Project Number: 6-CO082.00

Mt Cooee Landfill Resource Consent Application

Assessment of Effects on Groundwater and Surface Water

27 April 2023

CONFIDENTIAL

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Revision	Details
Rev0	Draft issued to client for comment.
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This report (‘**Report**’) has been prepared by WSP exclusively for Clutha District Council (‘**Client**’) in relation to the Mt Cooee Landfill Resource Consent Application Groundwater and Surface Water Assessment of Effects (‘**Purpose**’) and in accordance with the Briefing Notice dated 27 July 2022. The findings in this Report are based on and are subject to the assumptions specified in the Briefing Notice dated 27 July 2022. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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1 Introduction

1.1 Project Background

Clutha District Council (CDC) operates the Mt Cooee Landfill located near Balclutha township. The landfill operates under several existing resource consents held from the Otago Regional Council (ORC), which expire on 1 October 2023. CDC is seeking to renew the existing resource consents to allow for continued operation of the landfill.

As the landfill is nearing the end of its life, CDC is proposing to expand the landfill to the east by adding new landfill cells, a Resource Recovery Centre and transfer station. The expansion will provide more landfill capacity at the existing site as well as a new facility for recycling.

1.2 Project Overview

The Mt Cooee Landfill project proposal includes the following key components:

- Continued operation of the existing landfill cells.
- New landfill cells to the east of the site.
- Construction of a Resource Recovery Centre.
- Facilities supporting the operation of the landfill such as staff and maintenance facilities.
- Infrastructure to safely contain, collect, manage and dispose of landfill leachate, landfill gas, groundwater and stormwater so as to avoid adverse effects on receiving environments.
- Environmental monitoring systems to support the management of the landfill and its potential discharges.

1.3 Purpose of this Report

The existing Mt Cooee Landfill and proposed expansion requires resource consents from Otago Regional Council relating to its effects on groundwater and surface water. The existing landfill cells and the proposed landfill expansion activities will require the following consents:

- Discharge permit to discharge waste and leachate onto land for the purpose of the construction and operation of a Class 1 landfill.
- Discharge permit to discharge water and contaminants from sediment retention ponds to water, for the purpose of the construction and operation of a Class 1 landfill.
- Water permit to take groundwater for the purpose of managing groundwater collected beneath a Class 1 landfill.

This report provides a technical assessment of the potential effects on groundwater and surface water quality and quantity in relation to the existing and proposed activities at the Mt Cooee Landfill.

1.4 Scope of Assessment

WSP carried out site investigations at the Mt Cooee Landfill between May 2022 and March 2023 to provide information to support the design of the new landfill facilities and carry out technical assessments of environmental effects. This report draws on results from these site investigations, prior investigations and compliance monitoring at the existing landfill to assess the effects of the existing and proposed activities on receiving groundwater and surface water quantity and quality.

2 Description of the Proposed Activities

2.1 Site Description

The CDC operates Mt Cooee Landfill on Kaitangata Highway approximately 1.2 km east of Balclutha township (Figure 1). The landfill has been operating since 1985 and is the only sanitary landfill in the Clutha District. CDC contracts WasteCo to oversee daily landfill operations. The landfill serves a district population of approximately 18,400 and accepts approximately 9,000 tonnes per year of refuse from residential, commercial and some industrial customers primarily via CDC’s kerbside collection service and waste transfer stations.

The landfill site is approximately 16.5 ha. in total. The existing landfill cells and associated facilities have been built within a shallow stream valley orientated northeast to southwest. The proposed expansion area on the eastern side of the site comprises outcropped bedrock, grazing paddocks and a wetland area to the southeast. A small rock quarry is located on the south side of the site, to the south of the public road entrance from the highway. The northern and western boundaries of the site are bordered by the South Island main trunk railway and its railway reserve. The Balclutha Golf Course is located beyond the railway corridor to the north. The site is bordered to the east by private farmland and a residential property. To the south, the landfill site is adjacent to the Clutha River/Mata-Au.

Map data sources: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors, Esri, USGS, Esri, Garmin, FAO, NOAA, USGS

Mt Cooee Landfill Development Plan
Mt Cooee Location Map

Map Projection: NZGD 2000 NZ Transverse Mercator

2.2 Existing Landfill Activity Renewal

The existing landfill has an estimated total volume of 300,000 m^3 and approximate footprint of 2.56 ha. It is expected the existing landfill cells will reach their total capacity in 2023. The landfill cells are unlined, and the original design assumed the underlying greywacke has sufficiently low permeability to minimise leachate migration beneath the cells. In 1995, once the landfill had been operational for ~10 years, a steel sheet pile cut-off wall was installed across the valley floor at the landfill toe. The sheet piles were driven to refusal and are assumed to extend to bedrock depth across the full width of the valley. The sheet pile wall was capped with a low-permeability compacted clay bund. The design intention is that the sheet pile wall and bund dam groundwater flow within the cell, thereby making the preferential flow path to the leachate collection system. Of note, there are no as-built construction details for the sheet pile cut-off wall or details on the current integrity of the wall (e.g., in regard to corrosion). Refer to the WSP Sheet Pile Review (WSP, 2023) for further details on the cut-off wall.

The existing leachate control system consists of the following (Clutha District Council, 2022):

- A drainage system comprising leachate collection lines of perforated pipes (primarily drilled DN 100 mm HDPE and DN 110 mm Novaflo) laid on the original valley floor (i.e., underneath the landfill cell) and leachate collection manholes.
- A pump station at the downstream face of the landfill to transfer leachate/contaminated groundwater collected from the leachate collection lines and conveyed to the CDC sewer for treatment.
- The sheet pile cut-off wall driven down to the greywacke rock to contain groundwater flow.
- A pond with a volume of 770 m^3 (lined with 600 mm clay with a permeability of $<10^{-9}$ m/s) provided as emergency storage for leachate overflow from the pump station.

The landfill cap requirements are specified in the Mt Cooee Landfill Management Plan as follows (Clutha District Council, 2022):

- 200 mm final cover over refuse.
- 500 mm of compacted silt or quarry strippings (permeability range 10^{-6}–10^{-8} m/s.
- 150-200 mm topsoil and/or green waste mulch or other supplement.

As per the Landfill Management Plan, capping of a finished cell is to be complete within six months of final refuse placement in the cell.

Operational stormwater management of the existing landfill is described in Section 3.4.

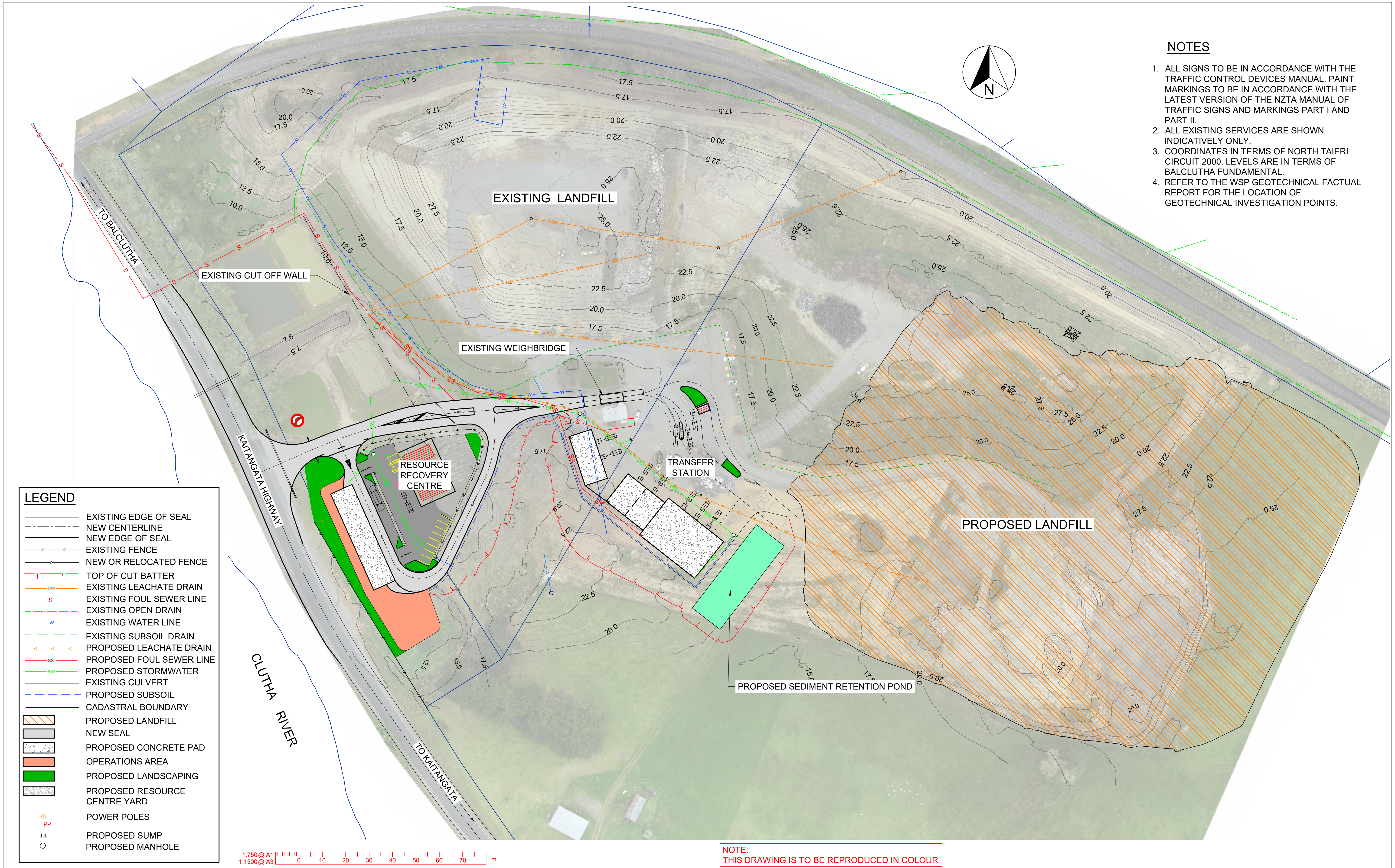
Landfill Closure

The end use of the site is expected to be for passive recreation or grazing (Clutha District Council, 2022). If grazed, this would likely be for light stock (e.g., sheep or calves), which would not damage the capping soil.

The existing landfill elements listed above and their effects are assessed as part of the renewal resource consent application.

2.3 Proposed Landfill Expansion Activity

The proposed expansion activities involve establishing new landfill cells on the east of the existing site and upgrading the current landfill facilities to include a Resource Recovery Centre and transfer station. A layout of the proposed activities is shown in Figure 2.



NOTES

1. ALL SIGNS TO BE IN ACCORDANCE WITH THE TRAFFIC CONTROL DEVICES MANUAL. PAINT MARKINGS TO BE IN ACCORDANCE WITH THE LATEST VERSION OF THE NZTA MANUAL OF TRAFFIC SIGNS AND MARKINGS PART I AND PART II.
2. ALL EXISTING SERVICES ARE SHOWN INDICATIVELY ONLY.
3. COORDINATES IN TERMS OF NORTH TAIERI CIRCUIT 2000. LEVELS ARE IN TERMS OF BALCLUTHA FUNDAMENTAL.
4. REFER TO THE WSP GEOTECHNICAL FACTUAL REPORT FOR THE LOCATION OF GEOTECHNICAL INVESTIGATION POINTS.

LEGEND

EXISTING EDGE OF SEAL
NEW CENTERLINE
NEW EDGE OF SEAL
EXISTING FENCE
NEW OR RELOCATED FENCE
TOP OF CUT BATTER
EXISTING LEACHATE DRAIN
EXISTING FOUL SEWER LINE
EXISTING OPEN DRAIN
EXISTING WATER LINE
EXISTING SUBSOIL DRAIN
PROPOSED LEACHATE DRAIN
PROPOSED FOUL SEWER LINE
PROPOSED STORMWATER
EXISTING CULVERT
PROPOSED SUBSOIL
CADASTRAL BOUNDARY
▨ PROPOSED LANDFILL
▨ NEW SEAL
▨ PROPOSED CONCRETE PAD
🟧 OPERATIONS AREA
🟩 PROPOSED LANDSCAPING
▨ PROPOSED RESOURCE CENTRE YARD
PP POWER POLES
▥ PROPOSED SUMP
○ PROPOSED MANHOLE

NOTE:
THIS DRAWING IS TO BE REPRODUCED IN COLOUR

REVISION	AMENDMENT	APPROVED	DATE
A	PLANS ISSUED TO CLIENT FOR REVIEW	C. FOX	2023-04-06

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CIVIL

SCALES		ORIGINAL SIZE
1:750@ A1, 1:1500@A3		A1
DRAWN	DESIGNED	APPROVED
J.L. BOYDE	J.L. BOYDE	CHRIS FOX
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
CALLUM FEELY	ROWAN LATHAM	2023-04-06

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL, TRANSFER STATION & RESOURCE RECOVERY CENTRE
OVERALL SITE PLAN

WSP PROJECT NO. (SUB-PROJECT)	SHEET NO.	REVISION
6-CO082.00	C101	A

Original sheet size A1 (841x594) Plot Date 2023-04-05 at 4:31:10 pm U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\07_Phase 2 Design report\Task 3_Civil technical Drawings\(C) Civil\6-CO082.00_C101(A).dwg C101(A)

Landfill Expansion

The proposed landfill expansion area is being designed to be a Class 1 landfill with a total refuse volume of 320,400 m^3 covering a footprint of 2.61 ha. The expansion area has been designed with five cells that will be progressively filled over an expected landfill lifespan of 35 years. The stages will be developed sequentially with three base cells (Stages 1-3) constructed against the existing landfill footprint in a clockwise direction. Two future stages (Stages 4 and 5) will then be developed on top of the landfill base up to a final height of 36.0 m RL. Each landfill filling stage will progress through several sub-stages: exposed liner, exposed waste, daily cover and final capping. Refer to the WSP Landfill Expansion Design Report (WSP, 2023) for further details on the proposed activities.

Construction will involve excavation of the existing landform to develop the landfill base. It is anticipated that some excavated material will need to be moved off site with some materials being used for the initial stage of landfill construction.

The new cells will be built up against the existing landfill cells. While options are being considered for how to construct this interface, the preferred design consists of placing a liner on the existing refuse fill. This side liner would consist of the following components:

- 300 mm compacted intermediate cover to the existing refuse.
- 600 mm of compacted soil to permeability of 1×10^{-8} m/s.
- GCL (reinforced as appropriate to slope).
- 1.5 mm HDPE.
- Liner protection layer.
- Gravel drainage layer.

Landfill Leachate Management System

No underdrainage has been designed, as it is anticipated that groundwater is >1 m below the base layer of the landfill liner. This is largely based on the water level contour mapping (Figure 10) showing groundwater levels below the designed base elevation of the landfill cells.

Leachate drains will be installed above the liner and consist of a main centre drain and lateral collectors running across the slope back to the perimeter batters at 80 m spacing. Leachate drains will consist of DN 160 SDR 13.6 PE 80C HDPE pipe. Leachate drains have been positioned to provide a maximum horizontal flow path of 90 m. This has been calculated to maintain the leachate depth on the liner between drains at less than 300 mm.

A temporary flap on the liner will be used to divide sub-cells and allow clean stormwater to be diverted away from the leachate system.

Landfill Liner Design

The design of the liner has been based on the Class 1 landfill alternative liner design in the WasteMINZ Technical Guidelines for Disposal to Land (WasteMINZ, 2018). The liner comprises (from top to bottom):

- 300 mm thick granular drainage layer.
- Geomembrane protection layer of non-woven geotextile.
- 1.5 mm HDPE geomembrane, textured on both sides.
- Geosynthetic Clay Liner.
- 300 mm compacted soil base constructed to a strength and permeability specification. The permeability of the compacted base layer is not to exceed 1×10^{-9} m/s.

Landfill Capping

The landfill cells will be capped with the following materials (from top to bottom):

- Maintained grass cover.

- 150–200 mm topsoil and/or green waste mulch or other supplement.
- Undefined depth of subsoil layer.
- 500 mm of compacted silt or quarry strippings – permeability range 10^{-6}–10^{-8} m/s.
- 200 mm final cover over refuse.

Landfill Closure

A detailed landfill aftercare plan will be developed at least six months prior to full closure of the landfill cells. Aftercare will include all ongoing maintenance, monitoring activities and outline ongoing use/site access, with a preference to make the site available once landfilling is completed as a public recreation area.

Resource Recovery Centre and Transfer Station

The proposed expansion of the landfill's public waste receival facilities includes the development of a front-end Resource Recovery Centre (RRC) and enhanced transfer station operations.

The RRC will provide a free drop-off facility for household recycling and divertible materials, with all received waste contained in mobile containers/skips. The recycling drop-off will be covered by a roof structure to ensure unloading and storage of recyclables can occur without being exposed to the elements. Full recycling containers will be stored in the back of house areas as required, prior to being transferred to a separate collection area for transfer off site. Recovered materials will be assessed by operations staff and transferred to the re-use shop and education area as required. The education space and re-use shop will be developed with a dedicated carparking area.

The transfer station area will be enhanced with public access to a dedicated refuse tipping floor, an area to unload hazardous materials, and an area to deposit green waste. Hazardous substance storage will be provided in a bunded shipping container. A dedicated flat floor push pit facility will provide a multiuse facility for general waste and recoverable construction and demolition materials. Two organics pads will be constructed from reinforced concrete for receiving green waste.

Vehicle access to the site will be provided by the existing entrance located on Kaitangata Highway. To accommodate the new Resource Recovery Centre, the existing access road will be widened and recontoured.

Erosion and Sediment Control During Construction of RRC and Transfer Station

All practicable measures will be undertaken to prevent sediment from entering water including, but not limited to:

- Establishing sediment controls prior to the onset of works and maintaining them in place until disturbed areas are stabilised.
- Stabilisation of disturbed areas as soon as practicable following the works.
- No washing down of equipment where sediment may enter any waterbodies.

Erosion, sediment and dust control will need to be provided throughout the duration of the construction works particularly around the Clutha River/Mata-Au, to ensure protection of the receiving environment. A site-specific Erosion, Sediment and Dust Control Plan (ESDCMP) will be developed by the Contractor once appointed and developed for the various stages of the project.

The key approaches for managing erosion and sediment risks are:

- Minimise disturbance – Only work in areas required for the construction to take place.
- Stage construction – Plan works to minimise area of disturbance at any one time.
- Protect steep slopes – Use cut-off drains, bund armouring and use of flumes as appropriate.
- Protect watercourses – Plan works to prevent sediment-laden flows from entering watercourses without treatment.

- Develop methodologies and sequences for works in close proximity to the Clutha River/Mata-Au and any other waterways nearby.
- Stabilise exposed areas rapidly – Stabilise areas using a mixture of gravel, mulch and hydro seeding as appropriate.
- Install perimeter controls – Divert clean water away from areas of disturbance and divert sediment-laden flows to control devices.
- Employ detention devices – Treat runoff by methods that allow the sediment to settle out.
- Cover, stabilise and bund/silt fence stockpiles.
- Update Site-Specific ESDCMPs – As construction proceeds, the plan needs to be modified to reflect the changing conditions of the site.
- Assess and adjust – Inspect, monitor and maintain control measures.

Operational Stormwater Management

Stormwater from the Resource Recovery Centre will be conveyed to a centralised point and transferred to the existing stormwater retention pond. Grates will be fitted with sump cages to catch any litter prior to discharging via the stormwater network. A routine maintenance task will be established to clear grates and ensure functionality of the stormwater network.

Stormwater from the transfer station area, including water from a new proposed sediment retention pond (servicing the landfill construction area) will be piped via a new stormwater main and discharged to the existing stormwater retention ponds.

Works are planned to link the existing stormwater retention ponds to a single manhole from which the stormwater will be pumped and used for irrigating the landscaping on site.

Any liquid generated in either the organics or general waste receival areas will be captured and transferred to the leachate pump station via a new leachate line around the rear of the operational area.

Leachate for the landfill expansion area will be transferred across the centre of the operational site via a new leachate line and discharged to the existing leachate pump station where it will be conveyed to the CDC sewage system.

The ground levels and site contouring in the transfer station and RRC will allow gravity drainage of operational areas.

