.63 ± 3.18	20.18 ± 0.14
Leachate (from monitoring wells)	-4.54 ± 2.05	18.68 ± 8.88	16.11 ± 0.23

The study concluded that there was the potential for stable isotopes to be used as environmental monitoring tool at the Site. A distinct isotopic signature for the leachate from the Site was determined using $\delta\ ^{13}C\text{-}CO_2$ and $^{15}N\text{-}NH_4^+$ values. In combination with conventional monitored chemical parameters such as ammonium concentrations, isotopic ratios of ^{13}C and ^{15}N enabled the positive identification of leachate in the Kaikorai Estuary. The source of leachate was not certain as either (or both) of the two landfills (Green Island Landfill and the Fairfield) that are located on the banks of the Kaikorai Stream, are likely to be contributing to the contamination.

1.5 Statement of limitations

This report: has been prepared by GHD for Dunedin City Council and may only be used and relied on by Dunedin City Council for the purpose agreed between GHD and Dunedin City Council as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Dunedin City Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

[3] GHD (2021) DCC Green Island Landfill: Altered Monitoring Suite – Isotopes. Letter report. Final_Rev2. Project reference 125092010. Dated 20 January 2021.
[4] North, J. C. (2002) Landfill leachate monitoring: Applications of stable isotopes. University of Otago.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Dunedin City Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.6 Assumptions

It is assumed that the data and information provided to GHD by Dunedin City Council, subconsultants, subcontractors and government agencies is true and correct.

2. Methodology

2.1 General sampling program

Between July 2022 and June 2023, samples of surface water, groundwater and groundwater / leachate were collected from all locations on the dates shown in Table 2.

Table 3 Isotope sampling and analysis regime for the Green Island Landfill July 2022 – April 2023

Sampling Date	Isotope Analysis Undertaken	Monitoring location
13, 15 & 25 July 2022	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3
11 & 12 October 2022	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3
17 & 18 January 2023	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3
11, 12 & 13 April 2023	^{2}H, ^{18}O, ^{13}C, ^{15}N-NH_4^+	GI1, GI2, GI3, GI5, MW2D, MW4D, MW7D, PS3

2.2 Sampling methodology

All samples were collected using standard GHD groundwater and surface water sampling procedures and techniques, from the established monitoring sites at the Green Island Landfill.

Surface water samples were collected from the four (4) stream sites (GI1, GI2, GI3 and GI5) using a laboratory supplied unpreserved laboratory container which was held below the surface of the water with a 'mighty gripper' pole extended to its maximum extent. The sample collected in the container was then decanted into individual bottles supplied by the laboratory at each location along with the laboratory supplied preservative.

The groundwater monitoring wells (MW2D, MW4D, MW7D) were purged and sampled using a battery-operated low-flow peristaltic pump. The samples were collected once water quality parameters had stabilised as indicated by the inline flow cell connected to a YSI water quality meter. The water sample was placed directly into the laboratory supplied sample container along with the required amount of preservative.

In addition, the combined leachate / groundwater sample was collected from a dedicated tap at pump station PS3. The fluid discharging from the tap was placed directly into the laboratory supplied bottle along with the required amount of preservative.

Samples were placed into a laboratory supplied chilly bin with ice and delivered by courier under GHD standard chain of custody procedures to the Geological and Nuclear Science (GNS) National Isotope Centre laboratory in Lower Hutt for analysis.

Laboratory reports and analysis methodologies are included in Attachment 1 at the rear of this report.

2.3 Rainfall data

There is a weather station located at the Green Island Kaikorai Estuary where it was recorded that 871 mm of precipitation (rain) fell over the July 2022 to June 2023 period. The rainfall data is presented in Figure 3.

As can be see from the graph, there were several significant rainfall events over the monitoring year. The sampling in July 2022 was undertaken during a period when over 118 mm of rain fell over a few days.

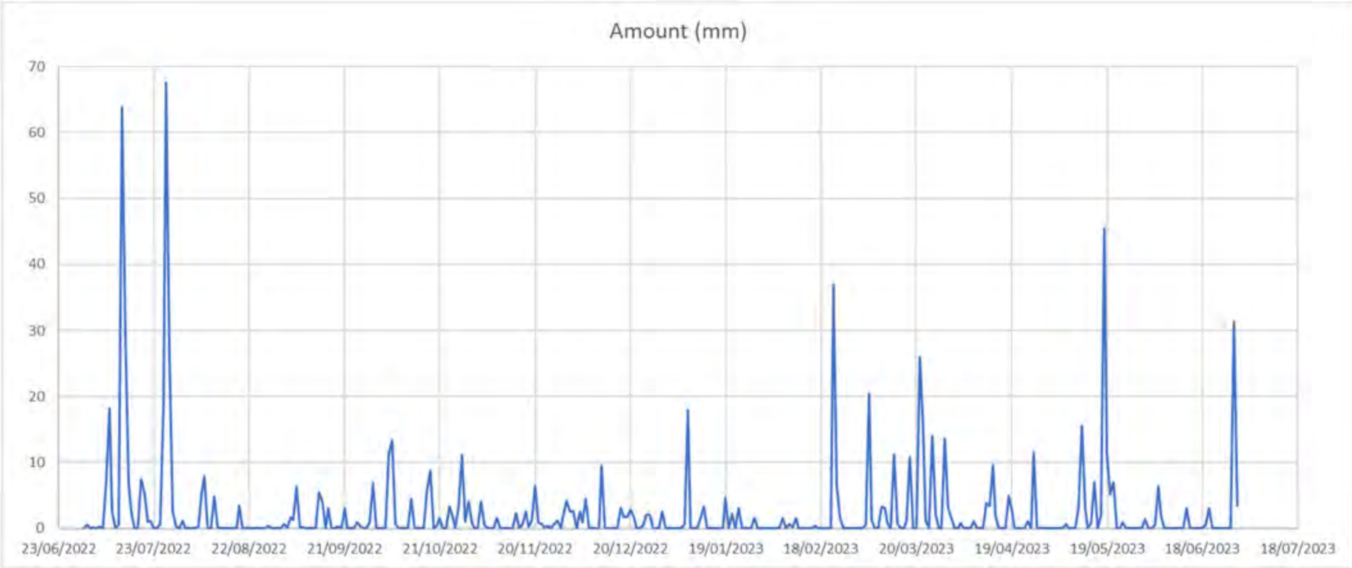


Figure 3 ***Rainfall recorded at the Green Island Kaikorai Estuary weather station over July 2022 to June 2023.***

3. Results

A detailed description of the terminology and theory behind the measurement of isotopes can be found in the 2016 report issued by the University of Otago (Van Hale and Frew, 2016)[5].

3.1 Time series – all sites

The analytical results, from 2008 to 2023 for the majority of the isotopes, for the various isotopes are presented on time series graphs in Figure 3 through to Figure 7. The results for leachate samples collected at pump stations PS3 and PS4 were combined as they were both representative of the leachate/groundwater within the interception trench.

3.1.1 Nitrate (^{15}N-NO_3) dataset

The ^{15}N-NO_3 isotope has not been analysed for in several years as it is no longer a part of the adopted analysis regime; it has been included for background information and context alone. The ^{15}N-NO_3 data points are presented on the time series graph Figure 4.

As can be seen from the graph, the surface water data (GI1 through to GI5) plot together and follow a similar pattern, indicating that leachate is not affecting the isotopic signature at the downstream locations.

The data for groundwater locations MW7D and MW4D also have a similar pattern, with the exception of October 2019 where a laboratory note for the result for monitoring location MW4D stated that there were very large errors due to its low concentration. The data also indicates that the results of analysis for the leachate monitoring location was relatively stable until October 2019, where a decrease in concentration was observed.

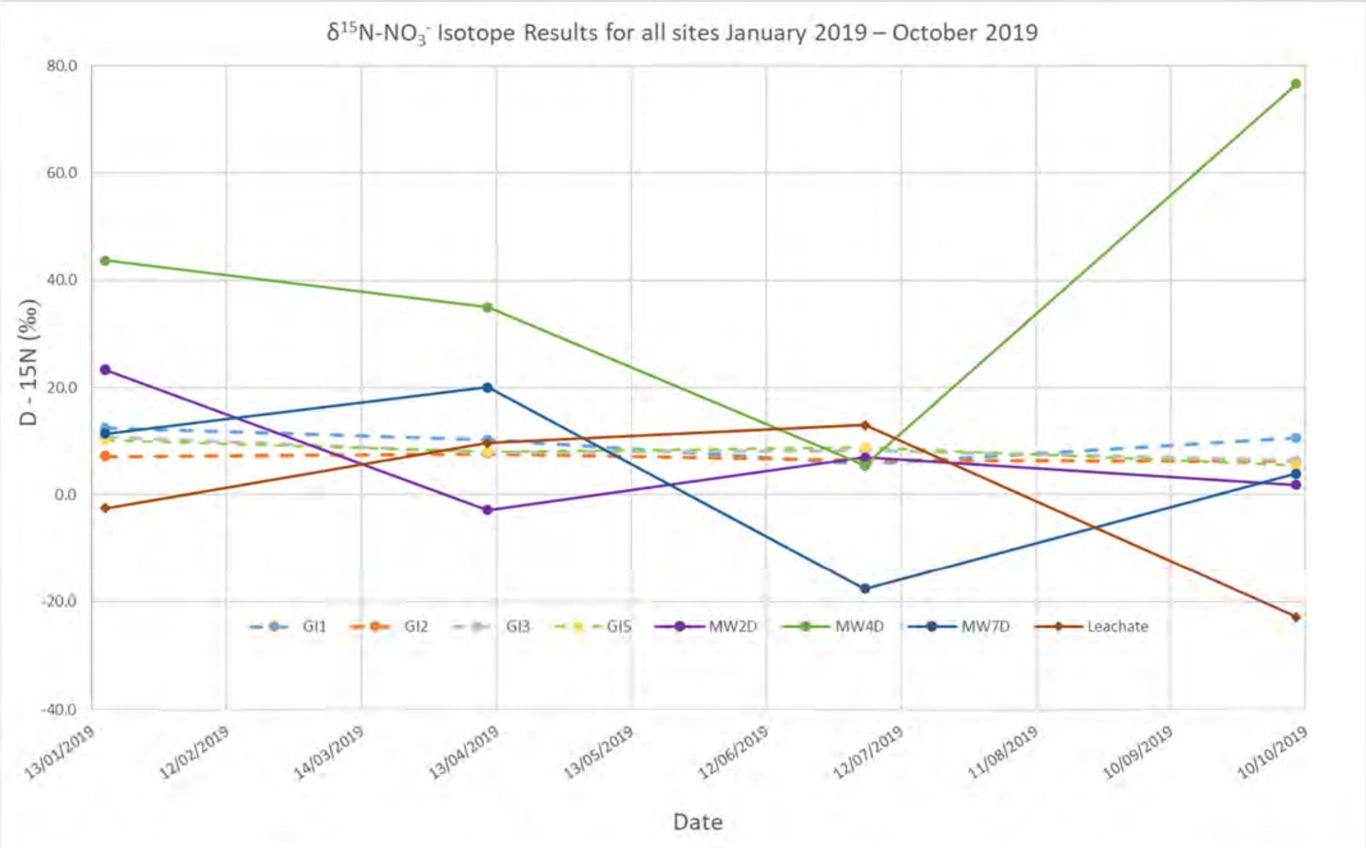


Figure 4 $\delta^{15}N$-NO_3^- Isotope Results for all sites January 2019 – October 2019

[5] Van Hale, R. & Frew, R. 2016. Report of Results and Interpretations: Isotopic Monitoring at Green Island Landfill – March 2015 to June 2016. Dunedin, NZ: Department of Chemistry - University of Otago.

3.1.2 Ammonium ($^{15}N\text{-}NH_4$+) Dataset

Figure 5 presents the available data for the nitrogen-15 ammonium isotope ($^{15}N\text{-}NH_4^+$). Analysis for this isotope was resumed in October 2019. Although there are only three and a half years of data available, there are some observable points of interest in the current dataset, as described below.

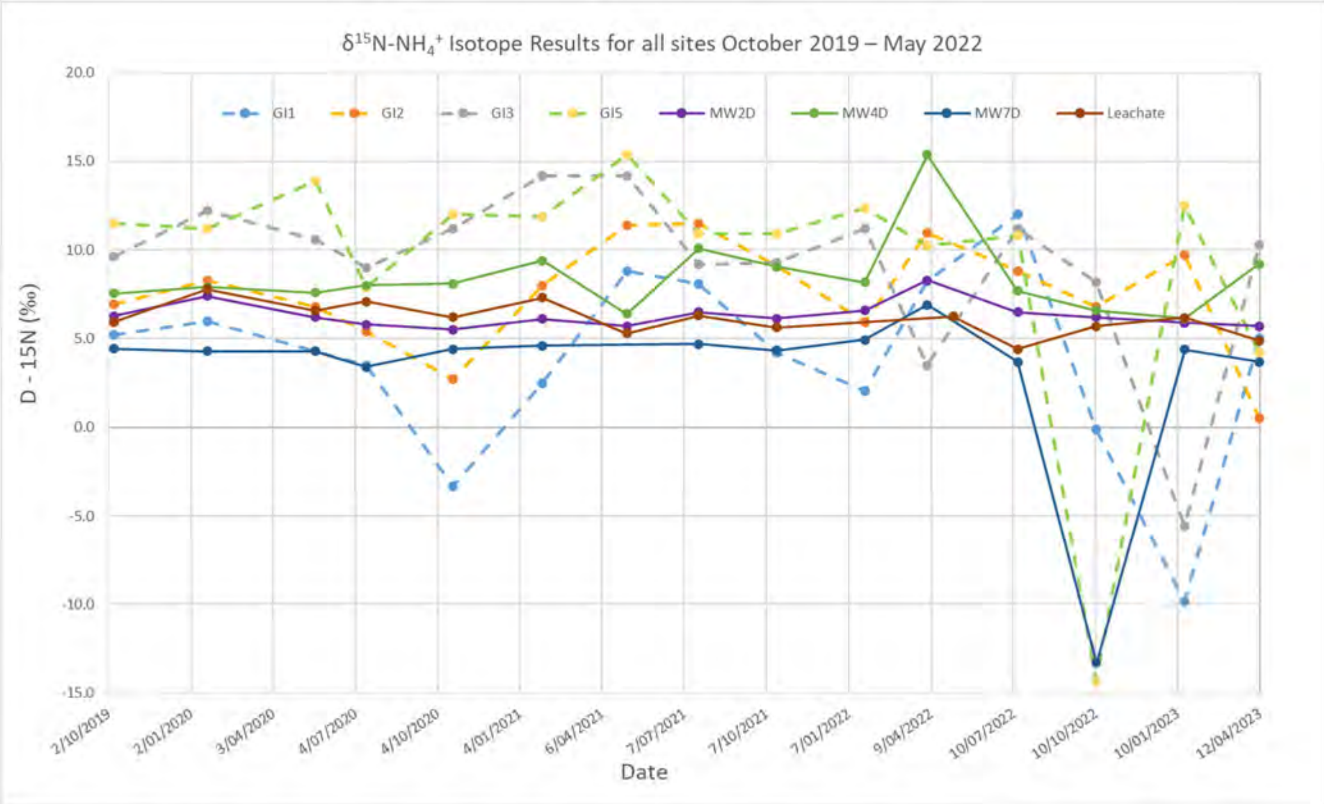


Figure 5 ***$\delta^{15}N\text{-}NH_4^+$ Isotope Results for all sites October 2019 – April 2023***

Between October 2019 and April 2022, similar trends can be noted in $^{15}N\text{-}NH_4^+$ concentrations at surface water sample locations GI1 and GI2. Between April 2022 and April 2023, a significant decrease in concentration at sample location GI1 was noted, with a trough (value below the historical minimum) in January 2023 before increasing in April 2023. GI2 remains relatively consistent over the monitoring period with a notable decrease in concentration in April 2023.

Reported concentrations at sample locations GI3 and GI5 have remained relatively consistent between October 2019 and January 2022. Since January 2022, reported concentrations of $^{15}N\text{-}NH_4^+$ at GI3 have fluctuated with troughs occurring in Apil 2022 and January 2023 (minimum concentration to date) and peaks in July 2022 and April 2023. Relatively stable concentrations at sample location GI5 have been reported until October 2022 where a significant decrease in $^{15}N\text{-}NH_4^+$ was observed before increasing again during the January 2023 event. A decrease in concentration is again observed during the April 2023 sampling event, however, remains within the historical range. It is noted that the sample collected at surface water location GI5 in October 2022 contained a $^{15}N\text{-}NH_4^+$ isotope at a concentration 'too low to detect'. Re-analysis was undertaken on this sample and a concentration of -14.3%₀ was reported.

Between October 2019 and July 2022, the majority of the analytical data for the surface water sampling locations has plotted on the positive side of the graph. However, in October 2022 and January 2023, results plotted on the negative (deficit) side of the graph, with all values decreasing in October 2022 and then in January 2023 values increased at GI2 and GI5 but decreased further at GI1 and GI3. This pattern then reversed in April 2023.

Between October 2019 to July 2022, the isotope concentrations at groundwater monitoring wells (MW2D – MW7D) had been relatively stable and consistent in trends, with an increase in all three samples noted in April 2022, most prominently in MW4D. Between July 2022 and January 2023, results for sampling locations MW2D and MW4D have remained relatively consistent. An increase in concentration was noted at MW4D in April 2023.

From April 2022, MW7D decreased to the minimum concentration reported to date during the October 2022 monitoring event before increasing to what has historically been observed in January 2023. A slight decrease in concentration was reported at MW7D in April 2023, however, the data point remains within the historical ranges. It is also noted that the reported concentration of MW7D in October 2022 was revised from the original concentration of -17.8‰ to -13.3 ‰ following re-analysis of the sample and the averaging of three results.

The analytical results for the samples collected representing combined groundwater / leachate have been relatively stable from October 2019 to April 202, with a slight overall decrease in concentrations apparent, from 5.9 to 4.9. The reported concentrations of $^{15}N\text{-}NH_4^+$ in the groundwater / leachate samples generally plot towards the centre of the groundwater data, indicating a similar $^{15}N\text{-}NH_4^+$ isotopic signature to the groundwater at the Site.

3.1.3 Deuterium (^{2}H) and Oxygen (^{18}O) Datasets

The ^{18}O oxygen and ^{2}H deuterium charts (Figure 6 and Figure 7 respectively) show a clear separation between where the surface water data and the groundwater data for MW2D and MW4D plot, in particular on the ^{2}H chart. The majority of the data for the groundwater monitoring locations MW2D and MW4D plot above the surface water data (less deficit) on both charts.

Both ^{2}H and ^{18}O charts show similar trend lines. In particular, the data collected for groundwater monitoring locations MW2D, MW4D has been relatively stable since monitoring begun in 2008. Considerable peaks and troughs in isotope concentrations can be noted in the samples collected from groundwater monitoring well MW7D especially within the first years of monitoring (July 2017 to July 2019). Most notably, was the October 2017 and January 2018 monitoring rounds where a considerable drop in concentrations can be seen in monitoring well MW7D.

Reported ^{2}H and ^{18}O concentrations at all surface water and the leachate monitoring locations were reported having a significant decrease (deficit) in July 2022. This is most likely due to the significant weather event when over 118 mm of rain fell between 13th and 25th of July. The sampling was undertaken during this period. Values increased to within the historical range in October 2022. Increases in concentrations are noted in monitoring locations GI2 and GI3 during the April 2023 monitoring event with the data reported at GI3 being a new maximum value.

On the ^{2}H isotope chart, the leachate data plots closer to the groundwater data whereas on the ^{18}O chart, the leachate data plots closer to the surface water data. The relevancy of the ^{2}H and ^{18}O charts is further discussed in section **Error! Reference source not found.**.

