Project Number: 6-CO082.00

Mt Cooee Landfill Development Plan and Resource Recovery Centre

Baseline Contamination Assessment Report

6 April 2023

Clutha
District Council

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1	24/03/2023	Tara Verhulst	Lisa Bond	Chris Fox	Initial review
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Revision Details

Revision	Details
1	Initial review – consistency with Geotechnical report ensured
2	Final review for issuing.

Contents

List of Appendices

Disclaimers and Limitations

This report **('Report')** has been prepared by WSP exclusively for the Clutha District Council **('Client')** in relation to the Mt Cooee Landfill Development Plan and Resource Recovery Centre project. The scope of this report is to present the findings from a baseline environmental investigation undertaken as part of the project to inform the Development Plan and Resource Recovery Centre for the landfill **('Purpose')** in accordance with the Short Form Agreement dated 11/11/2021. The findings in this Report are based on and subject to the assumptions specified in the Report. 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

WSP have been engaged by the Clutha District Council (CDC) provide engineering services for the renewal and development of the Mt Cooee Landfill ('landfill') in Balclutha. The scope of services was presented in the WSP Offer of Service dated 6 August 2021.

As part of the project, WSP undertook ground Investigations in October and November 2022 to inform ground and groundwater variability across the site Concurrent with these investigations environmental sampling and testing to provide baseline contamination data was completed. This Baseline Contamination Assessment (BCA) presents a summary of the baseline contamination profile of the site.

2 Site Description

The Mt Cooee Landfill site (the 'site') is situated on the Kaitangata Highway in the outskirts of Balclutha. The site encompasses Lot 1 (4.3 ha) and Lot 2 (11.4 ha) on the property DP 12203 and has a total area of approximately 12.8 hectares. The approximate location of the site relative to Balclutha is shown on Figure 1 below.

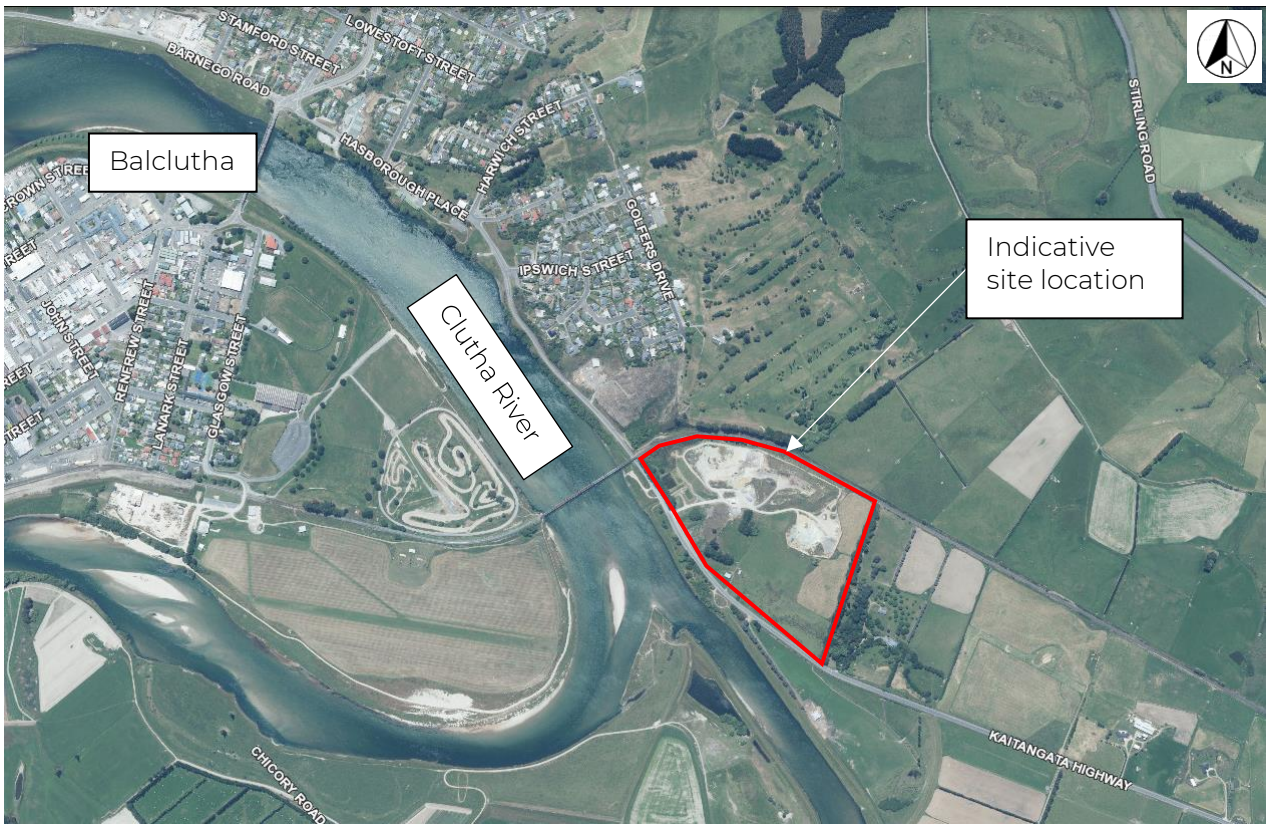


Figure 1: Approximate Location of the Site (Courtesy of the CDC Map Viewer).

The site consists of a gently sloping valley that drops southwest towards the Clutha River. The site is bounded by the Dunedin – Invercargill rail line to the north and the Kaitangata Highway to the south. The Highway runs adjacent to the Clutha River. The site adjoins private farmland to the east, from which it is screened by a windbreak of large macrocarpa trees. Access to the site is via a driveway off the Kaitangata Highway.

The area to the east of the site is rural land, with the nearest dwelling roughly 150 m from the site boundary. The Balclutha Golf Course is situated across the rail line to the north of the site.

The landfill has been operating circa 1985 and was originally developed by filling in the shallow valley, commencing from the downstream end and working up the valley. The landfill is currently

used for sanitary waste, including municipal waste, contaminants and hazardous waste. The existing landfill is now nearing closure design level and therefore requires upgrading and reconsenting to continue operation as the main landfill in Balclutha. The proposed expansion area extends to the south and east of the exisitng landfill, to within 15 m of the eastern boundary (refer Appendix A).

3 Data Quality Objectives

Systematic planning is critical for successful implementation of an environmental assessment and is used to define the type, quantity and quality of data needed to inform decisions. The United States Environmental Protection Agency (US EPA) has defined a process for establishing data quality objectives (DQOs), which has been referenced in the Ministry for the Environment's *Contaminated land management guidelines No. 5: Site investigation and analysis of soils* (MfE CLMG No. 5) (Ministry for the Environment , 2021).

DQOs ensure that:

- The study objectives are set;
- Appropriate types of data are collected (based on contemporary land use and chemicals of concern);
- The Tolerance Levels are set for potential decision-making errors.

The DQO process is a seven-step iterative planning approach. The outputs of the DQO process are qualitative and quantitative statements which are developed in the first six steps. They define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose and specify the performance requirements for the quality of information to be obtained from the data. The output from the first six steps is then used in the seventh step to develop the data collection design that meets all performance criteria and other design requirements and constraint. The DQO process adopted for the BCA is outlined in Appendix B.

4 Ground Investigations

4.1 Sampling Design

The MfE CLMG No. 5 outlines the three types of sampling patterns commonly used for site investigations, comprising judgemental, systematic and stratified sampling (Ministry for the Environment , 2021).

To achieve the objectives of the Baseline Contamination Assessment, a judgemental sampling strategy was adopted using the geotechnical boreholes to obtain soil samples. Samples were taken from varying depths and lithologies to provide adequate coverage across the site. This strategy enabled a general baseline of soil contaminant information to be obtained.

4.2 Investigation locations

Site-specific ground investigations were undertaken across the site between 11 October and 3 November 2022. The investigation locations were spread across the site to assess the nature and variability of the ground conditions and allow sampling of soils along with groundwater and gas monitoring through installation of piezometers.