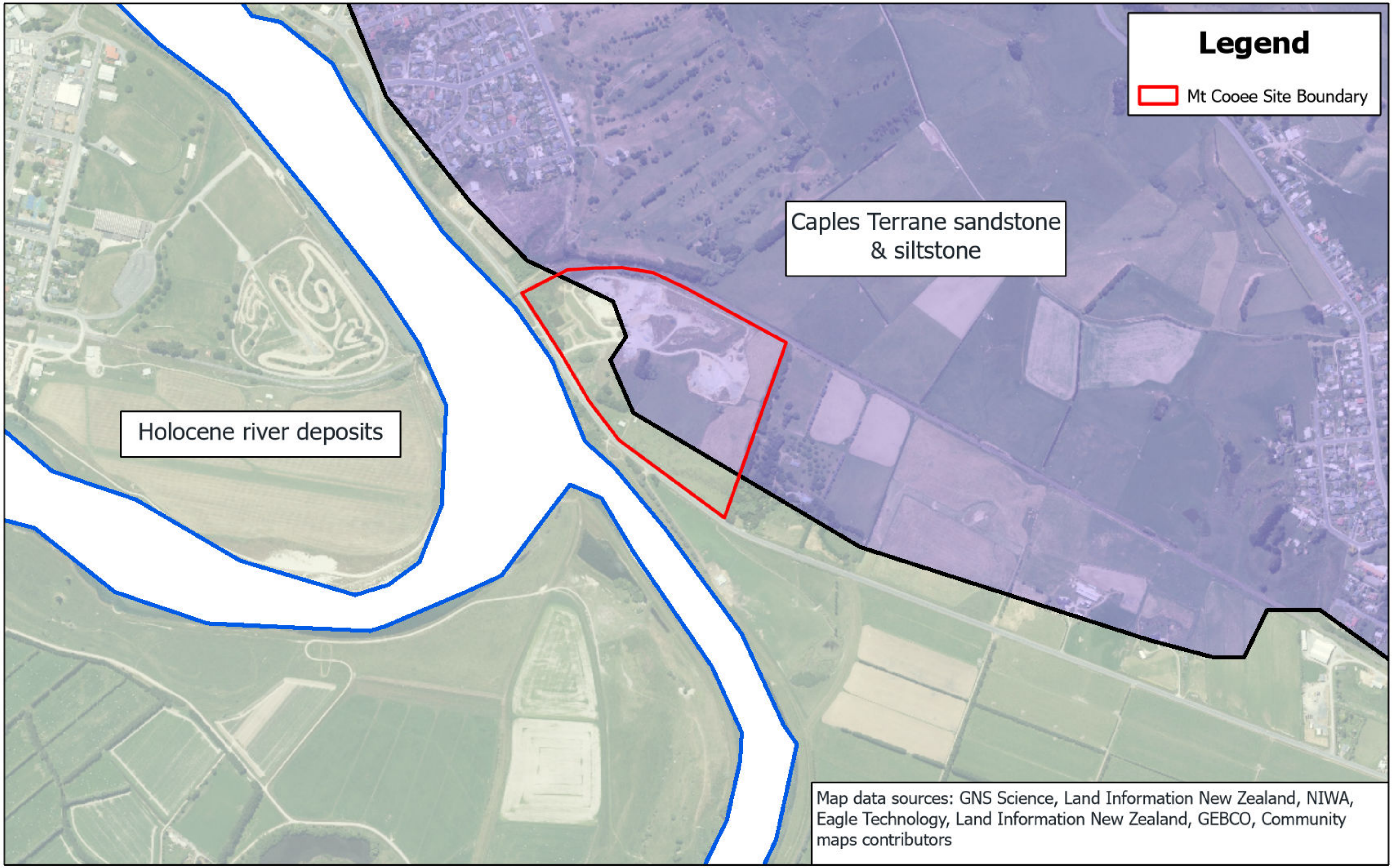
3 Environmental Setting

3.1 Geology

The geology of the area around Mt Cooee Landfill consists of Permian to Carboniferous-age schists and greywacke to the northwest and Cretaceous greywacke and coal deposits to the southeast (Royds Consulting Limited, 1994; GNS Science, 2020) (Figure 3). Holocene gravel, silt and sand deposits from the Clutha River/Mata-Au and its tributaries overlie the Cretaceous units (known as Caples Terrane sandstone and siltstone).

Within the landfill site, alluvial deposits overlie the basement greywacke, and these Holocene deposits thicken and fan out at the southwest of the site at the mouth of the unnamed stream that previously ran through the valley, where the existing landfill cells and sediment retention ponds are now located (Royds Consulting Limited, 1994). This stream was diverted around the northwest of the site when the existing landfill cells were built.

Geological mapping of the area does not show any fault lines in close proximity to the landfill site. The closest mapped fault is the Livingstone Fault approximately 5 km to the east, which strikes northwest to southeast (GNS Science, 2020).



Map data sources: GNS Science, Land Information New Zealand, NIWA, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Mt Cooee Landfill Development Plan
Geology of the Mt Cooee Area

Map Projection: NZGD 2000 NZ Transverse Mercator

3.2 Hydrogeology

In terms of groundwater, within the landfill site, both the alluvial sediments and underlying greywacke serve as water-bearing layers. The greywacke is relatively low permeability where the rock is massive, but higher permeability areas are found where the rock is highly fractured. Groundwater at the site is thought to be recharged from rainfall both on the site and in the area directly to the north within the contributing catchment. The general groundwater flow direction across the site is from the north towards the Clutha River/Mata-Au and is assumed to broadly follow topography.

The landfill site lies within what the Otago Regional Council zones as the Inch Clutha Gravel Aquifer (Figure 4). The closest registered groundwater bore (H46/0218) is approximately 1.5 km southeast of the site; however, it is not consented to take water in the ORC GIS database. There are no current downgradient surface water takes listed in the ORC GIS database.

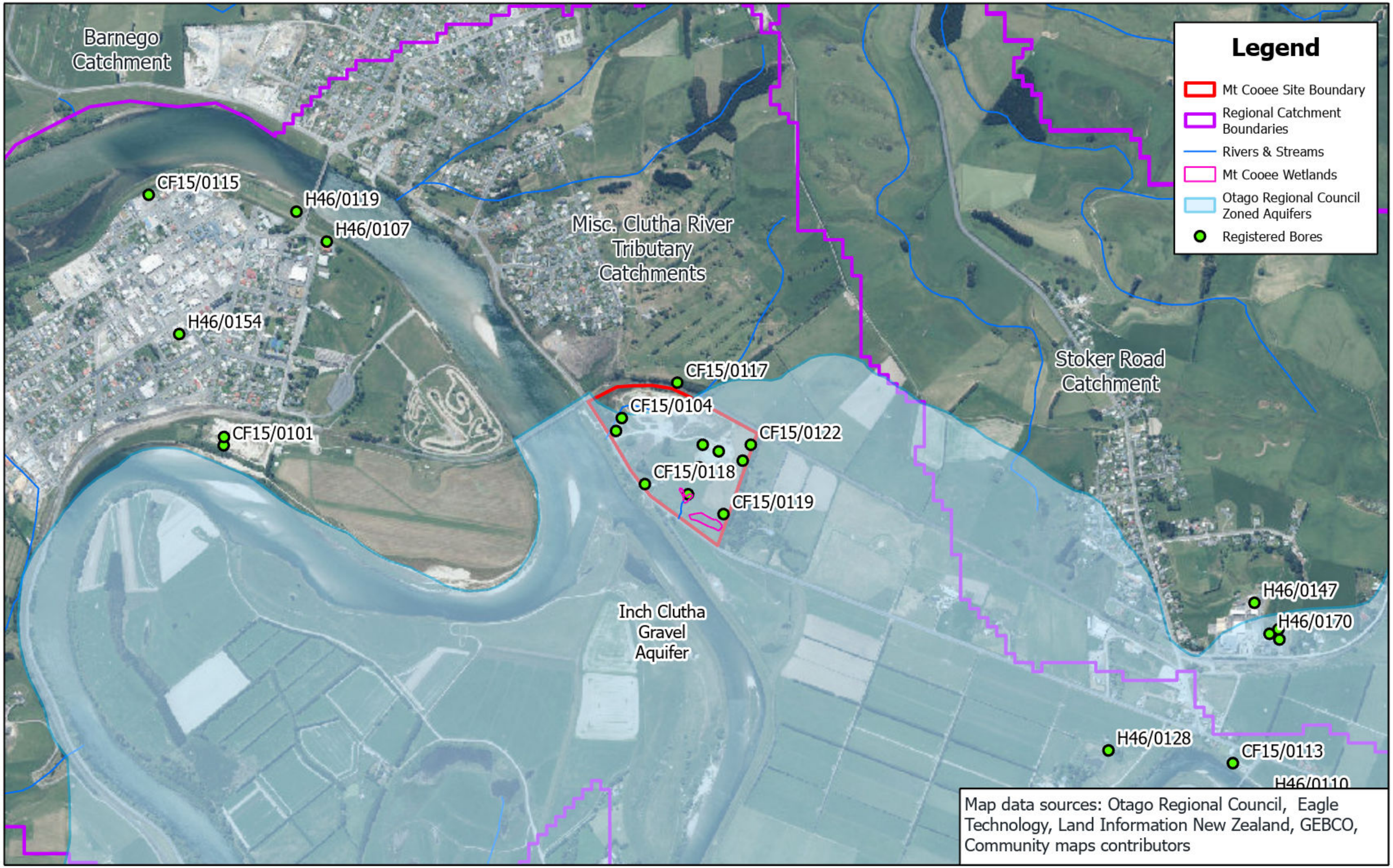
3.3 Hydrology

ORC zones the site hydrology within a minor Clutha River/Mata-Au tributary catchment (Figure 4). A small stream, which originates north of the Balclutha Golf Course previously flowed through the northwest side of the landfill site. To build the existing landfill cells and facilities, the stream was diverted on the northern boundary of the site and now discharges via a stormwater channel, which runs along the north and western boundaries of the site, discharging to the Clutha River/Mata-Au via a culvert underneath the Kaitangata Highway. The original stream path is shown in Figure 4. The existing landfill cells and associated facilities have been built within this stream's shallow valley orientated northeast to southwest. Prior to development, the valley was waterlogged and densely vegetated (Royds Consulting Limited, 1994).

The Clutha River/Mata-Au is adjacent to the southwest edge of the site. The landfill is located immediately north of where the river splits into two main branches: the Matau Branch to the east and Koau Branch to the west.

There are no regionally significant wetlands mapped within the ORC GIS database in the catchment where the landfill is located. The nearest mapped regionally significant wetland is 2.6 km to the east. As discussed later in this assessment, a wetland area has been identified in the southeast portion of the landfill site (4Sight Consulting, 2022).

In regard to climate, based on long-term records from the NIWA climate station at Balclutha (Telford), the landfill site receives on average 658 mm rain annually (based on 1991-2020 data) (National Institute of Water and Atmosphere (NIWA), 2023). Mean annual potential evapotranspiration calculated using the Penman method is 720 mm (based on 2006-2022 data) (National Institute of Water and Atmosphere (NIWA), 2023)).



Map data sources: Otago Regional Council, Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Mt Cooee Landfill Development Plan
Mt Cooee Hydrology Map

Map Projection: NZGD 2000 NZ Transverse Mercator

3.4 Stormwater Control

Stormwater is managed on the existing landfill site via a series of culverts, drains and retention ponds. Upgradient runoff is captured at the boundary between the golf course and railway line on the north side of the site. This runoff is conveyed via an open channel, through a culvert under the Kaitangata Highway and discharged to the Clutha River/Mata-Au. This stormwater diversion was constructed in 2021 and further details can be found in the related resource consent application (Fluent Solutions, 2020). No surface water inflow into the site is expected from the northern boundary, as this flow is captured by the stormwater diversion on the north side of the railway.

Within the existing landfill site, stormwater is conveyed from the northern boundary along the railway and discharged into a 1000 m^3 retention pond (monitoring site SP2) (Figure 5). Stormwater produced from the access roads and completed landfill areas that is not captured by this northern drain is conveyed along the southern end of the existing landfill area and discharged to a 600 m^3 retention pond (monitoring site SP1). Once they exceed capacity, both stormwater retention ponds are designed to discharge to a culvert that runs between the ponds, underneath the Kaitangata Highway and flow to the Clutha River/Mata-Au.

Runoff from any active landfill cell face is bunded so that it soaks to ground and is captured by the leachate collection system underneath the existing landfill area (Clutha District Council, 2022).

4 Investigation Findings and Interpretation

4.1 Current Monitoring Programme

To comply with existing resource consents for the Mt Cooee Landfill, surface water and groundwater is monitored on and around the site. Monitoring has been carried out since the landfill was established in 1985 and the programme has been altered through the years for various reasons (e.g., additional groundwater monitoring wells installed). For full details of the current monitoring programme and results please refer to the Mt Cooee Landfill Management Plan (Clutha District Council, 2022) and compliance monitoring reports (for the latest annual report, refer to WSP (2022).

The monitoring programme is summarised in Table 1 and the locations are shown in Figure 5.

Table 1 : Mt Cooee Landfill compliance monitoring programme summary.

Resource Consent No.	Consent Condition	Monitoring Location	Monitoring Frequency	Field ID	Analyses
95954	4(a)	Leachate sump (Pump Station)	January, April[1], July, October	PS	pH, EC, NH_3-N, Cl
95954	4(b)	Groundwater/leachate monitoring wells	January, April, July, October[1]	GW1A[2], GW2A, GW3, GW4, GW5, GW6, GW7	pH, EC, NH_3-N, Cl, K, NO_3-N, B (soluble)
94509	4	Silt pond discharges	January, April, July, October	SP1, SP2	pH, EC, suspended solids, turbidity, NH_3-N, BOD5

94509	7(b)	Watercourses	January, April, July, October	WC1, WC2, WC3	pH, EC, NH_3-N, Cl

Notes:

EC – Electrical Conductivity
NH_3-N – Ammoniacal Nitrogen
Cl – Chloride
NO_3-N – Nitrate-nitrogen
K – Potassium
B - Boron
BOD – Biological Oxygen Demand

[1] Extended analytical suite required annually (during the April quarterly monitoring event for the pump station and October quarterly monitoring event for four groundwater wells located outside the landfill boundaries). Includes calcium, magnesium, potassium, sodium, bicarbonate, sulphate, chemical oxygen demand (COD), 5-day Biochemical Oxygen Demand (BOD5), nitrate, iron, lead, zinc and cation/anion ratio. However, for practicality reasons it has been agreed with ORC that from 2022 onwards all extended analytical suites are to be undertaken in October.

[2] Groundwater monitoring well GW1 was destroyed due to earthworks between May 2021 and August 2021 with a replacement well (referred to as GW1A) installed on 19 October 2022.

In addition to the compliance monitoring specified in the resource consents, WasteCo is required to undertake additional monitoring and sampling under its contract with CDC. These contractual monitoring requirements include the following analysis in groundwater wells:

- Quarterly analysis for potassium, nitrate-nitrogen (NO_3-N) and soluble boron.
- Annual (in October) analysis at leachate monitoring wells GW2A, GW3, GW4 and GW5 for alkalinity, total organic carbon (TOC), total Kjeldahl nitrogen (TKN), dissolved reactive phosphorus (DRP), silica, and soluble trace elements (manganese, aluminium, arsenic, cadmium, chromium, copper and nickel).
- Biennial (in May) analysis for volatile organic compounds (VOCs), acid herbicides, and semi-volatile organic compounds (SVOCs) from the leachate sump at the pump station.

Map data sources: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Mt Cooee Landfill Development Plan
Mt Cooee Sampling Location Map

Map Projection: NZGD 2000 NZ Transverse Mercator

4.2 Site Investigation

WSP carried out site investigations at the Mt Cooee Landfill between May 2022 to March 2023 to support the design of the expanded landfill facilities and associated resource consenting applications.

The investigations included the following:

- Establishing surface water quality monitoring locations on the Clutha River/Mata-Au upstream and downstream of the landfill (SW1 and SW2/2A).
- Ten machine boreholes (BH1 to BH10) drilled between 11 October to 2 November 2022 to target depths between 3.0 m and 11.6 m below ground level for geotechnical and hydrogeological purposes.
- Installation of six new groundwater monitoring piezometers (in the abovementioned machine boreholes BH1 to BH6).
- Permeability testing in existing and new groundwater monitoring wells.
- Regular manual water level measurements in groundwater monitoring wells.
- Installation of continuous water level monitoring loggers in all groundwater monitoring wells.
- Water quality monitoring in new groundwater monitoring piezometers.

Investigation locations are shown on Figure 5 and further details on the geotechnical investigations can be found in the Geotechnical Factual Report (WSP, 2023) and Geotechnical Interpretative Report (WSP, 2023).

Details of the existing and new (2022) groundwater monitoring wells are summarised in Table 2. Note that for some existing wells, information such as well depth or screened unit is either unclear or unknown.

Table 2 : Groundwater monitoring bores at Mt Cooee Landfill.

Site ID	Impact/Control Bore	Construction Year/Monitoring Start	E (NZTM)	N (NZTM)	Total Bore Depth (m bgl)	Screen Length (m)	Screen Start (m bgl)	Screen End (m bgl)	Initial Static Water Level (m bgl)	Screened Unit Description
GW1A/BH2[1]	Control	2022	1350240.89	4873978.38	6	3	1	4	0.7	GRAVEL (1-1.5 m). Gravelly CLAY (1.5-3 m). Highly weathered SANDSTONE (3-4 m).
GW2A[2]	Impact	2021	1350069.03	4873839.533	6	2.9	2.5	5.4	1.67	Silty CLAY. Sandy SILT. Silty SAND.
GW3	Impact	2006[3]	1350057.665	4873782.709	6	Not available	Not available	Not available	Not available	No bore log available. Expected GREYWACKE.
GW4	Impact	2018	1350130.826	4873823.196	7.98	2.5	5.48	7.98	5.18	Blue rock. (Assumed GREYWACKE.) Installed within landfill refuse.
GW5	Impact	2018	1350249.445	4873789.102	11.13	3	8.13	11.13	5.01	Blue rock. (Assumed GREYWACKE.) Installed within landfill refuse.
GW6	Impact	2018	1350294.904	4873908.432	10.82	3	7.82	10.82	7.89	Landfill (7.82-8.5 m). CLAY to blue MUDSTONE (8.5-10.82 m). (Assumed GREYWACKE.)
GW7	Impact	2018	1350433.412	4,873,831.72	6.07	2	4.07	6.07	5.2	Blue rock. (Assumed GREYWACKE.) Installed within landfill refuse.
BH1	Impact	2022	1350038.21	4873816.82	11.6	3	8.2	11.2	2.0	Slightly weathered SANDSTONE. Highly fractured.

BH3	Impact	2022	1350135.07	4873642.22	4.5	1	1.5	2.5	1.6	Highly weathered SANDSTONE.
BH4	Impact	2022	1350398.84	4873540.04	5.5	4.5	1	5.5	2.45	Sandy GRAVEL (1-1.5 m). Slightly weathered to moderately weathered, highly fractured SANDSTONE (1.5-3 m). Slightly weathered to moderately weathered, highly fractured SILTSTONE (3-5.5 m).
BH5	Impact	2022	1350288.22	4873598.94	3	0.6	0.9	1.5	0.6	Highly weathered SANDSTONE.
BH6	Impact	2022	1350315.1	4873694.36	9.45	1.5	1	2.5	2.2	Moderate to highly weathered, highly fractured SANDSTONE.

Notes: [1] Replacement well for long-term compliance monitoring well GW1. [2] Replacement well for long-term compliance monitoring well GW2. [3] Limited records of well installation, believed to be installed in 2006.

4.3 Geology

A detailed description of the geological investigations undertaken at the Mt Cooee site and geological interpretations can be found in the Geotechnical Factual Report (WSP, 2023) and Geotechnical Interpretative Report (WSP, 2023).

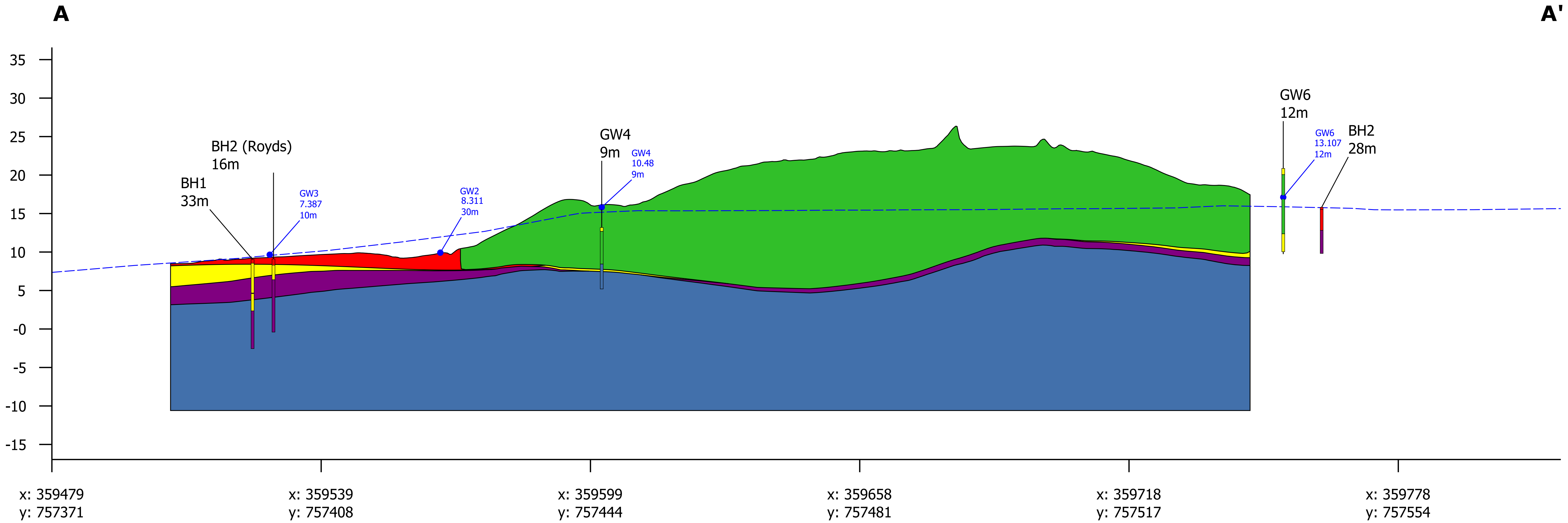
The 2022 site investigations in general confirmed what had previously been published on geology of the Mt Cooee site and surrounding area. Caples Terrane bedrock (generally referred to in this assessment as greywacke) is found across the northern half of the site, with shallow alluvial deposits overlying bedrock towards the southern end of the site.