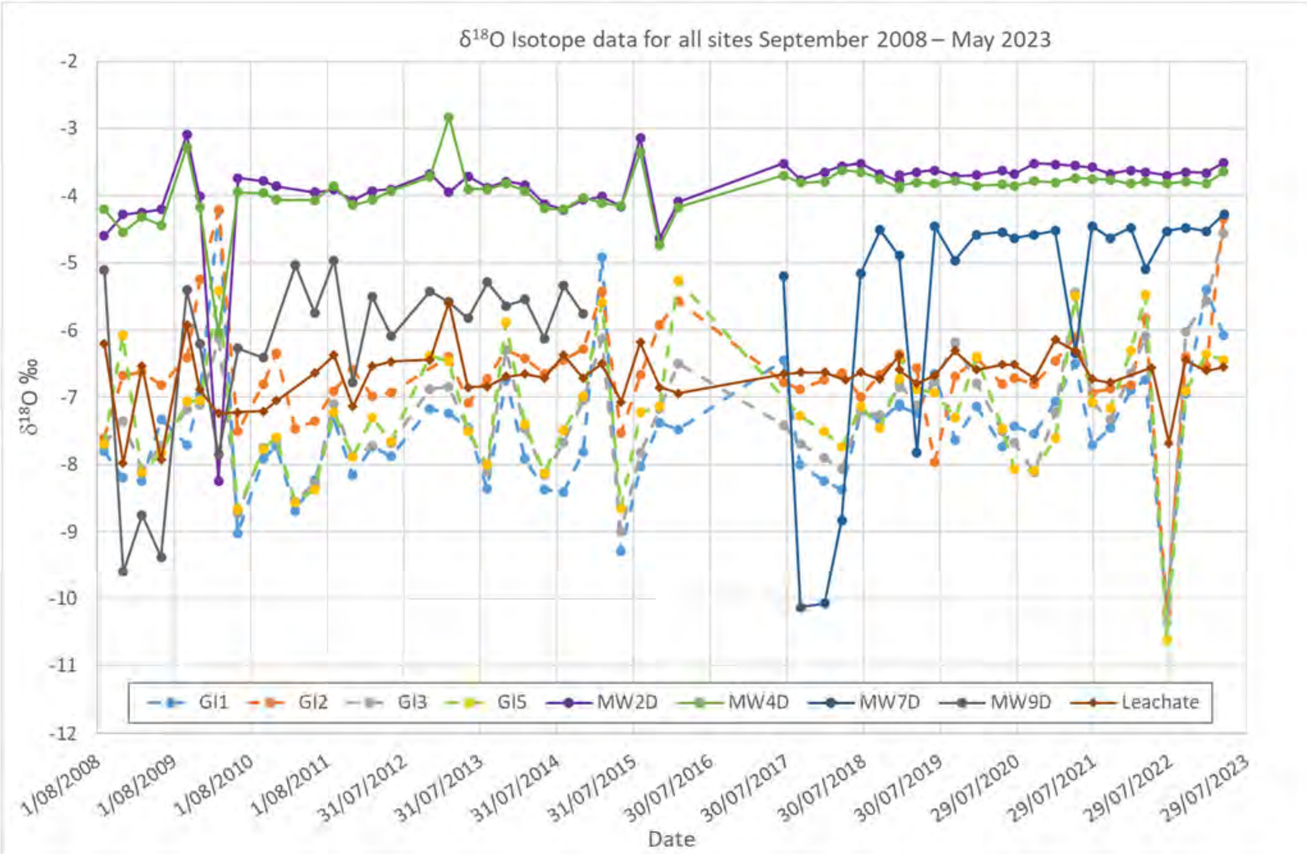


Figure 6 ***δ[18]O Isotope data for all sites September 2008 – April 2023***

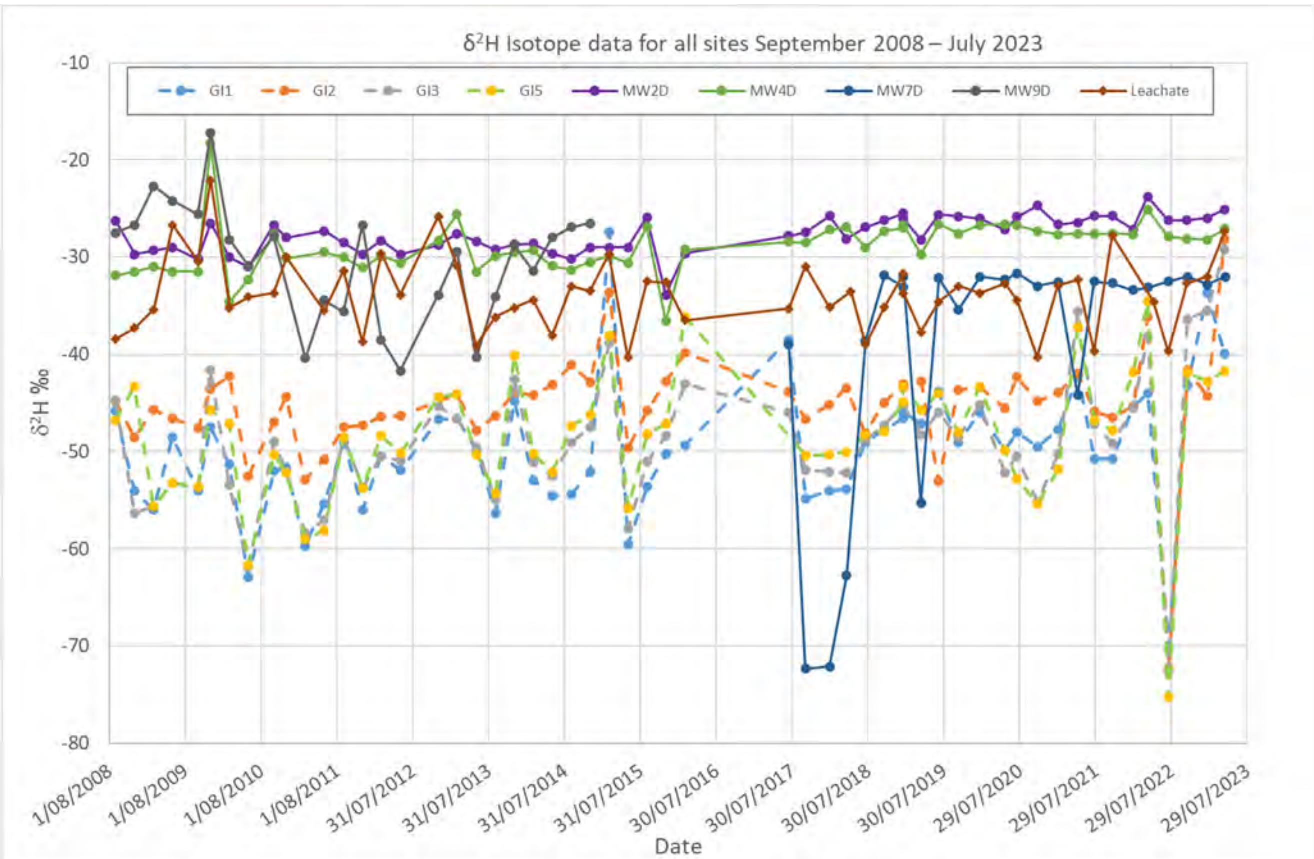


Figure 7 ***δ[2]H Isotope data for all sites September 2008 – April 2023***

3.1.4 Carbon (^{13}C) Dataset

Typically stream water CO_2 can range in $\delta^{13}C$ values from -5 to -25‰ whereas for leachate this can be up to +20‰.

The ^{13}C data for the groundwater and surface water are more similar and plot together (Figure 8) generally between -10‰ and -30‰.

The leachate and deep groundwater sample results from MW9D, from 2008 to 2015 (when it was lost), plot together on this graph above the rest of the data, generally within the 0 ‰ to +20 ‰ range. The enriched ^{13}C data for leachate is a by-product of methane-producing bacteria which use the lighter ^{12}C to form CH_4[6].

Since monitoring began, ^{13}C concentrations have been relatively stable with no one sampling location deviating greatly. A slight net increase in ^{13}C concentrations can be observed in the surface water and monitoring wells MW4D and MW7D data sets.

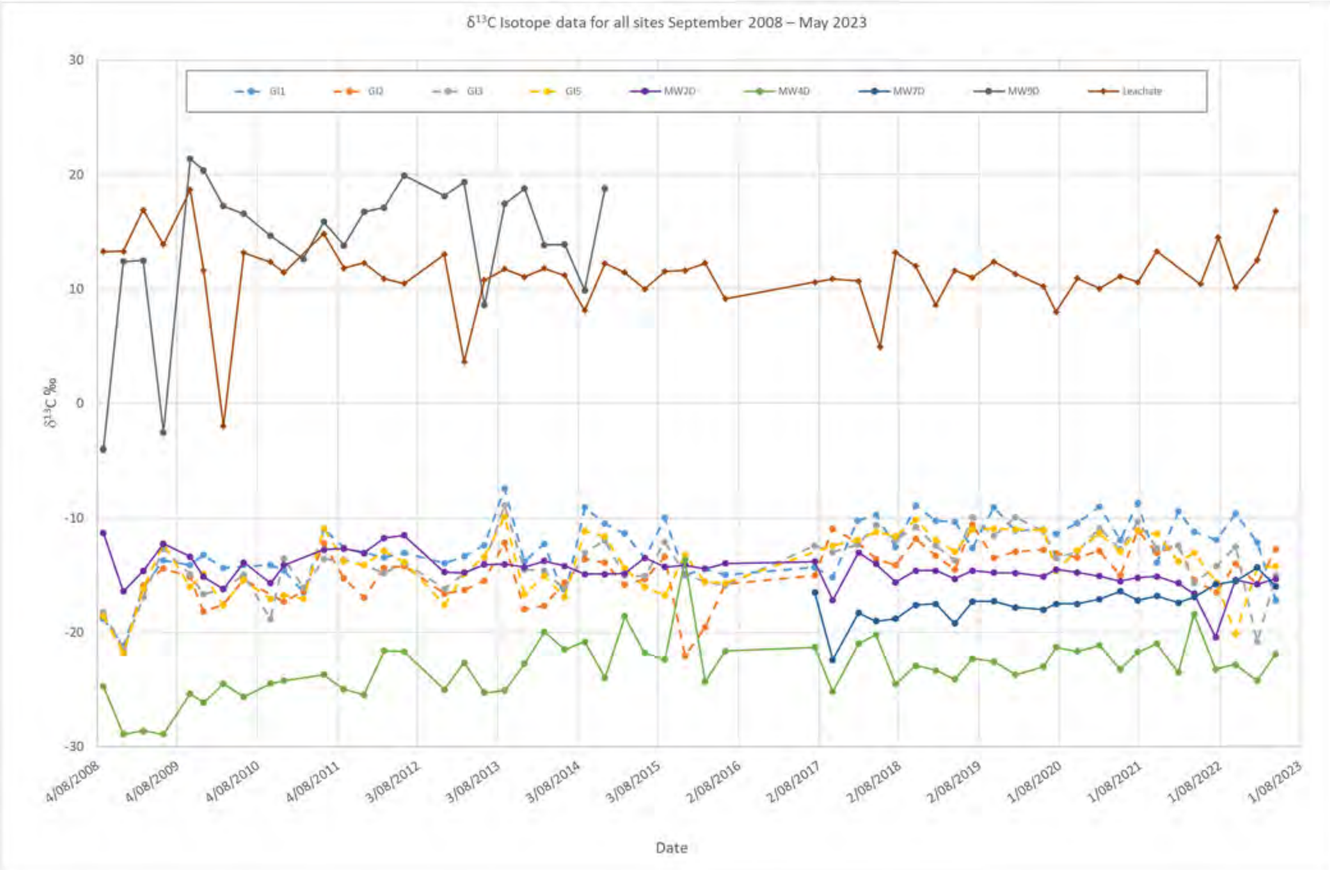


Figure 8 *$\delta^{13}C$ Isotope data for all sites September 2008 – April 2023*

3.2 Meteoric Water Line – All Sites

3.2.1 Global Meteoric Water Line

The Global Meteoric Water Line (MWL) describes the global annual average relationship between hydrogen and oxygen isotope (^{2}H and ^{18}O) ratios in natural meteoric waters (water derived from precipitation). When working on the global annual average isotopic composition of ^{2}H and ^{18}O in meteoric water in 1961, the geochemist Harmon Craig observed a correlation between these two isotopes. Most precipitations and groundwaters fall closely on this line. In cases where the measurements are shifted from this line, the type of shifting provides information regarding the process leading to the observed shift i.e., leachate leaching.

[6] Hackley, K., C. Liu, et al. (1996). "Environmental Isotope Characteristics of Landfill Leachates and Gases." Ground Water 34(5): 827-836.

A plot of the ratio of the ^{2}H and ^{18}O isotope values for each data point indicates that a majority of the surface water data is within ± 5% of the Global Meteoric Water Line (MWL) (Figure 9). The majority of the leachate and groundwater data fall outside of the ± 5% of the MWL but on opposite sides of the MWL.

It should be noted that the data for the surface water sampling location GI5 (most downstream location) does not appear to be influenced by the Green Island Landfill leachate, as it does not plot above the MWL and the data falls either within ±5% of the MWL or below the MWL, similar to the groundwater data.

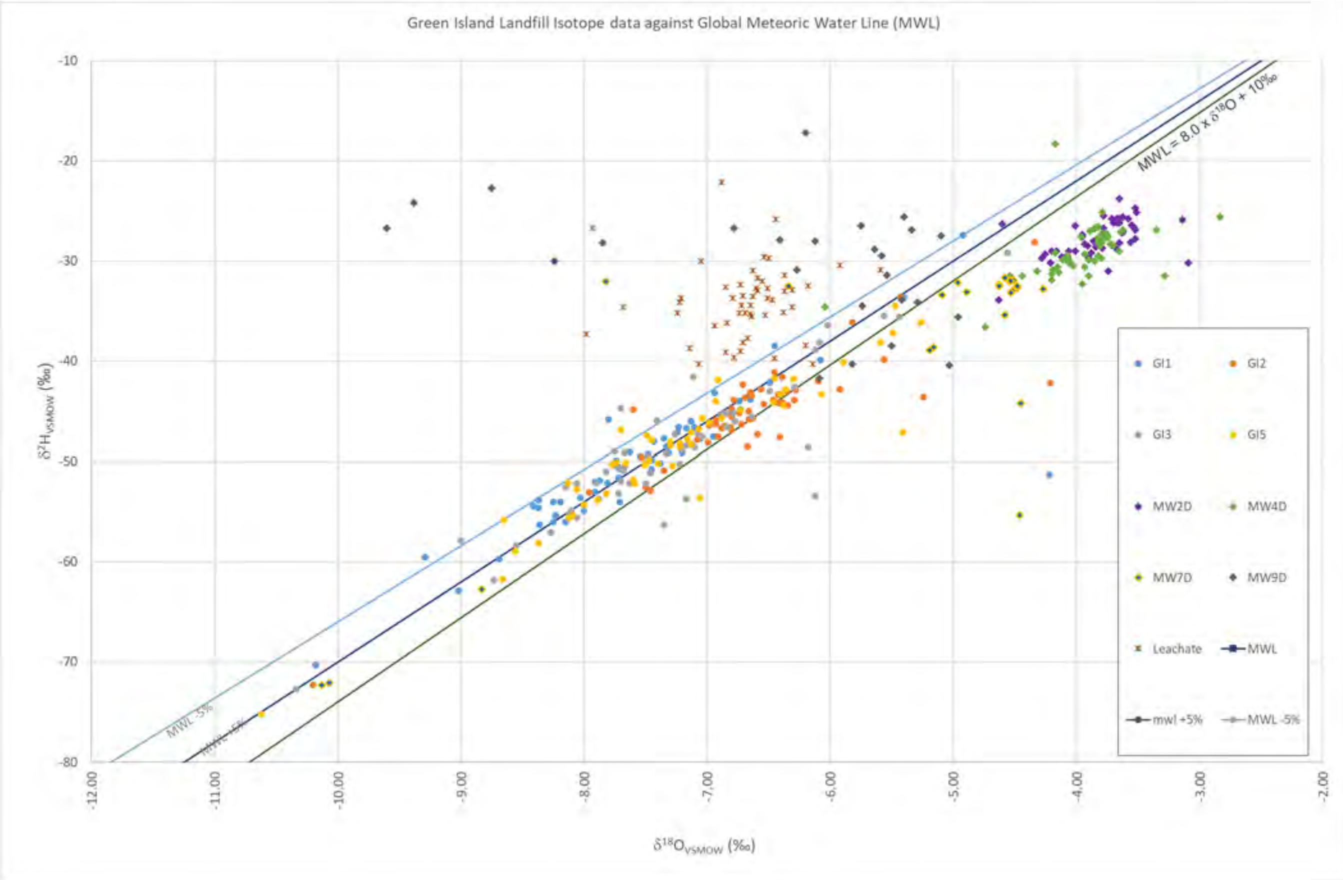


Figure 9 *Green Island Landfill Isotope data against Global Meteoric Water Line (MWL)*

3.2.2 Dunedin Meteoric Water Line

In comparison, North and Frew (2007)[7] interrogated the Green Island Landfill samples and estimated a specific MWL for Dunedin. Figure 10 presents the 2008 - 2022 results plotted against this localised 'Dunedin MWL'.

The following can be noted:

- The majority of the data points for monitoring wells MW2D and MW4D plot closely together within the MWL ±5% lines or below the +5% MWL.
- The majority of the surface water data plots with in MWL ±5% lines.
- The majority of the leachate data points sit as a cluster above the Dunedin MWL -5% line, with the exception of one data point which plots within the -5% MWL and the Dunedin MWL lines.
- The data points for MW9D show a dispersed layout sitting above the local Dunedin MWL -5% line.
- The majority of the MW2D – MW7D data sits below the MWL -5% line. Some outliers can be observed above the MWL -5%.

[7] NORTH, J. C. & FREW, R. D. 2007. Isotopic Characterisation of Leachate from Seven New Zealand Landfills. In: LEHMANN, E. C. (ed.) Landfill Research Focus. New York: Nova Science.

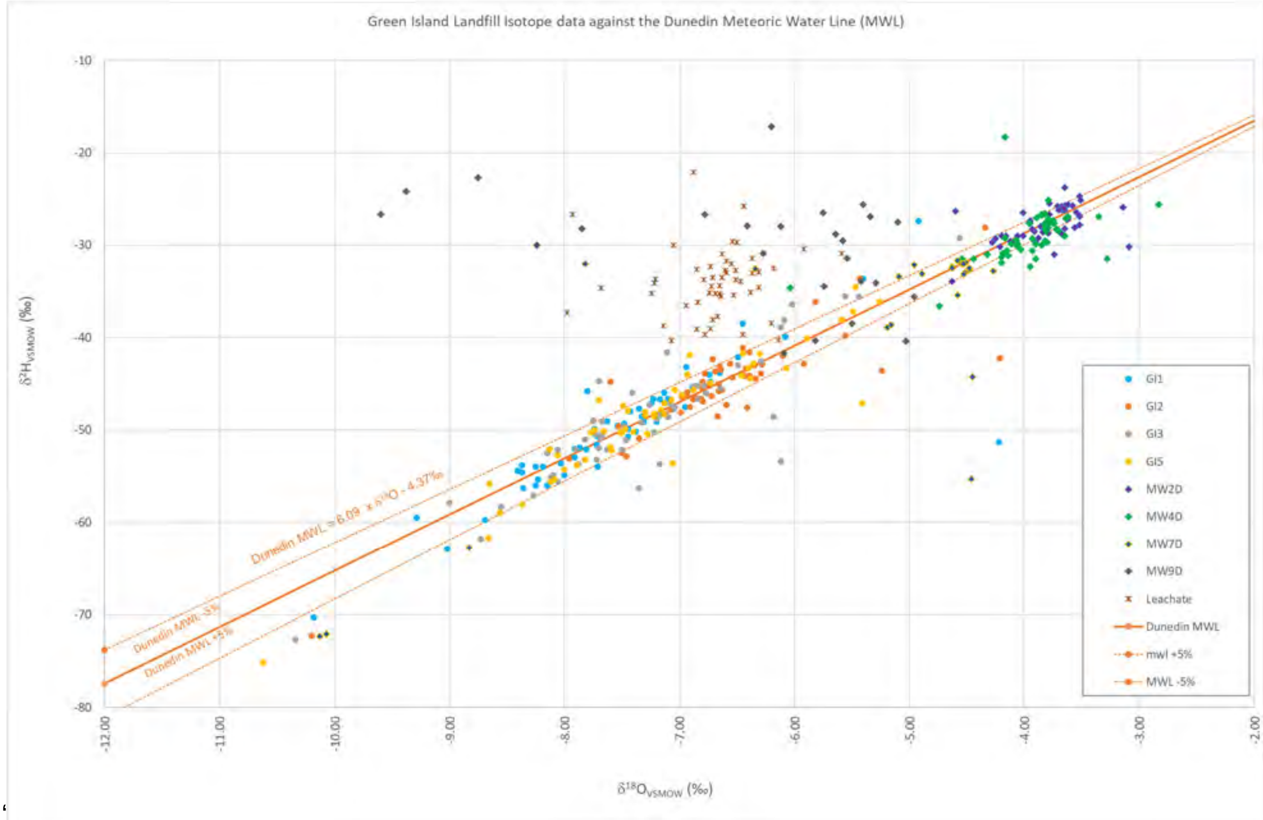


Figure 10 *Green Island Landfill Isotope data against the Dunedin Meteoric Water Line (MWL)*

4. Discussion

4.1 Summary of Results

The ^{2}H deuterium (Figure 7) and ^{13}C data (Figure 8) indicates that the leachate isotopic data has a different signature than that of the groundwater and surface water monitoring locations. In addition, leachate from the Green Island Landfill does not appear to be influencing the surface water quality downstream of the landfill.

However, the data available does indicate that the system is behaving consistently. This is evident by:

– The majority of the surface water and groundwater data points plot within the ±5% ranges of the Dunedin MWL.

– The majority of the surface water data points plot within the ±5% ranges of the Global MWL and the majority of the groundwater data for MW2D and MW4D cluster together and on the other side of the MWL than the leachate data points.

– The leachate and MW9D data points plot above both the Global MWL and the Dunedin MWL

It would appear that the leachate signature at the downstream surface water monitoring locations has changed since the study undertaken by North in 2000-2001, and the influence of leachate is not as significant as it has been.

North and Frew (2007) presented trends that deviate from the MWL due to various biogeochemical and physical processes as shown in Figure 11. Based on the data presented, it is inferred that the isotopic results from the samples collected from pump stations PS3 and PS4 (combined leachate/groundwater) indicate a mature stage of leachate methanogenesis.