The investigations comprised the following:

- A total of ten machine boreholes (BH1 to BH10) to target depths ranging between 3.0 m and 11.6 m below ground level (bgl) for geotechnical and hydrogeological purposes. Drilling was undertaken using the rotary coring method in both soils and in rock. Boreholes were terminated upon proving a sufficient thickness of bedrock or reaching the target depth.

- Installation of standpipe piezometers in BH1 to BH6 for groundwater and ground gas monitoring purposes.

The approximate locations of the machine boreholes are presented on the Site Plan presented in Appendix A.

4.3 Boreholes

Ten machine boreholes (BH01 to BH10) were drilled by McMillan Drilling between 11 October and 3 November 2022. The purpose of the boreholes to retrieve core for visual logging and samples for geotechnical and chemical laboratory testing.

BH1 was drilled near the existing oxidation ponds and is utilised for both geotechnical and hydrogeological purposes.

BH2 was drilled north of the rail line and serves as a shallow groundwater well.

BH3 to BH5 were drilled to the southeast of the site and serve as shallow groundwater monitoring wells.

BH6 to BH10 were drilled at the location of the proposed landfill development site. BH6 has a shared purpose as a geotechnical investigation borehole and shallow groundwater monitoring well. BH7 to BH10 are primarily for geotechnical purposes.

Details of the machine boreholes are presented in Table 1.

Table 1: Details of the machine boreholes

BH ID	Approximate Location	Northing [1] (m)	Easting[1] (m)	Approximate Borehole Depth (m bgl)
BH1	30m west of Kitagawa Highway, south of oxidation ponds	4873817	1350038	11.6
BH2	North of site, north side of railway	4873978	1350241	6.0
BH3	Western area of site, 15m north-east of Kaitangata Highway	4873642	1350135	4.5
BH4	South-east corner of site	4873540	1350398	5.5
BH5	Southern area of site, 80m north-east of Kaitangata Highway	4873598	1350288	3.0
BH6	Middle of site, southwest of proposed landfill expansion	4873694	1350315	9.45
BH7	Eastern most corner of site, 20m south of railway	4873800	1350492	6.0
BH8	Eastern area of site, 80m north of BH06	4873768	1350323	4.3
BH9	Eastern area of site, middle of proposed landfill expansion	4873747	1350377	6.9
BH10	Eastern edge of site, 20m from boundary	4873714	1350458	10.0

[1] The co-ordinates are based on the NZTM grid system and estimated using a hand-held GPS system, with estimated accuracy of +/-5m.

The recovered soils and rock were logged by a WSP Engineering Geologist. Logging was undertaken in accordance with the New Zealand Geotechnical Society Guideline (NZGS, 2005). Concurrent with logging of the materials, soil samples were taken at intervals from the core arisings of selected boreholes for chemical laboratory analysis.

Upon completion of drilling, standpipe piezometers were installed within BH1 to BH6 and BH10 to allow ongoing groundwater and ground gas monitoring. The piezometer details alongside photographs of arisings are presented in the borehole logs in Appendix C. The remaining boreholes were backfilled with bentonite, gravel and grout.

4.4 Groundwater

Groundwater was observed at depths ranging between approximately 1.23 m and 5.55 m bgl within the machine boreholes during the investigation. These are recorded on the borehole logs in Appendix C.

Several rounds of piezometer monitoring have been completed between October and November 2022, with the results recorded in Table 2 below.

Table 2: Piezometer details and groundwater depth monitoring results

Borehole ID	Piezometer Response Zone (m bgl)	Groundwater Level (m bgl)	Measurement Date	Measurement Time
BH1	7.7 – 11.6	2.06	31/10/2022	3:13pm
		2.26	29/11/2022	1:58pm
		2.70	01/02/2023	3:05pm
		2.61	09/03/2023	11:00am
BH2	0.5 – 4.5	0.73	31/10/2022	3:06pm
		2.80	9/11/2022	1:25pm
		1.03	29/11/2022	3:00pm
BH3	0.5 – 2.8	1.66	31/10/2022	1:30pm
		1.73	9/11/2022	11:23am
		1.89	30/11/2022	9:10am
		2.36	01/02/2023	1:56pm
		Dry	09/03/2023	1:15pm
BH4	0.5 – 5.5	2.48	31/10/2022	1:43pm
		2.92	9/11/2022	10:10am
		3.05	29/11/2022	1:25pm
		3.91	01/02/2023	2:20pm
		4.05	09/03/2023	12:54pm
BH5	0.45 – 1.8	0.62	31/10/2022	1:47pm
		0.56	9/11/2022	10:15am
		0.94	29/11/2022	1:12pm
		Dry	01/02/2023	2:26pm

Borehole ID	Piezometer Response Zone (m bgl)	Groundwater Level (m bgl)	Measurement Date	Measurement Time
BH6	0.5 – 3.5	2.30	31/10/2022	1:38pm
		Dry	9/11/2022	10:00am
		Dry	29/11/2022	1:00pm
		Dry	01/02/2023	2:13pm

No groundwater sampling was completed as part of this baseline investigation. However, separate hydrogeological assessments undertaken as part of the ongoing site assessment have sampled and assessed groundwater quality across the site.

5 Results

5.1 Subsurface Conditions

The soils and rock encountered within the historic and recent geotechnical investigations are generally consistent with the published geology and comprise Caples Terrane bedrock across the northern half of the site, with shallow alluvial deposits overlying bedrock towards the southern end of the site (GNS Science, 2023).

Based on the site investigation results and site walkover observations, the northern section of the site is pre-dominantly underlain by localised thin layers of FILL, overlying Caples Terrane bedrock. The FILL layer is typically up to 0.5m thick.

A summary of the geological conditions of the soil samples taken can be found in Table 3 below. Detailed logs of the boreholes can be found in Appendix C.

5.2 Laboratory Analysis

Soil samples were collected from three boreholes (BH01, BH06, BH10) across the site at 0.5m interval depths between 0.0-2.0m bgl. It should be noted that only one soil sample was taken from borehole BH06 (at 0.4m bgl) due to sandstone encountered below 1.0m bgl and analysis on the low soil content was not considered representative of the ground conditions.

Soils were sampled using a hand trowel after the core was extracted and placed in laboratory supplied jars, leaving minimal headspace, and closed with Teflon-coated lids.

Samples were stored in a sealed cooler and transported to the laboratory under chain of custody, which can be found in Appendix D. Dedicated disposable nitrile gloves were worn for each sampling episode and all non-dedicated equipment was decontaminated between sampling locations to minimise the potential of cross-contamination.

The soil samples were submitted to Analytica Laboratories for analysis of determined contaminants of concern, ie trace elements (heavy metals) and polycyclic aromatic hydrocarbons (PAHs). Analytica Laboratories are accredited by International Accreditation New Zealand (IANZ) for the analytical suites requested.

A summary of the samples taken, and scheduled analyses can be found in Table 3 below.

Table 3: Summary of samples and scheduled laboratory analyses.

Borehole ID	Sample name	Geological conditions	Analysis scheduled
BH01	BH01-0.5	TOPSOIL, grass, trace rootlets and trace fine quartz gravel. Woody organics present.	Heavy metals and PAHs
	BH01-1	Sandy SILT, light brown to brown, homogenous. Firm, moist to dry, low plasticity, micaceous. Sand; fine.	Heavy metals and PAHs
	BH01-1.5	Silty CLAY with trace sand and gravel, light brown with dark grey and brown specks, homogenous. Firm, moist, high plasticity. Gravel; fine, subangular. Sand; fine to coarse. 1.5m: orange mottle.	Heavy metals and PAHs
	BH01-2	Sandy SILT, light brown, homogenous. Firm, dry, low plasticity. Sand is fine.	Heavy metals and PAHs
BH06	BH06-0.4	TOPSOIL with some grass and rootlets, dark brown. >0.20m bgl becomes orangish brown.	Heavy metals and PAHs
BH10	BH10-0.5	TOPSOIL with grass and rootlets.	Heavy metals and PAHs
	BH10-1	SILT with some clay and trace gravel, homogenous. Firm, moist, low plasticity. Minor rootlets present. Gravel corestones are very weak.	Heavy metals and PAHs
	BH10-1.5	Clayey SAND with minor silt and gravel, orangish brown, homogenous. Moist, low plasticity. Gravel; fine to coarse, HW-CW Sandstone, very weak. Sand; medium to coarse, angular to subangular. Fines; soft.	Heavy metals and PAHs
	BH10-2	Clayey SAND with minor silt and gravel, orangish brown, homogenous. Moist, low plasticity. Gravel; fine to coarse, HW-CW Sandstone, very weak. Sand; medium to coarse, angular to subangular. Fines; soft.	Heavy metals and PAHs

5.3 Analytical Results

A summary of the analytical results for heavy metals can be found in Table 4.