The eastern section of the site is predominantly underlain by thin layers of topsoil (typically up to 0.5 m thick), overlying Caples Terrane bedrock. The upper layer of the Caples Terrane bedrock generally consists of several sequences of highly to moderately weathered, weak to moderately strong sandstone/siltstone. This layer is typically highly fractured. The bedrock transitions to slightly weathered to fresh, moderately strong to strong sandstone/siltstone at typical depths of >6.5 m bgl. The lower unit is also highly fractured, with thin interbeds of both sandstone and mudstone. The investigations found an approximately 1-2 m-thick layer of well-rounded alluvial deposits on the northeast of the site and a less than 1 m-thick layer of alluvium on the southeast of the site by BH3 and BH5.

The western section of the site is underlain by a thin layer (typically <1 m) of topsoil and underlying alluvium. The alluvium was approximately 5.5 m thick in BH1 and 2.5 m thick in BH2 to the south and north of the existing landfill area, respectively. The nature of the alluvium appears to be highly variable with silty clay interbedded with sandy silt and silty sand. The alluvium is underlain by Caples Terrane bedrock, consisting of sequences of moderately to slightly weathered, highly fractured, fine fabric sandstone and siltstone. From approximately 9 m bgl there is slightly weathered to fresh, moderately strong to strong sandstone and siltstone.

Figure 6 to Figure 8 show cross-sections based on the ground model developed from the geotechnical site investigations overlaid with an interpolated water level surface from a piezometric survey on 29 November 2022. We produced the interpolated water level surface using Leapfrog Works software, which was used to build the ground model.

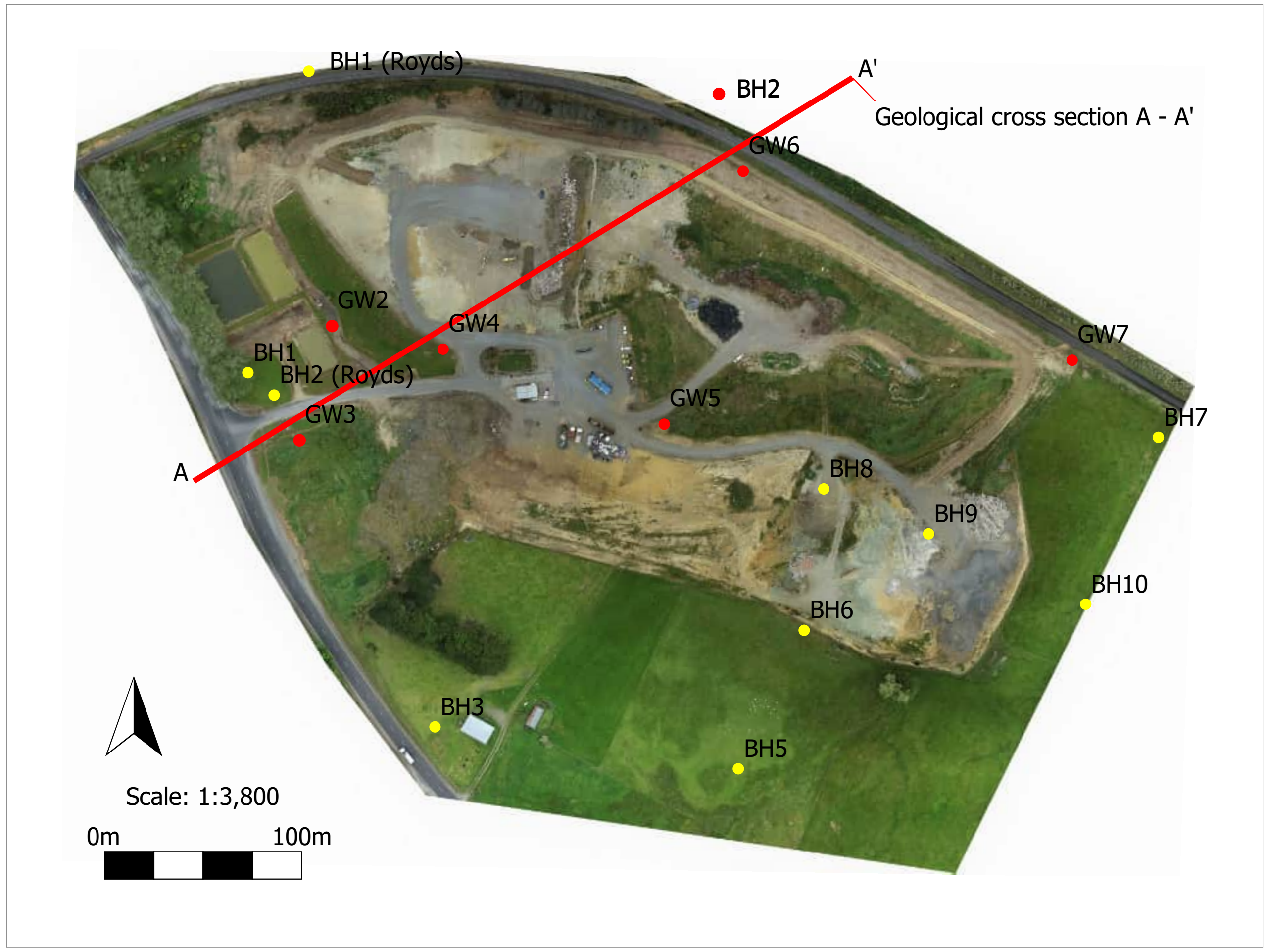
Geological Cross-Section and Water Level Surface A - A'



Scale: 1:1,100

Vertical exaggeration: 2x

0m 50m



Note: Groundwater surface interpolated using Leapfrog Works.

Location

A:	359479, 757371
A':	359814, 757576

Notes:
Distance to borehole from section is given in metres below borehole ID.
Water level and distance from section in metres provided in blue.

Legend

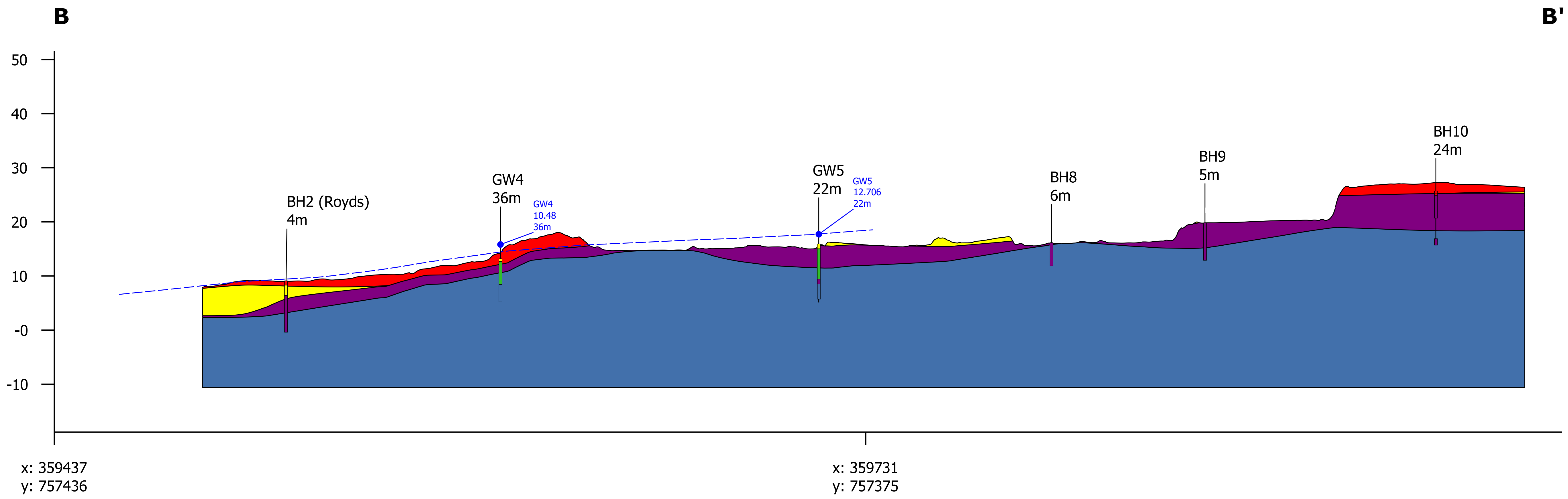
Refined Ground Model

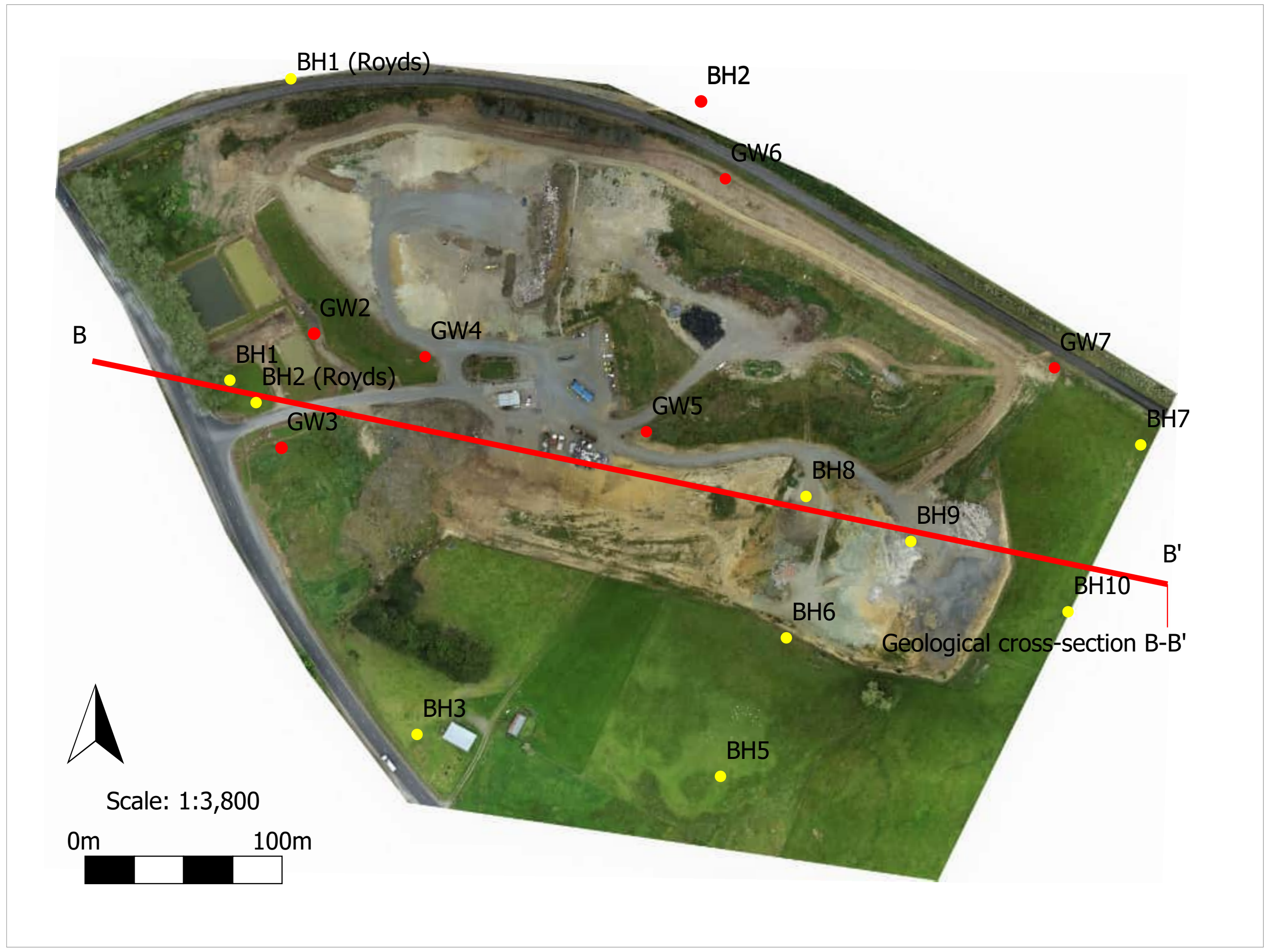
- 🟨 GM: Alluvium
- 🟩 GM: Landfill
- 🟥 GM: Topsoil
- 🟦 Greywacke: Fresh
- 🟪 Greywacke: Weathered greywacke

Surfaces

- ---- Interpolated Groundwater Surface

Geological Cross-Section and Water Level Surface B - B'





Scale: 1:1,600

Vertical exaggeration: 2x

0m 50m

Note: Groundwater surface has only been drawn where there are sufficient water level observations. Groundwater surface interpolated using Leapfrog Works.

Location

B:	359437, 757436
B':	359983, 757323

Notes:
Distance to borehole from section is given in metres below borehole ID.
Water level and distance from section in metres provided in blue.

Legend

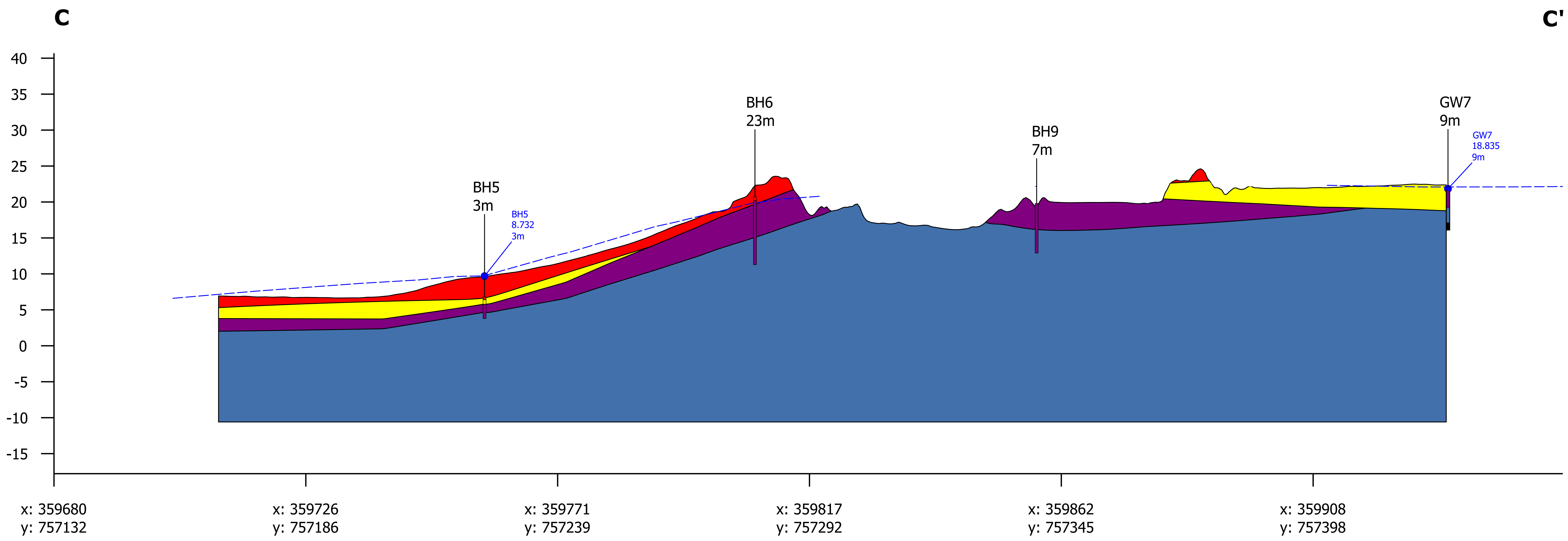
Refined Ground Model

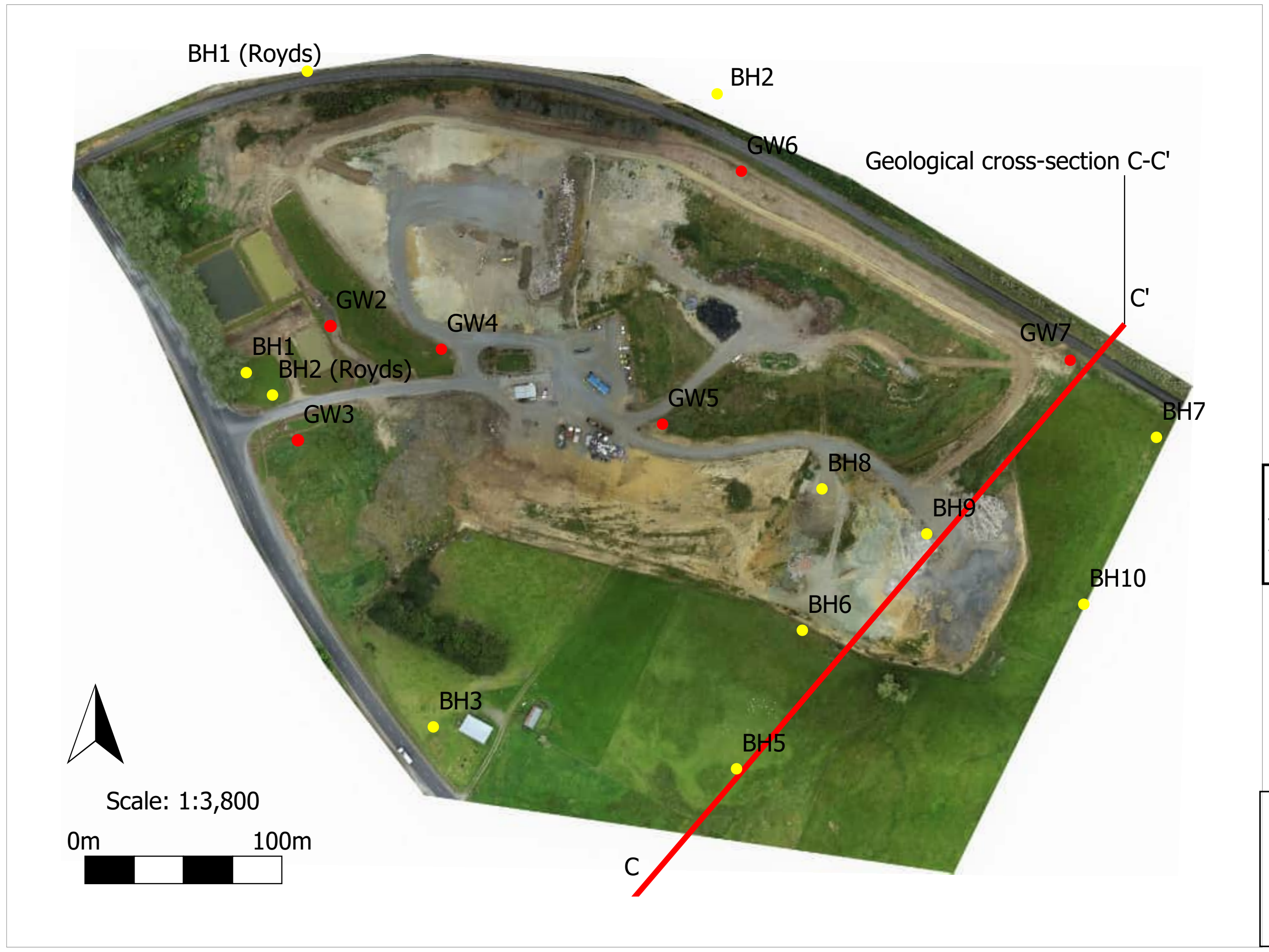
🟨	GM: Alluvium
🟥	GM: Topsoil
🟦	Greywacke: Fresh
🟪	Greywacke: Weathered greywacke

Surfaces

----	Interpolated Groundwater Surface

Geological Cross-Section and Water Level Surface C - C'





Scale: 1:1,200

Vertical exaggeration: 2x

0m 50m

Note: Groundwater surface has only been drawn where there are sufficient water level observations. Groundwater surface interpolated using Leapfrog Works.

Location

C: 359680, 757132
C': 359953, 757451

Notes:
Distance to borehole from section is given in metres below borehole ID.
Water level and distance from section in metres provided in blue.

Legend

Refined Ground Model

- 🟨 GM: Alluvium
- 🟥 GM: Topsoil
- 🟦 Greywacke: Fresh
- 🟪 Greywacke: Weathered greywacke

Surfaces

- - - - Interpolated Groundwater Surface

4.4 Hydrogeology

4.4.1 Groundwater Levels, Flow Directions and Hydraulic Gradients

Since the new monitoring wells were installed in late 2022, several rounds of manual water level measurements have been taken in all monitoring wells on site (Table 3). This assessment focuses on water levels recorded between November 2022 to January 2023 and therefore the data reflect late spring and early summer conditions.

Continuous groundwater levels were recorded from 16 November 2022 to 24 January 2023. Solinst Leveloggers (i.e., non-vented pressure transducers) were installed in all monitoring wells on site on 16 November 2022 to record groundwater levels at 15-minute intervals (Figure 9). We installed a Barologger in BH1 to record barometric pressure changes for atmospheric compensation of the water level data. We took manual water level measurements when the loggers were downloaded to calibrate the water level record. Wells BH3 and BH5 were dry for part of the monitoring period, while BH6 was dry through the entire monitoring period.

The monitoring period coincided with a relatively dry period, particularly from 18 December 2022 to 22 January 2023 when there was only 13 mm of rainfall at the Balclutha Finegrand climate station (National Institute of Water and Atmosphere (NIWA), 2023). This small amount of rainfall is potentially linked to some of the monitoring wells being dry during November 2022 to January 2023. Over this period, groundwater levels were relatively stable or had a declining trend (Figure 9). The greatest groundwater level fluctuations were observed in GW3 (1.76 m decline) and GW1A (1.48 m decline). In terms of rainfall response, water levels in GW2A and GW7 had clear rainfall responses (i.e., abrupt groundwater level rises following rainfall), with GW7 having the most significant response of all wells. GW1A and BH4 had relatively small responses to rainfall. There may have been a small rainfall response in wells GW4, GW5 and GW7, however it is difficult to ascertain, likely because these wells are screened at least in part within landfill cells. There was no discernible rainfall response in BH1, BH3, BH5, BH6 or GW3. As the relative differences are small, it is difficult to view rainfall responses in Figure 9.