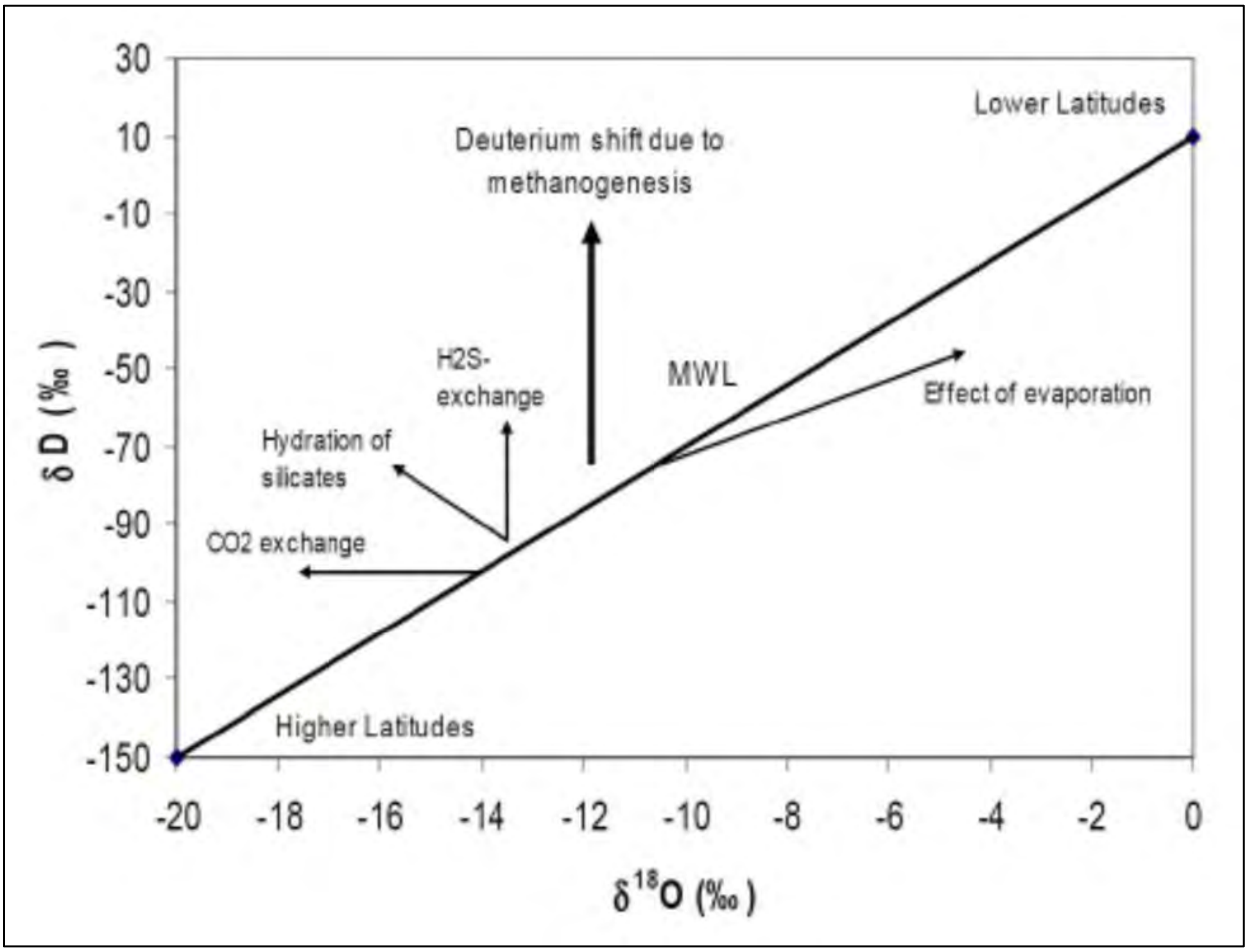


Figure 11 Deviations from the Meteoric Water Line caused by various biogeochemical and physical processes

5. Conclusions

It appears that a landfill leachate signature is not as distinctive as it was in 2001 at the downstream surface water monitoring locations. The data for the downstream and upstream surface water monitoring locations generally plot close to each other, indicating that landfill leachate is not affecting the analysed isotopes to the extent it did 20 years ago. As such, there seems to be little benefit in continuing this monitoring.

Consent no. 3839A_V1 expires on the 1st October 2023. Application for consent to continue operating the Site as a landfill and for subsequent closure have been submitted to the Otago Regional Council (ORC). On the basis of the findings of the monitoring and isotopic analysis undertaken to date, the requirement for the continuance of this monitoring has not been included in the consent application.

Until a decision is made on the consent(s) application, the 2007 consents have continued use status under Section 124 of the Resource Management Act (1991) and as such, monitoring for stable isotopes will continue as per the current consent conditions.

Attachments

Attachment 1

Laboratory Reports

STABLE ISOTOPE RESULTS

National Isotope Centre
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PO Box 31 312
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138 Victoria Street

Christchurch 8013
New Zealand

Project Title	DCC Landfills	**Invoice**	**GHD Christchurch**
SIL Order No.:	N-2200079	**Attn:**	**Cecilia Gately**
Client Ref.:	12553867		**cecilia.gately@ghd.com**
Date Received:	27/07/2022		
Date Measured:	1/08/2022		
Approved By:	Jannine		
Date Reported:	2/08/2022		

Sample Type: **nitrous oxide** **(Ammonia)**

SIL ID	External ID	Delta 15N (‰)	Sample Type	State or Province	Collection Date/Time (Start)
N-2200079	GI1	12.0	N15	Otago	15/07/2022
N-2200080	GI2	8.8	N15	Otago	15/07/2022
N-2200081	GI3	11.2	N15	Otago	15/07/2022
N-2200082	GI5	10.8	N15	Otago	15/07/2022
N-2200083	MW2D	6.5	N15	Otago	13/07/2022
N-2200084	MW4D	7.7	N15	Otago	13/07/2022
N-2200085	MW7D	3.7	N15	Otago	13/07/2022
N-2200086	PS3	4.4	N15	Otago	25/07/2022

Notes:

Ammonium was converted to nitrous oxide (N2O) for measurement of δ15N using the method of Zhang et al (2007). This method converts NH4+ to NO2- -using hypobromite (BrO-) for subsequent conversion using sodium azide to N2O gas, which is suitable for δ15N analysis using gas source isotope ratio mass spectrometry (IRMS). Submitters are normally requrest to stabilise samples to a pH≤3 using 10% HCl immediately following collection in the field. Measured concentrations of NH4+ were used to aliquot sample into 12 mL septum-capped glass reaction vials to produce a target sample size of 4 nanomoles of NH4+-N per sample. After conversion to N2O, samples were sparged with He gas, isolated on a a two trap cryogenic pre-concentration device, with N2O further separated from trapped trace gases using an isothermal GC column, and then measured on an IsoPrime IRMS. Standardisation was carried out directly against values of 0.4, 20.3 and -30.4 ‰ for the international ammonium sulphate standards IAEA N1, IAEA N2, and USGS25, respectively, where the reference for 0 ‰ is atmospheric N2. Analytical blanks were equivalent to ≤ 2 ng/L (ppb) NH4+-N, and analytical reproducibility for duplicate samples was 0.2 ‰, but should be considered to be ~1‰ for samples ≤ 10 ng/L (ppb) NH4+-N due to potential effects of the blank.

Zhang L, Altabet MA, Wu T, Hadas O 2007. Sensitive measurement of NH4 + 15N/ 14N (δ15NH4 +) at natural abundance levels in fresh and saltwaters. Analytical Chemistry 79(14): 5297-5303.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12553867		**cecilia.gately@ghd.com**
Date Received:	27/07/2022		
Date Measured:			
Approved By:			
Date Reported:	18/08/2022		

Sample Type: **DIC**

SIL ID	External ID	Delta 13C (‰)	Sample Type	Collection Date/Time (Start)
C-2200132	GI1	-11.9	C13	15/07/2022
C-2200133	GI2	-16.5	C13	15/07/2022
C-2200134	GI3	-14.2	C13	15/07/2022
C-2200135	GI5	-15.6	C13	15/07/2022
C-2200136	MW2D	-20.4	C13	13/07/2022
C-2200137	MW4D	-23.2	C13	13/07/2022
C-2200138	MW7D	-15.8	C13	13/07/2022
C-2200139	PS3	14.5	C13	25/07/2022

Notes:
DIC are analysed on GVI Isoprime, vials have 10ul of phosphoric acid added and then they are evacuated, 2mL of sample is then injected into the vial. The vials are shaken and left for 24 hours at room temperature. Samples of the head space are injected onto a Pora Plot 30m column. A series of carbonate standards GNS marble, NBS19, NBS18, GNS $NaHCO_3$ with 13C values 2.0‰, -5.0‰, -5.3‰ are used to calibrate. The analytical precision for these measurements on 13C DIC is 0.3‰

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Project Title	DCC Landfills 2022	**Invoice**	**GHD Christchurch**
SIL Order No.:	W-2201194	**Attn:**	**Cecilia Gately**
Client Ref.:	12553867		**cecilia.gately@ghd.com**
Date Received:	19/07/2022		
Date Measured:			
Approved By:			
Date Reported:	1/08/2022		

Sample Type: **water (H & O)**

SIL ID	External ID	Delta 2H (‰)	Delta 18O (‰)	Sample Type	Collection Date/Time (Start)
W-2201194	GI1	-70.3	-10.18	D, O18	15/07/2022
W-2201195	GI2	-72.3	-10.20	D, O18	15/07/2022
W-2201196	GI3	-72.7	-10.34	D, O18	15/07/2022
W-2201197	GI5	-75.2	-10.62	D, O18	15/07/2022
W-2201198	MW2D	-26.2	-3.70	D, O18	13/07/2022
W-2201199	MW4D	-27.9	-3.82	D, O18	13/07/2022
W-2201200	MW7D	-32.5	-4.53	D, O18	13/07/2022

Notes:

Water samples are analysed on an Isoprime mass spectrometer; for $\delta^{18}O$ by water equilibration at 25°C using an Aquaprep device, for $\delta^{2}H$ by reduction at 1100 °C using a Eurovector Chrome HD elemental analyser.

All results are reported with respect to VSMOW2, normalized to our internal standards: SM1 with reported values of -29.12‰ for $\delta^{18}O$, -227.4‰ for $\delta^{2}H$, and INS11 with reported values of -0.36‰ for $\delta^{18}O$, -3.8‰ for $\delta^{2}H$. The analytical precision for this instrument is 0.2‰ for $\delta^{18}O$ and 2.0‰ for $\delta^{2}H$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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138 Victoria Street

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Project Title	DCC Landfills 2022	**Invoice**	**GHD Christchurch**
SIL Order No.:	W-2201254	**Attn:**	**Cecilia Gately**
Client Ref.:	12553867		**cecilia.gately@ghd.com**
Date Received:	27/07/2022		
Date Measured:			
Approved By:			
Date Reported:	1/08/2022		

Sample Type: **water (H & O)**

SIL ID	External ID	Delta 2H (‰)	Delta 18O (‰)	Sample Type	Collection Date/Time (Start)
W-2201254	PS3 Leachate	-39.7	-7.68	D, O18	25/07/2022

Notes:
Water samples are analysed on an Isoprime mass spectrometer; for $\delta^{18}O$ by water equilibration at 25°C using an Aquaprep device, for $\delta^{2}H$ by reduction at 1100 °C using a Eurovector Chrome HD elemental analyser.

All results are reported with respect to VSMOW2, normalized to our internal standards: SM1 with reported values of -29.12‰ for $\delta^{18}O$, -227.4‰ for $\delta^{2}H$, and INS11 with reported values of -0.36‰ for $\delta^{18}O$, -3.8‰ for $\delta^{2}H$. The analytical precision for this instrument is 0.2‰ for $\delta^{18}O$ and 2.0‰ for $\delta^{2}H$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:	N-2200097	**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	18/10/2022		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	24/11/2022		

Sample Type: **nitrous oxide**

SIL ID	External ID	Delta 15N (‰)	Repeat Delta 15N	Sample Type	Collection Date/Time (Start)
N-2200097	GI1	-0.1		N15	12/10/2022
N-2200098	GI2	6.8		N15	12/10/2022
N-2200099	GI3	8.2		N15	12/10/2022
N-2200100	GI5	No result	-14.3 (low beam)	N15	12/10/2022
N-2200101	MW2D	6.2		N15	11/10/2022
N-2200102	MW4D	6.6		N15	11/10/2022
N-2200103	MW7D	-17.8	-13.3 (ave 3 results)	N15	12/10/2022
N-2200104	PS3	5.7		N15	11/10/2022

Notes:

All results are reported with respect to N-Air, normalized to our internal standards Leucine (2.0‰ for $\delta^{15}N$), EDTA (0.58‰ for $\delta^{15}N$), and Caffiene (-7.8‰ for $\delta^{15}N$). The analytical precision for these measurements are 0.3‰ for $\delta^{15}N$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	18/10/2022		
Date Measured:			
Approved By:			
Date Reported:	16/11/2022		

Sample Type: **DIC**

SIL ID	External ID	Delta 13C (‰)	Sample Type	Collection Date/Time (Start)
C-2200140	GI1	-9.6	C13	12/10/2022
C-2200141	GI2	-14.0	C13	12/10/2022
C-2200142	GI3	-12.5	C13	12/10/2022
C-2200143	GI5	-20.1	C13	12/10/2022
C-2200144	MW2D	-15.4	C13	11/10/2022
C-2200145	MW4D	-22.8	C13	11/10/2022
C-2200146	MW7D	-15.5	C13	12/10/2022
C-2200147	PS3	10.1	C13	11/10/2022

Notes:
DIC are analysed on GVI Isoprime, vials have 10ul of phosphoric acid added and then they are evacuated, 2mL of sample is then injected into the vial. The vials are shaken and left for 24 hours at room temperature. Samples of the head space are injected onto a Pora Plot 30m column. A series of carbonate standards GNS marble, NBS19, NBS18, GNS $NaHCO_3$ with 13C values 2.0‰, -5.0‰, -5.3‰ are used to calibrate. The analytical precision for these measurements on 13C DIC is 0.3‰

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	18/10/2022		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	14/11/2022		

Sample Type: **water (H & O)**

SIL ID	External ID	Delta 2H (‰)	Delta 18O (‰)	Sample Type	Collection Date/Time (Start)
W-2201490	GI1	-43.2	-6.94	D, O18	12/10/2022
W-2201491	GI2	-41.6	-6.39	D, O18	12/10/2022
W-2201492	GI3	-36.4	-6.02	D, O18	12/10/2022
W-2201493	GI5	-41.9	-6.91	D, O18	12/10/2022
W-2201494	MW2D	-26.2	-3.65	D, O18	11/10/2022
W-2201495	MW4D	-28.1	-3.79	D, O18	11/10/2022
W-2201496	MW7D	-32.0	-4.48	D, O18	12/10/2022
W-2201497	PS3	-32.7	-6.45	D, O18	11/10/2022

Notes:

Water samples are analysed on an Isoprime mass spectrometer; for $\delta^{18}O$ by water equilibration at 25°C using an Aquaprep device, for $\delta^{2}H$ by reduction at 1100 °C using a Eurovector Chrome HD elemental analyser.

All results are reported with respect to VSMOW2, normalized to our internal standards: SM1 with reported values of -29.12‰ for $\delta^{18}O$, -227.4‰ for $\delta^{2}H$, and INS11 with reported values of -0.36‰ for $\delta^{18}O$, -3.8‰ for $\delta^{2}H$. The analytical precision for this instrument is 0.1‰ for $\delta^{18}O$ and 1.0‰ for $\delta^{2}H$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:	N-2300001	**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	20/01/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	20/03/2023		

Sample Type: **nitrous oxide** **(Ammonia)**

SIL ID	External ID	Delta 15N (‰)	Sample Type	State or Province	Collection Date/Time (Start)
N-2300001	GI1	-9.8	N15	Otago	18/01/2023
N-2300002	GI2	9.7	N15	Otago	18/01/2023
N-2300003	GI3	-5.6	N15	Otago	18/01/2023
N-2300004	GI5	12.5	N15	Otago	18/01/2023
N-2300005	MW2D	5.9	N15	Otago	17/01/2023
N-2300006	MW4D	6.1	N15	Otago	17/01/2023
N-2300007	MW7D	4.4	N15	Otago	18/01/2023
N-2300008	PS3	6.2	N15	Otago	17/01/2023

Notes:
Ammonium was converted to nitrous oxide (N2O) for measurement of δ15N using the method of Zhang et al (2007). This method converts NH4+ to NO2- -using hypobromite (BrO-) for subsequent conversion using sodium azide to N2O gas, which is suitable for δ15N analysis using gas source isotope ratio mass spectrometry (IRMS). Submitters are normally requrest to stabilise samples to a pH≤3 using 10% HCl immediately following collection in the field. Measured concentrations of NH4+ were used to aliquot sample into 12 mL septum-capped glass reaction vials to produce a target sample size of 4 nanomoles of NH4+-N per sample. After conversion to N2O, samples were sparged with He gas, isolated on a a two trap cryogenic pre-concentration device, with N2O further separated from trapped trace gases using an isothermal GC column, and then measured on an IsoPrime IRMS. Standardisation was carried out directly against values of 0.4, 20.3 and -30.4 ‰ for the international ammonium sulphate standards IAEA N1, IAEA N2, and USGS25, respectively, where the reference for 0 ‰ is atmospheric N2. Analytical blanks were equivalent to ≤ 2 ng/L (ppb) NH4+-N, and analytical reproducibility for duplicate samples was 0.2 ‰, but should be considered to be ~1‰ for samples ≤ 10 ng/L (ppb) NH4+-N due to potential effects of the blank.

Zhang L, Altabet MA, Wu T, Hadas O 2007. Sensitive measurement of NH4 + 15N/ 14N (δ15NH4 +) at natural abundance levels in fresh and saltwaters. Analytical Chemistry 79(14): 5297-5303.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	20/01/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	3/04/2023		

Sample Type: **DIC**

SIL ID	External ID	Delta 13C (‰)	Sample Type	Collection Date/Time (Start)
C-2300001	GI1	-12.1	C13	18/01/2023
C-2300002	GI2	-15.8	C13	18/01/2023
C-2300003	GI3	-20.8	C13	18/01/2023
C-2300004	GI5	-14.3	C13	18/01/2023
C-2300005	MW2D	-15.8	C13	17/01/2023
C-2300006	MW4D	-24.2	C13	17/01/2023
C-2300007	MW7D	-14.3	C13	18/01/2023
C-2300008	PS3	12.5	C13	17/01/2023

Notes:
DIC are analysed on GVI Isoprime, vials have 100ul of phosphoric acid added and then they are evacuated, 2mL of sample is then injected into the vial. The vials are shaken and left for 24 hours at room temperature. Samples of the head space are injected onto a Pora Plot 30m column. A series of carbonate standards GNS marble, NBS19, NBS18, GNS NaHCO3 with 13C values 2.0‰, -5.0‰, -5.3‰ are used to calibrate. The analytical precision for these measurements on 13C DIC is 0.3‰

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SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	20/01/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	3/03/2023		

Sample Type: **water (H & O)**

SIL ID	External ID	Delta 2H (‰)	Delta 18O (‰)	Sample Type	Collection Date/Time (Start)
W-2300078	GI1	-33.6	-5.40	D, O18	18/01/2023
W-2300079	GI2	-44.3	-6.54	D, O18	18/01/2023
W-2300080	GI3	-35.5	-5.56	D, O18	18/01/2023
W-2300081	GI5	-42.8	-6.36	D, O18	18/01/2023
W-2300082	MW2D	-26.0	-3.66	D, O18	17/01/2023
W-2300083	MW4D	-28.2	-3.82	D, O18	17/01/2023
W-2300084	MW7D	-32.8	-4.53	D, O18	18/01/2023
W-2300085	PS3	-32.0	-6.60	D, O18	17/01/2023

Notes:

Water samples are analysed on an Isoprime mass spectrometer; for $\delta^{18}O$ by water equilibration at 25°C using an Aquaprep device, for $\delta^{2}H$ by reduction at 1100 °C using a Eurovector Chrome HD elemental analyser.