All PAH results were reported below their limit of reporting (LOR) and as such have not been summarised.

The detailed laboratory reports and chain of custody can be found in Appendix D.

Table 4: Summary of analytical results for heavy metals.

		Heavy Metals							
		Arsenic	Cadmium	Chromium (VI)	Copper	Lead	Mercury	Nickel	Zinc
Background Concentrations[1]	Sandstone	11.77	0.31	62.07	60.85	37.96	-	34.38	143.1
Limit of Reporting (LOR)	mg/kg	0.125	0.005	0.125	0.075	0.25	0.025	0.05	0.05
NESCS[2]	Commercial/industrial outdoor worker (unpaved)	70	1,300	6,300	>10,000	3,300	4,200	-	-
IRB NEPM SGV HILD[3]		-	-	-	-	-	-	6,000	400,000
NZRB[4]	Eco-SGV	8	1.5	100	120[5]	55	-	-	45[6]

Sample Name	Sampling Date	Depth (m bgl)	mg/kg							
BH01	14/12/2022	0.5	13.8	0.046	21.7	30.4	37.3	0.092	21.8	80.5
BH01		1	11	0.061	24	28.6	54.7	0.12	21.1	75.9
BH01		1.5	13.4	0.049	26.9	36.3	31	0.12	25	80.4
BH01		2	14.2	0.023	17.4	25.3	15.8	<0.025	18	65.7
BH06		0.4	2.7	0.013	24.6	20.2	7.43	0.96	11.3	49.2
BH10		0.5	6.4	0.065	30	20.7	13.8	0.19	20.6	72.6
BH10		1	3.5	0.034	31.5	48.7	8.91	0.13	22.7	88.4
BH10		1.5	3.3	0.034	37.4	50.1	6.41	0.15	26.1	91.2
BH10		2	3.8	0.044	39.1	50	6.44	0.17	22	92.3

Key:

Purple Fill	Exceedance of Predicted Background Concentrations
Grey Fill	Exceedance of SGV for Commercial/Industrial outdoor worker
Red Fill/outline	Exceedance of Eco-SGV

Notes:

1. LRIS Predicted Background Soil Contaminants, New Zealand, Landcare Research Limited, Updated 2016.
2. Ministry for the Environment, 2012. National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.
3. National Environmental Protection (Assessment of Site Contamination) Measure 1999 (Australia); Schedule B1 (as amended May 2013) - Guideline on Investigation Levels For Soil and Groundwater, Federal Register of Legislative Instruments F2013C00288, National Environmental Protection Council. (HIL - Health Investigation Level).
4. New Zealand Risk Based Guidelines: Development of Soil Guideline Values for the Protection of Ecological Receptors (Eco-SGVs) Landcare Research 2016 - Areas of ecological significance.
5. Based on local background concentrations relevant to the site.
6. Based on Aged Zinc in tolerant soils.

6 Quality Assessment and Quality Control

The field and laboratory quality assurance and quality control (QA/QC) programme was based on data quality indicators (DQIs) chosen to assess the suitability of the dataset. These are discussed in the following sections.

6.1 Field Quality Programme

Table 5 summarises the field quality programme for the BCA.

Table 5: Field Quality Programme

Environmental consultant	The environmental consultant maintains Quality Assurance Systems certified to AS/NZS ISO 9001:2000. Qualified and experienced personnel with at least 5 years' experience completed the field works.
Procedures	All work was conducted in accordance with relevant statutory health, safety and environmental (HSE) sampling guidelines, as well as standard company HSE and environmental field procedures. Standard field sampling sheets were used. Details recorded included WSP staff and contractors present, time on/off-site, weather conditions, calibration records and other observations relevant to the works.
Sampling	Collection of samples was undertaken by appropriately qualified and experienced personnel following WSP standard field procedures which are based on industry accepted standard practice. Chain of custody was used to ensure the integrity of samples from collection to receipt by the laboratory.
Equipment decontamination	Undertaken after each sampling episode where equipment used was not dedicated. Field sampling procedures conformed to WSP QA/QC protocols to prevent cross contamination, preserve sample integrity, and allow for collection of a suitable data set from which to make technically sound and justifiable decisions with data of satisfactory usability.
Transportation	Samples were stored in coolers on-site and during transport by the field engineer to the laboratory. Chain of custody forms were completed on-site and sent with the samples. Chain of custody forms are presented with laboratory reports in Appendix D, and include the sampler's name, date of sampling, sample matrix, sample containers and preservation used, and analysis requested. The laboratory confirmed receipt of the samples and specified the condition on delivery and the scheduled analyses. Laboratory sample receipt documentation indicated that appropriate holding times were met for the primary laboratory and intra-laboratory duplicates.
Reporting	Report generally complies with the MfE CLMG No. 1 (Ministry for the Environment, Revised 2021).

6.2 Laboratory Quality Programme

Table 6 summarises the laboratory quality program for the BCA.

Table 6: Laboratory Quality Programme

Holding times	Samples were transported to the primary laboratory, and all primary samples were extracted and analysed within the holding times for the analyses requested.
Methods	Analysis was carried out by laboratories with IANZ certification for the required analyses. Methods used by the laboratories were consistent with MfE CLMG No. 5 (Ministry for the Environment , 2021).
Reporting Limits	Detection limits were sufficient to enable comparison against the appropriate guidelines

7 QA/QC Data Evaluation

7.1 Consistency

Consistent and repeatable sampling techniques and methods were utilised. The same sampler and methodology were used for all sampling locations. The sampling was in general accordance with the sampling and analysis procedures and as per standard industry procedures.

Each sample was analysed using identical methods for each analyte and laboratory practical quantitation limits (PQLs) were consistent over each laboratory batch.

7.2 Completeness

All critical samples were analysed for the contaminants of concern identified at the site. Appropriate methods and PQLs were adopted for the investigation. All sample documentation was completed appropriately and sample holding times were complied with.

7.3 Summary

WSP considers that the sample collection, documentation, handling, storage and transportation procedures utilised are of an acceptable standard and the analytical results provided by the laboratories are deemed reliable and complete, therefore the data are considered fit for purpose.

It is considered that the QA/QC procedures and results were acceptable and that the conclusions of the report have not been significantly affected by the sampling or analytical procedures.

8 Discussion and Site Characteristics

8.1 Geological conditions

During the drilling of the majority of the boreholes, sandstone was encountered at approximately 1.0m bgl with various amounts of gravel and cobbles, and often turned into siltstone at deeper depths.

Boreholes BH01 and BH10, located at the outer edges of the landfill, comprised a top layer of topsoil, followed by a combination of sand, silt and clay, the dominant geological unit changing often with depth increase. Sandstone was encountered at approximately 7m bgl and 3m bgl for BH01 and BH10 respectively.

The depth to groundwater generally increased as the borehole was in a more northern or eastern location on the landfill. This is consistent with the site having a general slope towards the south-west.

8.2 Analytical Results

8.2.1 Background Concentrations

All of the samples taken from borehole BH01 reported arsenic concentrations exceeding background, except for the sample taken at 1.0m bgl, which showed an elevated lead concentration.

Although no background concentration is predicted for mercury by LRIS, the sample taken at borehole BH06 revealed a considerably higher mercury concentration than the other samples. As such, the result has been indicated as above the predicted background concentration.

As hydrocarbons are generally not considered to be a naturally occurring substance, the relevant LOR has been taken as the background level. All samples showed PAH results below their respective LOR and thus can be considered below background concentrations.

8.2.2 Human Health

None of the samples showed human health exceedances for heavy metals nor PAHs, as per the NESCS Regulations 2011 (Ministry for the Environment , 2012).