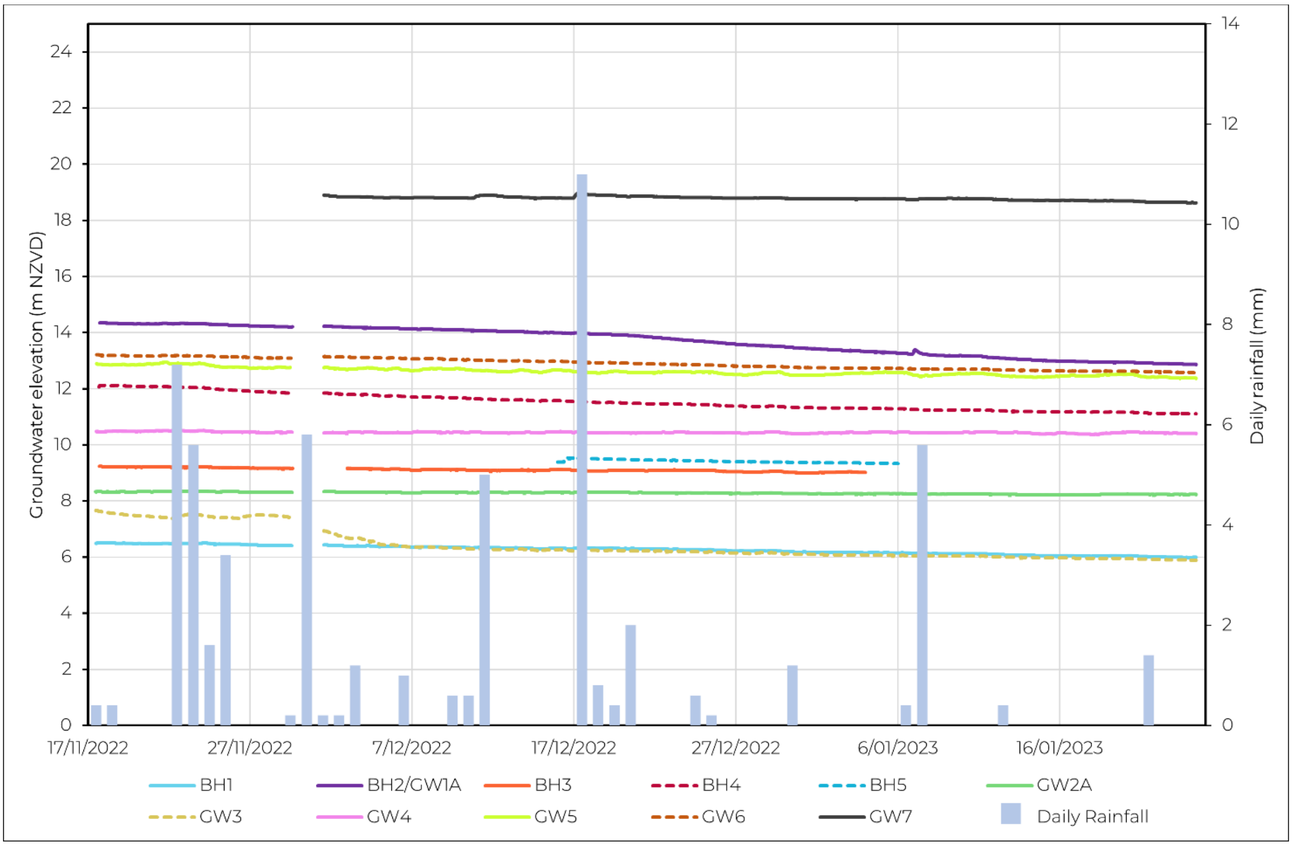


Figure 9 : Groundwater elevations measured at 15-minute intervals from 16 November 2022-24 January 2023. Rainfall data sourced from NIWA Cliflo Balclutha Finegand station. Data notes: Gap in data on 29-30 November 2022 during permeability testing. Data record for GW7 begins on 1 December 2022. Additional gaps for BH3 and BH5 when wells were dry. BH6 was dry for entire period and is not shown on the plot.

Table 3 : Manual groundwater level measurements in Mt Cooee Landfill monitoring wells.

Well Details		16/11/2022			29/11/2022			24/01/2023		
Site ID	Top of Well Casing (m NZVD 2016)	Water Level (m bTOC[1])	Time	Water Level (m NZVD 2016)	Water Level (m bTOC)	Time	Water Level (m NZVD 2016)	Water Level (m bTOC)	Time	Water Level (m NZVD 2016)
GW1A/BH2	15.797	1.39	17:15	14.41	1.53	15:00	14.27	2.97	11:00	12.83
GW2A	10.044	1.73	11:02	8.31	1.73	14:15	8.31	1.82	11:15	8.22
GW3	9.324	1.66	11:29	7.66	1.94	14:00	7.39	3.43	12:00	5.89
GW4	16.070	5.58	11:59	10.49	5.59	14:30	10.48	5.66	16:15	10.41
GW5	18.194	5.38	12:30	12.81	5.49	11:45	12.71	5.88	15:30	12.31
GW6	17.472	4.29	12:58	13.18	4.36	12:30	13.11	4.97	13:30	12.50
GW7	22.122	3.31	15:37	18.81	3.29	11:45	18.84	3.50	14:30	18.62
BH1	9.198	2.71	10.23	6.49	2.79	13:58	6.41	3.21	9:45	5.99
BH3	11.877	2.36	16:00	9.52	2.41	9:10	9.47	DRY	10:45	DRY
BH4	15.425	3.22	15:37	12.21	3.53	13:25	11.90	4.33	9:00	11.09
BH5	10.315	1.40	15:25	8.92	1.58	13:12	8.74	DRY	10:00	DRY
BH6	21.019	DRY	15:53	DRY	DRY	13:00	DRY	DRY	10:00	DRY

Notes: [1] m bTOC refers to metres below top of well casing.

Groundwater levels recorded in a piezometric survey on 29 November 2022 are plotted as an interpolated contour map in Figure 10. For this map, we interpolated groundwater levels using ArcPro. The water level mapping suggests a general northeast to southwest flow direction from the north of the landfill site towards the Clutha River/Mata-Au. In general, groundwater flow direction appears to follow the topographic gradient on the site.

As shown in the water level contour map (Figure 10), there appears to be a horizontal hydraulic gradient within groundwater from the north of the site towards the Clutha River/Mata-Au. There are no groundwater wells clearly installed in different aquifer units adjacent to each other on the existing landfill site (i.e., nested wells), so on that basis, it is difficult to draw strong conclusions about the degree of vertical hydraulic gradients on site. As noted above, based on the water levels observed, it appears that groundwater level gradients largely follow topography, reducing in elevation southwest towards the Clutha River/Mata-Au.

4.4.2 Hydraulic Conductivity

Permeability testing was carried out in all groundwater monitoring wells in November 2022 and January 2023 to estimate hydraulic conductivity of the geological units at the site. Rising and falling head tests were undertaken either with solid slugs, or in wells with slow responses, with introduced water slugs. One well (BH1) was tested with a bailer due to equipment availability at the time to add/remove a volume of water. Results are summarised in Table 4 and the full results are included in Appendix A.

Table 4 : Summary of hydraulic conductivity values in geological units at Mt Cooee Landfill obtained from permeability testing in November 2022 and January 2023.

Geological Unit	Hydraulic Conductivity Range (m/s)	Groundwater Wells Included in Hydraulic Conductivity Range[1]
Alluvium	2.4×10^{-6}	GW2A
Weathered greywacke	1.4×10^{-9} to 3.9×10^{-4}	GW1A, BH3, BH4, BH5
Fresh greywacke	5.2×10^{-7} to 9.0×10^{-7}	BH1, GW7

Note: [1] Additional wells were tested for hydraulic conductivity but were excluded from this summary table where there was low confidence in the results.

Permeability testing showed a large range in hydraulic conductivity values for the greywacke (10^{-9} to 10^{-4} m/s) with the lowest permeabilities in highly weathered greywacke with little fracturing. The presence of fractures in the greywacke appears to result in higher permeabilities (as high as 10^{-6} m/s). Of note, some of the wells screened in greywacke units appear to have also been screened within the overlying alluvium to some degree, which may make it difficult to assign the estimated permeability to either unit (e.g., GW1A, BH4).

Map data sources: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Mt Cooee Landfill Development Plan
Mt Cooee Piezometric Map
Map Projection: NZGD 2000 NZ Transverse Mercator
Vertical Datum: NZ Vertical Datum (2016)

4.4.3 Groundwater Recharge and Flow

To estimate groundwater flow through the Mt Cooee Landfill site, for the purposes of this assessment, we have defined a Mt Cooee catchment, which is presented in Figure 11. The catchment is approximated by topographic highs to the northwest and southeast (ridgeline), by the Clutha River/Mata-Au to the south and by a regional catchment boundary defined by Otago Regional Council (Figure 11). The defined catchment has an area of approximately 80.9 ha.

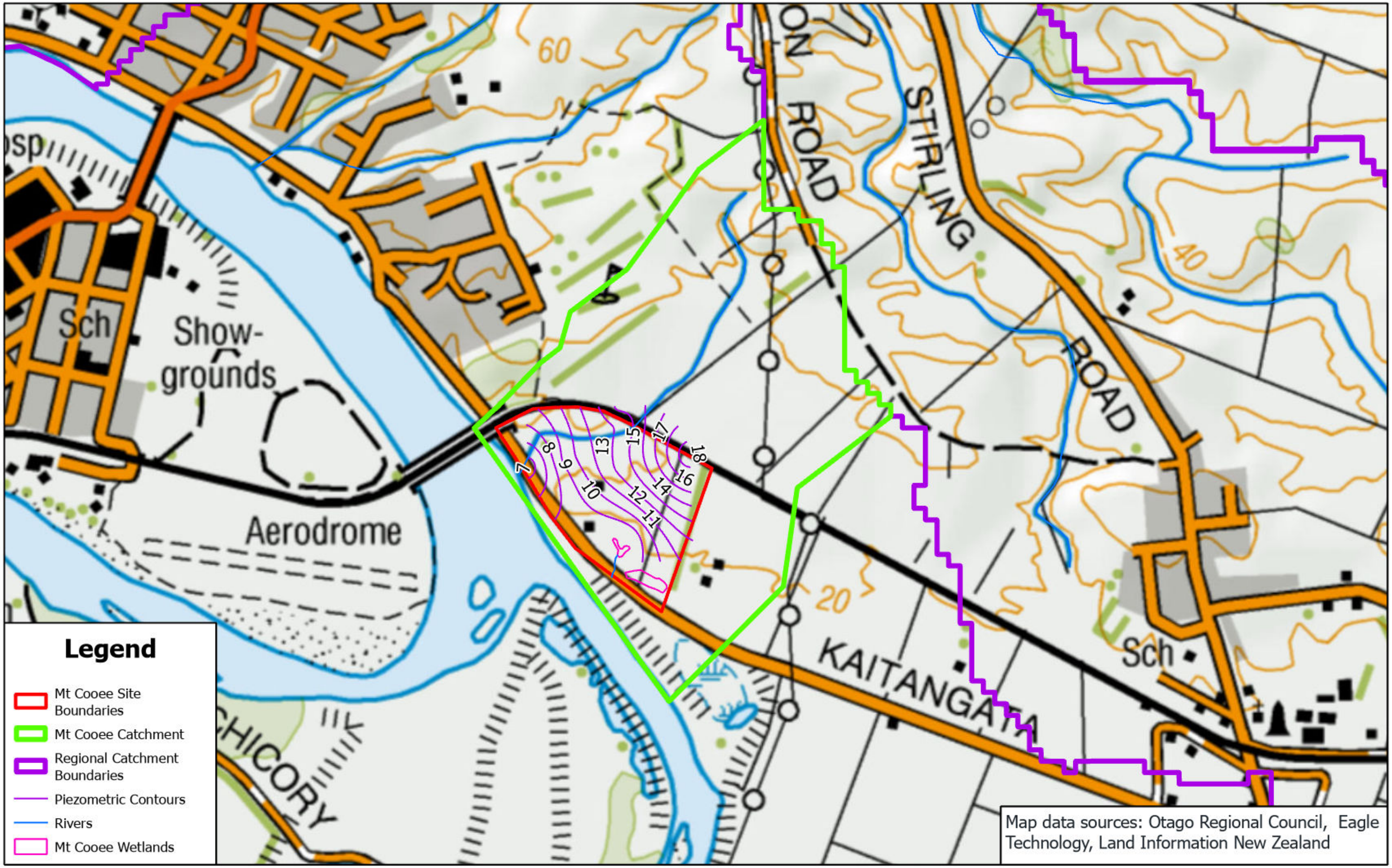
Groundwater recharge in the catchment is expected to occur largely via rainfall. As greywacke outcrops at the surface in most the catchment, for the purposes of this assessment, we have assumed all groundwater flow to occur within the greywacke. In reality, some proportion of groundwater flow would occur within alluvium or soils overlying the greywacke, though as these units are in general thin within the catchment, we have assumed that all flow occurs in the greywacke. Based on a Darcy's Law calculation, we estimate that approximately 34,500 m^3/year of groundwater flow moves through the Mt Cooee catchment (Table 5).

We note that this catchment groundwater flow estimate is based on a relatively low hydraulic conductivity value (7.1×10^{-7} m/s), which is an average value based on permeability testing of the greywacke units on site. As reported in Table 4, some permeability values obtained in on-site testing were several orders of magnitude higher (up to 10^{-4} m/s). If a higher hydraulic conductivity value were to be used for the catchment groundwater flow calculation, total groundwater discharge estimates would be greater. Therefore, we consider our estimate to be conservative.

Total rainfall across the 80.9 ha. catchment is estimated to be approximately 532,322 m^3/year based on the average annual rainfall in Balclutha of 658 mm (see Section 3.3). Given this rainfall rate, horizontal groundwater through the catchment would comprise approximately 6% of total rainfall.

Table 5 : Estimated groundwater flow in the Mt Cooee catchment.

Variable	Adopted Value	Unit	Data Source(s)/Justification
Area (*A*)	54,494	m^2	Saturated thickness x Aquifer width
Saturated Thickness	65	m	Highest elevation 69 m RL minus lowest elevation 4 m RL. Assumed to be reflective of water level in greywacke. Based on Otago 2020 LIDAR.
Aquifer Width	838	m	Average width across defined Mt Cooee catchment
Hydraulic Conductivity (*K*)	7.1×10^{-7}	m/s	Median *K* value from permeability testing in weathered and fresh greywacke units using data from GW1A, BH3, BH4, BH5, BH1, GW7
Hydraulic Gradient (*i*)	0.028	-	Average change in head x Average distance between wells
Average Change in Head	6.13	m	Average change in head between following wells: GW5 & GW7 = 6.13 m GW1A & GW2A = 5.96 m GW5 & BH1 = 6.30 m
Average Distance Between Wells	217	m	Average distance between following wells: GW5 & GW7 = 210 m GW1A & GW2A = 229 m GW5 & BH1 = 213 m
Discharge (Q)	34,486	m^3/year	$Q = KiA$ (Darcy's Law)



Map data sources: Otago Regional Council, Eagle Technology, Land Information New Zealand

Mt Cooee Landfill Development Plan
Mt Cooee Catchment Map
Map Projection: NZGD 2000 NZ Transverse Mercator
Vertical Datum: NZ Vertical Datum 2016

4.5 Water Quality

4.5.1 Groundwater Quality

We carried out groundwater quality sampling to support this assessment on the site between November 2022 and January 2023. This sampling included both existing compliance monitoring wells and wells newly installed in November 2022. Prior to November 2022, there has been quarterly water quality data collected for consent compliance monitoring purposes (refer to Mt Cooee Landfill compliance reports for full historic results). Water quality samples could not be collected from BH3 or BH6 due to insufficient water available in the wells at the time of sampling.

As mentioned in Section 3.4, in 2021, a stormwater diversion on the north side of the landfill site was constructed. This diversion was put in place as it was thought that leachate collected from the existing landfill cells was mixing with stormwater collected in a drain below the landfill cells, which then flowed to the watercourse between the sediment ponds and eventually to the Clutha River/Mata-Au. The constructed diversion closed off this stormwater path so that stormwater no longer mixes with landfill leachate underneath the existing cells. As this may result in significant changes to water quality downgradient of the existing landfill cells, this report focuses in particular on water quality data after the stormwater diversion was constructed. The March 2022 environmental monitoring report (WSP, 2022) is the first quarterly monitoring report that refers to the diversion being complete. Based on this, this assessment was carried out with the assumption that water quality sampling from March 2022 onwards reflects the completed stormwater diversion works. The full sampling results from March 2022 to January 2023 are reported in Appendix B.

Overall, water quality sampling shows a likely impact of landfill activities in some downgradient monitoring wells (select parameters shown in Table 6). GW2A, GW3 and BH1 are all wells installed beyond the cut-off wall of the existing landfill cells and are in the downgradient groundwater flow direction of the existing cells. In GW2A, GW3 and BH1 sampling shows elevated boron compared to upgradient bores (GW1A and GW7). Boron has previously been identified as a useful indicator of leachate contamination at Mt Cooee due to high levels at the site, likely due to coal ash disposal. Of note, elevated boron in BH1 indicates there is likely to be landfill leachate moving through the greywacke bedrock on the site. There is also elevated nitrate-nitrogen in GW2A and GW3 compared to upgradient bores. Upgradient bores showed nitrate-nitrogen concentrations largely below detection or <1 mg/L while levels in GW2A and GW3 ranged widely but were generally >1 mg/L and as high as 10.9 mg/L. Given the high concentrations of ammonia observed in monitoring wells installed within the landfill refuse (GW4 and GW5), the high nitrate-nitrogen observed downgradient in GW2A and GW3 may be oxidised ammonia. Of note, GW2A and GW3 had chemistry reflecting oxidised conditions (i.e., low ammonia and nitrite-nitrogen, higher sulphate). GW2A, GW3 and BH1 all have high bicarbonate alkalinity, which is also seen in GW4 and GW5. BH1 also has elevated chloride levels compared to other wells, which may be a landfill contaminant indicator.

Table 6 : Summary statistics for select water quality parameters sampled from March 2022-January 2023 upgradient and downgradient of the existing landfill cells.

Field ID		Boron (mg/L)	Nitrate-Nitrogen (mg/L)	Chloride (mg/L)	Bicarbonate Alkalinity as HCO_3 (mg/L)
Downgradient					
GW2A	Sample number	5	5	5	1
	Min	0.33	0.001	12.4	460
	Max	2.6	10.9	67	460
	Median	1.87	1.52	51	460

GW3	Sample number	5	5	5	2
	Min	0.26	0.005	32	250
	Max	0.58	10.3	47	340
	Median	0.29	1.11	33	295
BH1	Sample number	2	2	2	2
	Min	0.49	0.001	126	700
	Max	0.54	0.001	133	740
	Median	0.515	0.001	129.5	720
Upgradient					
GW1A	Sample number	2	2	2	2
	Min	0.046	0.002	25	79
	Max	0.046	0.003	66	108
	Median	0.046	0.0025	45.5	93.5
GW7	Sample number	5	5	5	1
	Min	0.038	0.001	59	94
	Max	0.041	0.089	97	94
	Median	0.04	0.018	87	94

Note: Where results were below detection, half the detection limit was used to calculate summary statistics.

For three key potential landfill contaminant indicators (boron, chloride and nitrate-nitrogen) we have analysed long-term trends (2007-2023) in impact wells GW2 and GW3 (Figure 12 to Figure 17). GW2 was replaced by GW2A in 2021 with the new located very close to the original well, so we have grouped results for both wells together. To analyse for long-term trends, we carried out Mann-Kendall analysis using NIWA Time Trends software and considered p values <0.05 as statistically significant. Table 7 summarises the trends for these three variables. There were strong increasing trends for nitrate-nitrogen in both GW2/GW2A and GW3. There was also an increasing trend in boron in GW3 but no trend in GW2/GW2A. Long-term data for chloride on the other hand showed a strong decreasing trend in GW2/GW2A but no significant trend in GW3.

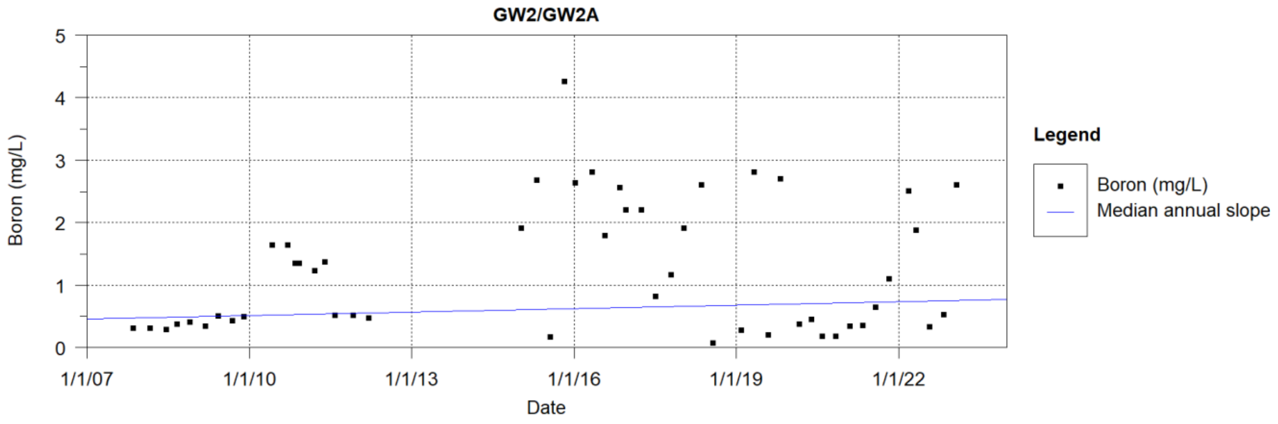


Figure 12 : Long-term trend analysis for boron in impact well GW2/GW2A.