All results are reported with respect to VSMOW2, normalized to our internal standards: SM1 with reported values of -29.12‰ for $\delta^{18}O$, -227.4‰ for $\delta^{2}H$, and INS11 with reported values of -0.36‰ for $\delta^{18}O$, -3.8‰ for $\delta^{2}H$. The analytical precision for this instrument is 0.1‰ for $\delta^{18}O$ and 1.0‰ for $\delta^{2}H$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

STABLE ISOTOPE RESULTS

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GHD
138 Victoria Street

Christchurch 8013
New Zealand

Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:	N-2300017	**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	21/04/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	6/06/2023		

Sample Type: **nitrous oxide** **(Ammonia)**

SIL ID	External ID	Delta 15N (‰)	Sample Type	Collection Date/Time (Start)
N-2300017	GI1	5.0	N15	11/04/2023
N-2300018	GI2	0.5	N15	11/04/2023
N-2300019	GI3	10.3	N15	11/04/2023
N-2300020	GI5	4.2	N15	11/04/2023
N-2300021	MW2D	5.7	N15	12/04/2023
N-2300022	MW4D	9.2	N15	12/04/2023
N-2300023	MW7D	3.7	N15	13/04/2023
N-2300024	PS3	4.9	N15	12/04/2023

Notes:
Ammonium was converted to nitrous oxide (N2O) for measurement of δ15N using the method of Zhang et al (2007). This method converts NH4+ to NO2- -using hypobromite (BrO-) for subsequent conversion using sodium azide to N2O gas, whichAmmonium was converted to nitrous oxide (N2O) for measurement of δ15N using the method of Zhang et al (2007). This method converts NH4+ to NO2- -using hypobromite (BrO-) for subsequent conversion using sodium azide to N2O gas, which is suitable for δ15N analysis using gas source isotope ratio mass spectrometry (IRMS). Submitters are normally requrest to stabilise samples to a pH≤3 using 10% HCl immediately following collection in the field. Measured concentrations of NH4+ were used to aliquot sample into 12 mL septum-capped glass reaction vials to produce a target sample size of 4 nanomoles of NH4+-N per sample. After conversion to N2O, samples were sparged with He gas, isolated on a a two trap cryogenic pre-concentration device, with N2O further separated from trapped trace gases using an isothermal GC column, and then measured on an IsoPrime IRMS. Standardisation was carried out directly against values of 0.4, 20.3 and -30.4 ‰ for the international ammonium sulphate standards IAEA N1, IAEA N2, and USGS25, respectively, where the reference for 0 ‰ is atmospheric N2. Analytical blanks were equivalent to ≤ 2 ng/L (ppb) NH4+-N, and analytical reproducibility for duplicate samples was 0.2 ‰, but should be considered to be ~1‰ for samples ≤ 10 ng/L (ppb) NH4+-N due to potential effects of the blank.
Zhang L, Altabet MA, Wu T, Hadas O 2007. Sensitive measurement of NH4 + 15N/ 14N (δ15NH4 +) at natural abundance levels in fresh and saltwaters. Analytical Chemistry 79(14): 5297-5303.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	21/04/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	26/05/2023		

Sample Type: **DIC**

SIL ID	External ID	Delta 13C (‰)	Sample Type	Collection Date/Time (Start)
C-2300016	GI1	-17.2	C13	11/04/2023
C-2300017	GI2	-12.7	C13	11/04/2023
C-2300018	GI3	-15.0	C13	11/04/2023
C-2300019	GI5	-14.2	C13	11/04/2023
C-2300020	MW2D	-15.3	C13	12/04/2023
C-2300021	MW4D	-21.9	C13	12/04/2023
C-2300022	MW7D	-16.0	C13	13/04/2023
C-2300023	PS3	16.8	C13	12/04/2023

Notes:
DIC are analysed on GVI Isoprime, vials have 100ul of phosphoric acid added and then they are evacuated, 2mL of sample is then injected into the vial. The vials are shaken and left for 24 hours at room temperature. Samples of the head space are injected onto a Pora Plot 30m column. A series of carbonate standards GNS marble, NBS19, NBS18, GNS $NaHCO_3$ with 13C values 2.0‰, -5.0‰, -5.3‰ are used to calibrate. The analytical precision for these measurements on 13C DIC is 0.3‰

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Project Title	DCC Landfills 2023	**Invoice**	**GHD Christchurch**
SIL Order No.:		**Attn:**	**Cecilia Gately**
Client Ref.:	12587765		**Level 3, 138 Victoria Street**
Date Received:	21/04/2023		
Date Measured:			**Christchurch 8013**
Approved By:			**New Zealand**
Date Reported:	28/04/2023		

Sample Type: **water (H & O)**

SIL ID	External ID	Delta 2H (‰)	Delta 18O (‰)	Sample Type	Collection Date/Time (Start)
W-2300380	GI1	-39.9	-6.08	D, O18	11/04/2023
W-2300381	GI2	-28.1	-4.34	D, O18	11/04/2023
W-2300382	GI3	-29.2	-4.56	D, O18	11/04/2023
W-2300383	GI5	-41.7	-6.45	D, O18	11/04/2023
W-2300384	MW2D	-25.1	-3.51	D, O18	12/04/2023
W-2300385	MW4D	-27.1	-3.64	D, O18	12/04/2023
W-2300386	MW7D	-32.0	-4.27	D, O18	13/04/2023
W-2300387	PS3	-27.3	-6.55	D, O18	12/04/2023

Notes:

Water samples are analysed on an Isoprime mass spectrometer; for $\delta^{18}O$ by water equilibration at 25°C using an Aquaprep device, for $\delta^{2}H$ by reduction at 1100 °C using a Eurovector Chrome HD elemental analyser.

All results are reported with respect to VSMOW2, normalized to our internal standards: SM1 with reported values of -29.12‰ for $\delta^{18}O$, -227.4‰ for $\delta^{2}H$, and INS11 with reported values of -0.36‰ for $\delta^{18}O$, -3.8‰ for $\delta^{2}H$. The analytical precision for this instrument is 0.1‰ for $\delta^{18}O$ and 1.0‰ for $\delta^{2}H$.

Samples will be kept for 3 months from the date of the report and discarded unless otherwise notified.

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→ The Power of Commitment

Appendix G

Complaints Register and Landfill Gas Monitoring

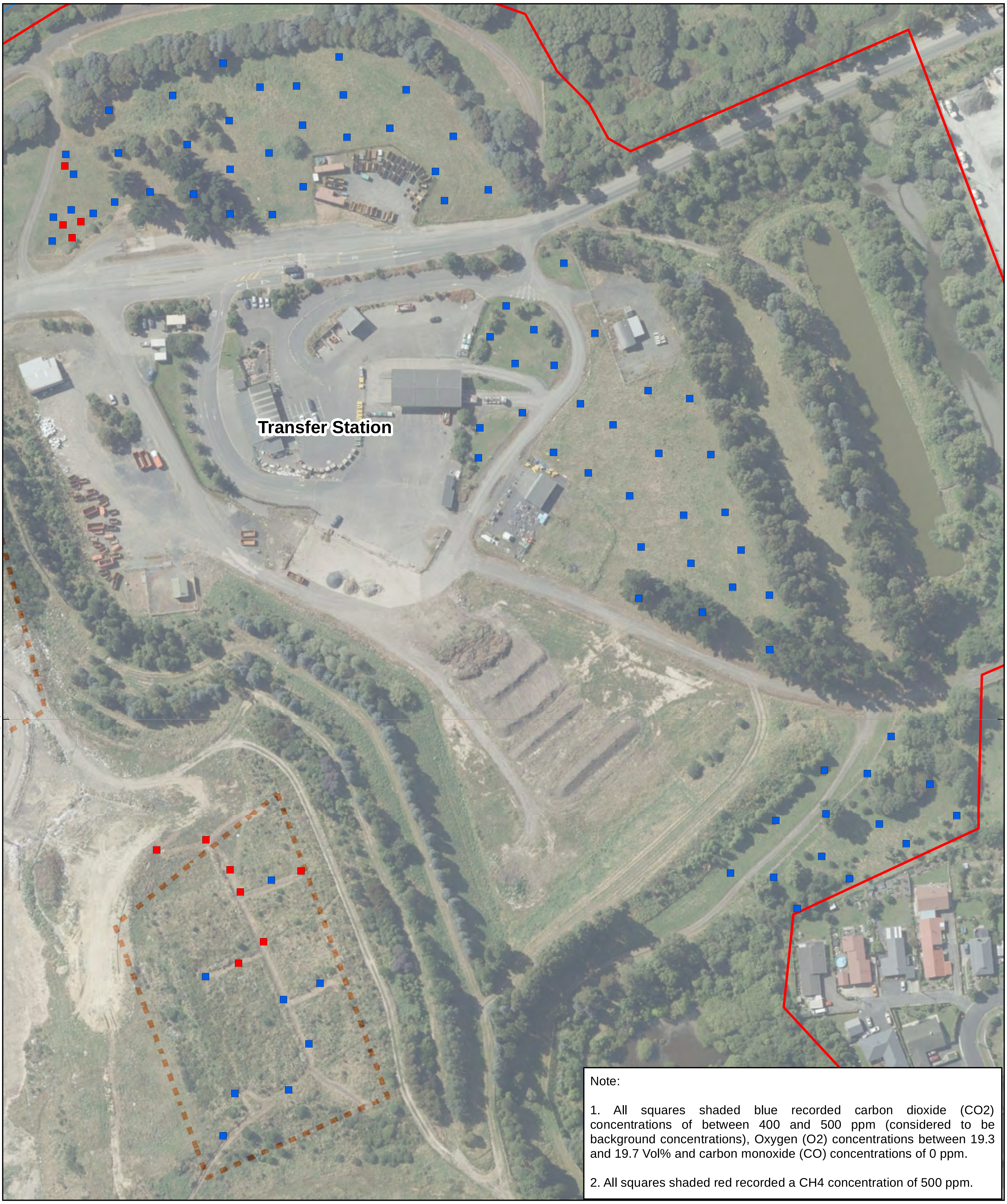
Table G1: Green Island Odor Complaints Form

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

Waste Management

Time	Date	Name	Address	Phone	Rego No	Wind Speed	Direction	Nature of Complaint	Complaint Rectified Name of person recording form	Time Rectified	Date Rectified	Actions Taken	Customer complaint and remarks
1.30pm	2/08/2022	Alysha from the ORC	Not provided	Not provided, Waldronville	N/A	33.6 gust and an average of 17.5 kmph	NNW	There is a different odour coming from the landfill. The complainant also noticed it at about 6pm last night	Paul Withers	2.35pm	2/08/2022	Under took a site inspection and the site surronds. Interviewed landfill staff. There had been no odour causing events on site and no dectable odour on site or the site neighbourhood. However the site is very wet and as material is being moved to provide for good drying and compaction, odours can occur.	
4.51pm	3/08/2022	Desiree Crooks	13 Burgess St, Green Island	Not provided, from DCC customer services	N/A	6.1km gust and 3.3 average	WSW	Smell is horiffic from landfill - can we please look into this	Andy de Bruin	5.00pm	3/08/2022	Under took a site inspection and the site surronds. Interviewed landfill staff. There had been no odour causing events on site and no detectable odour on site. Andy de Bruin call Desiree back and the odour had disapated. This was a short duration most likely associated with a load of odourous waste being pushed out and compacted.	Andy de Bruin call Desiree back and the odour had disapated.
1.13pm	24/08/2022	Alysha from the ORC	Not provided	Not provided, Abbotsford	N/A	The wind was strengthening from an average of 5km per hr to 30 km in the hr prior to and up to the time the complaint was received. The maximum gust 30km hr		Complainant could smell an odour	Paul Withers	1.26	24/08/2022	Site inspection completed with no detectable odours. A small drainage trench was being dug for a drain but had been backfilled. Conor reported that the Waste Water Treatment plant was the worst he had smelt it today.	Alysha from the ORC called back to say no dectable odours found in their investigation.
12.16pm	4/12/2022	John Neil	17 Clariton Avenue	0279553749	N/A	Gusts up to 45 kmh were experiences just prior to the complaint	West South West bu surging around	John from Clariton Avenue complained about the odour coming from the landfill.	P Withers	1.00pm	4/12/2022	Interviewed landfill staff. The dozer operator had been working on a particularly wet patch due to liquid wastes received. In completing this work the wind increased while there was old waste exposed. The operator moved quickly to cover the area and to prevent further exposure	This information was feed back to the complainant and the response received was 'That's greatlooking forward to being able to enjoy being out in the garden again soon.'
09.00am	6/03/2023	Not known (ORC)	Not known.	Customer Service	IN23.0209	Unknown	Unknown	General odor complaint from public regarding the Green Island Landfill.	C Mulcahey/Alysha Bennett	Not long afer complaint	6/03/2003	Odor dissipated at time of call. ORC notified landfill.	Bad smell coming from the Green Island Landfill.
11.00am	7/03/2023	Not known (ORC)	Not known.	Customer Service	IN23.0214	Unknown	Unknown	General odor complaint from public regarding the Green Island Landfill.	C Mulcahey/Peter-Don Bonthuys	No longer occurring at time of call.	7/03/2023	Quickly went away on its own. ORC notified landfill.	Bad smell coming from the Green Island Landfill.
After hours	12/03/2023	Not known(ORC)	Not known.	After hours Call Centre	IN23.0236	Unknown	Unknown	General odor complaint from public regarding the Green Island Landfill.	C Mulcahey/Andrew Gibson	Was no longer a concern the following day.	13/03/2023	Was unaware of complaint.	Bad smell coming from the Green Island Landfill.
10.43am	17/03/2023	Eve Aitken	190 Brighton Road	N/A	A1769102	Unknown	Unknown	General odor complaint from public and FIDOL regarding the Green Island Landfill.	C Mulcahey	11.35am	17/03/2023	Took "Enviromental Officers" for look around landfill. Highly suspect the odor came from a 1/2 treated SLB emptied on tipface from GIWWTP.	"Sweet rubbish smell, similar to silage at times".
11.52am	22/03/2023	Helen	Unknown	Unknown. Made contact with DCC	None	Unknown	Unknown	General odor complaint from public regarding the Green Island Landfill.	C Mulcahey	12.00pm	22/03/2023	Investigated and inquired landfill team. Conclusion: Load of offal followed by a load of blood was most likely the cause.	"a smell coming from the landfill. Occasionally almost smells a fishy smell".
10.00am	18/04/2023	Not known (ORC)	Unknown	Unknown. Made contact with DCC	None	Unknown	Unknown	General odor compaint from the public regarding a bad odor. Assumed it was coming from the Green Island Landfill.	C Mulcahey	10.30am	18/04/2023	ORC came to landfill to investigate. Went on "walk around" w/member of landfill team. No odors were identified or noticed.	Foul smell from somewhere in the surrounding area of the landfill.
12.30pm	19/04/2023	Resident of Fairfield.	Fairfield	Unknown. Made contact with DCC	None	Unknown	Unknown	General odor complaint from a resident of Fairfield. Assumed it was coming from the Green Island Landfill.	C Mulcahey	13.00pm	19/04/2023	Contacted resident regarding compaint. Odor did not last long.	Resident stated that they had notice more odour "in the past few weeks". However, was most possibly due to the rendering plant.
12.00pm	20/04/2023	Phil Taylor	291 Brighton Road, Waldronville	273103962	None	4 km/h	SW	20th April 2023, most of the day was odorous. 21 April 2023, odorous between 1030 and 1100.	C Mulcahey	12.00pm	21/04/2023	I contacted Mr. Taylor regarding his odour complaint. Inquired landfill team of any potential for complaint.	"Smelled like rubbish. Rubbish at the Green Island Landfill." On 20th April 2023, two trenches were dug to accommodate two new laterals. However, this occurred at 1300 with low windspeed. No other notable activity took place.
16.30pm	10/05/2023	Helen	Clariton Avenue	N/A	None	7km/h	SW	Odour complaint @ 1700hrs from Clariton Avenue.	L Coe, C Mulcahey	16.59pm	10/05/2023	I (C Mulcahey), went to Clariton Avenue to inspect complaint of odour from Green Island Landfill and was unable to identify any odorous smell. Perhaps it had dissipated by the time I had arrived.	"wanting to let you know that there is a odour smell coming from the landfill has been like this for about 15min."
08.30am	16/05/2023	ORC	Dunedin/Green Island area	N/A	None	5km/h	SW	Odour complaint from general public claiming it was from the Green Island Landfill.	C Mulcahey	09.00am	16/05/2023	ORC came to landfill to investigate. No odors were identified or noticed on drive around.	From my understanding, a person from the public called the ORC and complained about odours from the landfill.
13.00pm	16/05/2023	ORC	Dunedin/Green Island area	N/A	None	5km/h	SW	Odour complaint from general public claiming it was from the Green Island Landfill.	C Mulcahey	13.30pm	16/05/2023	Spoke to DCC. Odour Cannon was in operation most of the morning and afternoon. Was turned off due to needing more water and fuel. A skip of offal had been tipped and landfill was wet. May have been the cause of the odour. The offal was disposed of as quickly as possible due to the conditions.	A general complaint about odour.
13.03pm	31/05/2023	ORC/General Public	Dunedin/Green Island area	N/A	N/A	Unknown	Unknown	Odour complaint from general public claiming it was from the Green Island Landfill.	C. Mulcahey	13.30pm	31/05/2023	Unfortunately, no actions were taken because the landfill, as well as the DCC, were unaware of the complaint. No investigation completed this day.	"Foul odour coming from Green Island Landfill-can smell it when standing outside in his garden." All information regarding this complaint is direct from ORC Complaints Form.

14.30pm	1/06/2023	ORC/General Public	Dunedin/Green Island area	N/A	N/A	Unknown	Unknown	Odour complaint from general public claiming it was from the Green Island Landfill.	Mia & C Mulcahey	15.00pm	1/06/2023	ORC logged/recorded complaint.	"Hi Mia, I have been smelling the landfill for about 20 mins, strong smell like a piggery. Thanks"
08.28am	2/06/2023	ORC/General Public, Elwyn Cresent	Dunedin/Green Island area	N/A	N/A	Unknown	Unknown	Odour complaint from general public claiming it was from the Green Island Landfill.	ORC/C Mulcahey	09.30am (?)	2/06/2023	ORC logged/recorded complaint.	Green Island Landfill is disgusting today-Just terrible" "This morning it is just disgusting".
13.00pm	3/06/2023	John Neal and Helen Neal	Clariton Avenue	N/A	N/A	Unknown	Unknown	Odour complaint from general public claiming it was from the Green Island Landfill.	L Coe, C Mulcahey	13.30pm	3/06/2023	Member of Public notified DCC. No "odorous loads" came in this Saturday. SLB with heavy dosage of liming came in. Wind direction would have carried an amonia type smell.	"Sorry to trouble you on a Saturday. I arrived home about 15min ago to a terrible odour".
16.00pm	5/06/2023	John Neal and Helen Neal	Clariton Avenue	N/A	N/A	Unknown	Unknown	Odour complaint from general public claiming it was from the Green Island Landfill.	L Coe, C Mulcahey	16.30pm	5/06/2023	John and Helen notified DCC individual about foul smell. DCC member assured John and Helen that a follow up would happen the next morning. Again, the outcome was overlimed sludge and the engine was down as well, which contributed to a gasy smell mixed with the overlimed batch of sludge.	"At the moment it stinks like Offal mixed with sweage."



Note:

1. All squares shaded blue recorded carbon dioxide (CO_2) concentrations of between 400 and 500 ppm (considered to be background concentrations), Oxygen (O_2) concentrations between 19.3 and 19.7 Vol% and carbon monoxide (CO) concentrations of 0 ppm.

2. All squares shaded red recorded a CH_4 concentration of 500 ppm.

LEGEND

- Landfill Gas Samping Point - No landfill gas detected (above background)
- Landfill Gas Sampling Point - Landfill Gas Detected
- Site Boundary
- Capped Landfill Boundary

Paper Size A3
0 5 10 20 30 40
Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Dunedin City Council
DCC Landfills 2023

Job Number	12553867
Revision	A
Date	27 Sep 2023

Green Island Active Landfill
ISM Landfill Gas Monitoring Survey

Figure G1

G:\51\12587765\GIS\Maps\Deliverables\Green Island\12587765_Green_Island_Gas_survey_23.mxd

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Data source: Service Layer Credits: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors. Created by:herasmus

Appendix H

Audit Reports

Auditor	Hayden Erasmus
Audit date	14 July 2022
Audit type	Environmental Audit
Reason for Audit	Resource consent compliance (Condition 7 of Consent No. 2003.740)
Audit categorisation	Routine
Site/premises name	Green Island Landfill
GIS Coordinate of Site Latitude / Easting Longitude / Northing	NZTM (NZGD 2000) -45.907987 / 1399091 170.409622 / 4912913

General Comments

Size of the working face	No significant changes to the size of the working face.
New areas of disposal, changes onsite	The working face of the landfill has moved to the west. Capping works over the northern portion of the landfill have ceased until the Spring.

Summary of Audit

Rating	Description
1	Significant issues and risk– non-compliance with consent
2	Major issues on site
3	Moderate issues on site
4	Minor issues on site
5	No issues

Rating	Number of items within each rating	Details of issue
1	0 - No items were considered to fall in this rating category	N/A
2	0 - No items were considered to fall in this rating category	N/A
3	1	Overflow from PS1 discharged to the Western Sedimentation pond overflow which eventually discharges to the Kaikorai Stream.
4	7	• Windblown litter • Orange netting around silt pond to be replaced. • Potential damage to the final cap in the eastern portion of the landfill due to mature vegetation growth • Vermin droppings observed • Repair of the well heads for MW7D needed. • Higher bund or road adjacent to PS1. • Stormwater collection / management to be improved to manage high rainfall events
5	14	N/A

General Site Compliance

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
General Housekeeping and Observations	4	A moderate volume of wind blown waste was observed to have accumulated across the site specifically within the stormwater channels and around the 'final cap' area of the landfill (Photograph 1 - 4 and Figure 1). No fires have occurred within the composting area due to frequent stirring of the windrows. Temperatures are taken weekly and should record <60 ˚C. Recently recorded temperatures have all been around 20˚C. The sludge pit has been relocated from adjacent to the tip face to north of the asbestos area (Photograph 5). In the 48 hours prior to the site audit, Dunedin received a large volume of rainfall which caused the Kaikorai Stream to flood. A number of the stormwater channels were also flooded around the landfill (Photograph 6 – 9).	DCC / Waste Management to organise for a litter pick to be undertaken.	October 2022

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
General observations and changes at site	4	The tip face has moved to the north west (Photograph 10 and 11). The previously stockpiled phosphorous contaminated soil material has been removed from the tip face and placed within the area to the north of the asbestos area. It has been spread out and is being allowed to degrade over time. Once this process has finished, the material will likely be used as daily cover material. Excavations have taken place on the site immediately south of Taylor Street, south of the north eastern wetland (Photograph 12). Crushed Asphalt has been placed around the entrance to the composting area. A pile of tyres (used as a ‘suck hole’) is also present adjacent to the entrance of the composting area (Photograph 13). A new access road has been constructed (as identified in Figure 1) from demolition waste (bricks) and crushed asphalt (Photograph 14). The orange netting around the silt pond (as identified on Figure 1) has become damaged and requires replacement (Photograph 15).	None DCC / Waste management (WM) to organise for netting to be replaced.	Not applicable October 2022
Evidence of the prevention of waste materials moving offsite	5	Site access is controlled by lockable gates and restricted opening hours. A litter fence is in place around the working face area (Photograph 16).	None	Not applicable
Any new Discharges	5	None noted.	None	Not applicable

	Rating	Notes / Comments	Actions assigned to personnel	Date to be achieved by
Management and control of hazardous waste	5	Access to the landfill is restricted by way of access gates, specified opening hours and check-ins/check-outs at the weighbridge. Disposal of hazardous waste requires acceptance of the waste prior to being delivered to the landfill, by DCC. Waste disposal dockets are provided to vehicle drivers when exiting the landfill. A leachate collection drain is installed around the majority of the perimeter of the landfill. Collected leachate / groundwater is pumped to the Wastewater Treatment Plant (WWTP) for treatment and discharge. Soil contaminated with asbestos is placed in certain managed areas of the landfill (Figure 1). Road sweepings which potentially contain asbestos are also managed and disposed of in a specific access controlled and secure area.	DCC / Waste Management responsible for the management of access and control of waste being received.	Ongoing
Management and control of hazardous waste - Odour	5	Odour, likely associated with the sludges received from the various WWTPs, occurs when sludge is deposited into the sludge pits (which can take place up to 6 times per day). Odour issues are generally short lived, and the associated complaints are dependent on the wind direction at the time of disposal. Odour mitigation methods are activated when the wind is blowing in specific directions. The sludge pit has been relocated to the base of the landfill (Photograph 5, Figure 1).	None	Not applicable.