8.2.3 Eco-SGVs

All of the samples taken from borehole BH01 revealed arsenic concentrations above the relevant Eco-SGV.

In addition, all samples taken from the different boreholes reported zinc concentrations above the Eco-SGV based on aged zinc in tolerant soils. It should be noted however that the naturally occurring background concentrations for zinc in the area are also higher than the Eco-SGV and these results should therefore be considered to be the norm for the local area.

9 Conclusion

A Baseline Contamination Assessment was undertaken by WSP for the proposed upgrade of the Balclutha landfill, located along Kaitangata Highway.

Ground investigations were carried out in October and November 2022, during which 10 new boreholes were installed across the proposed location for the landfill expansion. Ground conditions were geologically logged, and soil samples were taken and analysed for total heavy metal and PAH concentrations.

Results revealed that the site generally comprises sand, silt and clay underlain by sand- and siltstone at approximately 1m bgl. Areas along the southern and eastern boundary reported sandstone at deeper levels. The site slopes downwards in a south-westerly direction, which is consistent with the depth to groundwater generally increasing in a north-easterly direction.

Soil samples were taken from the core of three boreholes, one of which reported elevated arsenic and lead concentrations above predicted local background concentrations. All samples were found to contain zinc concentrations above Eco-SGVs, but below local background., Samples taken from borehole BH01 also show arsenic above its relevant Eco-SGV. In addition, slightly elevated mercury concentrations were found at borehole BH06 compared to the other sample locations.

No exceedances were reported of NESCS human health criteria for a commercial/industrial end use.

All PAHs reported concentrations below their limit or reporting and can thus be considered below background concentrations.

10 References

GNS Science. (2023). *New Zealand Geology Web Map*. Retrieved from GNS Science : https://maps.gns.cri.nz/

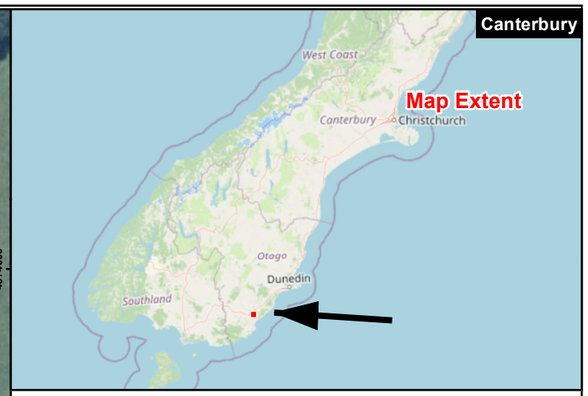
Ministry for the Environment . (2012). *Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health. .* Wellington.

Ministry for the Environment . (2021). *Contaminated land management guidelines No 5: Site investigation and analysis of soils (Revised 2021).* Wellington : Ministry for the Environment .

Ministry for the Environment. (Revised 2021). *Contaminated Land Management Guideline No 1: Reporting on Contaminated Land Sites in New Zealand.* Wellington: Ministry for the Environment.

NZGS. (2005). *Field Description Of Soil and Rock. Guideline for the Field Classification and Description fo Soil and Rock for Engineering Purposes.* New Zealand Geotechnical Society Inc.

Appendix A
Site Plan



LEGEND

- Proposed New Shallow Groundwater Well
- Proposed Shared Hydro/Geotech Borehole
- Proposed Geotechnical Boreholes
- Existing Groundwater Monitoring Well
- Sediment Pond Monitoring Site
- Surface Water Monitoring Site
- Oxidation Ponds
- Pump Station
- Royds Boreholes (1993)
- Proposed Fill Area Expansion

ISSUED FOR COMMENT

DRAFT

NOTES

1. Map image: © OpenStreetMap (and) contributors, CC-BY-SA Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
2. Schematic only, not to be interpreted as an engineering design or construction drawing.

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Meters

REFERENCE SCALE: 1:2,200 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
CLUTHA DISTRICT COUNCIL

PROJECT
MT COOEE LANDFILL DEVELOPMENT PLAN

TITLE
MT COOEE PROPOSED DRILLING PLAN

CONSULTANT
wsp

YYYY-MM-DD	2022-07-06
PREPARED	KC

PROJECT NO.	REPORT	REV.	FIGURE
6-CO082.00	N/A	N/A	**01**

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Appendix B
Data Quality Objectives (DQOs)

Table DQO1 DQO process

STEP	DESCRIPTION	OUTCOMES
1	State the problem	Based on our understanding of the project, the following "problem" has been identified: It is understood that the client is proposing to renew and develop the Mt Cooee Landfill ("landfill") in Balclutha. The site is being used for a land use which is indicative of an increased risk of contamination. Activities associated with a landfill are activities described on the MfE Hazardous Activities and Industries List (HAIL). The client has an obligation under the Health and Safety at Work Act to identify risks to workers and contractors working on the site. One such risk is the risk of exposure to contaminants and therefore in order to properly understand the level of risk and how best to manage it further, investigations of the soil contaminant conditions is required. Contaminants of concern include heavy metals and polycyclic aromatic hydrocarbons (PAHs). As the area of the landfill will be expanding to the south and east of the existing landfill, the suitability of the site for the proposed end use should be investigated. As such, ground investigations have been undertaken to inform ground and groundwater variability across the site. In addition, environmental sampling and testing has been carried out to provide baseline contamination data. The upgrade works trigger the Resource Management (National Environmental Standard for Assessment and Management of Contaminated Soils to Protect Human Health) Regulations. Soil contaminant conditions must be understood in order to determine consenting requirements and risks to human health.
2	Identify the decisions/goal of the investigation	The decisions to be made based on the results of the investigation are as follows: — Is the site investigation design sufficiently robust to meet the requirements of Contaminated Land Management Guideline No. 5, Site Investigation and Analysis of Soil? — Have all the contaminants of concern been identified? — Are the data gaps at the site clear? — Are there contaminant risks which need to be managed during the works? — Are there contaminant risks that need to be managed on completion of the works? — What controls are needed to manage the contaminant risks during and on completion of the works? — What consents and permits are triggered by the presence of contamination? — What is the cost of managing contamination risks and what impact will this have on the overall works budget?

STEP	DESCRIPTION	OUTCOMES
3	Identify the inputs to the decision	The inputs required to make the above decisions are as follows: — Background data on site history and waste disposed of at the landfill. — Observation data including presence of odours and discolouration of the soil — Geological data — Concentrations of contaminants of concern in soil — Site assessment criteria for soil — Distribution of identified soil contamination (if any)
4	Define the study boundaries/constraints on data	The boundaries of the investigation have been identified as follows: — Spatial boundaries: the spatial boundary of the investigation area is defined as the geographical extent of the proposed works, as shown on Figure 1 and the depth of exploration. — Temporal boundaries: the date of the project inception (October 2022) to the completion of the field work under the proposed investigation.
5	Develop a decision rule *The purpose of this step is to define the parameters of interest, specify the action levels, and combine the outputs of the previous DQO steps into an 'if…then…' decision rule that defines the conditions that would cause the decision maker to choose alternatives actions.*	If concentrations exceed the adopted assessment criteria and development of the area is desired, then: — Consent will be sought — Controls will be implemented to manage contaminant risks during and on completion of works — Requirements for further assessment, remedial and/or management options will be considered.
6	Specify limits on decision errors	The acceptable limits on decision errors to be applied in the investigation and the manner of addressing possible decision errors have been developed based on the data quality indicators (DQIs) of precision, accuracy, representativeness, comparability and completeness and are presented in Tables DQO2 and DQO3.
7	Optimise the design for obtaining data *The purpose of this step is to identify a resource effective data collection design for generating data that satisfies the DQOs.*	This assessment has been designed considering the information obtained during the desktop review of information undertaken by WSP (2023) and presented in this report. The data collection design that is expected to satisfy the DQOs is described in detail in Section 4.1 & 4.2 (Sampling Design and Investigation locations). It is based on the principles set out in CLMG No. 5 and the details of the proposed works. To ensure the design satisfies the DQOs, DQIs (for accuracy, comparability, completeness, precision and reproducibility) have been established to set acceptance limits on field methodologies and laboratory data collected. Further detail has on DQI has been provided below.