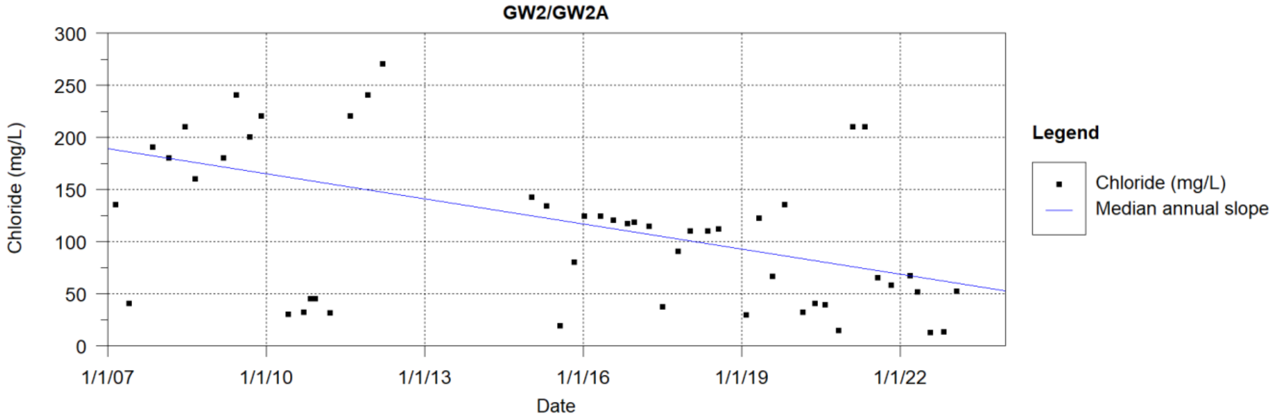


Figure 13 : Long-term trend analysis for chloride in impact well GW2/GW2A.

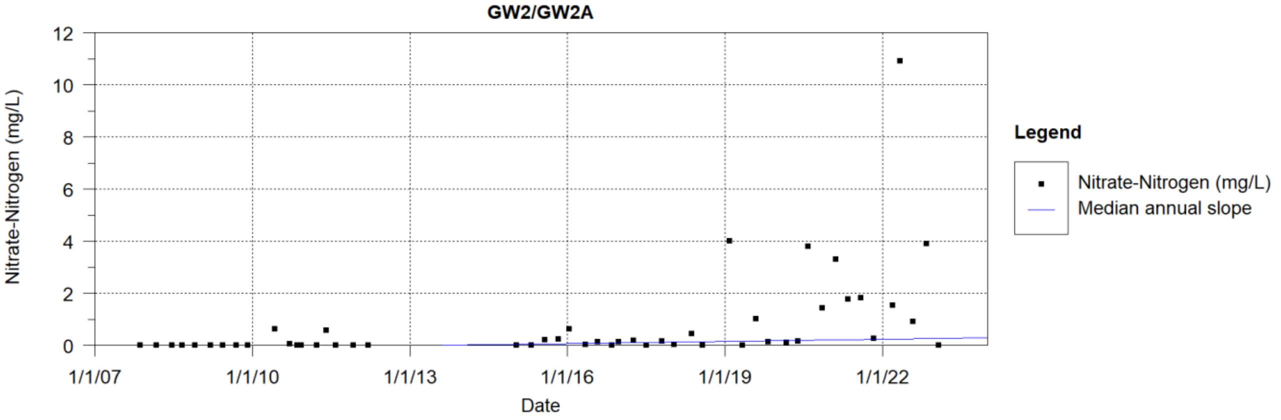


Figure 14 : Long-term trend analysis for nitrate-nitrogen in impact well GW2/GW2A.

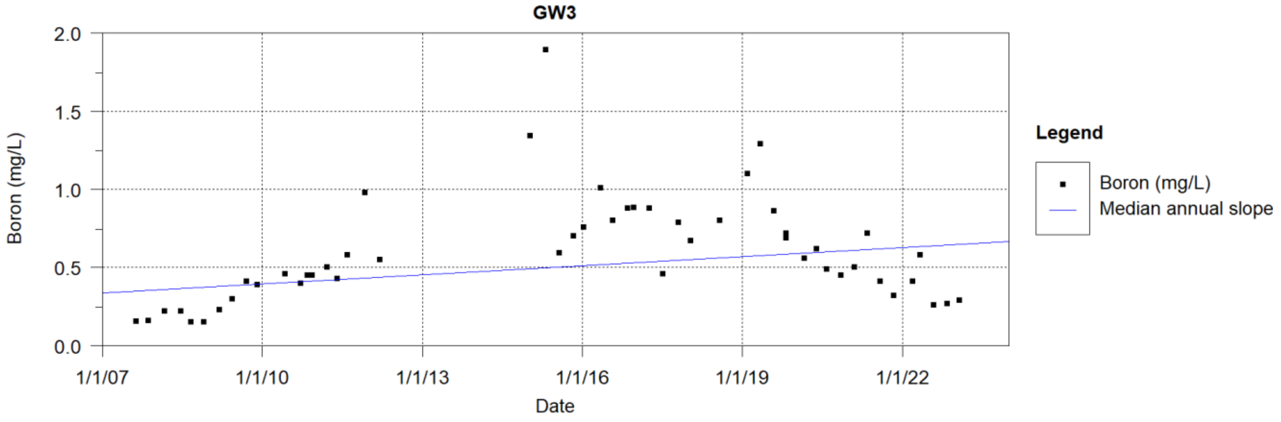


Figure 15 : Long-term trend analysis for boron in impact well GW3.

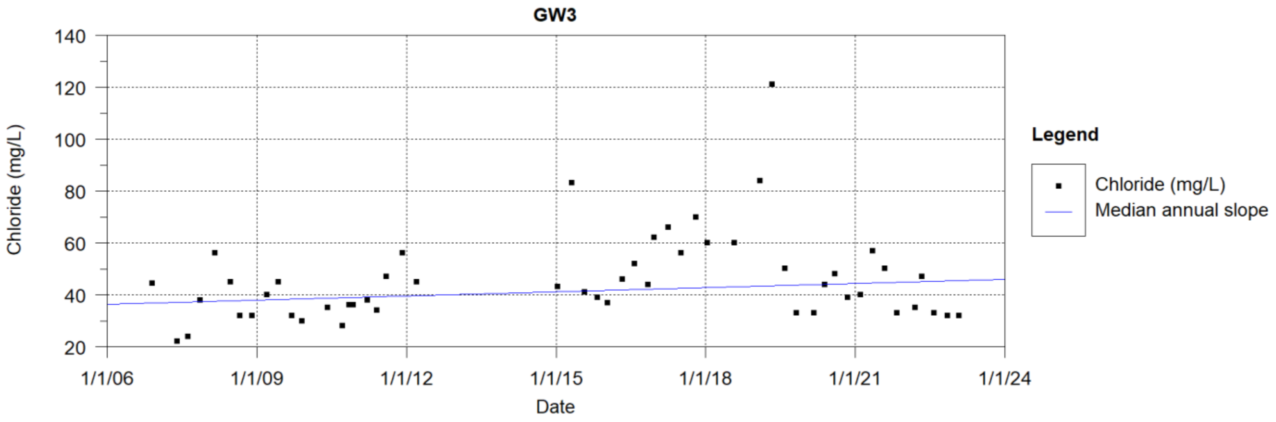


Figure 16 : Long-term trend analysis for chloride in impact well GW3.

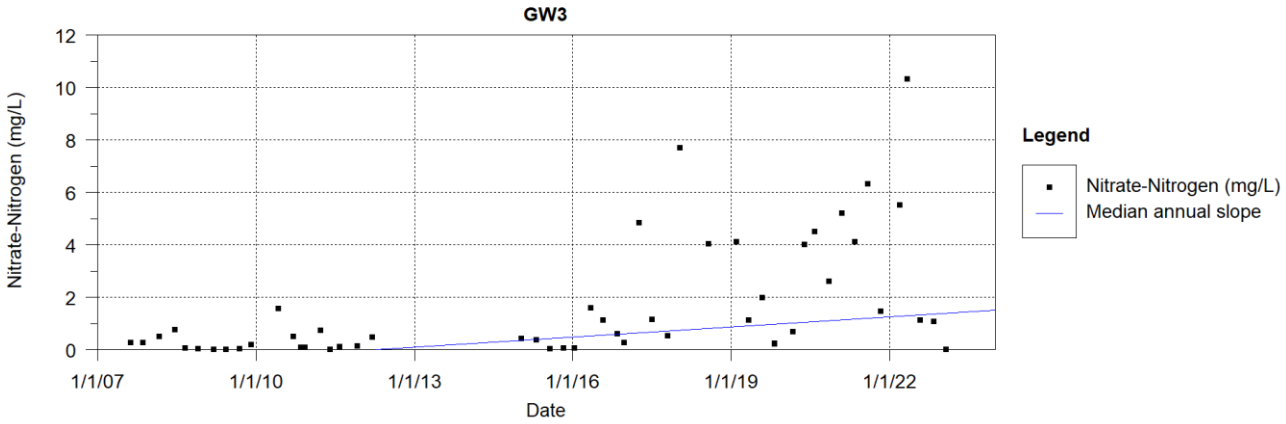


Figure 17 : Long-term trend analysis for nitrate-nitrogen in impact well GW3.

Table 7 : Summary of Mann-Kendall trend analysis for select landfill contaminant indicators in impacts wells GW2/GW2A and GW3. Trends with p values <0.05 have been considered significant.

Field ID	Parameter	p Value	Trend
GW2/GW2A	Boron	0.363	No significant trend
	Chloride	0.001	Strong decreasing trend
	Nitrate-nitrogen	0.001	Strong increasing trend
GW3	Boron	0.035	Increasing trend very likely
	Chloride	0.110	No significant trend
	Nitrate-nitrogen	0.001	Strong increasing trend

We note that BH1 is a new downgradient groundwater monitoring well, screened in the greywacke and deeper than GW2A and GW3; therefore, it is worthwhile looking generally at whether water chemistry in BH1 is similar to that of GW2A and GW3. Alternatively, it could be more reflective of upgradient water chemistry, i.e., representing deeper flowpaths within the greywacke that are not influenced by landfill leachate. However, when major ion chemistry is plotted on a piper plot to examine water types, it appears that water sampled in BH1 is similar to GW2A and GW3 (these samples plot to the left side of the top diamond in Figure 18. Upgradient wells GW7 and GW1A plot on other end of the piper plot (Figure 18) suggesting different water types (i.e., sources).

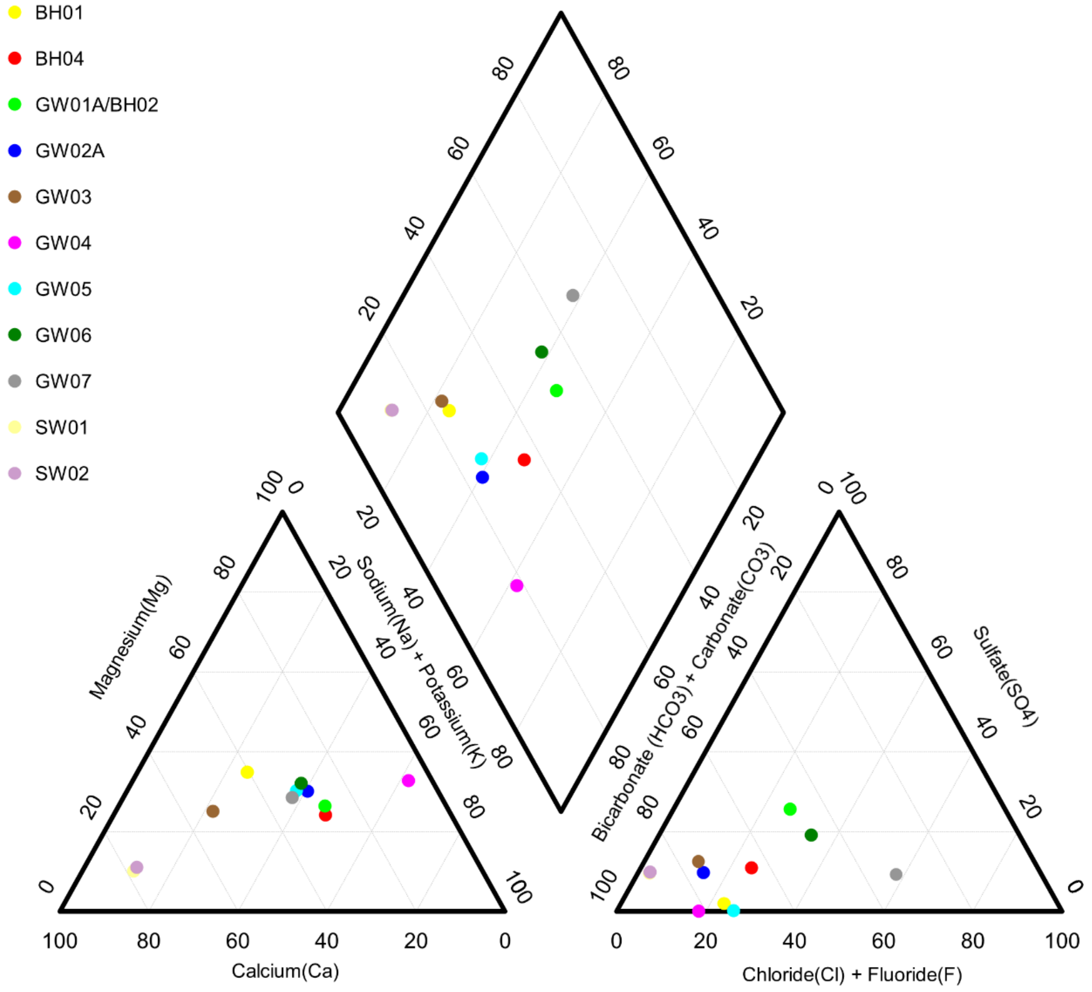


Figure 18. Piper plot showing major ion chemistry in groundwater and surface water sampling locations. Based on sampling data from 23-24 January 2023.

Given the predicted general groundwater flow direction on the site is from the northeast to the southwest, it is unclear how relevant wells BH4 and BH5 are in terms of assessing active landfill impacts. However, we note these wells are still downgradient of the active landfill, and may therefore show some impacts, particularly given the possibility that flow within bedrock fractures may not follow a clear northeast to the southwest direction. In general, BH4 does not appear to show signs of landfill contamination that are seen in impact wells GW2A, GW3 and BH1 (e.g., elevated chloride, boron, nitrogen), and is more reflective of upgradient chemistry. BH5 however is an outlier as its chemistry is different from many other upgradient and downgradient wells for several parameters. As in GW4 and GW5, BH5 has elevated potassium, biological oxygen demand, total organic carbon, iron and total alkalinity. However, in some cases, concentrations are much higher than in GW4 and GW5 – e.g., for calcium and biological oxygen demand. BH5 does not have elevated boron or chloride, both of which are likely landfill contaminant indicators.

4.5.2 Surface Water Quality

Surface water sampling to support this assessment was carried out from April 2022 to January 2023. As with the groundwater sampling, there is historic data collected as part of compliance monitoring. This assessment focuses on data collected since the stormwater diversion was operational (March 2022 onwards). The full sampling results from March 2022 to January 2023 are reported in Appendix B.

There are two long-term water quality monitoring locations in the watercourse that runs between the sediment ponds, downgradient of the existing landfill area identified as WC2 and WC3 (Figure 5). WC2 is close to the leachate pump station while WC3 is on the south side of the Kaitangata Highway approximately 30 m upstream of where it discharges to the Clutha River/Mata-Au. Note, these two locations were not sampled in January 2023. During sampling in 2022, there was evidence of landfill contamination at both sampling sites in all monitoring rounds (elevated electrical conductivity, chloride and ammonia) (Table 8).

Table 8 : Water quality results for WC2 and WC3.

		Electrical Conductivity @ 25°C	pH (Lab)	Chloride	Ammoniacal Nitrogen
		uS/cm	-	mg/L	mg/L
Field ID	Date				
WC2	08 Mar 2022	1,762	7.9	193	9.20
	28 Apr 2022	1,247	7.8	134	3.10
	29 Jul 2022	458	7.6	37	2.30
	26 Oct 2022	879	7.4	79	3.80
WC3	08 Mar 2022	1,673	8.3	200	4.10
	28 Apr 2022	1,188	8.1	128	1.34
	29 Jul 2022	492	7.8	38	1.21
	26 Oct 2022	944	8.1	98	1.07

Two sampling locations were established on the left bank of the Clutha River/Mata-Au in 2022, with the first samples collected in April 2022, and quarterly samples collected thereafter (four sampling rounds in total). An upstream sampling site (SW1) was established approximately 80 m upstream of the southwest corner of the landfill site. A downstream site was set up approximately 150 m south of the southeast corner of the landfill site on the Matau Branch of the Clutha River/Mata-Au. Due to periodic access issues at SW2, an alternative downstream river was sampled on 29 July 2022 and 1 November 2022. This site ('SW2 Alternative') is approximately 315 m upstream of SW2. Based on the four sampling rounds carried out at these two sites.

4.6 Conceptual Hydrological and Hydrogeological Model

The current understanding of the groundwater and surface water systems at the Mt Cooee Landfill site is that of a groundwater system dominated by flow through the variably permeable greywacke bedrock. Some flow also occurs through overlying alluvial sediments, particularly in the valley floor that runs through the southwest side of the landfill site where the alluvial sediments are thicker.

Groundwater level measurements have not shown clear differences in water levels within the greywacke and overlying alluvium. Therefore, we conceptualise the groundwater system as effectively one connected system. We assume that groundwater is largely recharged by rainfall in the catchment and flows from the topographic highs to the northeast towards the southwest.

Groundwater level measurements at the landfill and river bank elevations from LiDAR indicate that groundwater is likely connected to the Clutha River/Mata-Au and the river gains groundwater from the landfill site.

The main surface water body within the Mt Cooee Landfill catchment is the stream that runs along the southeast boundary of the golf course and is then diverted along the northwest boundary of the landfill site until it discharges into the Clutha River/Mata-Au.

A small stream and wetland have also been identified in the southeast corner of the landfill site (4Sight Consulting, 2022). The head of the stream and wetland originate very close to the location of BH5. Groundwater level mapping indicates the groundwater level in this area is close to the land surface elevation at this location. Therefore, it is likely that the stream and wetland are groundwater fed to at least some degree. However, as observed on site, groundwater levels have been >1.5 m bgl in BH5 for an extended period of time during summer 2023. During periods of lower groundwater levels, groundwater flow to this stream and wetland could reduce.

5 Assessment of Effects

This report section assesses the potential effects of the existing and proposed landfill activities. The existing landfill at Mt Cooee and proposed expansion activities have the potential to affect the following aspects of the surrounding environment:

- Groundwater recharge and flows.
- Groundwater levels and gradients.
- Flows to surface water and wetlands.
- Water quality in groundwater, surface water and wetlands.

5.1 Assessment Approach

We have carried out the assessment of effects on water quantity using water balance modelling as a general approach. These water balance models specifically inform:

- Volume of runoff generated from the landfill cells.
- Volume of leachate generation.
- Volume of leachate leakage which is not captured by leachate collection systems.

Understanding these effects on the immediate groundwater environment due to the proposed landfill activities allow for an assessment of the wider environment, such as nearby surface water bodies and groundwater-fed features.

5.2 Landfill Water Balance and Leachate

5.2.1 Landfill Runoff

This section presents an estimate of runoff from the landfill cells (Table 9). We have considered the following scenarios for runoff areas:

- Existing landfill area – fully closed and capped. Assumed to be a realistic scenario as this landfill area has nearly reached full capacity.
- Expansion area Stage 1
- Expansion area Stage 1 + 2
- Expansion area Stage 1 + 2 + 3
- Expansion area – Closed and capped. Note, as Stages 4 and 5 will be built on top of Stages 1-3, we have assumed these stages will not increase the runoff area.

We used the Rational Method to estimate rainfall runoff to the landfill areas listed above. We assumed a runoff coefficient of 0.6 based on a low-permeability clay capping material and 14%

average surface slope as included in the expansion area design. We have assumed the same slope for the existing landfill area. We used the average annual rainfall (1991-2020) from the Balclutha Telford site (National Institute of Water and Atmosphere (NIWA), 2023).

Table 9 : Rainfall runoff estimates for landfill cells.

Landfill Section	Area (m^2)	Surface Runoff m^3/year
Existing landfill	25,626	10,117
New Landfill - Stage 1	4,100	1,619
New Landfill - Stage 2	4,300	1,698
New Landfill - Stage 3	7,300	2,882
New Landfill - Stage 4/5 Final Area	10,400	4,106

5.2.2 Leachate Generation and Leakage

In this section we estimate leachate generated from the existing and expansion area landfill cells, as well as leachate leakage to groundwater underneath the cells (Table 10, Figure 19, Figure 20). We have used the same landfill scenarios, footprint areas and surface runoff estimates as in Table 9.