	Rating	Notes/Comments	Notes/Comments	Date to be achieved by
Faults, leaks or emergency repairs onsite	5	A minor quantity of gas escape was observed within a puddle adjacent to Line 5. No other faults noted or known of.	None	Not applicable
Complaints register	5	A digital complaints register is kept by DCC / Waste Management. This is populated by complaints received by email and telephone calls from the public.	The register is to be provided to GHD for annual compliance reporting purposes by DCC.	July 2023
Evidence from contractor of the vermin and bird control that has been done	4	Vermin bait stations / traps were noted around Well Line 0 (Photograph 17) and Line 8. Rabbit droppings were observed within the paddock adjacent to the bicycle storage area. Seagull / bird numbers are difficult to manage due to the protected status of some of the bird species and the long term nature of occurrence of the birds (generational).	Waste Management to undertake bird deterrent measures as necessary. Additional bait traps may be required	Ongoing October 2022

Landfill Cap

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Seepage	5	None seen	None	Not applicable
New landfill cap survey information	4	The construction of the final cap over the northern portion of the landfill has ceased over the winter months and will resume again in spring (Photograph 18). A final cap is in place over a portion of the eastern part of the landfill. However, the root systems of mature vegetation growth over this area (cabbage trees and other natives) may be damaging the cap.	None DCC – vegetation to be cleared and suitable vegetation (shallow rooting) to be planted.	Not applicable January 2024

Landfill Gas

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to gas collection system	5	A new landfill gas main has been installed around the southern perimeter of the landfill (as indicated on Figure 1). This has been connected into the gas main coming from the top of the landfill at around where monitoring well line 3 is located.	None	Not applicable

Groundwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to wells	4	The following was noted: - The conditions of the monitoring wells appear to be relatively unchanged since the last audit inspection, with the exception of Line 8 where asphalt has been placed around the well plinths to stabilise them (Photograph 19). - There were no well caps present on any of the piezometers. A survey of cap numbers has been undertaken by GHD. - The concrete well head of MW7D is unstable (Photograph 20).	None DCC / GHD to organise replacements. DCC / WM to inspect and scope repairs.	Not applicable October 2022 October 2022

Surface water

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any offsite discharges into Kaikorai Stream and Estuary	3	Due to very high rainfall, volumes of stormwater overloaded the leachate collection trench and overflow out of the PS1 manhole was noted. The overflow (leachate / groundwater) was noted flowing across the access track and discharging into the Western Sedimentation Pond overflow pond which discharges to the Kaikorai Stream. Measurement markers at the base of the staff gauges are obscured by adhered sediment and algal growth. A high water level was noted within all of the surface water ponds and wetlands.	DCC to investigate how this can be managed better during future high rainfall events. None	Not applicable Not applicable

Stormwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in stormwater collection system, including condition of the trench	4	Trenches around the boundary access track contained vegetation. A large volume of rain had fallen in the 48 hours prior to the audit commencing. The majority of the storm water drains were flooded with water topping the bund adjacent to PS1 built following a previous flood event. Lincoln Coe (DCC) was present at the landfill and noted that they (DCC) would inform ORC of the flooding around the landfill.	DCC to organise for trenches to be cleared of vegetation. Bund or road to be built higher to prevent breaching in future.	October 2022 January 2023
Is stormwater draining to the correct catchment	5	All stormwater collected is channelled towards PS1, PS3 and PS5. Stormwater appears to be draining into the correct drains and sedimentation ponds.	None	Not applicable
Any spills from the landfill faults	4	Stormwater from the trenches overflowing / flooding across the access track to the Kaikorai Stream in places.	DCC to investigate how stormwater can be managed more effectively during future high rainfall events.	July 2023

Leachate

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in leachate collection system, including condition of the trench	5	No upgrades noted.	None	Not applicable
Is leachate draining to correct capture system	5	All leachate appears to be collecting into the correct drainage system.	None	Not applicable
Any pump faults	5	All pumps operational.	None	Not applicable

Summary

Further work or requirements	Stormwater management / storage to be improved to deal with future high rainfall events. Wind blown litter needs to be collected and disposed of appropriately. Orange netting around the silt pond requires replacement. Clear vegetation from the area where final capping has taken place. Additional measures may need to be considered to reduce the rabbit population. Piezometer well caps require fitting on each piezometer. Staff gauges need to be cleaned or replaced so that they can be read. The concrete well pad at MW7D requires repairing. Clear vegetation from surface drains and access track around the leachate drain access track. Clear rubbish from the north eastern wetland culvert and stormwater trenches.
Nature and extent of continuing risk	Capacity of the stormwater collection / storage system to be investigated to prevent overflow of the leachate collection trench. Wind blown litter migrating from the tip face, potentially off-site. The orange netting acts as a barrier between the gravel road and the silt pond. Vegetation within surface drain could impede or change the drainage pathway. Established vegetation within the final capped area could be penetrating the cap and impacting on its performance.
Outcome of the audit	Overall, more litter was observed across the landfill, however little else has changed since the April 2022 audit. The site continues to operate efficiently and is relatively well maintained.

1.1 Site Photos:

Photograph 1: Large volume of wind blown waste within the 'final cap' area outside of the litter fence.

Photograph 2: Wind blown waste within stormwater channel between the previous tyre storage location and the silt pond, looking north.

Photograph 3: Waste around the culvert pipe within the north eastern wetland.

Photograph 4: Moderate volume of waste materials present in the stormwater channel along the south west boundary of the compost area.

Photograph 5: Sludge pit, located north of the asbestos area looking towards the tip face.

Photograph 6: Flooding of the leachate channel and overflow from PS1 into the W pond (by MW0C), looking north.

Photograph 7: Water gauge adjacent to PS1, looking east.

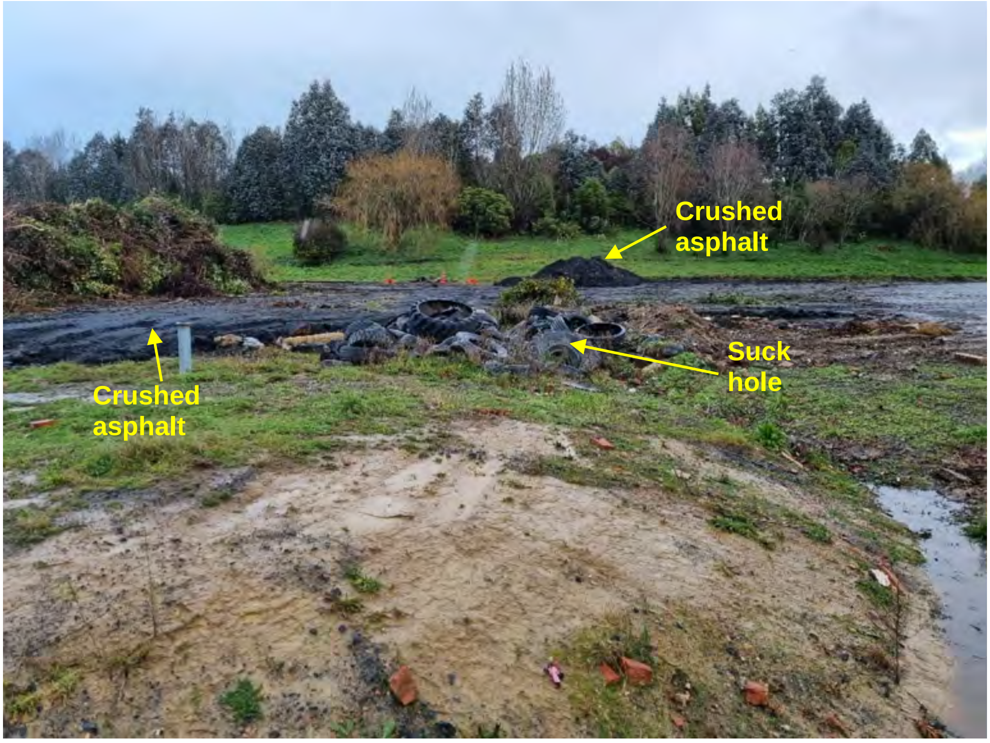
Photograph 8: Flooding of the Kaikorai Stream adjacent to MW3C, looking north.

Photograph 9: Flooding adjacent to Line 6.

Photograph 10: Current tip face, looking to the west.

Photograph 11: Access road at the base of the tip face, looking north.

Photograph 12: Excavation of material has occurred immediately south of Taylor Street, south of the north eastern wetland.



Photograph 13: Tyres present within a 'suck hole' adjacent to the composting area. Crushed asphalt has also been placed. A pile of additional crushed asphalt is also present.

Photograph 14: New access road constructed of demolition materials (brick) and crushed asphalt.

Photograph 15: Orange netting to be replaced around the silt pond, adjacent to the previous tyre storage location.

Photograph 16:The litter fence and stockpiled material within the vicinity of the tip face which will be utilised as final capping material.

Photograph 17: Bait within traps within the vicinity of MW0C.

Photograph 18: Recently placed capping material over the northern portion of the landfill, looking north.

Photograph 19: Crushed asphalt has been lain along well line 8 to stabilize the concrete well plinths.

Photograph 20: Well MW7D's concrete base has been undercut and is unstable.

1.2 Figure 1 – Site Audit Observations

Auditor	Hayden Erasmus
Audit date	12 October 2022
Audit type	Environmental Audit
Reason for Audit	Resource consent compliance (Condition 7 of Consent No. 2003.740)
Audit categorisation	Routine
Site/premises name	Green Island Landfill
GIS Coordinate of Site Latitude / Easting Longitude / Northing	NZTM (NZGD 2000) -45.907987 / 1399091 170.409622 / 4912913

General Comments

Size of the working face	No significant changes to the size of the working face observed during the visual inspection.
New areas of disposal, changes onsite	The working face of the landfill has moved to the south since the July 2022 Audit. A new leachate delivery line has been installed, leading to Pump Station 1. Capping works over the northern portion of the landfill have ceased until the Spring.

Summary of Audit

Rating	Description
1	Significant issues and risk– non-compliance with consent
2	Major issues on site
3	Moderate issues on site
4	Minor issues on site
5	No issues

Rating	Number of items within each rating	Summary of issue
1	0 - No items were considered to fall in this rating category	N/A
2	0 - No items were considered to fall in this rating category	N/A
3	0 - No items were considered to fall in this rating category	N/A
4	10	• Hole beneath gas line adjacent to Line MW0. • Orange netting around silt pond requires replacement. • More windblown litter around line 5 than seen during previous audits. Windblown litter also present throughout the remainder of site. • High bird numbers at tip face and pest control of cats to be undertaken throughout the site. • Potential damage to the final cap in the eastern portion of the landfill due to mature vegetation growth • Surveyors to inspect MW4D and confirm well depth. • Repair of the well head for MW7D needed as concrete plinth is unstable (undercut).
5	39	N/A – No issues noted.

General Site Compliance

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
General Housekeeping and Observations	4	A slight hole is present in the ground surface beneath the gas line to the east of well Line MW0, (Photograph 1).	DCC / Waste Management (WM) to fill in hole.	January 2023
	5	Fallen plant material has been removed from around monitoring well MW5C (Photograph 2).	None.	Not applicable.
	4	The orange netting around the northern stormwater / sedimentation pond (as identified on Figure 1) has become damaged and requires replacement (Photograph 3).	DCC / WM to organise for netting to be replaced.	January 2023
	5	Decommissioned whiteware was in the process of being removed from site during the audit (Photograph 4).	None.	Not applicable.
	5	Stock piled clay material adjacent to the asbestos disposal area will be used as capping material (Photograph 5).	None.	Not applicable.
	5	The solar landfill gas flare has been relocated so that it is currently adjacent to the tip face (Photograph 6).	None.	Not applicable.
	5	No fires have occurred within the composting area since prior to the July 2022 site audit.	None.	Not applicable.
	5	The tip face has moved to the south (**Error! Reference source not found.**7).	None.	Not applicable.
Evidence of the prevention of waste materials moving offsite	5	Site access is controlled by lockable gates and restricted opening hours.	None.	Not applicable.
	5	The temporary litter fence is in place around the working face area (Photograph 8).	None.	Not applicable.
	5	The permanent litter fence is likely to be moved in the coming months, so that it is closer to the tip face (Photograph 9).	DCC / WM	February 2023
	4	Windblown waste materials were observed to have collected around line 5 adjacent to the stream (Photograph 10).	Waste Management staff to undertake a litter pick within the area to ensure waste materials do not migrate into the stream.	December 2022
Any new Discharges	5	None noted.	None.	Not applicable.

	Rating	Notes / Comments	Actions assigned to personnel	Date to be achieved by
Management and control of hazardous waste	5	Access to the landfill is restricted by way of access gates, specified opening hours and check-ins/check-outs at the weighbridge.	None.	Not applicable.
	5	Disposal of hazardous waste requires acceptance of the waste prior to being delivered to the landfill, by DCC.	None.	Not applicable.
	5	Waste disposal dockets are provided to vehicle drivers when exiting the landfill.	None.	Not applicable.
	5	A leachate collection drain is installed around the majority of the perimeter of the landfill. Collected leachate / groundwater is pumped to the Wastewater Treatment Plant (WWTP) for treatment and discharge.	None.	Not applicable.
	5	Soil contaminated with asbestos is placed in certain managed areas of the landfill (Figure 1).	None.	Not applicable.
	5	Road sweepings which potentially contain asbestos are also managed and disposed of in a specific access controlled and secure area.	None.	Not applicable.
Management and control of hazardous waste - Odour	5	Odour, likely associated with the sludges received from the various WWTPs, occurs when sludge is deposited into the sludge pits (which can take place up to 6 times per day). Odour issues are generally short lived, and the associated complaints are dependent on the wind direction at the time of disposal. Odour mitigation methods are activated when the wind is blowing in specific directions.	None.	Not applicable.
	5	The odour cannon was in use while cleaning/scraping of surface material took place. This material has been stockpiled in the corner of the composting area.	None.	Not applicable.
	5	The sludge disposal area remains in the same place as the July 2022 site audit (Photograph 11). It is likely that a new sludge pit will be created in the near future.	None.	Not applicable.
	5	No asbestos containing material has been disposed of recently.	None.	Not applicable.

	Rating	Notes/Comments	Notes/Comments	Date to be achieved by
Faults, leaks or emergency repairs onsite	5	No faults noted or known of.	None.	Not applicable.
Complaints register	5	A digital complaints register is kept by DCC / Waste Management. This is populated by complaints received by email and telephone calls from the public.	The register is to be provided to GHD for annual compliance reporting purposes by DCC.	July 2023
Evidence from contractor of the vermin and bird control that has been done	5 4 4	Vermin bait stations / traps were noted around Well Line 0 (**Error! Reference source not found.**12), bait was present within the traps. Seagull / bird numbers are difficult to manage due to the protected status of some of the bird species and the long term nature of occurrence of the birds (generational). Two cats were observed to be present (on separate occasions) between line 1 and 2.	None. Waste Management to undertake bird deterrent measures as necessary. Waste management staff to set cat traps. Traps to be checked daily and cats to be collected by an appropriate animal welfare organisation.	Not applicable. Ongoing Ongoing

Landfill Cap

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Seepage	5	None noted.	None.	Not applicable.
New landfill cap survey information	5 5 4 4	An area to the west of the current tip face has been used as a recent disposal area and has been covered with intermediate cap (Photograph 13). A new asbestos disposal area will be located in this area (Photograph 14). Construction of the final cap in the northern section of the site will re-commence in the coming weeks. A final cap is in place over a portion of the eastern part of the landfill. However, the root systems of mature vegetation growth over this area (cabbage trees and other natives) may be damaging the cap. Large volumes of windblown waste also accumulate here.	None. None. DCC / WM – vegetation to be cleared and suitable vegetation (shallow rooting) to be planted. Litter pick to be undertaken.	Not applicable. Not applicable. January 2024 January 2023

Landfill Gas

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to gas collection system	5	The solar gas flare has been relocated (Figure 1).	None.	Not applicable.
	5	All gas wells throughout the northern portion of the landfill (final cap construction) have been brought back on line.	None.	Not applicable.

Groundwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to wells		The following was noted:		
	4	- Monitoring well MW4D has recorded basal depths of 12.2 m over the past few months. Prior to this, a maximum depth of 8.3 m was recorded. Historical DCC survey information indicate that it is 10.5 m to the base of well.	DCC to inspect and re-survey well to confirm well depth.	January 2023
	5	- The conditions of the monitoring wells appear to be relatively unchanged since the last audit inspection.	None.	Not applicable.
	5	- There were no well caps present on any of the piezometers. A survey of cap numbers has been undertaken by GHD.	DCC / GHD to organise replacements.	January 2023
	4	- The concrete well head of MW7D is unstable.	DCC / WM to inspect and scope repairs.	January 2023

Surface water

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any offsite discharges into Kaikorai Stream and Estuary	4	The Kaikorai Stream level was high during the site audit, likely due to the estuary mouth being blocked. Surface water flooding has occurred around the peripheries of the access track as a result (Photographs 15). The access track around the landfill had not been breached at the time of the audit.	DCC to address with improvements during closure designs.	2028
	5	The water level at ST5 was just below the '8' marker line (Photograph 16). For reference, the water level site around the '4' marker line.	None.	Not applicable.
	5	The north east wetland contained a high volume of water with minimal flow exiting the culvert t (Photograph 17). Water continues to flow from the south east wetland into the culvert.	None.	Not applicable.

Stormwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in stormwater collection system, including condition of the trench	5	None noted.	None.	Not applicable.
Is stormwater draining to the correct catchment	5	All stormwater collected is channelled towards PS1, PS3 and PS5.	None.	Not applicable.
	5	Stormwater appears to be draining into the correct drains and sedimentation ponds.	None.	Not applicable.
Any spills from the landfill faults	5	None noted.	None.	Not applicable.

Leachate

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in leachate collection system, including condition of the trench	5	New leachate delivery line being installed along the front of the tip face to be connected to PS1.	None.	Not applicable.
Is leachate draining to correct capture system	5	All leachate appears to be collecting into the correct drainage system.	None.	Not applicable.
Any pump faults	5	All pumps operational.	None.	Not applicable.

Summary

Further work or requirements	DCC / Waste Management to fill in hole beneath the gas line to the east of line MW0 in order to prevent any potential health and safety incidents. Orange netting to be replaced around the northern stormwater detention / sedimentation pond. Wind blown litter needs to be collected and disposed of appropriately. Waste Management to set cat traps between line 1 and 2 to catch cats. Clear vegetation from the area where final capping (east portion of landfill) has taken place. Well MW4D to be re-surveyed to determine depth of borehole. Piezometer well caps require fitting on each piezometer. The concrete well pad at MW7D requires repairing.
Nature and extent of continuing risk	The hole poses a risk to site staff walking adjacent to the gas line, it also enables the pooling of potentially contaminated water. The orange netting acts as a barrier between the gravel road and the stormwater detention / sedimentation pond. Wind blown litter migrating from the tip face, potentially off-site into waterways. Cats pose a risk to the native fauna of the site i.e. native birds. Established vegetation within the final capped area could be penetrating the cap and impacting on its performance. Well MW4D to be inspected/re-surveyed to determine whether well’s condition is deteriorating.
Outcome of the audit	Overall, little has changed since the April 2022 audit. The site continues to operate efficiently and is relatively well maintained with the main concerns being: - Replacement of orange netting around the silt pond. - Undertake a litter pick. - Clear deep rooting vegetation from area of landfill which has a final cap. - Inspect MW4D.

1.1 Site Photos:

Photograph 1: A slight hole is present in the ground surface beneath the gas line to the east of line MW0.

Photograph 2: Fallen plant material has been removed from around MW5A well head.

Photograph 3: Orange netting which requires replacement around the northern stormwater detention / sedimentation pond.

Photograph 4: Removal of whiteware from site.

Photograph 5: Stockpiled clay material adjacent to the current asbestos disposal area to be used as capping material.

Photograph 6: The flare has been relocated to the west of the current tip face, looking south.

Photograph 7: The tip face has moved to the south of the site.

Photograph 8: Showing the temporary litter fence located to the east of the current tip face.

Photograph 9: Current permanent litter fence to be relocated closer to the tip face.

Photograph 10: Windblown waste materials accumulated around line 5.

Photograph 11: Sludge pit nearing capacity and will likely be capped in coming weeks.

Photograph 12: Bait stations around line 0, containing bait.

Photograph 13: Intermediate cap over an area to the west of the current tip face.

Photograph 14: Area prepared to receive asbestos materials to the west of the current tip face.

Photograph 15: Flooding associated with the Kaikorai Stream / Estuary mouth being blocked.

Photograph 16: Staff gauge 5 indicating the high water level.

Photograph 17: The north eastern wetland, with outflow pipe from south eastern wetland to the right of picture. High water levels can be noted.

1.2 Figure 1 – Site Audit Observations

Auditor	Hayden Erasmus
Audit date	18 January 2023
Audit type	Environmental Audit
Reason for Audit	Resource consent compliance (Condition 7 of Consent No. 2003.740)
Audit categorisation	Routine
Site/premises name	Green Island Landfill
GIS Coordinate of Site Latitude / Easting Longitude / Northing	NZTM (NZGD 2000) -45.907987 / 1399091 170.409622 / 4912913

General Comments

Size of the working face	No significant changes to the size of the working face observed during the visual inspection.
New areas of disposal, changes onsite	The working face of the landfill has extended to the south since the October 2022 Audit. Capping works over the northern portion of the landfill have been completed.