DQIs for sampling techniques and laboratory analysis of collected soil samples define the acceptable level of error required for this assessment. The adopted field methodologies and data obtained have been assessed by reference to DQIs as follows:

- Precision: a quantitative measure of the variability (or reproducibility) of data.
- Accuracy: a quantitative measure of the closeness of reported data to the true value.
- Representativeness: the confidence (expressed qualitatively) that data is representative of each media present on the site.
- Comparability: a qualitative parameter expressing the confidence with which one data set can be compared with another.
- Completeness: a measure of the amount of useable data (expressed as a percentage) from a data collection activity.

A summary of the field and laboratory DQIs for the validation assessment are provided in Tables DQO2 and DQO3.

Table DQO2 DQIs for field techniques

DQI
Precision
Standard operating procedures (SOPs) appropriate and complied with
Accuracy
WSP SOPs appropriate and complied with
Representativeness
Appropriate media samples
Sample design appropriate to identify potential sources
Comparability
Same SOPs used on each occasion
Experienced sampler
Climatic conditions (temperature, rainfall, wind)
Same type of samples collected
Completeness
SOPs appropriate and complied with
All required samples collected

Table DQO3 DQIs for laboratory

DQI	ACCEPTABLE LIMITS
Precision	
International Accreditation New Zealand (IANZ) certified laboratory	IANZ accreditation for analyses performed
Accuracy	
Analysis of laboratory matrix spikes, laboratory control samples and surrogate recoveries	70-130% inorganics/metals 60-140% organics 10-40% semi-volatile organic compounds
Representativeness	
All required samples analysed	As per Section 4
Comparability	
Sample analytical methods used (including clean-up)	As per MfE CLMG No. 5
Same units	Justify/quantify if different
Same laboratories	Justify/quantify if different
Sample PQLs	Less than nominated criteria
Completeness	
All critical samples analysed	As per Section 5
All required analytes analysed	As per Section 5
Appropriate methods and PQLs	As per MfE CLMG No. 5
Sample documentation complete	
Sample holding times complied with	

Appendix C

Machine Borehole Logs and Photographs

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 11.6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL, grass, trace rootlets and trace fine quartz gravel. 0.40-0.50m - Woody organics present.											RC	80					Cement seal
Alluvium	Silty CLAY with trace gravel and rootlets, dark grey, homogenous. Soft to firm, moist, high plasticity. Gravel; coarse, subangular. Core loss.	8	1															
	Sandy SILT, light brown to brown, homogenous. Firm, moist to dry, low plasticity, micaceous. Sand; fine.				6	3// 1/2/1/2						SPT	100					
	Silty CLAY with trace sand and gravel, light brown with dark grey and brown specks, homogenous. Firm, moist, high plasticity. Gravel; fine, subangular. Sand; fine to coarse. 1.50m - Orange mottle.										Lab: 1.8 - 3.0m PSD and Atterberg Limits	RC	100					
	Sandy SILT, brown, homogenous. Firm, dry, low plasticity. Sand; fine. 1.80m - Becomes light brown.		2		5	2// 1/1/1/2						SPT	100					31/10/2022
	Silty fine to coarse SAND with trace rootlets, brown, homogenous. Loose, moist, micaceous. Silt; low plasticity.											RC	100					
	Becomes light grey to grey with trace of orange mottles, homogenous. Dry to moist, non-plastic, micaceous.	6	3								2.85-3.00m - Broken during removal from core catcher							
					7	2// 1/2/2/2						SPT	100					
	Silty CLAY with trace sand, light grey with orange mottles throughout, homogenous. Soft to firm, moist, high plasticity, micaceous. Sand; fine to medium. 3.50m - Becomes firm.											RC	100					
	3.90m - Becomes light grey with trace orange mottles (less than above), homogenous.		4															
	Sandy SILT, light brownish grey, homogenous. Soft, non-plastic dry. Sand; fine to medium.				6	2// 2/1/2/1						SPT	100					
	Silty CLAY, light greenish grey, homogenous. Soft to firm, moist, high plasticity.										Lab: 4.4 - 6.1m PSD and Atterberg Limits	RC	100					
		4	5															
					1	0// 0/0/0/1						SPT	100					
	5.45-5.65m - Becomes light greyish green with trace green sandy laminations. 5.65-6.00m - Green sandy lenses. Becomes greenish grey.											RC	100					
		6																
					60+	13// 9/22/22/7 for 20mm						SPT	100					9/03/2023
	Silty CLAY with trace gravel and sand, dark grey with orange mottles, homogenous. Very soft, moist to wet, high plasticity. Gravel; fine to coarse, subangular to angular. Sand; fine to medium, subangular to subrounded.											RC	100					
Caples Terrane	Slightly weathered, highly fractured, light brownish grey, fine fabric SANDSTONE; moderately strong; very closely spaced joints and white veins. Recovered as: sandy GRAVEL with some silt, light brown. Gravel and sand; fine to coarse, subangular. 7.50-8.00m - Gravel becomes; fine to coarse, coarser gravel is angular to subangular, finer gravel is rounded to subrounded.	2	7								6.70-9.35m - Rock broken up by drilling.							
					60+	12// 14/46 for 75mm						SPT	100					
												RC	100				SWL 2.35m	
		8			60+	60 for initial 110mm	MS	SW	VC			SPT	100					
	Slightly weathered, highly fractured, light bluish grey, fine fabric SANDSTONE; moderately strong; closely spaced joints and white veins. Recovered as: Fine to coarse GRAVEL with minor sand, light greyish brown. Very dense, well graded, non-plastic. Gravel; coarser gravel is angular to subangular, finer gravel is rounded to subrounded. Sand; medium to coarse, rounded. 9.17-9.35m - Recovered as: fine to coarse GRAVEL with minor cobbles, light grey. Very dense, well graded. Gravel; subangular, Greywacke, mm-scale white veins. Cobbles: max 80mm.	0	9									RC	100	0				
					60+	60 for initial 105mm			VC C VC		Lab: 9.0 - 11.0m UCS testing 9.17-9.35m - Rock broken up by drilling. Any matrix appears to be lost due to drilling.	SPT	100	0				
							S		C			RC	100	0				50 mm slotted pipe (3.0 m L)

Rotary cored

PQ size wireline (85 mm nom. dia. core)

50 mm Blank pipe (8.2 m L) with grout backfill

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 11.6 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Slightly weathered, fractured, light grey, fine fabric SANDSTONE; strong; white veins smooth and tight aperture. Recovered as: COBBLES, with some gravel and sand. Well graded. Cobbles and gravel; angular to subangular. Sand; fine to medium.*(continued)* 10.11-11.00m - Thinly laminated veins throughout. Veins are mostly white, some are greenish white. Apertures extremely closely spaced, very narrow. 10.40-10.60m - Heavily veined. Minor sand. 10.80-11.00m - Angular GRAVEL and COBBLES.	-2 / 11		60+	60 for initial 105mm	S	SW	VC			SPT	100	0	Rotary cored			
								C			RC	100	0				
								VC									
				60+	60 for initial 95mm			C			SPT	100	0				
								VC			RC	100	0				
	END OF BOREHOLE AT 11.6m - Target Depth Reached	12															
		-4 / 13															
		14															
		-6 / 15															
		16															
		-8 / 17															
		18															
		-10 / 19															

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 19/10/2022
Finished: 20/10/2022
Drilling Co.: McMillan Drilling
Drilling Rig: Hanjin D&B-8D - track
Logged by: C. Hall
Checked by: C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.1
BH1 Box 1: 0.0m - 2.4m

Photo BH1.2
BH1 Box 2: 2.4m - 4.45m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.3
BH1 Box 3: 4.45m - 7.0m

Photo BH1.4
BH1 Box 4: 7.0m - 9.35m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.5
BH1 Box 5: 9.35m - 11.0m