Existing Landfill

For the existing landfill area, we have used actual CDC leachate pump station records as the leachate estimate. We have used pumping records from 5 January 2022 to 26 October 2022 (latest data available), assuming this period represents volumes collected from the leachate system after the stormwater diversion was fully operational and adequately reflects seasonal and annual variations in pumping volumes. In this landfill scenario, we estimate leachate production once the landfill cells have been filled (nearly their current state), so we have assumed leachate production has effectively reached its maximum. For the existing landfill area, upgradient groundwater inflow to the landfill cells needs to be considered as the cells are unlined. Here, we have assumed the pumping volumes include upgradient groundwater inflow to the landfill cells.

Proposed Landfill Expansion

For the expansion area, we used the following formula to calculate leachate generation (Centre for Advanced Engineering, 2000):

$$L_O = P - SRO - ET - DS$$

Where L_O is leachate generation (m^3/year), P is precipitation (m^3/year), SRO is surface runoff (m^3/year), ET is evapotranspiration (m^3/year), and DS is change in leachate storage of the waste.

For all expansion area leachate scenarios, we used the following adopted values: We used an annual average precipitation rate of 658 mm/year (1991-2020) from the Balclutha Telford site (National Institute of Water and Atmosphere (NIWA), 2023). For evapotranspiration, we subtracted rainfall from potential evapotranspiration (based on the Penman method, from NIWA Cliflo data for the Balclutha Telford station). We assumed the change in leachate storage of the waste (*DS*) to be zero for the purposes of this assessment. Over time, the volume of water entering the landfill cell will approximately equal the amount of leachate produced. However, initially there is a lag period while the landfill wastes increase in moisture content until this equilibrium is reached (Centre for Advanced Engineering, 2000). For the expansion area scenarios, we have adopted a conservative approach by assuming the moisture capacity has been reached and the landfill cells are producing the maximum amount of leachate.

As the expansion area will be lined, we have assumed no upgradient groundwater flow into the landfill cells.

Table 10 : Estimates of leachate generated and leachate leakage from landfill cells at Mt Cooee. Note: volumes are cumulative for the new landfill scenarios.

Landfill Section	Leachate Estimate (m^3/year)	Leachate Leakage Estimate (m^3/year)	Leachate Leakage Percentage
Existing Landfill Area - Actual Current Volume	26,962	674	2.5%
New Landfill - Stage 1	825	0.4	0.05%
New Landfill - Stage 2	865	0.4	0.05%
New Landfill - Stage 3	1,469	0.7	0.05%
New Landfill - Stage 4/5 Final Area	2,092	1.0	0.05%

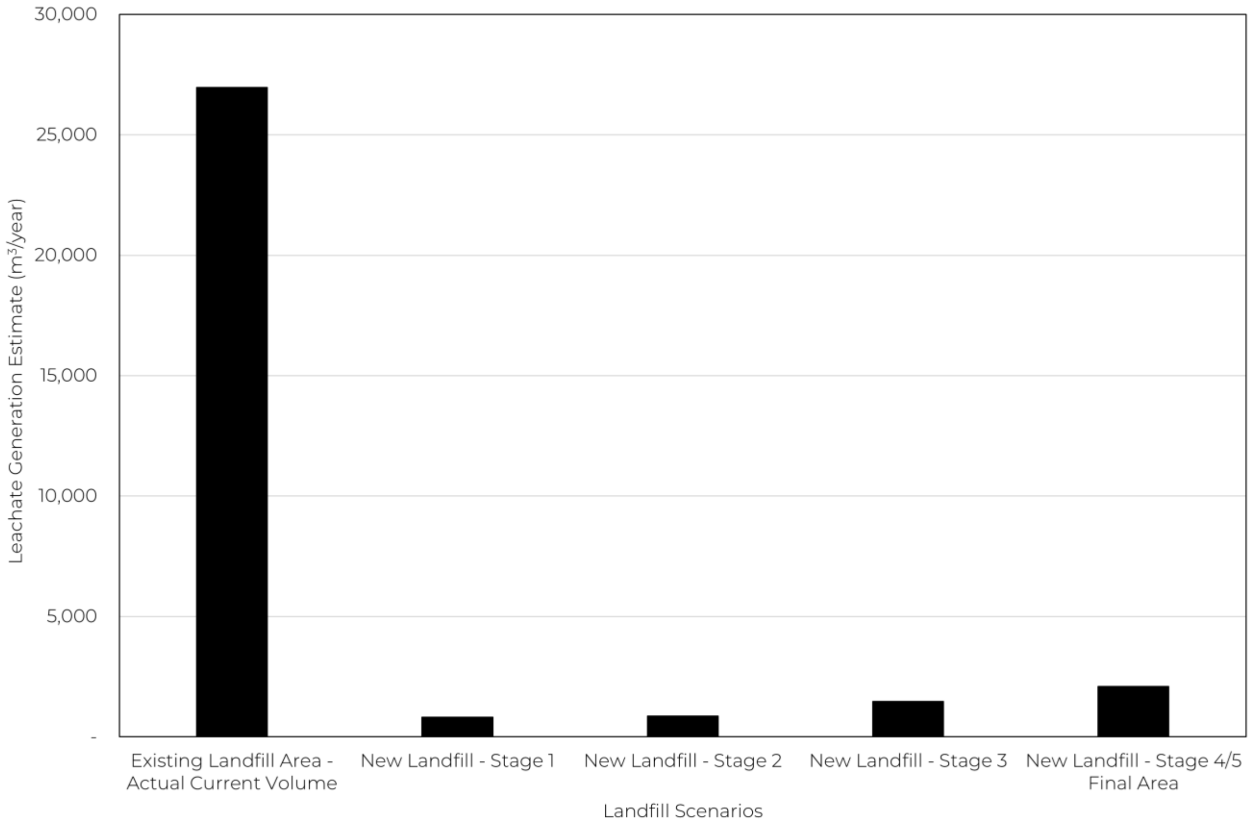


Figure 19 : Leachate generation estimates for five landfill scenarios at Mt Cooee. Note that for Stages 1 to 4/5 of the expansion area, leachate volumes are cumulative.

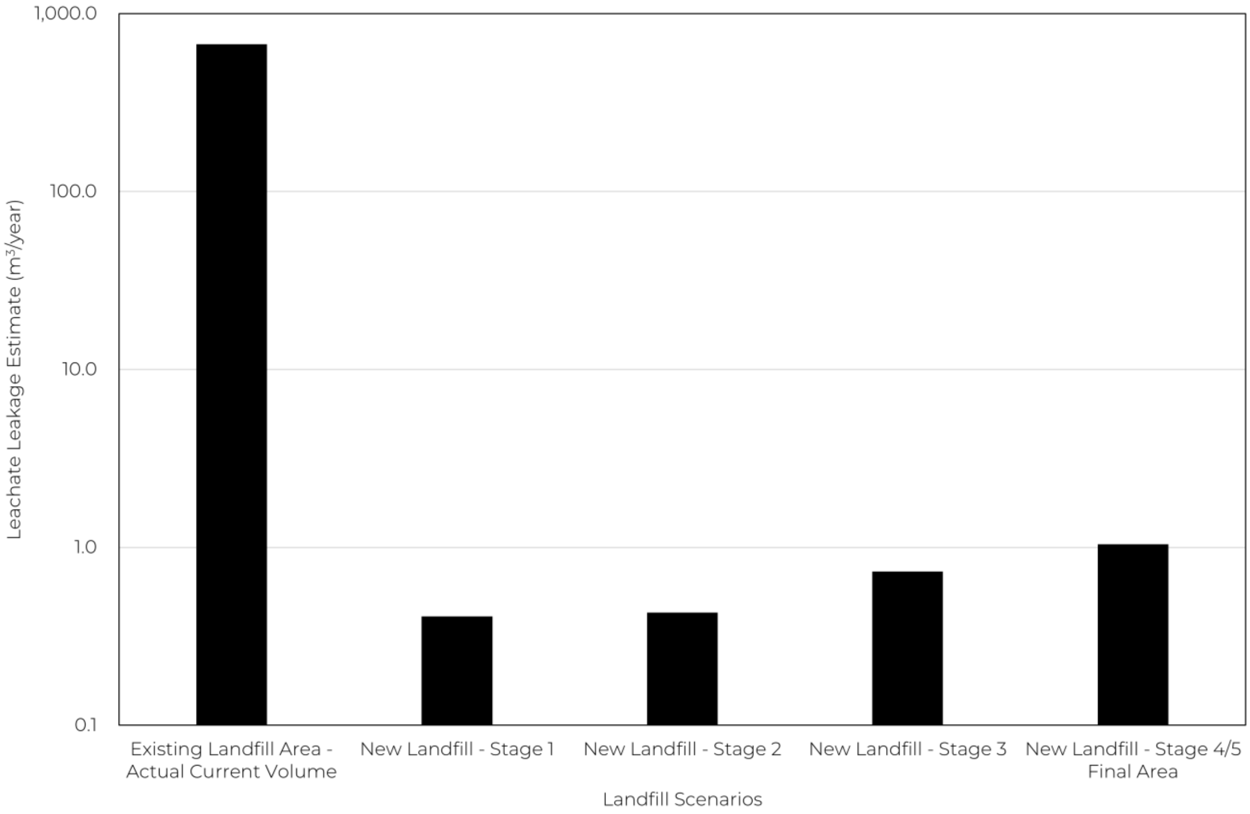


Figure 20 : Leachate leakage estimates for five landfill scenarios at Mt Cooee. Note that data is presented on a log scale. Note that for Stages 1 to 4/5 of the expansion area, leachate volumes are cumulative.

Leachate estimates are highest in the existing landfill area compared to the expansion area based on the actual pump station volumes (26,962 m^3/year). This is likely due to upgradient groundwater inflow, which would not occur in the expansion area given it will be lined. We note that based on the actual leachate volumes collected at the pump station, the estimate of total groundwater catchment discharge of 34,485 m^3/year (Table 5) is likely an underestimate. This is based on a number of assumptions, some with moderate to high uncertainty, and this estimate should be considered further. Adopting a higher hydraulic conductivity value in the catchment groundwater discharge estimate (as discussed in Section 4.4.3), could account for the actual pump station volumes.

Leachate estimates are 2-3 orders of magnitude lower for the expansion area. Estimates range from 0.4 m^3/year of leachate produced once the Stage 1 cell is complete up to 2.61 m^3/year of leachate produced once all five cells are complete. We note that in reality, leachate generation should decrease over time once the landfill is closed and capped, however the estimates produced here are not detailed enough to predict this.

We have also produced estimates of leachate leakage to groundwater below the landfill cells (Table 10 and Figure 20). Given the existing cells are unlined and the base of the landfill cells are greywacke, the permeability of this rock and hydraulic gradients will largely regulate leachate leakage rates. For leachate leakage to the underlying groundwater system, we have assumed a leakage rate of 2.5% resulting in an estimated 674 m^3/year of leakage from the existing cells using the actual leachate collection volume as a basis for the calculation.

We have adopted an assumed maximum leachate rate from the Class 1 GCL liner proposed for the expansion area of 0.1 mm/year. This results in a maximum of 1 m^3/year of leachate leakage from the final landfill area filled to full capacity (Stage 4/5). We based our estimates of leachate loss through the base liner on HELP models[1] from a similar relatively arid climate (500 mm annual rainfall) with a HDPE-over-GCL liner system. This yielded loss rates of 0.00004 mm/year, i.e., an infinitesimal amount. As a conservative (i.e., high) estimate, we have used 0.1 mm/yr.

5.2.3 Leachate Quality

Leachate is produced by rainfall infiltration or groundwater flows interacting with landfill refuse. The composition of the leachate will be a factor of the type and age of the waste, physiochemical conditions within the landfill cells, and the microbiology and water balance of the landfill (Centre for Advanced Engineering, 2000). In most cases, the contaminant concentrations in leachate are highest when the waste has recently been deposited and has not yet been covered. Contaminant concentrations generally decrease once the landfill closes.

In this assessment, we have used leachate concentrations from eight New Zealand landfills as benchmarks for comparison (Centre for Advanced Engineering, 2000) (Table 11). We also note that samples from the pump station at Mt Cooee are regularly analysed for chemical constituents. However, the sampling suite is limited compared to the results in the Centre for Advanced Engineering Landfill Guidelines (CAE) (2000); therefore, to provide a more conservative assessment, we have adopted the CAE (2000) data as base concentrations for leachate flux estimates for Mt Cooee.

Table 11 : Average chemical concentrations in leachate (using high end of range) for eight solid waste Class 1 New Zealand landfills (Adapted from Centre for Advanced Engineering (2000)).

Parameter	Units	Average High Concentrations
Aluminium	mg/l	41.0
Ammoniacal Nitrogen	mg/l	542.5
Arsenic	mg/l	0.11
Boron	mg/l	9.9
Cadmium	mg/l	0.01
Calcium	mg/l	273
Chloride	mg/l	1834
Chromium	mg/l	6.41
Dissolved Reactive Phosphorus	mg/l	2.32
Iron	mg/l	81.8
Lead	mg/l	0.11
Magnesium	mg/l	229.1
Manganese	mg/l	4.68
Nickel	mg/l	2.55
Nitrate-nitrogen	mg/l	0.58
pH	pH units	7.63
Potassium	mg/l	456
Silica	mg/l	36
Sodium	mg/l	1317
Sulphate	mg/l	217
Total Kjeldahl Nitrogen	mg/l	1081
Zinc	mg/l	3.71

Note: Metals are reported as total metals. Some parameters not reported for all landfills.

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[1] Refers to the Hydrologic Evaluation of Landfill Performance (HELP), developed by the US Environmental Protection Agency, to calculate the water balance of landfills.

5.3 Catchment Water Balance

To assess the effects of the existing and proposed landfill operations, we have estimated a water balance for the 80.9 ha. Mt Cooee catchment (Table 12). We have estimated water budgets under three scenarios:

- Pre-landfill development.
- Existing landfill, fully closed.
- Full development and closure of expansion area.

Table 12 : Estimated water balance for the Mt Cooee Landfill catchment.

	Pre-Landfill	Existing Landfill (Fully Closed)	Worst Case During Operation of New Area (Includes Full Closure of Landfill)[1]
Inputs (m^3/year)			
Rainfall	532,322	532,322	532,322
Outputs (m^3/year)			
Evapotranspiration	284,907	284,907	284,907
Runoff	212,929	212,929	212,929
Groundwater Discharge	34,486	6,849	4,756
Leachate Collection System	-	26,963	29,055
Leachate Leakage	-	674	675

Notes: [1] Includes impacts on groundwater discharge and leachate quantities from the existing landfill.

For a runoff estimate, we have assumed the catchment (pre-landfill development) was mostly cultivated fields with clay soil and adopted a runoff coefficient of 0.4, which equates to 212,929 m^3 of runoff annually. We have assumed the same runoff quantity under the landfill scenarios. In reality, runoff may increase under the landfill development scenarios as the capping material would be low permeability and final surface slopes are likely to be greater than the pre-development landforms. However, given the estimated runoff from the landfill cells is very small in comparison to the total catchment runoff (Table 9), we have assumed the difference is negligible and within the margin of error for the catchment water budget.

For evapotranspiration, we have assumed this is the balance of the other outputs from the water budget. As with runoff, we assume that given the small size of the landfill cells (5.17 ha.) relative to the total catchment size (80.9 ha.), the difference in evapotranspiration under the landfill scenarios would be within the margin of error of the water balance for the catchment.

For outputs for leachate collection and leachate leakage, we used the estimates from Section 5.2.2.

For predictions of groundwater discharge, we based this on estimates from Table 5. Under the existing landfill area scenario, we assumed net groundwater discharge in the catchment would decrease by 26,963 m^3 to 7,523 m^3/year due to abstraction to the leachate collection system within the landfill cells (Table 12). Under the expansion area scenario, we predict a further increase of 2,092 m^3/year groundwater abstraction to the leachate management system, resulting in 4,756 m^3/year total groundwater discharge in the catchment. We refer to 'net' groundwater discharge here as this includes leachate leakage, which would still flow out of the catchment. This results in total groundwater discharge reductions within the catchment of 78% and 84%, respectively. As stated earlier, we expect the estimated total groundwater flow in the catchment (Table 5) likely to be an underestimate. Therefore, we expect the actual reductions in groundwater discharge to be much lower than 78%.

5.4 Effects to Groundwater and Surface Water Quantity

5.4.1 Methodology

The assessments discussed in this section are based on estimates of recharge and discharge in the Mt Cooee catchment reported earlier. We have adopted a simple analytical approach to assess impacts on water quantity as a result of landfill development. This assessment examines the potential impacts of two scenarios:

- The existing landfill area, fully closed and capped.
- The existing landfill plus the development of the expansion area. This assumes the worst-case scenario as the landfill being fully closed and capped.

5.4.2 Groundwater Recharge and Flow

As the existing landfill area is unlined, we do not anticipate a reduction in groundwater recharge into the landfill site as a result of the existing landfill cells. However, as leachate is captured from the cells, we estimate a reduction in total groundwater recharge to the system by 78% or 26,963 m^3/year (Section 5.3). As we have noted in Section 5.3, we expect the actual reduction in groundwater discharge to be less than 78%.

Given the proposed expansion area design incorporates a requirement for the landfill cell base to be positioned above the groundwater table, it cannot intercept upgradient groundwater should the liner lose its integrity. As the wall of the landfill cells will provide a low-permeability barrier to groundwater flow, we anticipate an increase in groundwater flow around the new landfill cells. Impact on the quantity of groundwater recharge should only be in the form of a reduction in groundwater infiltration in the landfill cell area. This infiltration will instead be captured by the leachate drains and transferred off site. We estimate an 84% reduction in total groundwater recharge in the catchment once the expansion area has been fully constructed, representing the total existing and proposed landfill cell footprint across the site (Section 5.3).

The proposed RRC and transfer station will increase the amount of hardstand on the site by ~0.6 ha. The proportion of the footprint area of the hardstand compared to the total catchment area is 0.74%. Based on this, the proposed hardstand areas would decrease total groundwater infiltration by 257 m^3/year, i.e., 0.74% of the total catchment groundwater discharge. Most of the stormwater produced on the hardstand areas will be conveyed to the stormwater ponds, some of which will be lost to evaporation from the ponds, but some may discharge into the Clutha River/Mata-Au if the ponds exceed capacity.

5.4.3 Groundwater Levels and Gradients

Current groundwater levels and gradients on the site reflect the impacts of the existing landfill area operation. Contour mapping of current groundwater levels on the site (Figure 10) do not suggest the existing landfill cells are measurably impacting groundwater levels or gradients. This is based on a snapshot view of groundwater levels in the existing on-site groundwater wells where suitable measurements could be made. Therefore, there may be actual impacts not reflected in the water level mapping in Figure 10.

Construction of the expansion area is predicted to reduce groundwater flow by 2,092 m^3/year. Using Darcy's Law, the change in head across the groundwater catchment can be reduced proportionally by the same amount. This results in a reduction of 0.37 m in groundwater levels underneath and downgradient of the expansion area, assuming a uniform drop in head. Given the high uncertainties with some aspects of this assessment, we expect this head reduction to be within the margin of error in this assessment and likely not measurable in reality.

5.4.4 Surface Water Flow

As described in Section 4.6, we assume for the purposes of this assessment that most groundwater discharge in the Mt Cooee catchment flows to the Clutha River/Mata-Au. A minor proportion is likely to flow to the small stream on the southeast corner of the landfill site identified in the Terrestrial, Wetland and Waterway Assessment for this consent application (4Sight Consulting, 2022) (Figure 21). As identified by 4Sight, this stream originates approximately 130 m south of the southern edge of the proposed landfill expansion area. As the stream originates in the middle of a paddock with no surface flows into its headwaters, we assume the stream is fed by shallow groundwater. The stream has not been gauged, so we do not currently have an estimate of its range of flow. However, during the time of the 4Sight survey in November 2022, the stream had visibly low flow with very little flow discharging out of the culvert where it drains on the south side of the Kaitangata Highway (4Sight Consulting, 2022). In their assessment, 4Sight states there are no anticipated impacts on this stream from the proposed landfilling activities ~130 m to the north. As discussed in Section 5.4.3, we estimate a maximum 0.37 m of groundwater level reduction resulting from the leachate collection system being installed in the expansion area. This head reduction is unlikely to affect this small stream and would be difficult to measure the change in practice. As we noted in Section 5.4.2, the construction of the new landfill cells will block off some upgradient shallow groundwater flow, which would then naturally follow the path of least resistance and divert around the expansion area. Based on the level of detail of this assessment, it is not known how much of this flow would continue to flow to the small stream.

Figure 21 : Small stream and wetlands identified on the southeast corner of the Mt Cooee site. Source: 4Sight Consulting (2022).

In terms of total groundwater discharge reduction as a result of the landfill activities, as noted in Section 5.3, we estimate a reduction in total catchment groundwater discharge resulting leachate collection from the existing landfill cells to be 26,963 m^3/year and a maximum of 2,092 m^3/year from the expansion area. At the long-term ORC flow gauging site at Balclutha, mean annual low flow in the Clutha River/Mata-Au is 272 m^3/s. The anticipated reduction in groundwater flow as a result of the existing landfill and expansion area leachate abstraction is on the order of 0.0003% of Clutha River/Mata-Au mean low flow. This impact would not be measurable in practice.