Rating & Description	Number of items within each rating
1 - Significant issues and risk– non-compliance with consent	0 items were considered to fall in this rating category
2 - Major issues on site	0 items were considered to fall in this rating category
3 - Moderate issues on site	0 items were considered to fall in this rating category
4 - Minor issues on site	8 items were considered to fall in this rating category
5 - No issues	36 items were considered to fall in this rating category

Summary of Audit

- Minor slump noted to be present adjacent to the access road to the borrow pit (Photograph 7).
- Wind blown litter present across the site, minor to moderate volumes noted present along the access tracks and within eastern final capped portion of the landfill (Photographs 8 & 9).
- Weed growth through paddocks around the transfer station higher than seen previously.
- CCTV inspection of inner well casing of MW4D to be undertaken to confirm well depth.
- Repair of the well head for MW7D needed as concrete plinth is unstable (undercut).
- Staff gauges to be cleaned of algae and sediment build-up (Photograph 13).

General Site Compliance

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
General Housekeeping and Observations	5	A wire fence has replaced the orange netting around the northern sedimentation and leachate pond (Photograph 1).	None	Not applicable
	5	The area of final capping, in the northern portion of the landfill, has been completed with hydroseed (Photograph 2).	None	Not applicable
	5	The transfer station has been kept clean and tidy with no wind blown litter visible (Photograph 3).	None	Not appliable
	5	No fires have occurred within the composting area since prior to the July 2022 site audit.	None	Not applicable
	5	The grass has been cut on the landfill side of the perimeter access track.	None	Not applicable
	5	Two crushed cars (fluids drained) were observed present between the tyre and whiteware storage locations (Photograph 4). These are to be relocated to a scrap metal yard.	None	Not applicable
	5	The tip face has extended towards the south (Photograph 5).	None	Not applicable
	5	A new access track has been created from close to the location of line 0 towards the borrow pit (Photograph 6). This track will be used to provide access to allow for the construction of a new sedimentation pond associated with the borrow pit.	None	Not applicable
	4	A minor slump was noted to be present on the southern side of the access track to the borrow pit (Photograph 7).	WM to monitor this area to ensure excess sediment is not eroded into the stormwater system and monitor bank stability.	Ongoing
Evidence of the prevention of waste materials moving offsite	5	Site access is controlled by lockable gates and restricted opening hours.	None	Not applicable
	5	Temporary litter fences are in place around the working face area (Photograph 5).	None	Not applicable
	5	The permanent litter fence is likely to be moved in the coming months, so that it is closer to the operational working face.	DCC / WM	July 2023
	4	Windblown waste materials were observed to have collected in multiple locations across the site (Photographs 8 & 9).	Waste Management to organise for a litter pick to be undertaken throughout the site	July 2023

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any new Discharges	N/A	None noted.	None	Not applicable
Management and control of hazardous waste	5	Access to the landfill is restricted by way of access gates, specified opening hours and check-ins/check-outs at the weighbridge.	None	Not applicable
	5	Disposal of hazardous waste requires acceptance of the waste prior to being delivered to the landfill, by DCC.	None	Not applicable
	5	Waste disposal dockets are provided to vehicle drivers when exiting the landfill.	None	Not applicable
	5	A leachate collection drain is installed around the majority of the perimeter of the landfill. Collected leachate / groundwater is pumped to the Green Island Wastewater Treatment Plant (WWTP) for treatment and discharge.	None	Not applicable
	5	Soil contaminated with asbestos is placed in certain managed areas of the landfill (Figure 1).	None	Not applicable
	5	Road sweepings which potentially contain asbestos are also managed and disposed of in a specific access controlled and secure area.	None	Not applicable
Management and control of hazardous waste - Odour	5	As the most recently used sludge pit had reached capacity, it has been sealed over with intermediate cap material. A new sludge pit has been dug to the north (Photographs 10 & 11 and on the Figure). During the site audit, vapour was observed to be venting from the new sludge pit. Odour, likely associated with the sludges received from the various WWTPs in the area, occurs when sludge is deposited into the sludge pits (which can take place up to 6 times per day). Odour issues are generally short lived, and the associated complaints from the public are quite dependent on the wind direction at the time of disposal. Odour mitigation methods are activated when the wind is blowing in specific directions.	None	Not applicable
	5	The odour cannon has not been used since prior to the October 2022 audit report.	None	Not applicable

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Faults, leaks or emergency repairs onsite	5	No faults noted or known of.	None	Not applicable
Complaints register	5	A digital complaints register is kept by DCC / Waste Management. This is populated by complaints received by email and telephone calls from the public.	The register is to be provided to GHD for annual compliance reporting purposes by DCC	July 2023
Evidence from contractor of the vermin and bird control that has been done	5	Vermin bait stations / traps were noted around Well Line 0 (Photograph 6), bait was present within the traps.	None	Not applicable
	4	Seagull / bird numbers are difficult to manage due to the protected status of some of the bird species and the long term nature of occurrence of the birds (generational).	Waste Management to undertake bird deterrent measures as necessary.	Ongoing
	5	No cats were observed during the audit.	None	Not applicable

Landfill Cap

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Seepage	N/A	None noted.	None	Not applicable
New landfill cap survey information	5	Construction of the final cap in the northern section of the site has been completed and hydroseed has been laid (Photograph 2).	None	Not applicable
	4	A final cap is in place over a portion of the eastern part of the landfill. However, the root systems of mature vegetation growth over this area (cabbage trees and other natives) may be damaging the cap. Large volumes of windblown waste has also accumulated here.	DCC / WM – vegetation to be cleared and suitable vegetation (shallow rooting) to be planted.	January 2024
	4	The number of thistle weeds have increased significantly in the paddocks around the transfer station and should be sprayed / removed.	DCC / WM to organise for the removal / spraying of weeds	April 2023

Landfill Gas

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to gas collection system	N/A	Minor changes occur to the collection network as the landfill face progresses.	None	Not applicable

Groundwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes to wells	4	Monitoring well MW4D has recorded basal depths of 12.2 m over the past few months. Prior to this, a maximum depth of 8.3 m was recorded. Historical DCC well installation details indicate that the well was drilled to a depth of 10.5 m bgl.	DCC to inspect and re-survey well to confirm well depth.	July 2023
	5	The conditions of the monitoring wells appear to be relatively unchanged since the last audit inspection.	None	Not applicable
	5	There were no well caps present on any of the piezometers. A survey of cap numbers and sizes has been undertaken by GHD.	DCC / GHD to organise replacements.	April 2023
	4	The concrete well head of MW7D is unstable.	DCC / WM to inspect and scope repairs.	July 2023
	5	7 groundwater wells were installed in late 2022 as part of closure and consenting works. These wells are located around the landfill perimeter and in the proposed resource recovery and processing precinct.	None	Not applicable

Surface water

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any offsite discharges into Kaikorai Stream and Estuary	5	The Kaikorai Stream level had dropped to 'normal' levels following what was observed during the October 2022 Audit report.	None	Not applicable
	5	A biological sheen was noted to be present on the surface water adjacent to GI3 (Photograph 12).	None	Not applicable
Sedimentation Ponds	5	During the week of the 16th January, the water level in the south-western pond was low. It was noted during a following visit on the 26th January, that the water level had increased.	None	Not applicable
	5	The water level in the eastern sedimentation pond was low. High pH (9.36) and dissolved oxygen (252.2%) measurements were recorded during the site works. These measurements are indicative of the presence of an oxidizing agent (or similar).	None	Not applicable
Staff Gauges	4	All staff gauges require cleaning. At present, the values are obscured due to algal growth and sediment adherence (Photograph 13).	WM	April 2023

Stormwater

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in stormwater collection system, including condition of the trench	5	A new culvert in the eastern portion of the site, servicing the haul road, has been installed adjacent to the green waste disposal area to (Photograph 14). No other changes were reported to GHD.	None	Not applicable
Is stormwater draining to the correct catchment	5	All stormwater collected is channelled towards PS1, PS3 or PS5. No faults or repairs were reported as occurring to GHD.	None	Not applicable
	5	Stormwater appears to be draining into the correct drains and sedimentation ponds.	None	Not applicable
Any spills from the landfill faults	N/A	None noted.	None.	Not applicable.

Leachate

	Rating	Notes/Comments	Actions assigned to personnel	Date to be achieved by
Any changes in leachate collection system, including condition of the trench	N/A	None noted.	None	Not applicable
Is leachate draining to correct capture system	5	All leachate appears to be collecting into the correct drainage system.	None	Not applicable
Any pump faults	5	All pumps operational.	None.	Not applicable.

1.1 Site Photos:

Photograph 1: A new barrier has been constructed around the northern sedimentation / leachate pond.

Photograph 2: Newly constructed access road, also showing grass seed on the recently capped area, looking east.

Photograph 3: Transfer station, clean, showing no wind blown waste present.

Photograph 4: Drained, crushed cars located between the tyre and whiteware storage areas.

Photograph 5: View of the current tip face, indicating the location of the temporary litter fences looking north.

Photograph 6: Newly created track leading from close to Line 0, to the north east, towards the borrow pit.

Photograph 7: Area of minor slump / erosion on the constructed road to the borrow pit.

Photograph 8: Wind blown waste throughout the area of final caped area in the eastern portion of the landfill.

Photograph 9: Minor to moderate amounts of windblown litter around the landfill access tracks.

Photograph 10: Location of previous sludge pit, looking north.

Photograph 11: Location of the current sludge pit, looking south east.

Photograph 12: Biological sheen noted on the surface water adjacent to GI3 in the Kaikorai Stream.

Photograph 13: All staff gauges require cleaning to make the numbers and ticks legible.

Photograph 14: New culvert has been installed adjacent to the green waste disposal area, looking south west.

1.2 Figure 1 – Site Audit Observations

Auditor	Paige Wills
Audit date	12/04/2023
Audit type	Environmental Audit
Reason for Audit	Resource consent compliance (Condition 7 of Consent No. 2003.740)
Audit categorisation	Routine
Site/premises name	Green Island Landfill
GIS Coordinate of Site Latitude / Easting Longitude / Northing	NZTM (NZGD 2000) -45.907987 / 1399091 170.409622 / 4912913

General Comments

Size of the working face	No significant changes to the size of the working face observed during the visual inspection.
New areas of disposal, changes onsite	The working face of the landfill has moved to the south since the January 2023 Audit.

Audit Rating Categories

Rating	Description
1	Significant issues and risk– non-compliance with consent
2	Major issues on site
3	Moderate issues on site
4	Minor issues on site
5	No issues

General Site Compliance

	Rating	
General Housekeeping, Observations and summary of interview with landfill manager	4	New sludge pit has been created southeast of previously covered sludge pit. Installed one month ago. Gas bubbles were seen escaping from surface of the liquid in the sludge pit. Photograph 1
	5	A large volume of Whiteware was noted present within the Whiteware storage area. Photograph 2
	4	Miscellaneous waste (mostly scrap metal) has been placed between tyre and whiteware storage areas. This material should be placed in a designated scrap metal area. Photograph 3
Evidence of the prevention of waste materials moving offsite	5	The tip face has extended towards the south of previous tip face.
	4	Litter has migrated past the extent of the temporary litter fences. Photograph 4
	4	Waste including buckets and wooden poles have been placed in the construction and demolition pile at the landfill face working area. This waste needs to be placed in correct area. Photograph 5

	Rating	Notes/Comments
Any new Discharges	5	No changes have been observed
Management and control of hazardous waste	5	No changes have been observed

	Rating	Notes/Comments
Faults, leaks or emergency repairs onsite	5	No changes have been observed and no emergency repair work was reported to the auditor.
Evidence from contractor of the vermin and bird control	5	Vermin trap located by well MW0 has been damaged and destroyed.

Landfill Cap

	Rating	Notes/Comments
Seepage	5	No changes have been observed
New landfill cap survey information	4	Significant weed growth noted over the new final cap area.
	5	Auditor was informed by Waste Management staff that additional topsoil and grass seed is to be placed over the new final capped area.

Landfill Gas

	Rating	Notes/Comments
Any changes to gas collection system	5	No changes have been observed.

Groundwater

	Rating	Notes/Comments
Any changes to wells	4	Well caps have been installed on all wells excluding MW6A and MW8A within the monitoring network.

Surface water

	Rating	Notes/Comments
Any offsite discharges into Kaikorai Stream and Estuary	5	No discharges were observed.
Sedimentation Ponds	4	A significant amount of litter was noted present both on the surface and on the pond floor at the western sedimentation pond. It is recommended that the litter is removed from the pond. Photograph 6 The auditor noticed a sheen on surface of the pond.
Staff Gauges	4	No changes have been observed

Stormwater

	Rating	Notes/Comments
Any changes in stormwater collection system, including condition of the trench	4	Two new sedimentation ponds have been constructed on the southwestern side of the landfill, one large and one small. They both have fences constructed around them. Photograph 7
Is stormwater draining to the correct catchment	5	It appears to be.
Any spills from the landfill faults	5	No faults have been observed.

Leachate

	Rating	Notes/Comments
Any changes in leachate collection system, including condition of the trench	5	No changes have been observed.
Is leachate draining to correct capture system	5	It appears to be.
Any pump faults	5	Auditor was not informed of any pump faults.

1.1 Site Photos:

Photograph 1: New sludge pit located east of old sludge pit.

Photograph 2: Large volume of Whiteware goods awaiting degassing and removal from site.

Photograph 3: Miscellaneous scrap metal present between the Whiteware and tyre storage areas.

Photograph 4: Temporary fences have been moved but wind-blown waste has migrated beyond the fence boundaries.

Photograph 5: ***Timber and buckets noted present in the bricks / demolition waste stockpile.***

Photograph 6: *Wind-blown litter present on the surface and base of the Western Sedimentation Pond*

Photograph 7: ***The smaller of the two new sedimentation ponds.***

1.2 Figure 1 – Site Audit Observations

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→ The Power of Commitment

Appendix C

Addendum Report PFAS and Hydrology

Addendum Report – PFAS and Hydrology

30 April 2024

To	Chris Henderson	**Contact No.**	N/A
Copy to	N/A	**Email**	chris.henderson@dcc.govt.nz
From	Stephen Douglass/Dusk Mains	**Project No.**	12613624
Project Name	Green Island Landfill Consenting to Closure and RRPP Consenting		
Subject	Addendum Report – Updated Groundwater and Surface Water PFAS results for Green Island landfill and Surface Water Management		

Introduction

Dunedin City Council (DCC) submitted consent applications for the operation and closure of Green Island Landfill (GILF) in March 2023. This addendum has been prepared to correct two aspects of the Surface Water Report (GHD, 2023), namely:

– Erroneous laboratory data reported for PFAS and PFOA
– Hydrological functioning of Western Sedimentation Pond and the South-Western Pond based on new information

Background

PFAS/PFOA

The groundwater and surface water technical assessments prepared to support the consent applications include the results of water quality analysis for presence of Persistent Organic Pollutants (POP), specifically PFOS and PFOA (i.e. perfluoroalkyl and polyfluoroalkyl substances)[1]. In March 2023 results were reported for sampling rounds undertaken in October 2022 and January 2023. Two samples (MW4C and W Pond) collected in October 2022 reported anomalous results, significantly higher than other samples 9all sample locations are shown on Figure 1). GHD requested re-testing of two samples (MW4C and Western Sediment Pond) by the laboratory provider (Eurofins). The retested sample for MW4C produced significantly different results (15 µg/L in the initial testing and <0.001 µg/L for the re-test). The laboratory stated that for sample location Western Sedimentation Pond, they did not have sufficient sample volume to perform a repeat analysis. Due to the inconsistencies in the laboratory data, Eurofins have concluded that the October 2022 dataset should be discarded. Further detail is provided in Eurofins letter attached to this report (Appendix A). GHD has subsequently undertaken additional sampling in April 2023 and August 2023 for POP in groundwater and surface waters at the site and the results are presented in the following sections of this report.

[1] GHD, 2023a. Waste Futures – Green Island Landfill Closure: Groundwater Technical Assessment. Prepared for Dunedin City Council 9 March 2023.
[1] GHD, 2023b. Waste Futures – Green Island Landfill Closure: Surface Water Technical Assessment. Prepared for Dunedin City Council 9 March 2023.

Hydrology of Western Sediment Pond

The Surface Water Report (GHD, 2023) stated in Section 3.4.1 (page 11) that the *"SW Pond is located outside the landfill designation and does not have any direct connection to water management catchments or leachate collection systems".* Whilst this statement is accurate, as the SW Pond is not directly connected to water management catchments on the landfill or leachate collection systems, the hydrology of the Western Sedimentation Pond and the South Western Pond has been updated to better characterise the functioning of the ponds.

Purpose of this report

This addendum report has been prepared to provide an update of the PFAS analyses and interpretation presented in the Groundwater Technical Assessment and the Surface Water Technical Assessment reports. This is on the basis of the October 2022 results being discarded, whilst the results from two additional monitoring rounds (April 2023 and August 2023) are now included and have been presented along with the previous January 2023 results which remain valid.

In addition, the functioning of the Western Sedimentation Pond and the adjacent South Western Pond has been updated to clarify the flow paths and connections to the landfill and the receiving Kaikorai Estuary.

This addendum report should be read in conjunction with the March 2023 application technical reports which provide further background on the site setting and technical related matters along with plans showing the location of the monitoring results presented in this report.

The results from this addendum have also been incorporated into the Human Health and Ecological Risk Assessment completed for the site[2].

Scope and limitations

Scope of work

The scope of this report is to:

– Present the results of sampling for PFOS and PFOA compounds in surface water and groundwater monitoring locations at Green Island Landfill.
– Clarify the hydrological functioning of Western Sedimentation Pond and the South Western Pond.

Water Quality Results

Laboratory results from the three sampling rounds, January 2023, April 2023 and August 2023 are included in Appendix A. Samples were collected from groundwater (Monitoring Wells), surface water (Kaikorai Stream) and site ponds and constructed wetlands. Samples were also collected from the leachate collection trench (PS3). All sampling locations are shown on Figure 1. The laboratory results from the sampling indicate the following:

Groundwater

– PFAS compounds were detected in all the groundwater monitoring wells sampled at least once, with the exception of MW4C and MW7D.
– MW3C recorded the highest Total PFAS of the groundwater monitoring wells in all three sampling events (0.02 - 0.0274 µg/L).

There was no clear pattern in the concentration and occurrence of PFAS in groundwater and the distribution of waste (particularly in areas where historic waste is present outside of the trench). The two monitoring wells

[2] GHD, 2024. Green Island Landfill: Human Health and Ecological Risk Assessment. Prepared for Dunedin City Council 10 April 2024.

(MW4C and MW7D) where PFAS has not been detected, are located in areas identified as being influenced by historic waste. Conversely, monitoring wells MW1C and MW2C, which are inferred to be located outside of historic waste, contained PFAS compounds at low concentrations.

– The concentration of Total PFAS obtained from PS3, which is representative of leachate mixed with groundwater, was consistently similar for all sampling events, with concentrations (0.22 - 0.441 µg/L) and at least an order of magnitude above the groundwater samples. If leachate was migrating beyond the leachate trench it would be reasonable to expect that the concentrations of PFAS in the groundwater perimeter wells would be similar to the leachate PS3 sample.

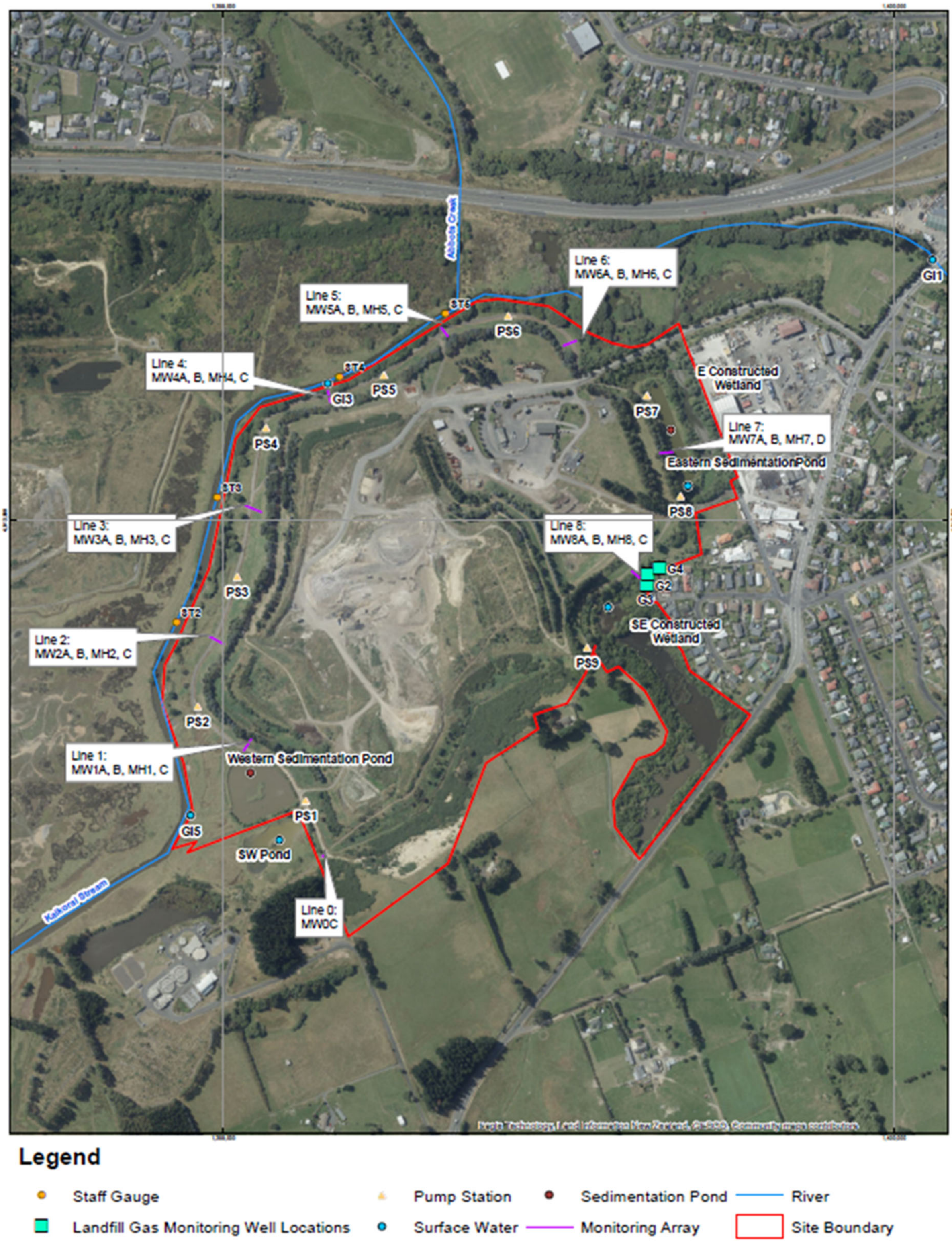

Figure 1 – Surface Water and Groundwater Sampling Locations

Surface water

The Kaikorai Estuary sample results indicated the following:

January 2023 surface water indicated low concentrations of PFAS compounds within the upstream monitoring site (GI1 result of 0.001 µg/L for Total PFOS), and the site immediately below the confluence of Kaikorai Stream and Abbots Creek (GI3 result of 0.0012 µg/L for Total PFOS). Results were below laboratory detection limits of 0.001 µg/L for GI2 (upstream on Abbotts Creek), GI5 (downstream on Kaikorai), and the Estuary site (near Brighton Road bridge).