Photo BH1.6
BH1 Box 6: 11.0m - 11.6m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 116.39 m
Location:	Near Clutha River Bridge Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 15 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some fine gravel.	116															
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. [TUAPEKA GROUP GREYWACKE] - weathered, fractured zone at top of layer - very hard - some quartz filled joints	1												Rotary open hole			4/03/2001 Slotted pipe
		2															
		114															
		3															
		4															
		112															
		5															
		6															
		110															
		7															
		8															
		108															
		9															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-QPUS2019_VER11X.GDT 30/3/23

Notes:

Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 28/01/1994 *Finished:* 28/01/1994

Drilling Co.: *Drilling Rig:*

Logged by: *Checked by:*

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 116.39 m
Location:	Near Clutha River Bridge Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 15 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. [TUAPEKA GROUP GREYWACKE] - weathered, fractured zone at top of layer - very hard - some quartz filled joints*(continued)*	106 / 11 / 12 / 104 / 13 / 14 / 102 / 15												Rotary open hole			Slotted pipe
	END OF BOREHOLE AT 15m	16 / 100 / 17 / 18 / 98 / 19															

Notes:
Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 28/01/1994
Finished: 28/01/1994
Drilling Co.:
Drilling Rig:
Logged by:
Checked by:

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350241 E 4873978 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m
Location:	North of site, north side of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Alluvium	GRAVEL with minor sand, brownish grey. Loose. Gravel; fine to coarse, subrounded, sandstone. Clay/silt/sand matrix inferred washed away. 0.70m - Some matrix present at 0.7m Core loss.	14	1									RC	55	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 1.00m	13/10/2022 Cement seal 50 mm slotted pipe (3.0 m L) Grout
Alluvium	Gravelly CLAY with some silt and minor sand, brown. Homogenous, soft, moist, high plasticity. Gravel; fine to coarse, angular, well graded. Core loss.	13	2									RC	45	0				
Caples Terrane	Completely weathered grey and orange/brown, fine fabric SANDSTONE. Extremely weak. Recovered as: SILT with minor gravel and some sand and clay. Homogenous, stiff to very stiff, moist, low plasticity. Gravel; fine to medium, subangular. Sand; fine. Core loss.	12	3 4				EW W EW	CW SW CW	EC VC EC			RC	80	0				
Caples Terrane	Moderately weathered greenish grey, fine fabric SANDSTONE. Very weak to weak. Completely weathered grey and orangeish brown, indistinctly bedded SANDSTONE. Extremely weak. Residual soil recovered as: SILT with some clay. Homogenous, stiff to very stiff, moist, and low plasticity. Moderately weathered greenish grey, indistinctly bedded SANDSTONE. Very weak to weak.	10	5 6				EW W VW W	CW HW MW	EC C VC C VC			RC	100	30				
	END OF BOREHOLE AT 6m - Target Depth Reached	8	7 8 9															
		6																

Notes:

Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 18/10/2022 *Finished:* 19/10/2022

Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track

Logged by: N. Ahern *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350241 E 4873978 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m	*Inclination:*	Vertical
Location:	North of site, north side of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH2.1
BH2 Box 1: 0.0m - 4.2m

Photo BH2.2
BH2 Box 2: 4.2m - 6.0m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	18/10/2022	*Finished:*	19/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 109.29 m
Location:	Near gate to landfill Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 9.5 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some fine gravel.																
Pleistocene Glacial Deposits	Grey brown mottle yellow brown sandy silty fine GRAVEL.	1 108															
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. - Weathered, fractured zone at top of layer - Very hard - Some quartz filled joints	2 3 106 4 5 104 6 7 102 8 9 100												Rotary open hole			
	END OF BOREHOLE AT 9.5m																

Notes:
Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 30/01/1994
Finished: 30/01/1994
Drilling Co.:
Drilling Rig:
Logged by:
Checked by:

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH3

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350135 E 4873642 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 11 m
Location:	Western area of site, 15m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 4.5 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Alluvium	SILT with some clay and minor sand, grey/dark brown, homogenous. Soft, moist, low plasticity. Sand; fine to medium.																	
	Clayey SILT with minor sand, light brownish orange. Homogenous, soft, moist, with low to medium plasticity. Sand; fine.																	
Caples Terrane	0.90-0.92m - Cobble of moderately weathered, light brown massive SANDSTONE. Weak.	10	1				EW	CW	EC			RC	100		Rotary cored	PQ size wireline (85 mm nom. dia. core)		Cement seal
	Completely weathered, brownish orange, fine fabric SANDSTONE. Extremely weak. Recovered as: sandy SILT with minor clay, brownish orange, homogenous. Stiff, dry to moist, low plasticity. Sand; fine to medium.								C									Blank (1.5 m L)
	Highly weathered orange/brown, fine fabric SANDSTONE. Very weak. Recovered as: sandy GRAVEL with some cobbles and minor silt and clay, homogenous. Gravel; fine to coarse, subrounded. Cobbles; max 100mm, subrounded. Sand; fine to coarse.		2				VW	HW	EC			RC	65	0				31/10/2022
	Core loss.	8	3						C		2.40-2.50m - Core broken during removal from catcher.							1/02/2023
	Moderately weathered dark green/orange, fine fabric SANDSTONE. Weak. Orange staining on all joint faces. Recovered as: COBBLES with minor gravel. Cobbles; max 100mm, mostly subangular with some subrounded (due to drilling). Gravel; medium to coarse, subangular.						W	MW	VC		3.00-4.30m - Possible weaker material washed out by drilling.	RC	80	0				Bentonite
			4						C									50 mm slotted pipe (1.0 m L)
	Core loss.								VC								SWL 1.60m	
	END OF BOREHOLE AT 4.5m - Target Depth Reached	6	5															
			6															
		4	7															
			8															
		2	9															

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 11/10/2022 *Finished:* 12/10/2022
Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track
Logged by: N. Ahern *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH3

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350135 E 4873642 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	4.5 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 11 m	*Inclination:*	Vertical
Location:	Western area of site, 15m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH3.1
BH3 Box 1: 0.0m - 3.0m

Photo BH3.2
BH3 Box 2: 3.0m - 4.5m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	11/10/2022	*Finished:*	12/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH4

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350398 E 4873540 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	South-east corner of site Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 5.5 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with roots and grass.																	
Caples Terrane	Sandy GRAVEL with trace rootlets, light brown to grey. Loosely packed, well graded, non-plastic. Gravel; angular to subangular, greywacke. Sand; fine to coarse, subrounded. 0.50-0.80m - Gravel; subangular to subrounded. Coarse sand; subangular to angular. Core loss.	8	1								0.15-3.70m - Assumed some fines or weaker seams were present but these have been washed away by drilling.	RC	53	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 2.30m	Blank 1m Cmt. seal
	Slightly weathered to moderately weathered, highly fractured, orangish brown, fine fabric SANDSTONE; extremely weak; extremely closely spaced tight white veins; extremely weathered defects. Recovered as: COBBLES with some gravel and trace silt and rootlets, orangey brown to grey. Cobbles and gravel; fine to coarse. Cobbles; max 100mm, subangular. Sand; fine to coarse, subangular to subrounded. Silt; dark grey, lensoidal. 2.20-2.40m - Trace pockets of dark grey silt. Core loss.	6	2				EW	MW	EC		1.50-5.50m - Fracturing due to drilling	RC	40	0				31/10/2022
	Slightly weathered to moderately weathered, highly fractured, dark grey SILTSTONE. Very weak, bedding is thinly laminated. Recovered as: Sandy GRAVEL with some cobbles and silt, dark grey with some orange and white veins. Sand; fine to coarse, angular to subangular. Gravel and cobbles; fine to coarse, subangular. Cobbles; max 60mm. Fines; non-plastic. Core loss.	4	3				VW	MW	EC			RC	80	0				
	Slightly weathered, highly fractured, dark bluish grey, fine fabric SILTSTONE. Weak. Mm scale mostly closed and oxidised defects. Recovered as: COBBLES with some gravel and trace silt, dark bluish grey with orange staining. Cobbles and gravel; fine to coarse, subangular. Cobbles; max 150mm. Sand; fine to coarse, subangular to subrounded. 5.00m - Slickenslides on one piece of gravel.	4	5				W	SW	VC	50 / 45	4.10m - J, 50° 4.20m - J, 45°	RC	100	0				09/03/2023
	END OF BOREHOLE AT 5.5m - Target Depth Reached	0	6 7 8 9															50 mm slotted pipe (4.5 m L)