5.4.5 Flow to Wetlands

Based on estimated reductions in groundwater levels and flow downgradient of the expansion area as discussed elsewhere, we do not anticipate a measurable impact on flows to the wetlands at the southeast corner of the site. As we have noted, the construction of the new landfill cells will block off some upgradient shallow groundwater flow, which would then naturally follow the path of least resistance and divert around the expansion area. As with impacts of this on the small stream (see Section 5.4.4), it is unclear with the current level of detail in this assessment how much of this diverted flow would still flow through the wetlands. Also, given the level of assumptions made in the water balance calculations in this assessment, it is not possible to say with high confidence what the water quantity effects would be on the wetlands.

5.5 Effects to Water Quality

5.5.1 Predicted Changes to Contaminant Flux

Based on Class 1 leachate reference values presented in Table 11, we have estimated the changes in contaminant flux resulting from leachate leakage from the existing and expansion area landfill cells (Table 13). We have assumed that water quality analysis in control monitoring wells GW1A and GW7 are representative of groundwater water quality throughout the Mt Cooee catchment upgradient of the landfill. We note that the CAE Landfill Guidelines (2000) reference leachate data used here to calculate the predicted flux rates from leachate is given as total metals, while sampling data for GW1A and GW7 is for filtered metals, so direct comparisons should be made with caution.

Table 13 : Estimated changes in contaminant flux resulting from leachate leakage.

Parameter	Upgradient Water Quality - Average of GW1A & GW7 (mg/L)[1]	Existing Flux Across Total Groundwater Catchment (kg/year) (34,487 m^3/year Catchment Flow)	Predicted Flux from Existing Landfill Leachate (kg/year) (674 m^3/year Leakage)	Predicted Flux from Expansion Landfill Leachate (kg/year) (2.61 m^3/year Leakage)
Aluminium[2]	0.01975	0.0000007	0.000028	0.00000011
Ammoniacal Nitrogen	0.6405	0.0000221	0.000366	0.00000142
Arsenic	0.0005	0.000000017	0.00000007	0.00000000029
Boron	0.0428	0.0000015	0.000007	0.00000003
Cadmium	0.000025	0.000000001	0.00000001	0.00000000003
Calcium	28.25	0.0009742	0.000185	0.00000071
Chloride	64.95	0.0022399	0.001237	0.00000479
Chromium	0.00025	0.000000009	0.000004	0.00000002
Dissolved Reactive Phosphorus	0.2925	0.0000101	0.000002	0.00000001
Iron	0.175	0.0000060	0.000055	0.00000021
Lead	0.000065	0.000000002	0.00000007	0.00000000029

Magnesium	15.575	0.0005371	0.000154	0.00000060
Manganese	0.64	0.0000221	0.000003	0.00000001
Nickel	0.00175	0.0000001	0.000002	0.00000001
Nitrate-nitrogen	0.01825	0.0000006	0.00000039	0.00000000151
Potassium	2.915	0.0001005	0.000308	0.00000119
Silica	25.85	0.0008915	0.000024	0.00000009
Sodium	39.75	0.0013708	0.000888	0.00000344
Sulphate	37	0.0012760	0.000146	0.00000057
Total Kjeldahl Nitrogen	0.995	0.0000343	0.000729	0.00000282
Zinc	0.005375	0.0000002	0.000003	0.00000001

Notes: [1] Water quality sampling data from 2022-2023 used to calculate average concentrations. [2] Leachate reference data based on data presented in CAE (2000) for eight New Zealand Class 1 landfills. [3] CAE (2000) data is given as total metals, while sampling data for GW1A and GW7 is for filtered metals.

5.5.2 Predicted Changes in Groundwater

As water quality is currently monitored downgradient of the existing landfill and arguably represents landfill impacts, we have used this data to examine actual and potential effects on groundwater quality. Table 14 presents average groundwater quality in GW2A and GW3 since the stormwater diversion works. When compared to water quality criteria (Otago Regional Council, 2016; ANZG, 2018), ammoniacal nitrogen, boron, manganese, nitrate-nitrogen and zinc exceed guideline values. We highlight that long-term monitoring of some key potential landfill contaminant parameters (nitrate-nitrogen, boron) show increasing trends (see Section 4.5.1). As the existing landfill is nearly at capacity, we assume that leachate volumes are at or nearly at their maximum. Given this, we would assume these increasing trends will not continue. However, we note this assessment has not taken into consideration potential lag times in contaminant transport through the groundwater system or biogeochemical changes to contaminants once they are within the groundwater system.

As reported in Section 5.2.2, we estimate leachate leakage from the proposed expansion landfill area to be 2-3 orders of magnitude less than leakage from the existing landfill. Given this, and considering data in Table 14, we do not expect there to be a measurable impact on groundwater quality due to leachate from the expansion area. This assumes the leachate collection system operates as designed and the liner has no defects which would cause increased leakage.

Table 14 : Comparison of groundwater quality downgradient of the existing landfill against water quality criteria. Cells in bold represent exceedances of guideline values.

Parameter	Downgradient Water Quality - Average of GW2A & GW3 (mg/L)[1][2]	Water Quality Criteria (mg/L)
Aluminium	0.01	0.055[3]
Ammoniacal Nitrogen	**0.27**	0.2[4]
Arsenic	0.0005	0.013[3]
Boron	**0.96**	0.37[3]
Cadmium	0.00004	0.0002[3]
Calcium	68.3	
Chloride	37.5	

Chromium	0.0003	0.001[3]
Dissolved Reactive Phosphorus	0.02	0.045[4]
Iron	0.13	
Lead	0.00009	0.0034[3]
Magnesium	26.8	
Manganese	**3.834**	1.9[3]
Nickel	0.0042	0.011[3]
Nitrate-nitrogen	**3.52**	2.42[3]
Potassium	6.8	
Silica	12.2	
Sodium	51.3	
Sulphate	43.0	
Total Kjeldahl Nitrogen	1.03	
Zinc	**0.011**	0.008[3]

Notes: [1] Water quality data from 2022-2023 used representing conditions post-stormwater diversion. [2] Where results were below detection, half the detection limit was used to calculate average values. [3] ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Default guideline values for freshwater protection: 95% of species. [4] ORC (2016). Otago Regional Council. Regional Plan: Water for Otago. Schedule 16A: Discharge Thresholds for Discharge Threshold Area 1.

5.5.3 Predicted Changes in Surface Water

As with groundwater, we have used monitoring results from the downgradient monitoring location on the Clutha River/Mata-Au (SW2) to assess actual and potential effects from landfill leachate Table 15. Based on sampling at SW2 in 2022 and early 2023, water quality at this location does not exceed any guideline values in ANZG (2018) or ORC (2016). We note that compliance monitoring has regularly shown impacts of landfill activities in the watercourse (WC2 and WC3) that drains to the Clutha River/Mata-Au downgradient of the existing landfill area (WSP, 2022). However, it is likely that effects of landfill activities are not observable downstream in the Clutha River/Mata-Au because of dilution effects. Based on landfill leakage estimates in Table 10, leachate leakage from the existing landfill area and expansion area would be 0.000008% and 0.00000003%, respectively of annual mean flow on the Clutha River/Mata-Au (272 m^3/s). As for impacts of stormwater flow from the landfill site, all stormwater produced from operational areas of the site either already flows to the on-site retention ponds or will do if the proposed design is implemented. From monitoring data collected to date (Table 15), there are no apparent impacts on water quality from monitoring at SW2 relating to stormwater discharges, and therefore, we do not anticipate further activities to increase adverse stormwater discharge effects. However, we do note that this statement applies where the stormwater system operates within its designed capacity (10% AEP rainfall event). Stormwater discharges that exceed designed capacity may have adverse impacts on downstream water quality.

As for water quality impacts on the small stream and wetland in the southeast area of the site, we anticipate this largely to reflect effects of any changes to shallow groundwater quality and overland flow. As stated in Section 5.5.2, we do not anticipate measurable impacts on groundwater quality downgradient of the expansion area. As for stormwater, the current proposed design would direct stormwater flow from the operational landfill area towards the site's stormwater retention ponds. Assuming this system works as designed and does not exceed capacity, we do not anticipate adverse water quality effects to the small stream or wetland as a result of stormwater flow.

Table 15 : Comparison of Clutha River/Mata-Au water quality downgradient of the landfill compared to water quality criteria.

Parameter	Average Downgradient Clutha River/Mata-Au Water Quality at SW2 (mg/L)	Water Quality Criteria (mg/L)
Aluminium	0.03	0.055[3]
Ammoniacal Nitrogen	0.01	0.2[4]
Arsenic	0.0005	0.013[3]
Boron	0.00375	0.37[3]
Cadmium	0.00003	0.0002[3]
Calcium	11.2	
Chloride	1.6	
Chromium	0.0003	0.001[3]
Dissolved Reactive Phosphorus	0.002	0.045[4]
Iron	0.06	
Lead	0.0001	0.0034[3]
Magnesium	1.0	
Manganese	0.006	1.9[3]
Nickel	0.0002	0.011[3]
Nitrate-nitrogen	0.037	2.42[3]
pH		
Potassium	0.6	
Silica	2.9	
Sodium	1.9	
Sulphate	3.5	
Total Kjeldahl Nitrogen	0.05	
Zinc	0.001	0.008[3]

Notes: [1] Water quality data from 2022-2023 used representing conditions post-stormwater diversion. [2] Where results were below detection, half the detection limit was used to calculate average values. [3] ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Default guideline values for freshwater protection: 95% of species. [4] ORC (2016). Otago Regional Council. Regional Plan: Water for Otago. Schedule 16A: Discharge Thresholds for Discharge Threshold Area 1.

6 Summary and Conclusions

This assessment describes the existing and proposed activities at the Mt Cooee Landfill in Balclutha. The information in this report is intended to support resource consent applications relating to these activities.

In terms of potential impacts on groundwater recharge and flow, we do not anticipate any changes in how the existing landfill cells affect the groundwater system in terms of water quantity. This is largely because the existing cells are unlined, therefore, groundwater flows through the existing landfill area. We estimate that due to leachate captured by the leachate collection system in the existing landfill area, this results in a 78% reduction (26,963 m^3/year) in groundwater recharge to the Mt Cooee catchment. However, we expect actual total groundwater flow within the catchment to be higher, therefore, the overall reduction in flow resulting from leachate collection would be lower than 78%.

The proposed landfill expansion cells will be lined, so we do not anticipate they will intercept upgradient groundwater flow, however shallow groundwater is likely to be redirected around the new cells to some degree. Due to leachate collection, we estimate a further 6% reduction (2,092 m^3/year) in groundwater recharge to the Mt Cooee catchment once the expansion cells have been filled to capacity.

The estimated reduction in total groundwater discharge from the Mt Cooee catchment to the Clutha River/Mata-Au is not likely to impact the river. The reduced flow accounts for approximately 0.0003% of mean annual low flow in the Clutha River/Mata-Au.

We anticipate a small decrease in groundwater levels (0.37 m) downgradient of the expansion area, which is unlikely to be measurable. This reduction in groundwater levels is not likely to adversely affect the small stream and wetland in the southeast corner of the site; however, we cannot make a highly confident conclusion given the high level of uncertainties within calculations in this assessment.

Water quality monitoring on the site indicates leachate from the existing landfill is migrating beyond the existing landfill cells to some extent. Monitoring in groundwater wells and the watercourse directly downgradient of the existing landfill area show potential leachate impacts, particularly in the form of elevated ammoniacal nitrogen, boron, and nitrate-nitrogen. No impacts of landfill activities have been observable in water quality sampling in the Clutha River/Mata-Au downstream from the site.

Given the existing landfill cells are unlined, we anticipate leachate to continue to migrate out of the cells and impacts be observed in downgradient groundwater. As this area of the landfill has nearly reached full capacity, we anticipate leachate volumes are nearly at their maximum levels, therefore, we believe downgradient impacts from leachate should not worsen from their current state due to the existing landfill area. This assumes that the current leachate collection system (including underlying drainage and sheet pile cut-off wall) remains functional.

Given the estimated low volumes of leachate leakage produced from the proposed expansion area, we do not anticipate this will adversely impact downgradient groundwater or surface water conditions. It is considered the proposed landfill expansion will be an improvement in landfill practice in the region and decrease potential adverse effects to the environment overall.

7 References

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Appendix A
Hydraulic Conductivity Results

Table A1: Hydraulic conductivity results from field investigations at Mt Cooee

WELL ID	GEOLOGY OF SCREENED INTERVAL	TEST #	TEST TYPE	SLUG TESTING METHOD	ANALYSIS METHOD	K (M/S)	AVERAGE K (M/S)
BH1	Slightly weathered SANDSTONE, highly fractured	1	Rising head	Bailer	Barker-Black	8.8 x 10^{-7}	9.0 x 10^{-7}
		2				9.2 x 10^{-7}	
GW1A/BH2	GRAVEL / Gravelly CLAY / Highly weathered SANDSTONE	1	Falling head	Solid slug	Bouwer-Rice	3.7 x 10^{-4}	3.9 x 10^{-4}
		2	Rising head			4.0 x 10^{-4}	
BH3	Highly weathered SANDSTONE	1	Falling head	Introduced water slug	Bouwer-Rice	1.6 x 10^{-8}	1.6 x 10^{-8}
BH4	Sandy GRAVEL / Slightly weathered to moderately weathered, highly fractured SANDSTONE / Slightly weathered to moderately weathered, highly fractured SILTSTONE	1	Rising head	Solid slug	Barker-Black	3.5 x 10^{-6}	3.5 x 10^{-6}
BH5	Highly weathered SANDSTONE	1	Falling head	Introduced water slug	Bouwer-Rice	1.4 x 10^{-9}	1.4 x 10^{-9}

BH6	Moderate to highly weathered, highly fractured SANDSTONE	1	Falling head	Introduced water slug	Bouwer-Rice	8.1 x 10^{-9}	8.1 x 10^{-9}
GW2A	Clayey SILT / SILT / Sandy SILT / Silty SAND	1	Falling head	Solid slug	Bouwer-Rice	2.7 x 10^{-6}	2.4 x 10^{-6}
		2	Rising head			2.2 x 10^{-6}	
GW3	Unknown	1	Rising head	Solid slug	Bouwer-Rice	2.8 x 10^{-7}	2.8 x 10^{-7}
GW4	Landfill material / "Blue rock" (from drillers' logs)	1	Falling head	Solid slug	Bouwer-Rice	1.1 x 10^{-6}	1.1 x 10^{-6}
GW5	"Oxidised rock / Blue rock" (from drillers' logs)	1	Falling head	Solid slug	Bouwer-Rice	1.5 x 10^{-5}	1.5 x 10^{-5}
GW6	Landfill / CLAY / blue MUDSTONE	1	Falling head	Solid slug	Bouwer-Rice	5.5 x 10^{-6}	5.2 x 10^{-6}
		2	Rising head			4.9 x 10^{-6}	
GW7	"Blue rock" (from drillers' logs)	1	Falling head	Solid slug	Bouwer-Rice	4.5 x 10^{-7}	5 x 10^{-7}

		2	Rising head			5.9×10^{-7}	

Appendix B
Water Quality Results

Table B1 : Water Quality Sampling Results

		Water Quality Parameters																						
		Electrical Conductivity @ 25°C	pH (Lab)	Sodium (filtered)	Potassium (filtered)	Calcium (filtered)	Magnesium (filtered)	Chloride (filtered)	Sulphate (as SO4) (filtered)	Bicarbonate Alkalinity as (HCO3)	Hardness (as CaCO3)	Total Alkalinity (as CaCO3)	Nitrate (as N) (filtered)	Nitrite (as N) (filtered)	Nitrate + Nitrite (filtered)	Ammonium Ion (as N) (filtered)	Total Kjeldahl Nitrogen (as N)	Dissolved Reactive Phosphorus (filtered)	Reactive Silica (filtered)	Biological Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Anions	Total Cations (filtered)
		uS/cm	pH	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/m3 as SiO2	g O2/m3	g O2/m3	mg/L	meq/L	meq/L
ANZG (2018) 95% species protection													2.4											
ORC (2016) Discharge Thresholds for Area 1															3.6	0.2		0.045						
Field ID	Date																							
BH1	25 Jan 2023	1,421	7.2	92	6.2	136	71	133	15.0	740	630	610	<0.002	<0.002	<0.002	<0.010	0.14	<0.004	18.1	<2		6.2	16.2	16.8
	17 Nov 2022	1,401	7.8		5.4			120					<0.002	<0.002	<0.002	<0.10								
		1,409	7.8	80	5.3	125	67	126	19.1	700	590	580	<0.002	<0.002	<0.002	<0.010	0.15	<0.004	16.8	8		12.0	15.6	15.4
BH4	25 Jan 2023	230	6.2	23	2.5	12.6	6.5	19.0	11.1	84	58	69	0.030	0.003	0.032	0.061	0.17	<0.004	27	<2		<0.5	2.2	2.3
	17 Nov 2022	240	7.0	21	2.4	12.9	6.8	20	10.4	89	60	73	0.042	0.004	0.047	<0.010	<0.10	<0.004	26	<2		2.4	2.3	2.2
		231	6.9		2.3			20					0.098	0.011	0.109	<0.010								
BH5	17 Nov 2022	6,630	12.4	84	34	390	<0.02	11.8	0.7	1.9	970	1,720	0.007	0.006	0.013	1.19	5.3	<0.004	0.56	99		73	35	24
		6,670	12.4		46			11.7					0.006	0.005	0.011	1.19								
GW1A	31 Oct 2022	555	6.5		2.9			66					<0.002	<0.002	0.002	<0.10								
		557	6.3	47	2.9	31	18.9	66	73	108	155	89	0.002	<0.002	0.003	<0.10	0.44	<0.004	17.4	<2	20	6.5	5.2	5.2
	25 Jan 2023	295	6.1	30	2.2	16.0	9.4	25	33	79	79	65	0.003	<0.002	0.003	0.036	0.18	0.008	22	<2		1.4	2.7	3.0
GW2A	08 Mar 2022	919	7.6		13.9			67					1.52	0.013	1.54	1.28								
	28 Apr 2022	770	7.5		12.4			51					10.9	0.013	10.9	0.24								
	28 Jul 2022	285	7.3		3.3			12.4					0.90	<0.002	0.91	0.050								
	31 Oct 2022	391	7.2		5.7			12.7					3.9	0.005	3.9	<0.10								
	24 Jan 2023	925	6.7	90	17.2	63	39	52	46	460	320	380	<0.002	0.002	0.004	0.95	1.60	0.014	12.4	<2		8.7	10.0	10.9
GW3	08 Mar 2022	653	8.0		3.4			35					5.5	<0.002	5.5	<0.010								
	28 Apr 2022	737	7.7		3.7			47					10.3	0.002	10.3	<0.010								
	28 Jul 2022	568	7.7		2.9			33					1.11	0.002	1.11	0.047								
	31 Oct 2022	587	8.0		3.1			32					1.07	<0.002	1.07	<0.10								
		590	7.9	29	3.0	65	19.5	33	39	250	240	210	1.10	<0.002	1.10	<0.010	0.74	0.024	11.4	<2	32	11.9	6.0	6.2
	24 Jan 2023	682	7.2	35	2.5	77	22	32	44	340	280	280	0.005	0.004	0.009	0.048	0.75	0.011	12.7	<2		10.6	7.3	7.6
GW4	08 Mar 2022	12,760	7.8		490			1,160					<0.10	<0.10	<0.10	500								
	28 Apr 2022	12,830	7.6		520			1,370					<0.10	<0.10	<0.10	710								
	28 Jul 2022	9,860	7.5		400			870					<0.10	<0.10	<0.10	420								