– There were no samples collected for the surface water locations GI1, GI2, GI3, GI5 and Estuary in April 2023.
– The August 2023 results shows similar levels of PFAS concentrations throughout all the surface water monitoring locations. GI1 exhibited a concentration of 0.0008 µg/L, whilst GI2 returned a concentration of 0.0004 µg/L. At GI3 the concentration was 0.0009 µg/L, increasing to 0.0028 µg/L at GI5. The Estuary concentration was 0.0009 µg/L.
– It is noted that the laboratory detection limits for the August 2023 sampling round for PFAS of 0.0004 µg/L was lower than the January 2023 sampling round.

The samples collected from the constructed wetlands at the landfill indicated the following:

– In January 2023 sample result for the NE Wetland for Total PFAS was 0.031 µg/L and the SE Wetland was 0.0013 µg/L. The wetlands were sampled again in August 2023, with the two samples showing that Total PFAS did not exceed the laboratory detection limit.
– The two wetlands are connected via a concrete culvert as described in the application documents. The culvert has been shown to have a minor ingress of groundwater impacted by leachate, which explains the increase in concentration in Total PFAS between the two sites in January. It is also noted that the sample is collected directly at the outfall of the culvert into the NE wetland.

The two sedimentation ponds located at the eastern and western edges of the landfill indicated the following:

– The Eastern and Western Sedimentation Ponds, which receive stormwater runoff from the landfill, were sampled in April and August 2023. The samples collected from the ponds in April 2023 indicates Total PFAS in similar concentrations, with the Eastern Sedimentation Pond exhibiting a concentration of 0.011 µg/L and the Western Sedimentation Pond sample having a concentration of 0.0126 µg/L.
– In August 2023 the Eastern Sedimentation Pond sample was similar to the April result, with a concentration of 0.015 µg/L. The Western Sedimentation Pond sample was approximately half an order of magnitude lower than the April result, with a concentration of 0.0043 µg/L.

The PFAS concentrations in both ponds were lower than the leachate sample from PS3, but higher than the results recorded in the groundwater perimeter wells and the surface water samples (from Kaikorai Estuary and Abbotts Creek). The ponds are located outside the leachate interception trench with the water level in the ponds recorded above the groundwater level in the shallow wells (i.e. shows a downward vertical hydraulic gradient from the ponds to groundwater). This suggests that a groundwater pathway from the landfill to the sedimentation ponds is unlikely to be complete.

The South Western Pond, which is located near monitoring well MW0 indicated the following:

– In January 2023 the Total PFAS concentration was reported as 0.0011 µg/L. In April the result was similar, with a concentration of 0.0018 µg/L reported. In August 2023 the concentration increased by an order of magnitude to 0.0139 µg/L.

The presence of PFAS compounds in the water has similar concentrations to those measured in the Western Sedimentation Pond. However, surcharging of water during tidal events from the Kaikorai Estuary cannot be discounted, with the results from GI5 in August showing a concentration slightly higher than that recorded in the Pond for the same sampling event.

– The concentrations found in groundwater from MW0 do not support a groundwater pathway.

Western Sedimentation Pond Hydrology

The section provides an update on the hydrology of the Western Sediment pond and the adjacent South West Pond.

The Western Sedimentation Pond is presently isolated from the landfill catchments, with no known direct inflows from landfill catchments (see drawing C401 in the Design Report). However, historically the pond received stormwater inflows from western parts of the site, which were not otherwise contaminated by landfilling activities. Historical Landfill Management Plans show the changes to the catchment over time, with the catchment shrinking as landfilling activities progressed to the SW corner of the landfill. The previous landfill management plans up to circa 2007 show that inflows to the pond occurred via a surface culvert located in the northern corner of the pond, which conveyed surface flow from cleanfill areas of the site via surface drainage channels and down the western bund. A secondary inflow pathway was via a buried culvert, which is located approximately 50 m to the south. The inlet of the culvert is at approximately 105.5 m RL and the outlet is at or about 100.7 m RL (i.e. at the approximate base of the Western Sedimentation Pond). Details of the buried culvert are shown in Appendix B. Both of these culverts have been blocked off and are not thought to be an active pathway for landfill impacted surface water to enter the Western Sedimentation Pond.

The Western Sedimentation Pond has a low weir and associated culvert which allows for discharge of water to the Kaikorai Estuary. The design of the weir is provided in Appendix B. It shows a low level 80 mm PVC pipe outlet, with an invert of 101.2 mRL, with the outlet intended to have a non-return valve installed. The overflow weir has an invert of 102.0 mRL. At some point during the construction of the Western Sedimentation Pond, the South Western Pond was also enhanced and developed. A 2000 drawing shows the designs and changes to the outlets from the Western Sedimentation Pond and the use of the South Western Pond as polishing pond prior to discharge to the Kaikorai Estuary (See Appendix B).

The figure shows that the low-level PVC pipe beneath the weir was to be blocked off, with a new 80mm PVC pipe to be installed between the Western Sedimentation Pond and the South Western Pond. The invert of the pipe outlet is 101.35 m RL, whilst the South Western Pond has a low level weir with an invert of 101.25 m RL at its outlet to the channel that connects the pond to the Kaikorai Estuary. The South Western Pond also receives stormwater inflows from the southern valley catchment, where an earth bund cuts off stormwater flow from the hills to the south of the landfill and directs it away from the landfill southern valley leachate drain and into the pond.

Since circa 2000 the Western Sedimentation Pond has had a low level discharge into the South Western Pond via the 80 mm diameter pipe. The South Western Pond then discharges to the Kaikorai Estuary via a channel which is open to the Estuary. Surcharging of water from the Estuary into the pond can occur during tidal cycles when water levels exceed the low level weir elevation of approximately 101.25 mRL.

Photographs showing these changes are provided in Appendix B.

Summary

The sampling for POP, in particular PFAS and PFOA compounds, in surface waters and groundwater around the Green Island landfill has been undertaken to characterise the potential impacts of the historical and ongoing landfilling activities on the surrounding environment. This sampling adds further context to the environmental monitoring that has been undertaken as part of the resource consent conditions that DCC holds for the landfill (which are continuing to be exercised under s.124 of the RMA).

The number of samples that have been collected for PFAS and PFOA compounds to date is limited to two to three samples per site. The small number of samples does limit the degree of confidence that can be applied to the results, noting that statistical analysis is not able to be undertaken on such a small sample set. However, the results collected to date provided a number of early indicators:

PFAS and PFOA compounds have been found in all sampling locations, including upstream locations in the Kaikorai Stream and Abbotts Creek. This indicates that the catchment as a whole is reflective of an impacted urban stream, as described in the consent application.

– Groundwater monitoring results from some shallow perimeters wells (i.e. C wells) show low concentrations of PFAS compounds. However, the concentrations are typically lower than those measured in surface water samples (GI1, GI2, GI3, GI5 of Estuary). There is also indication that PFAS compounds are found in some of the deeper well samples, with concentrations lower than those in the shallow wells and surface water samples.

The sedimentation ponds exhibit concentrations of PFAS that are typically greater than found in shallow groundwater and surface water of the Kaikorai Estuary. The ponds are located outside the leachate collection trench and are unlikely to receive significant groundwater inflow.

– The South Western Pond, which is located near MW0, exhibits similar concentrations of PFAS compounds as the Western Sedimentation Pond and the Kaikorai Estuary. There is a low flow discharge that occurs between the sedimentation pond and the South Western Pond, which then flows to the Kaikorai Estuary. It is also noted that surcharging the SW Pond from the estuary is likely to occur during tidal cycles.
– The hydraulic connection during high rainfall and flow events is also uncertain, and there may be potential pathways that are created during these events. The proposed improvements to the stormwater, leachate collection and flood protection structures in the applications are targeted to improve the water quality outcomes.

Limitations

This report: has been prepared by GHD for Dunedin City Council and may only be used and relied on by Dunedin City Council for the purpose agreed between GHD and Dunedin City Council as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Dunedin City Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 2 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

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Appendices

Appendix A - Eurofins letter and PFAS Data

eurofins | Environment Testing

13th September 2023

ATN: Cecilia Gately
GHD
Level 3, 138 Victoria Street
Christchurch, New Zealand, 8141

PFAS analysis performed on Eurofins report 931160 (Project Ref GILF Closure Consent 12547621) was initially reported on the 31st of October 2022 with report reference 931160-W_INT. PFAS results for locations MW4C (K22-Oc0022580) and W Pond (by MW0) (K22-Oc0022586) were then queried by GHD on the 2nd March 2023. Both sample locations showed elevated PFAS levels and profiles across PFOS and PFHxS compared to the remainder of the sample location dataset. Sample location MW4C was repeated and returned non-detect. This was repeated further to confirm the non-detect of PFAS within the location. Sample location W Pond (by MW0) did not have sufficient volume to perform repeat analysis, and unfortunately, no further investigation could be performed.

Additional duplicate analysis was also performed on a selection of samples for further QA/QC purposes and encompassed the following sample locations – MW0C, MW8C, and E Pond. All duplicate analyses confirmed the originally reported results.

Considering the error identified in sample location MW4C and the insufficient remaining volume for location W Pond (by MW0), there is a gap in the ability to sufficiently investigate and assess the robustness of the data set as a whole. As a result, the dataset within report 931160 should be voided from site characterisation, assessment, and action.

As a result of the identified error, a formal corrective and preventative action (CAPA-0338-B) process has been initiated to document the investigation to date, the determination of the root cause and the required steps for preventative action. I apologise for the timeline and outcome of this process in answering the raised questions. If there are any further questions, please don't hesitate to contact me.

Regards,

Jonathon Angell
General Manager - QLD

Eurofins Environment Testing Australia

Environment Testing

Green Island Closure Consents PFAS Sampling Results - January 2023

GHD Sample Name	Units	LOR	MW0C	MW1C	MW2C	MW2D	MW3C	MW4C	MW4D	MW5C	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-01370-1	23-01370-2	23-01370-3	23-01370-4	23-01370-5	23-01370-6	23-01370-9	23-01370-7				
Sample Date			17/01/2023	17/01/2023	17/01/2023	17/01/2023	17/01/2023	17/01/2023	17/01/2023	17/01/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.001	<0.0010	<0.0010	<0.0010	<0.0010	0.0017	<0.0010	<0.0010	0.002	-	-	-	-
PFOS (Total)	µg/L	0.001	<0.0010	<0.0010	<0.0010	<0.0010	0.0073	<0.0010	<0.0010	<0.0010	0.00023	0.13	2	-
PFOA	µg/L	0.001	<0.0010	<0.0010	<0.0010	<0.0010	0.011	<0.0010	<0.0010	0.0088	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	-	N/A	N/A	N/A	N/A	0.009	N/A	N/A	0.002	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	N/A	N/A	N/A	N/A	0.019	N/A	N/A	0.0088	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	N/A	N/A	N/A	N/A	0.02	N/A	N/A	0.011	-	-	-	-

GHD Sample Name	Units	LOR	MW6C	MW7D	MW8C	W POND (BY MW0)	NE WETLAND	SE WETLAND	ESTUARY	PS3	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-01370-8	23-01704-4	23-01704-5	23-02828-01	23-01704-1	23-01704-2	23-01704-3	23-01371-3				
Sample Date			17/01/2023	18/01/2023	18/01/2023	27/01/2023	18/01/2023	18/01/2023	18/01/2023	17/01/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.001	<0.0010	<0.0010	<0.0010	<0.0010	0.069	<0.0010	<0.0010	0.049	-	-	-	-
PFOS (Total)	µg/L	0.001	<0.0010	<0.0010	0.0019	0.0011	0.031	0.0013	<0.0010	0.057	0.00023	0.13	2	-
PFOA	µg/L	0.001	<0.0010	<0.0010	<0.0010	0.002	0.18	0.0046	0.0014	0.11	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	-	N/A	N/A	0.0019	0.0011	0.1	0.0013	N/A	0.11	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	N/A	N/A	0.0019	0.0031	0.22	0.0059	0.0014	0.17	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	N/A	N/A	0.0019	0.0031	0.29	0.0059	0.0014	0.22	-	-	-	-

GHD Sample Name	Units	LOR	GI1	GI2	DUP 01	GI3	GI5	TRIP BLANK	FIELD BLANK	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-01714-1	23-01714-2	23-01704-8	23-01714-3	23-01714-4	23-01704-6	23-01704-7				
Sample Date			18/01/2023	18/01/2023	18/01/2023	18/01/2023	18/01/2023	18/01/2023	18/01/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances													
PFHxS (Total)	µg/L	0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-	-	-	-
PFOS (Total)	µg/L	0.001	0.001	<0.0010	<0.0010	0.0012	<0.0010	<0.0010	<0.0010	0.00023	0.13	2	-
PFOA	µg/L	0.001	0.0011	<0.0010	<0.0010	0.0012	<0.0010	<0.0010	<0.0010	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	-	0.001	N/A	N/A	0.0012	N/A	N/A	N/A	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	0.0021	N/A	N/A	0.0024	N/A	N/A	N/A	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	0.0021	N/A	N/A	0.0024	N/A	N/A	N/A	-	-	-	-

Notes:
LOR - Limit of Reporting
µg/L - micrograms per liter
MAV - Maximum Acceptable Limit
< - Less than the LOR
N/A - No data present due to results being reports as below the LOR.
Values shaded grey represent concentrations lower than the LOR
Dup 01 is a duplicate sample of sample GI2.
- symbol indicates that no data is avaliable.

1 - Ecological water quality guidelines for 99% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
2 - Ecological water quality guidelines for 95% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
3 - Ecological water quality guidelines for 90% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
4 - Water services (Drinking water standards for New Zealand (DWSNZ)) Regulations 2022.

Green Island Closure Consents PFAS Sampling Results - April 2023

GHD Sample Name	Units	LOR	MW0C	MW1C	MW2C	MW2D	MW3C	MW4C	MW4D	MW5C	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-11202-1	23-11202-2	23-11202-3	23-11202-4	23-11202-5	23-11202-6	23-11202-7	23-11285-1				
Laboratory Work Order			ES2313255-001	ES2313255-002	ES2313255-003	ES2313255-004	ES2313255-005	ES2313255-006	ES2313255-007	ES2313258-001				
Sample Date			12/04/2023	12/04/2023	12/04/2023	12/04/2023	12/04/2023	12/04/2023	12/04/2023	13/04/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0028	-	-	-	-
PFOS (Total)	µg/L	0.0003	0.0012	0.0009	<0.0004	<0.0004	0.0082	<0.0004	0.0012	<0.0004	0.00023	0.13	2	-
PFOA	µg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0192	<0.005	0.0008	0.0121	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	0.0003	0.0012	0.0009	<0.0004	<0.0004	0.0082	<0.0004	0.0012	0.0028	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	0.0012	0.0009	N/A	N/A	0.0274	N/A	0.002	0.0121	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	0.0012	0.0009	N/A	N/A	0.0274	N/A	0.002	0.0149	-	-	-	-

GHD Sample Name	Units	LOR	MW6C	MW7D	MW8C	W POND (BY MW0)	ESTUARY	PS3	E POND	W POND	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-11285-2	23-11285-3	23-11285-4	23-11202-9	23-11202-10	23-11202-11	23-11285-5	23-11202-8				
Laboratory Work Order			ES2313258-002	ES2313258-003	ES2313258-004	ES2313255-009	ES2313255-010	ES2313255-011	ES2313258-005	ES2313255-008				
Sample Date			13/04/2023	13/04/2023	13/04/2023	13/04/2023	13/04/2023	13/04/2023	13/04/2023	13/04/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.104	0.0043	<0.0005	-	-	-	-
PFOS (Total)	µg/L	0.0003	<0.0004	<0.0004	0.0024	0.0018	0.0047	0.0886	0.011	0.0126	0.00023	0.13	2	-
PFOA	µg/L	0.0005	<0.0005	<0.0005	0.0008	0.0014	0.0006	0.248	0.022	0.0137	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	0.0003	<0.0004	<0.0004	0.0024	0.0018	0.0047	0.193	0.015	0.0126	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	N/A	N/A	0.0032	0.0032	0.0053	0.337	0.033	0.0263	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	N/A	N/A	0.0032	0.0032	0.0053	0.441	0.0375	0.0263	-	-	-	-

Notes:
LOR - Limit of Reporting
µg/L - micrograms per liter
MAV - Maximum Acceptable Limit
< - Less than the LOR
N/A - No data present due to results being reports as below the LOR.
Values shaded grey represent concentrations lower than the LOR
- symbol indicates that no data is avaliable.

1 - Ecological water quality guidelines for 99% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
2 - Ecological water quality guidelines for 95% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
3 - Ecological water quality guidelines for 90% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
4 - Water services (Drinking water standards for New Zealand (DWSNZ)) Regulations 2022.

Green Island Closure Consents PFAS Sampling Results - August 2023

GHD Sample Name	Units	LOR	MW0C	MW1C	MW2C	MW2D	MW3C	MW4C	DUP01	MW4D	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-25665-1	23-25665-2	23-25665-3	23-25665-4	23-25665-5	23-25665-6	23-25665-14	23-25665-7				
Laboratory Work Order			ES2329846-001	ES2329846-002	ES2329846-003	ES2329846-004	ES2329846-005	ES2329846-006	ES2329846-0014	ES2329846-007				
Sample Date			28/08/2023	28/08/2023	28/08/2023	28/08/2023	28/08/2023	28/08/2023	28/08/2023	28/08/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.0005	<0.0005	<0.0005	0.0126	<0.0005	0.0024	<0.0005	<0.0005	<0.0005	-	-	-	-
PFOS (Total)	µg/L	0.0002	0.0004	<0.0004	0.0078	0.0026	0.0092	<0.0004	<0.0004	0.0009	0.00023	0.13	2	-
PFOA	µg/L	0.0005	0.0008	<0.0005	<0.0005	<0.0005	0.0127	<0.0005	<0.0005	<0.0005	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	0.0002	0.0004	<0.0004	0.0204	0.0026	0.0116	<0.0004	<0.0004	0.0009	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	0.0012	N/A	0.0078	0.0026	0.0219	N/A	N/A	0.0009	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	0.0012	N/A	0.0204	0.0026	0.0243	N/A	N/A	0.0009	-	-	-	-