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	27/10/2022	*Finished:*	27/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH4

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350398 E 4873540 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	5.5 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	South-east corner of site Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH4.1
BH4 Box 1: 0.0m to 3.8m

Photo BH4.2
BH4 Box 2: 3.8m - 5.5m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	27/10/2022	*Finished:*	27/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH5

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350288 E 4873598 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 7 m
Location:	Southern area of site, 80m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 3 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some grass and rootlets and minor quartz sand.																	
Alluvium	Silty CLAY with trace sand, orangish brown, homogenous. Firm to stiff, moist, high plasticity. Sand; medium.																	
Alluvium	Silty CLAY with minor sand, light greyish orange with minor white specks and orange mottle, homogenous. Stiff, moist, high plasticity. 0.90m - Becomes orange. Soft to firm.	6	1								Lab: 0.4 - 1.1m PSD and permeability testing.	RC	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 2.30m	31/10/2022; Blank pipe 0.9 m; Slotted pipe 0.6 m; Grout
Caples Terrane	Highly weathered, brownish orange, fine fabric indistinctly bedded SANDSTONE. Weak to very weak; orange defects. 1.20m - Becomes moderately weathered to slightly weathered. 1.80-2.00m - Grades into slightly weathered.						VW	HW / SW	VC		Lab: 1.1 - 2.6m UCS testing.							
Caples Terrane	Moderately weathered, greenish grey, fine fabric indistinctly bedded SANDSTONE. Weak to very weak; orange staining along open defects.	4	2				W	MW / SW	C / VC	J10	2.15m - J, 10° 2.50m - J, 10°	RC	100	17				
	END OF BOREHOLE AT 3m - Target Depth Reached		3						C		2.90-3.00m - Core broken during removal from catcher.							
			4															
		2	5															
			6															
		0	7															
			8															
		-2	9															

Notes:

Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 17/10/2022 *Finished:* 18/10/2022

Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track

Logged by: C. Hall *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH5

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350288 E 4873598 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	3 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 7 m	*Inclination:*	Vertical
Location:	Southern area of site, 80m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH5.1
BH5 Box 1: 0.0m to 2.2m

Photo BH5.2
BH5 Box 2: 2.2m to 3.0m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	17/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 9.45 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some grass and rootlets, dark brown. 0.20m - Becomes orangish brown.																	
Caples Terrane	Moderately weathered, light brownish orange, highly fractured, SANDSTONE. Moderately strong. Recovered as: gravelly COBBLES with some sand. Cobbles; angular, max 100mm. Gravel; medium to coarse, angular. Core loss.	20	1				MS	MW	VC			RC	73		Rotary cored	PQ size wireline (85 mm nom. dia. core)		50 mm blank pipe (1.0 m L)
	Highly weathered, light brownish orange, highly fractured SANDSTONE. Weak. Recovered as: Sandy GRAVEL with some clay, orangish brown. Gravel; fine to coarse, subangular. Fines; high plasticity.		2		56	15// 10/13/15/18	W	HW	EC			SPT	100					
	2.30m - Re-drilled cobble. Core loss.	18	3									RC	38					
	Moderately weathered, light grey to dark grey, highly fractured SANDSTONE. Moderately strong. Recovered as: GRAVEL with some sand, light grey to dark grey. Gravel; fine to coarse, subangular.				60+	17// 14/16/21/9 for 25mm	MS	MW	VC			SPT	100					
	Core loss.		4									RC	38					
	Completely weathered, greenish grey, fine fabric SILTSTONE. Extremely weak. Recovered as: clayey SAND with trace silt. Sand; fine to medium. Fines; high plasticity. 4.95-5.25m - Lenses of silty CLAY, greenish grey, homogenous. Soft, moist, high plasticity.	16	5		60+	15// 13/26/21 for 45mm	EW	CW	EC			SPT	100				SWL 2.20m	
	Moderately weathered, greenish grey, highly fractured fine fabric, indistinctly bedded SANDSTONE. Weak. Recovered as: sandy GRAVEL with some clay, bluish green. Gravel; medium to coarse. Fines; high plasticity.						W	MW										
	Slightly weathered greenish blue, massive SILTSTONE. Weak to moderately strong. 5.70-5.90m - Moderately weathered, highly fractured along defects. Defects; open or extremely closed spaced and closed. 6.45-6.55m - Pockets of silty SAND with pockets of clay, bluish green, homogenous. Loose, non-plastic. 6.55-7.20m - Black stained defects throughout.		6		60+	15// 20/24/16 for 50mm	MS	SW MW SW	C VC EC		Lab: 5.3 - 9.45m UCS testing.	RC	100					
	Moderately weathered greenish blue, fine fabric SILTSTONE. Weak; black stained defects. Recovered as: COBBLES with some gravel and silt. Cobbles and gravel; angular. Gravel; medium to coarse. 7.00-7.20m - Grades into completely weathered rock. 7.20-7.50m - Recovered as: sandy GRAVEL with some silt, dark greenish grey to black. Loose, non-plastic. Gravel; fine to coarse, subrounded Siltstone.	14	7		60+	36// 48/12 for 35mm			C EC			SPT	100	0				
	8.25m - Becomes slightly weathered, minor fractures, weak to moderately strong. Defects; closed aperture. Grainsize grading larger from Siltstone to Sandstone. 8.75-9.00m - Recovered as: sandy GRAVEL with some silt, dark greenish blue, homogenous. Loose. Gravel; highly weathered. 9.00-9.45m - Recovered as: silty SAND, greenish yellow, homogenous. Soft to firm, low plasticity. Sand; fine to medium.	12	8 9		60+	19// 22/38 for 75mm	W	CW MW SW HW	EC C EC			RC SPT	100 93	0 0			SWL 4.96m	Grout
	END OF BOREHOLE AT 9.45m - Target Depth Reached																	

31/10/2022

50 mm slotted pipe (1.5 m L)

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	9.45 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m	*Inclination:*	Vertical
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH6.1
BH6 Box 1: 0.0m to 4.5m

Photo BH6.2
BH6 Box 2: 4.5m to 6.8m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	9.45 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m	*Inclination:*	Vertical
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH6.3
BH6 Box 3: 6.8m to 9.45m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH7

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350492 E 4873800 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 25 m
Location:	Eastern most corner of site, 20m south of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Caples Terrane	Moderately weathered light grey to light brown with orange mottle, fine fabric SANDSTONE. Weak to moderately strong. Recovered as: gravelly COBBLES with some sand. Cobbles and gravel; angular. Gravel; medium, subrounded. 0.20-0.70m - Coarse to fine gravel, sandy silty matrix inferred fines washed away. Core loss.	24	1				W	MW	EC / VC		0.20-6.00m - Fractures opened by drilling.	RC	75	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		Surrounding ground collapse
	Highly weathered, light brown with orange mottle, highly fractured, fine fabric SANDSTONE. Strong. Recovered as: Gravelly COBBLES. Gravel and cobbles; angular. 1.00-2.00m - Sand/silt matrix inferred washed away. 1.55m - Becomes completely weathered.				60	31// 34/26	S	HW	VC			RC	85	0				
	Slightly weathered light grey with some orange mottle, fractured, fine fabric SANDSTONE. Moderately strong.		2				MS	SW	C / VC	40	2.40m - J, 40°	RC	100	30				
	2.70-2.90m - Moderately fractured same materials as above, rootlets present. 2.90-3.20m - Recovered as: silty SAND, brownish orange. Loosely packed, dry to moist, low plasticity.	22	3								2.90-3.00m - Core broken during removal from catcher. Core inferred to be baked during drilling.							Gravel
	Moderately weathered dark grey with light brown and orange mottle, fractured, interbedded SANDSTONE and SILTSTONE. Sst = strong, siltst = weak. 3.60-4.05m - Becomes moderately thickly bedded and more mudstone dominant.						W	MW	VC / C / VC			RC	100	10				
	4.05-4.20m - Recovered as: medium to fine gravel with some silt and sand, greenish grey. Loosely packed, moist. Silt; low plasticity.		4								4.00-4.20m - Core broken during removal from catcher.							
	Slightly weathered dark grey with orange mottle, fractured, indistinctly bedded SILTSTONE. Moderately strong. 4.30-4.70m - Discontinuities: extremely closely spaced very narrow to closely spaced closed aperture. 4.90-5.20m - Discontinuities: becomes thinly bedded, thinly laminated, sub-horiztonal planar bedding. 5.20-5.40m - Orange staining increasing. 5.40-5.55m - Minor orange mottle.	20	5				MS / W	SW / MW	C	40 / 60	5.30m - J, 60° 5.31m - J, 40°	RC	80	0			SWL 5.05m	
	Core loss.																	
	END OF BOREHOLE AT 6m - Target Depth Reached	18	6 7 8 9															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	1/11/2022	*Finished:*	1/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH7