		Water Quality Parameters																						
		Electrical Conductivity @ 25°C	pH (Lab)	Sodium (filtered)	Potassium (filtered)	Calcium (filtered)	Magnesium (filtered)	Chloride (filtered)	Sulphate (as SO4) (filtered)	Bicarbonate Alkalinity as (HCO3)	Hardness (as CaCO3)	Total Alkalinity (as CaCO3)	Nitrate (as N) (filtered)	Nitrite (as N) (filtered)	Nitrate + Nitrite (filtered)	Ammonium Ion (as N) (filtered)	Total Kjeldahl Nitrogen (as N)	Dissolved Reactive Phosphorus (filtered)	Reactive Silica (filtered)	Biological Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Anions	Total Cations (filtered)
		uS/cm	pH	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/m3 as SiO2	g O2/m3	g O2/m3	mg/L	meq/L	meq/L
ANZG (2018) 95% species protection													2.4											
ORC (2016) Discharge Thresholds for Area 1															3.6	0.2		0.045						
Field ID	Date																							
	31 Oct 2022	12,870	7.6	880	620	103	400	1,100	1.2	4,800	1,900	4,000	<0.10	<0.10	<0.10	790	760	2.8	29	45	770	250	111	149
		12,820	7.6		640			1,100					<0.10	<0.10	<0.10	850								
	24 Jan 2023	13,050	7.5	1,010	720	107	400	1,050	<5	8,000	1,930	6,600	0.33	0.03	0.36	860	810	2.0	29	62		420	162	162
GW5	08 Mar 2022	1,537	7.0		13.3			146					0.003	0.005	0.008	31								
	28 Apr 2022	3,270	7.3		73			430					<0.002	<0.002	<0.002	99								
	28 Jul 2022	3,020	7.1		72			370					0.025	0.005	0.029	96								
	31 Oct 2022	1,784	7.0	111	23	94	52	185	3.3	760	450	630	<0.10	<0.10	<0.10	45	44	0.005	24	<2	38	<20	17.8	17.8
		1,753	7.0		23			178					<0.10	<0.10	<0.10	44								
	24 Jan 2023	1,781	6.6	128	22	102	59	189	0.7	910	500	750	0.035	0.004	0.038	45	43	<0.004	24	<2		15	20	19.5
GW6	08 Mar 2022	747	6.4		2.8			106					0.75	0.020	0.77	1.09								
	28 Apr 2022	837	6.5		2.8			149					0.002	0.007	0.009	0.61								
	28 Jul 2022	816	6.3		3.0			102					0.46	0.003	0.46	0.78								
	31 Oct 2022	536	6.5		2.0			60					<0.002	<0.002	<0.002	0.65								
	24 Jan 2023	713	6.1	62	2.4	43	28	84	63	197	230	161	<0.02	<0.02	<0.02	0.52	1.04	<0.004	17.8	<2		5.0	6.9	7.7
GW7	08 Mar 2022	517	6.9		3.4			85					<0.002	0.005	0.006	1.02								
	28 Apr 2022	484	7.2		3.3			87					0.089	0.008	0.097	0.89								
	28 Jul 2022	389	7.1		2.8			59					0.018	0.010	0.028	2.2								
	31 Oct 2022	519	7.2		3.4			94					0.008	<0.002	0.010	1.35								
	24 Jan 2023	524	6.6	41	3.5	33	17.0	97	21	94	153	77	0.054	0.026	0.079	0.73	1.68	0.58	32	4		13.8	4.8	5.0
SW1	29 Apr 2022	74	7.7					0.7								<0.010								
	29 Jul 2022	86	7.6					3.7								<0.010								
	01 Nov 2022	74	7.7	1.98	0.65	10.7	1.10	1.3	3.8	35	31	29	0.067	<0.002	0.068	<0.010	<0.10	<0.004	3.4	<2	9	1.9	0.70	0.74
	25 Jan 2023	74	7.3	1.64	0.60	11.7	0.91	0.7	3.3	39	33	32	0.010	<0.002	0.010	<0.010	<0.10	<0.004	2.5	<2		1.3	0.73	0.75
SW2	29 Apr 2022	74	7.8					0.7								<0.010								
	29 Jul 2022	86	7.6					3.7								0.012								
	01 Nov 2022	72	7.7	2.0	0.66	10.8	1.07	1.2	3.7	35	31	29	0.066	<0.002	0.067	<0.010	<0.10	<0.004	3.3	<2	6	1.8	0.70	0.74
	25 Jan 2023	78	7.6	1.72	0.60	11.7	1.01	0.7	3.4	39	33	32	0.009	<0.002	0.010	<0.010	<0.10	<0.004	2.5	<2		1.3	0.74	0.76
WC2	08 Mar 2022	1,762	7.9					193								9.2								
	28 Apr 2022	1,247	7.8					134								3.1								
	29 Jul 2022	458	7.6					37								2.3								

		Water Quality Parameters																						
		Electrical Conductivity @ 25°C	pH (Lab)	Sodium (filtered)	Potassium (filtered)	Calcium (filtered)	Magnesium (filtered)	Chloride (filtered)	Sulphate (as SO4) (filtered)	Bicarbonate Alkalinity as (HCO3)	Hardness (as CaCO3)	Total Alkalinity (as CaCO3)	Nitrate (as N) (filtered)	Nitrite (as N) (filtered)	Nitrate + Nitrite (filtered)	Ammonium Ion (as N) (filtered)	Total Kjeldahl Nitrogen (as N)	Dissolved Reactive Phosphorus (filtered)	Reactive Silica (filtered)	Biological Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Anions	Total Cations (filtered)
		uS/cm	pH	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/m3 as SiO2	g O2/m3	g O2/m3	mg/L	meq/L	meq/L
ANZG (2018) 95% species protection													2.4											
ORC (2016) Discharge Thresholds for Area 1															3.6	0.2		0.045						
Field ID	Date																							
	26 Oct 2022	879	7.4					79								3.8								
WC3	08 Mar 2022	1,673	8.3					200								4.1								
	28 Apr 2022	1,188	8.1					128								1.34								
	29 Jul 2022	492	7.8					38								1.21								
	26 Oct 2022	944	8.1					98								1.07								

Notes: Shaded values exceed the corresponding water quality criteria.

Water Quality Criteria References:

ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Default guideline values for freshwater projection: 95% of species.

Otago Regional Council (ORC). (2016). Regional Plan: Water for Otago. Schedule 16A: Discharge Thresholds for Discharge Threshold Area 1.

Table B2: Heavy Metal Water Quality Results

		Heavy Metals										
		Aluminium (filtered)	Arsenic (filtered)	Boron (filtered)	Cadmium (filtered)	Chromium (filtered)	Copper (filtered)	Iron (filtered)	Lead (filtered)	Manganese (filtered)	Nickel (filtered)	Zinc (filtered)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection		0.055	0.013	0.37	0.0002	0.001	0.0014		0.0034	1.9	0.011	0.008
ORC (2016) Discharge Thresholds for Area 1												
Field ID	Date											
BH1	25 Jan 2023	<0.003	<0.0010	0.54	<0.00005	<0.0005	0.0005	<0.02	<0.00010	0.43	0.0007	0.0020
	17 Nov 2022			0.47								
		<0.003	<0.0010	0.49	<0.00005	<0.0005	<0.0005	<0.02	<0.00010	0.67	0.0010	0.0016
BH4	25 Jan 2023	0.29	<0.0010	0.051	<0.00005	<0.0005	0.0016	0.78	0.00046	0.55	0.0009	0.0028
	17 Nov 2022	0.014	<0.0010	0.040	<0.00005	<0.0005	0.0009	0.45	<0.00010	0.52	0.0009	0.0027
				0.044								
BH05	17 Nov 2022	0.184	0.0097	<0.005	<0.00005	0.051	0.075	1.50	0.00032	<0.0005	0.0075	<0.0010
				<0.005								
GW1A	31 Oct 2022			0.040								
		0.028	<0.0010	0.046	<0.00005	<0.0005	0.0051	0.09	<0.00010	1.14	0.0039	0.0026
	25 Jan 2023	0.048	<0.0010	0.046	<0.00005	<0.0005	0.0018	0.51	0.00011	0.72	0.0026	0.0011
GW2A	08 Mar 2022			2.5								
	28 Apr 2022			1.87								
	28 Jul 2022			0.33								
	31 Oct 2022			0.52								
	24 Jan 2023	0.008	<0.0010	2.6	<0.00005	<0.0005	0.0034	0.08	<0.00010	2.4	0.0034	0.0031
GW3	08 Mar 2022			0.41								
	28 Apr 2022			0.58								
	28 Jul 2022			0.26								
	31 Oct 2022			0.27								
		0.004	<0.0010	0.27	<0.00005	<0.0005	0.0056	<0.02	<0.00010	0.0011	0.0007	0.0027
	24 Jan 2023	0.010	<0.0010	0.29	0.00008	<0.0005	0.0040	0.30	0.00018	9.1	0.0085	0.028
GW4	08 Mar 2022			99								
	28 Apr 2022			105								
	28 Jul 2022			75								
	31 Oct 2022	<0.3	<0.10	63	<0.005	<0.05	<0.05	2	<0.010	0.29	0.07	<0.10
				66								

		Heavy Metals										
		Aluminium (filtered)	Arsenic (filtered)	Boron (filtered)	Cadmium (filtered)	Chromium (filtered)	Copper (filtered)	Iron (filtered)	Lead (filtered)	Manganese (filtered)	Nickel (filtered)	Zinc (filtered)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection		0.055	0.013	0.37	0.0002	0.001	0.0014		0.0034	1.9	0.011	0.008
ORC (2016) Discharge Thresholds for Area 1												
Field ID	Date											
	24 Jan 2023	<0.3	<0.10	63	<0.005	<0.05	<0.05	2	<0.010	0.34	0.07	<0.10
GW5	08 Mar 2022			6.1								
	28 Apr 2022			13.5								
	28 Jul 2022			13.3								
	31 Oct 2022	<0.06	<0.02	7.0	<0.0010	<0.010	<0.010	2.6	<0.002	3.0	<0.010	<0.02
				7.2								
	24 Jan 2023	<0.06	<0.02	8.2	<0.0010	<0.010	<0.010	1.6	<0.002	3.3	<0.010	<0.02
GW6	08 Mar 2022			0.24								
	28 Apr 2022			0.197								
	28 Jul 2022			0.194								
	31 Oct 2022			0.182								
	24 Jan 2023	0.022	0.0014	0.107	<0.00005	<0.0005	0.0012	4.1	<0.00010	5.8	0.0061	0.0025
GW7	08 Mar 2022			0.041								
	28 Apr 2022			0.040								
	28 Jul 2022			0.040								
	31 Oct 2022			0.039								
	24 Jan 2023	<0.003	<0.0010	0.038	<0.00005	<0.0005	<0.0005	0.05	<0.00010	0.35	<0.0005	0.0089
SW1	29 Apr 2022											
	29 Jul 2022											
	01 Nov 2022	0.057	<0.0010	<0.005	<0.00005	<0.0005	0.0005	0.12	0.00018	0.0145	<0.0005	<0.0010
	25 Jan 2023	0.010	0.0011	<0.005	<0.00005	<0.0005	<0.0005	0.05	<0.00010	0.0062	<0.0005	<0.0010
SW2	29 Apr 2022											
	29 Jul 2022											
	01 Nov 2022	0.057	<0.0010	<0.005	<0.00005	<0.0005	0.0006	0.11	0.00018	0.0129	<0.0005	<0.0010
	25 Jan 2023	0.004	<0.0010	0.005	<0.00005	<0.0005	<0.0005	<0.02	<0.00010	<0.0005	<0.0005	<0.0010
WC2	08 Mar 2022											
	28 Apr 2022											
	29 Jul 2022											
	26 Oct 2022											
WC3	08 Mar 2022											

		Heavy Metals										
		Aluminium (filtered)	Arsenic (filtered)	Boron (filtered)	Cadmium (filtered)	Chromium (filtered)	Copper (filtered)	Iron (filtered)	Lead (filtered)	Manganese (filtered)	Nickel (filtered)	Zinc (filtered)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection		0.055	0.013	0.37	0.0002	0.001	0.0014		0.0034	1.9	0.011	0.008
ORC (2016) Discharge Thresholds for Area 1												
Field ID	Date											
	28 Apr 2022											
	29 Jul 2022											
	26 Oct 2022											

Table B3: Miscellaneous Water Quality Results

		Other							Amino Aliphatics	Amino Aromatics	E-Nitrobenzenes	Explosives		Halogenated Benzenes										
		1&2-Chloronaphthalene	Benzo[a]pyrene Toxic Equivalence (TEF)	Fluazifop	Haloxyfop	Di(2-ethylhexyl) adipate	Freon 113	Quizalofop	N-Nitrosodi-n-propylamine	n-Nitrosodiphenylamine & Diphenylamine	Nitrobenzene	2,4-Dinitrotoluene	2,6-Dinitrotoluene	1,2,3-Trichlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3,5-Trichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2-Chlorotoluene	4-Chlorotoluene	Bromobenzene	Chlorobenzene	Hexachlorobenzene
		g/m3	g/m3	g/m3	mg/L	mg/L	g/m3	g/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection											0.55	0.065		0.01	0.17	0.16	0.013	0.26	0.06				0.055	0.0001
ORC (2016) Discharge Thresholds for Area 1																								
Field ID	Date																							
BH1	25 Jan 2023																							
	17 Nov 2022	<0.003	<0.008	<0.0004	<0.0004	<0.005	<0.003	<0.0004	<0.010	<0.010	<0.005	<0.010	<0.010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
BH4	25 Jan 2023																							
	17 Nov 2022	<0.003	<0.008	<0.0004	<0.0004	<0.005	<0.003	<0.0004	<0.010	<0.010	<0.005	<0.010	<0.010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
BH05	17 Nov 2022	<0.003	<0.008	<0.0004	<0.0004	<0.005	<0.003	<0.0004	<0.010	<0.010	<0.005	<0.010	<0.010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
SW1	29 Apr 2022																							
	29 Jul 2022																							
	01 Nov 2022	<0.0003	<0.0008	<0.0004	<0.0004	<0.0010	<0.0003	<0.0004	<0.0010	<0.0010	<0.0005	<0.0010	<0.0010	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
	25 Jan 2023																							
SW2	29 Apr 2022																							
	29 Jul 2022																							
	01 Nov 2022	<0.0003	<0.0008	<0.0004	<0.0004	<0.0010	<0.0003	<0.0004	<0.0010	<0.0010	<0.0005	<0.0010	<0.0010	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
	25 Jan 2023																							

Table A4: Miscellaneous Water Quality Results

		Herbicides																	MAH													
		2,4,5-Trichlorophenoxy Acetic Acid	2,4-D	2,4-Dichlorprop	2-Methyl-4-chlorophenoxyacetic acid	2-Methyl-4-Chlorophenoxy Butanoic Acid	4-(2,4-Dichlorophenoxy) butyric acid (2,4-DB)	Acifluorfen	Bentazone	Bromoxynil	Clopyralid	Dicamba	Fenoprop	Fluroxypyr	Mecoprop	Oryzalin	Picloram	Triclopyr	1,2,4-trimethylbenzene	1,3,5-Trimethylbenzene	Benzene	Toluene	Isopropylbenzene	n-Butylbenzene	n-Propylbenzene	p-Isopropyltoluene	sec-Butylbenzene	Styrene	tert-Butylbenzene	Ethylbenzene	Xylenes (m & p)	Xylene (o)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection		0.036	0.28		0.0014																0.95	0.18	0.03							0.08		0.35
ORC (2016) Discharge Thresholds for Area 1																																
Field ID	Date																															
BH1	25 Jan 2023																															
	17 Nov 2022	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	0.0015	<0.0004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.005	<0.005	<0.003	<0.005	<0.003	<0.005	<0.005	<0.003
BH4	25 Jan 2023																															
	17 Nov 2022	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.005	<0.005	<0.003	<0.005	<0.003	<0.005	<0.005	<0.003
BH05	17 Nov 2022	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.003	<0.003	<0.003	0.012	<0.003	<0.005	<0.005	<0.005	<0.003	<0.005	<0.003	<0.005	<0.005	<0.003
SW1	29 Apr 2022																															
	29 Jul 2022																															
	01 Nov 2022	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005	<0.0005	<0.0005	<0.0003	0.0009	<0.0003	<0.0005	<0.0005	<0.0003
	25 Jan 2023																															
SW2	29 Apr 2022																															
	29 Jul 2022																															
	01 Nov 2022	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0004	<0.0006	<0.0004	<0.0004	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005	<0.0005	<0.0005	<0.0003	0.0014	<0.0003	<0.0005	<0.0005	<0.0003
	25 Jan 2023																															

Table B5 : Miscellaneous Water Quality Results

		Organochlorine Pesticides																PAH																PAH-Others	Pesticides-Others
		p,p-DDE	a-BHC	Aldrin	b-BHC	d-BHC	DDD	DDT	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan sulphate	Endrin	Endrin ketone	g-BHC	Heptachlor	Heptachlor epoxide	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)&(j)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene	Phenanthrene	Pyrene	2-Methylnaphthalene	Carbazole
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection				0.000001				0.00001	0.00001				0.00002		0.0002	0.00009				0.0004		0.0002						0.0014			0.016	0.002			
ORC (2016) Discharge Thresholds for Area 1																																			
Field ID	Date																																		
BH1	25 Jan 2023																																		
	17 Nov 2022																																		
		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
BH4	25 Jan 2023																																		
	17 Nov 2022																																		
		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.005
BH05	17 Nov 2022																																		
		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.010	<0.010	<0.010	<0.010	<0.010	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
SW1	29 Apr 2022																																		
	29 Jul 2022																																		
	01 Nov 2022	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.0005	<0.0010	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.0003	<0.0005
	25 Jan 2023																																		
SW2	29 Apr 2022																																		
	29 Jul 2022																																		
	01 Nov 2022	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0005	<0.0010	<0.0010	<0.0010	<0.0005	<0.0010	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
	25 Jan 2023																																		

Table B6 : Miscellaneous Water Quality Results

		Phenolics					Phenolics-Halogenated							Phthalates						Solvents				
		2,4-Dimethylphenol	2-Methylphenol	2-Nitrophenol	3- & 4- Methylphenol	Phenol	2,3,4,6-Tetrachlorophenol	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2-Chlorophenol	4-Chloro-3-methylphenol	Pentachlorophenol	Bis(2-ethylhexyl) phthalate	Butylbenzyl phthalate	Diethyl phthalate	Dimethyl phthalate	Di-n-butyl phthalate	Di-n-octyl phthalate	Methyl Ethyl Ketone	Methyl iso-butyl ketone	Acetone	Isophorone	Methyl-t-butyl ether
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection		0.002				0.32	0.02		0.02	0.16	0.49		0.01	0.001		1	3.7	0.026						
ORC (2016) Discharge Thresholds for Area 1																								
Field ID	Date																							
BH1	25 Jan 2023																							
	17 Nov 2022																							
		<0.005	<0.005	<0.010	<0.010	<0.010	<0.0004	<0.010	<0.010	<0.005	<0.005	<0.010	<0.0004	<0.03	<0.010	<0.010	<0.010	<0.010	<0.010	<0.5	<0.10	<0.5	<0.005	<0.003
BH4	25 Jan 2023																							
	17 Nov 2022																							
		<0.005	<0.005	<0.010	<0.010	<0.010	<0.0004	<0.010	<0.010	<0.005	<0.005	<0.010	<0.0004	<0.03	<0.010	<0.010	<0.010	<0.010	<0.010	<0.5	<0.10	<0.5	<0.005	<0.003
BH05	17 Nov 2022																							
		<0.005	<0.005	<0.010	<0.010	<0.010	<0.0004	<0.010	<0.010	<0.005	<0.005	<0.010	<0.0004	<0.03	<0.010	<0.010	<0.010	<0.010	<0.010	16	<0.10	<0.5	<0.005	<0.003
SW1	29 Apr 2022																							
	29 Jul 2022																							
	01 Nov 2022	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010	<0.0004	<0.0010	<0.0010	<0.0005	<0.0005	<0.0010	<0.0004	<0.003	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.05	<0.010	<0.05	<0.0005	<0.0003
	25 Jan 2023																							
SW2	29 Apr 2022																							
	29 Jul 2022																							
	01 Nov 2022	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010	<0.0004	<0.0010	<0.0010	<0.0005	<0.0005	<0.0010	<0.0004	<0.003	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.05	<0.010	<0.05	<0.0005	<0.0003
	25 Jan 2023																							

Table B7 : Miscellaneous Water Quality Results

		SVOCs					Volatile Organic Compounds															
		Benzyl alcohol	Bis(2-chloroethoxy) methane	Bis(2-chloroethyl) ether	Bis(2-chloroisopropyl) ether	Dibenzofuran	1,1,1,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2-Trichloroethane	1,2,3-Trichloropropane	1,2-Dibromo-3-chloropropane	1,2-Dibromoethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	cis-1,2-Dichloroethene	trans-1,2-dichloroethene	1,2-Dichloropropane	1,3-Dichloropropane	1,1-Dichloropropene	cis-1,3-Dichloropropene
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection								0.4	0.27	6.5					1.9	0.7			0.9	1.1		
ORC (2016) Discharge Thresholds for Area 1																						
Field ID	Date																					
BH1	25 Jan 2023																					
	17 Nov 2022																					
		<0.05	<0.005	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
BH4	25 Jan 2023																					
	17 Nov 2022																					
		<0.05	<0.005	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
BH05	17 Nov 2022																					
		<0.05	<0.005	<0.005	<0.005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
SW1	29 Apr 2022																					
	29 Jul 2022																					
	01 Nov 2022	<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
	25 Jan 2023																					
SW2	29 Apr 2022																					
	29 Jul 2022																					
	01 Nov 2022	<0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
	25 Jan 2023																					

Table B8 : Miscellaneous Water Quality Results

		Volatile Organic Compounds																		
		trans-1,3-dichloropropene	Bromodichloromethane	Bromoform	Bromomethane	Carbon disulfide	Carbon tetrachloride	Chlorodibromomethane	Chloroethane	Chloroform	Chloromethane	Dibromomethane	Dichlorodifluoromethane	Dichloromethane	Hexachlorobutadiene	Hexachloroethane	Trichloroethene	Tetrachloroethene	Trichlorofluoromethane	Vinyl chloride
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZG (2018) 95% species protection						0.02	0.24			0.77				4		0.36	0.33	0.07		0.1
ORC (2016) Discharge Thresholds for Area 1																				
Field ID	Date																			
BH1	25 Jan 2023																			
	17 Nov 2022																			
		<0.005	<0.003	<0.003	<0.003	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.10	<0.003	<0.010	<0.003	<0.003	<0.003	<0.003
BH4	25 Jan 2023																			
	17 Nov 2022																			
		<0.005	<0.003	<0.003	<0.003	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.10	<0.003	<0.010	<0.003	<0.003	<0.003	<0.003
BH05	17 Nov 2022																			
		<0.005	<0.003	<0.003	<0.003	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.10	<0.003	<0.010	<0.003	<0.003	<0.003	<0.003
SW1	29 Apr 2022																			
	29 Jul 2022																			
	01 Nov 2022	<0.0005	<0.0003	<0.0003	<0.0003	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.010	<0.0003	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003
	25 Jan 2023																			
SW2	29 Apr 2022																			
	29 Jul 2022																			
	01 Nov 2022	<0.0005	<0.0003	<0.0003	<0.0003	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.010	<0.0003	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003
	25 Jan 2023																			

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