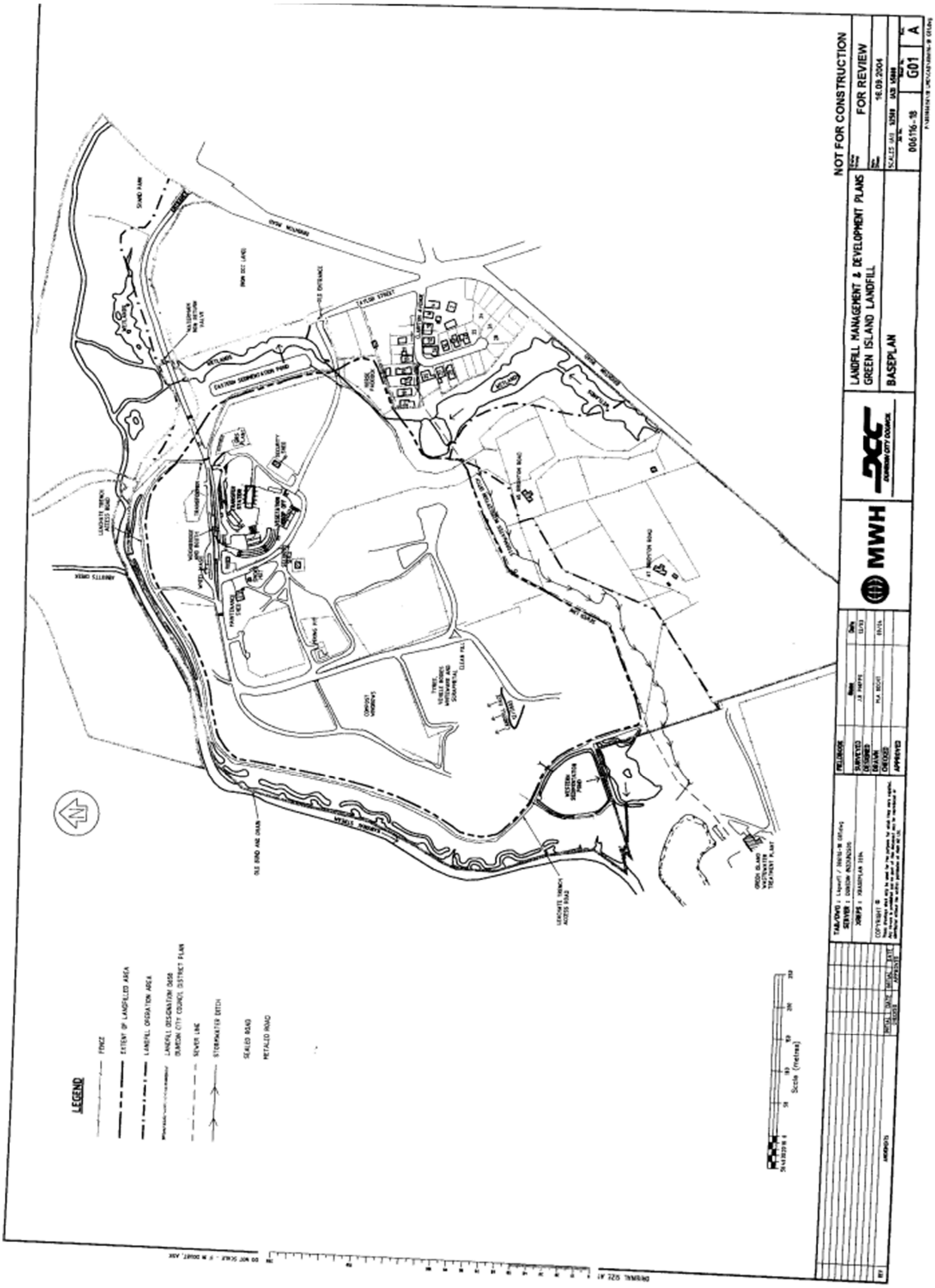
GHD Sample Name	Units	LOR	MW5C	MW6C	MW7D	MW8C	W POND (BY MW0)	NE WETLAND	SE WETLAND	ESTUARY	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-25665-8	23-25665-9	23-25665-10	23-25665-11	23-25926-5	23-25926-1	23-25926-2	23-25926-6				
Lab Reference			ES2329846-008	ES2329846-009	ES2329846-010	ES2329846-011	ES2332296-005	ES2332296-001	ES2332296-002	ES2332296-006				
Sample Date			28/08/2023	28/08/2023	28/08/2023	28/08/2023	29/08/2023	29/08/2023	29/08/2023	29/08/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.0005	0.0044	0.0021	<0.0005	<0.0005	0.0013	0.0046	<0.0040	<0.0005	-	-	-	-
PFOS (Total)	µg/L	0.0002	0.002	0.0024	<0.0004	0.002	0.0139	<0.0040	<0.0040	0.0009	0.00023	0.13	2	-
PFOA	µg/L	0.0005	0.011	0.0033	<0.0005	<0.0005	0.0063	0.0088	<0.0040	0.0007	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	0.0002	0.0064	0.0045	<0.0004	0.002	0.0152	0.0046	<0.0040	0.0009	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	0.013	0.0057	N/A	0.002	0.0202	0.0088	N/A	0.0016	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	0.0174	0.0078	N/A	0.002	0.0215	0.0134	N/A	0.0016	-	-	-	-

GHD Sample Name	Units	LOR	PS3	GI1	GI2	GI3	GI5	E POND	W POND	FIELD BLANK	99% species protection - Freshwater/ Interim marine[1]	95% species protection - Freshwater/ Interim marine[2]	90% species protection - Freshwater/ Interim marine[3]	DWSNZ guideline values 2022[4] (MAV)
Laboratory Project Reference			23-25665-12	23-25926-7	23-25926-8	23-25926-9	23-25926-10	23-25926-3	23-25926-4	23-25665-13				
Lab Reference			ES2329846-012	ES2332296-007	ES2332296-008	ES2332296-009	ES2332296-010	ES2332296-003	ES2332296-004	ES2329846-013				
Sample Date			28/08/2023	29/08/2023	29/08/2023	29/08/2023	29/08/2023	29/08/2023	29/08/2023	29/08/2023				
Perfluoroalkyl and Polyfluoroalkyl Substances														
PFHxS (Total)	µg/L	0.0005	0.0637	<0.0005	<0.0005	<0.0005	<0.0005	0.0044	0.0058	<0.0005	-	-	-	-
PFOS (Total)	µg/L	0.0002	0.1	0.0008	0.0004	0.0009	0.0028	0.015	0.0043	<0.0004	0.00023	0.13	2	-
PFOA	µg/L	0.0005	0.162	<0.0005	<0.0005	<0.0005	0.0013	0.0164	0.016	<0.0005	19	220	632	0.56
Sum (PFHxS (Total) + PFOS (Total))	µg/L	0.0002	0.164	0.0008	0.0004	0.0009	0.0028	0.0194	0.0101	<0.0004	-	-	-	0.07
Sum (PFOS (Total) + PFOA (Total))	µg/L	-	0.262	0.0008	0.0004	0.0009	0.0041	0.0314	0.0203	N/A	-	-	-	-
Sum (PFHxS (Total) + PFOS (Total) + PFOA)	µg/L	-	0.326	0.0008	0.0004	0.0009	0.0041	0.0358	0.0261	N/A	-	-	-	-

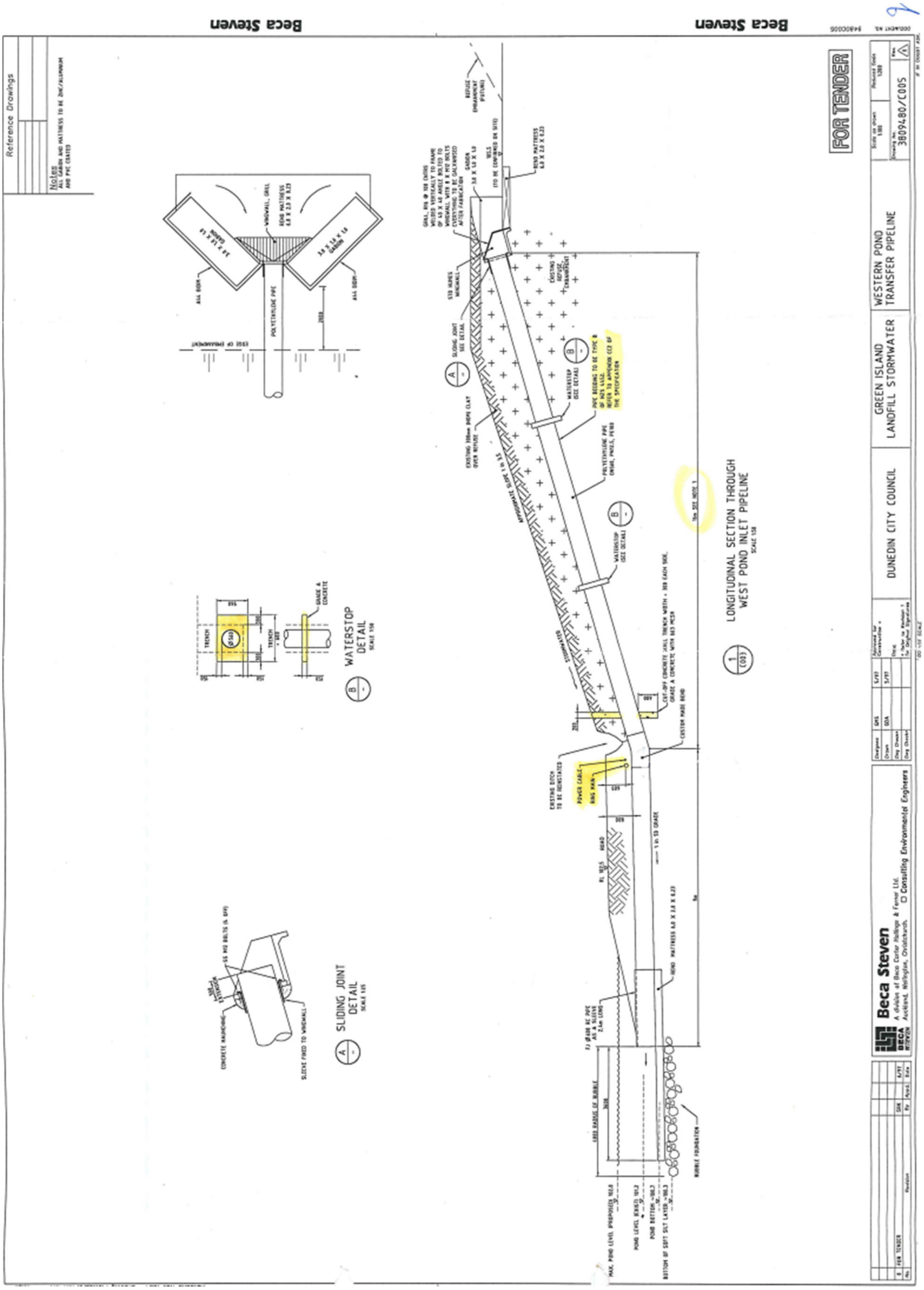
Notes:
LOR - Limit of Reporting
µg/L - micrograms per liter
MAV - Maximum Acceptable Limit
- symbol indicates that no data is avaliable.
< - Less than the LOR
N/A - No data present due to results being reports as below the LOR.
Values shaded grey represent concentrations lower than the LOR.
Dup 01 is a duplicate sample of sample MW4C.

1 - Ecological water quality guidelines for 99% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
2 - Ecological water quality guidelines for 95% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
3 - Ecological water quality guidelines for 90% (Freshwater and Interim marine) (PFAS National Environmental Management Plan Version 2.0).
4 - Water services (Drinking water standards for New Zealand (DWSNZ)) Regulations 2022.

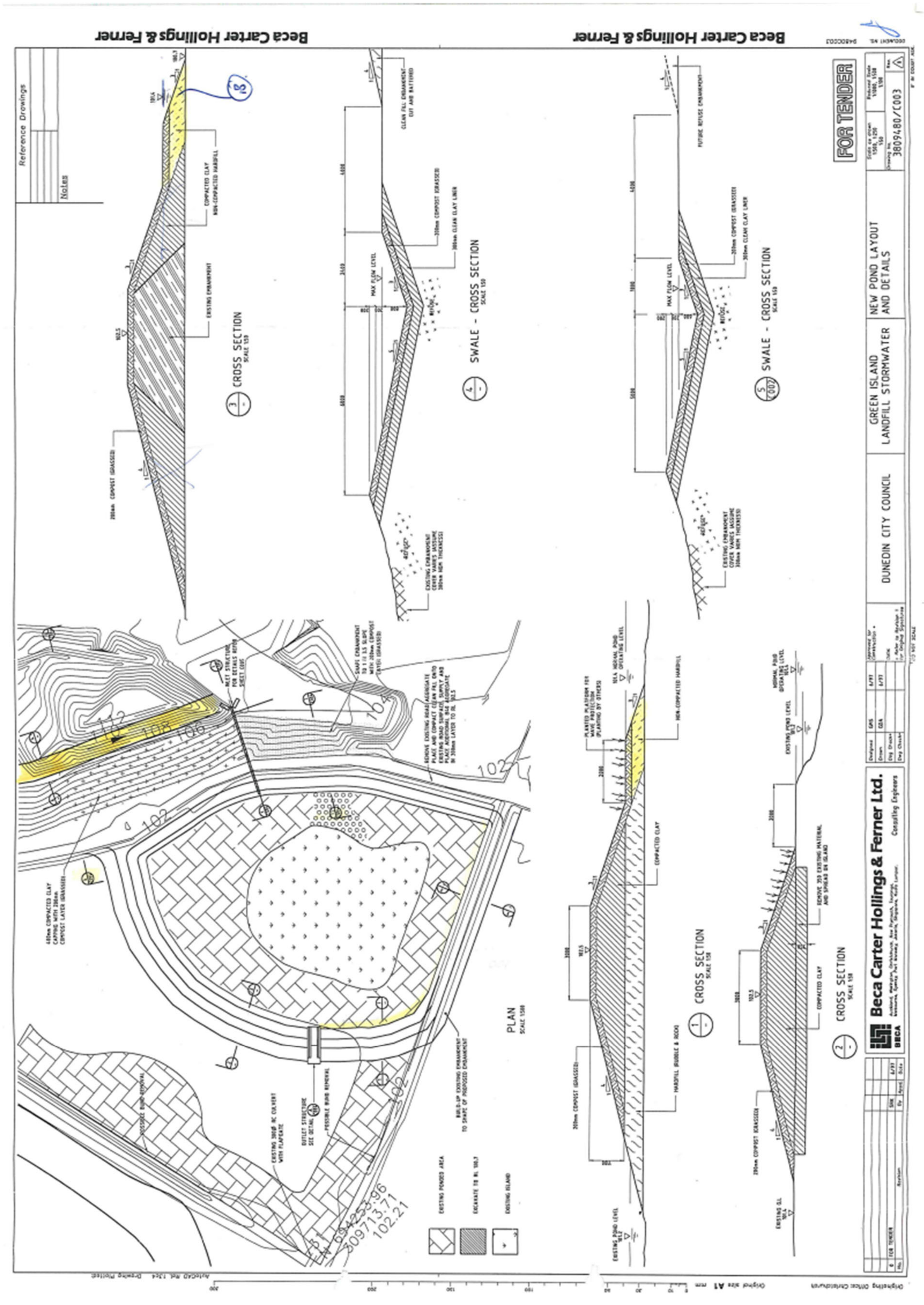
Appendix B - Figures



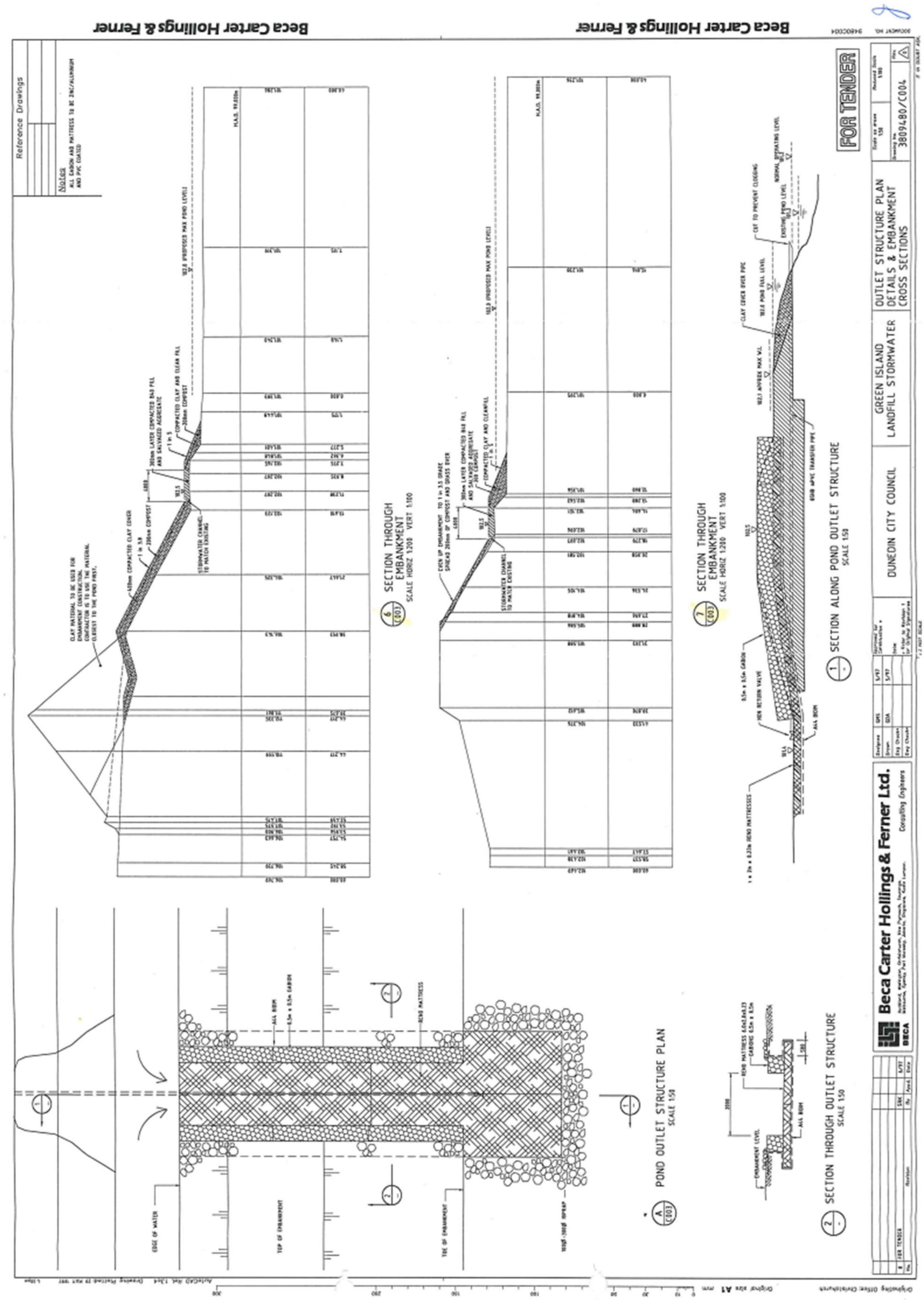
Green Island Landfill site plan Sept 2004



Beca Design for PE culvert inlet to Western Sedimentation Pond



Beca Design of Western Sedimentation Pond



Beca Design of weir outlet from Western Sedimentation Pond

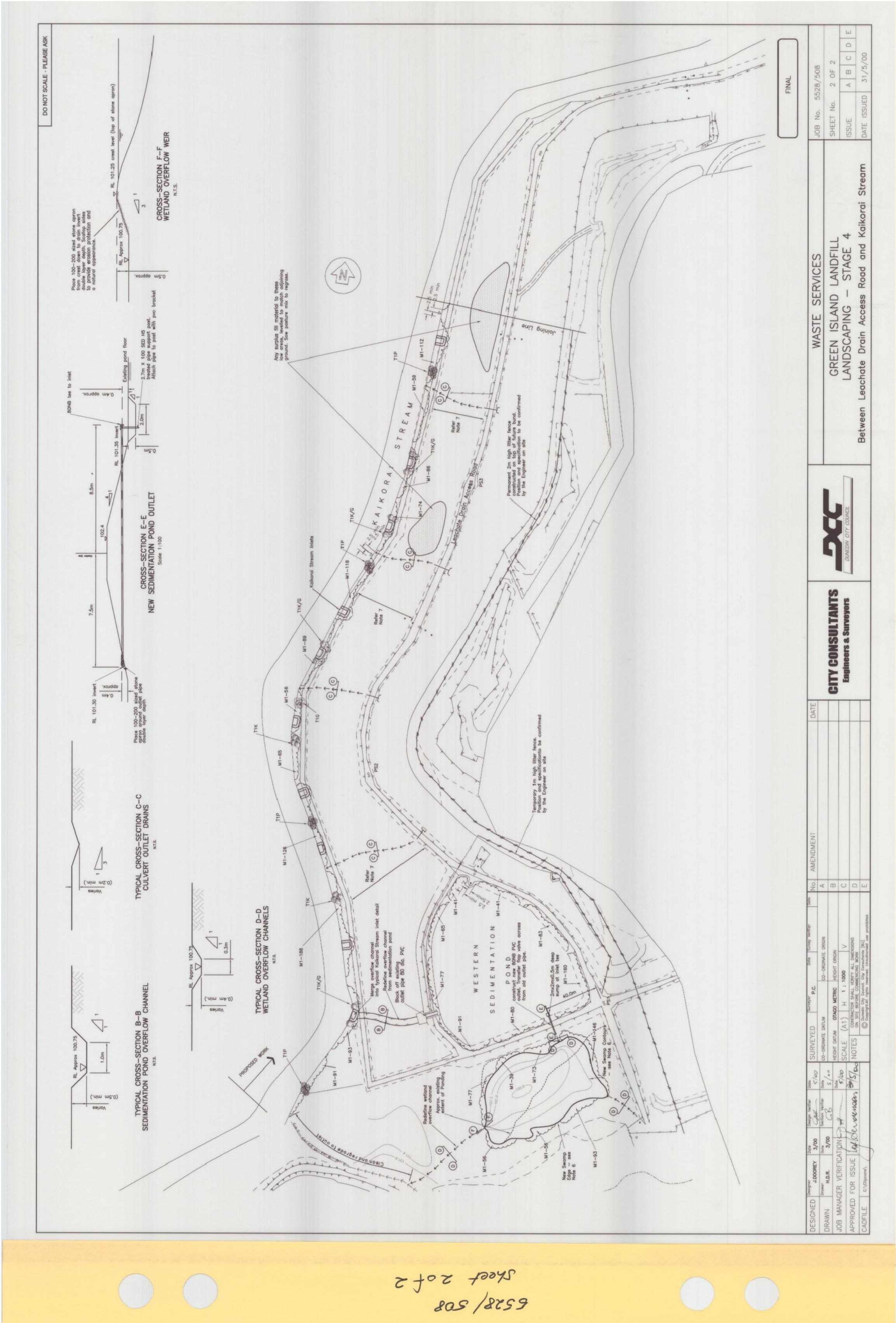


Figure xx: Design for South Western Pond connection to Western Sedimentation Pond (31/5/2000)

Photographs

Photograph 1 – 80mm PVC pipe inlet within the Western Sedimentation Pond

Photograph 2: 80mm PVC pipe outlet into the South Western Pond.

Photograph x: Capped Low level outlet under Western Sedimentation Pond weir

Project name	Green Island Landfill Consenting to Closure and RRPP Consenting
Document title	Addendum Report – PFAS and Hydrology | Addendum report – updated PFAS results for Green Island landfill
Project number	12613624
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Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S4	01	Dusk Mains/Stephen Douglass	Nick Eldred		Nick Eldred		30/4/24
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[Status code]							
[Status code]							
[Status code]							

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