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350492 E 4873800 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 25 m	*Inclination:*	Vertical
Location:	Eastern most corner of site, 20m south of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH7.1
BH7 Box 1: 0.0m to 3.0m

Photo BH7.2
BH7 Box 2: 3.0m to 6.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	1/11/2022	*Finished:*	1/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH8

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350323 E 4873768 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m
Location:	Eastern area of site, 80m north of BH06 Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 4.3 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Moderately weathered dark grey to greenish grey with white specks, highly fractured SANDSTONE. Weak. Recovered as: coarse to fine gravel, with some sand. Gravel; subangular. Sand; coarse. 0.20-0.40m - Becomes completely weathered.	14	1				W	MW	EC		Lab: 0.0 - 2.8m UCS testing. 0.40m - Vein, N	RC	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 0.60m	Grout
	Slightly weathered greenish grey with white specks, coarse grained, veined, indistinctly bedded SANDSTONE. Weak to moderately strong. 1.25-1.50m - Crushed zone. Recovered as: coarse to fine GRAVEL with minor sand. Gravel; angular. Sand; coarse. 1.50m - Becomes light greenish grey and coarse-grained.		2				VW MS	SW	W EC	Vein80	1.25m - CZ 1.50m - Vein, 80°, MW							
	2.50-4.30m - Crushed zone. Recovered as: COBBLES with some gravel and minor silt and sand. Cobbles and gravel; subangular, strong. Sand; fine to medium. 2.70-2.85m - Becomes moderately weathered. Very weak. Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; subangular. Core loss.		3						C	Vein75	2.00m - Vein, 75°, N	RC	95	60				
							VW	HW	VC		2.50m - CZ							
	Moderately weathered greenish grey with minor white specks, coarse grained highly fractured, indistinctly bedded SANDSTONE. Very weak. Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; subangular.	12	4				VW	HW	VC		3.05m - Vein, VN 3.10-4.10m - Highly factured insitu rock. Disturbed on removal from core catcher.	RC	90	53				
	END OF BOREHOLE AT 4.3m - Target Depth Reached		5															
		10	6															
			7															
		8	8															
			9															
			6															

Notes:
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 3/11/2022
Finished: 3/11/2022
Drilling Co.: McMillan Drilling
Drilling Rig: Hanjin D&B-8D - track
Logged by: N. Ahern
Checked by: C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH8

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350323 E 4873768 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	4.3 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m	*Inclination:*	Vertical
Location:	Eastern area of site, 80m north of BH06 Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH8.1
BH8 Box 1: 0.0m to 2.1m

Photo BH8.2
BH8 Box 2: 2.1m to 4.3m

Notes:
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	3/11/2022	*Finished:*	3/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH9

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350377 E 4873747 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 20 m
Location:	Eastern area of site, middle of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6.9 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Highly weathered to completely weathered light grey with some orange mottles, slightly interbedded SANDSTONE and SILTSTONE. Weak to moderately strong; bedding is thinly laminated and gently inclined, smooth undulating.						W	HW	EC			RC	60	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		Grout
	Recovered as: cobbly GRAVEL with minor trace sand and silt. Cobbles; subangular to subrounded (possibly due to drilling). Gravel; fine to coarse, angular.		1		60+	42// 60 for 25mm												
	Core loss.											SPT	100					
	HW to CW interbedded SANDSTONE and SILTSTONE. As above.						W	HW	EC									
	Core loss.	18	2									RC	47	0				
	HW to CW interbedded SANDSTONE and SILTSTONE. As above.						W	HW	EC			RC	30	0				
	Core loss.		3									RC	0	0				
		16	4															
	Slightly weathered, dark grey with yellowy white veins, interbedded SANDSTONE and SILTSTONE. Moderately strong to strong. Bedding is thinly laminated, undulating smooth, very narrow to closed, fine grained. Veining is stepped.				60+	5// 1/46 for 25mm	EW	CW	EC			SPT	100					
							MS	SW	C									
	4.50-4.70m - Completely weathered. Recovered as: silty SAND with minor gravel and cobbles, dark grey. Moist. Sand; coarse to medium. Gravel; fine to coarse, subangular. Silt; non-plastic.		5				S	SW	EC C EC VC		5.10-5.25m - Broken to gravel by drilling. 5.40-5.50m - Broken to gravel by drilling.	RC	100	50			SWL 1.70m	
	Slightly weathered, light bluish grey with minor white specks, indistinctly interbedded, fine fabric SANDSTONE and SILTSTONE. Strong. 5.90m - Becomes light grey and moderately strong.	14	6				MS		C C C EC	J35 J40	5.90m - J, 35°, SL, clean 6.00m - J, 40°, SL, clean 6.20-6.60m - Broken to gravel by drilling.	RC	100	0				
	Core loss.																SWL 0.00m	
	END OF BOREHOLE AT 6.9m - Target Depth Reached		7															
		12	8															
			9															
			10															

Notes:

SPT hammer energy ratio 91%
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 2/11/2022 *Finished:* 3/11/2022

Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track

Logged by: N. Ahern *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH9

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350377 E 4873747 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	6.9 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 20 m	*Inclination:*	Vertical
Location:	Eastern area of site, middle of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH9.1
BH9 Box 1: 0.0m to 5.5m

Photo BH9.2
BH9 Box 2: 5.5m to 6.9m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	2/11/2022	*Finished:*	3/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 10 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with grass and rootlets.																	
Fill	Clayey SILT with trace gravel, light brown with black specks, homogenous. Firm to stiff, moist, low plasticity. 0.65m - Becomes brownish orange and firm.											RC	100	0				
Caples Terrane	Completely weathered brownish orange highly fractured, fine fabric SANDSTONE. Extremely weak. Recovered as: SILT with some clay and trace gravel, homogenous. Firm, moist, low plasticity. Minor rootlets present. Gravel corestones are very weak. 1.42-2.75m - Remoulds to: clayey SAND with minor silt and gravel, orangish brown, homogenous. Moist, low plasticity. Gravel; fine to coarse, HW - CW Sandstone, very weak. Sand; medium to coarse, angular to subangular. Fines; Soft.	1			22	6// 5/5/6/6	EW	CW	EC			SPT	100	0				
			2									RC	100	0				
		24			57	13// 10/15/14/18						SPT	100	0				
	2.45-2.75m - Trace rootlets.											RC	100	0				
	Grading to highly weathered, dark brown with orange weathering and white specks, fractured, fine fabric SANDSTONE. Extremely weak. Recovered as: sandy GRAVEL with minor silt. Moist, non-plastic. Gravel; fine to coarse, angular to subangular. Sand; fine to coarse.		3		60+	21// 17/20/23 for 70mm						SPT	100	0				
	Highly weathered, dark orangish brown highly fractured SANDSTONE. Very weak to weak. Recovered as: Sandy GRAVEL with some cobbles and minor silt. Low plasticity. Gravel; fine to medium, angular to subangular. Sand; fine to coarse, angular to subangular.	22	4				VW	HW				RC	100	0			SWL nilm	
					57	18// 12/12/16/17						SPT	100	0				
	Moderately weathered, orangish brown fractured SANDSTONE. Weak. Recovered as: gravelly COBBLES with some sand. Cobbles and gravel; fine to coarse, cobbles max 100mm, subangular. Sand; medium to coarse, rounded.						W	MW	VC			RC	100	0				
	Slightly weathered, orangish brown with oxidised defects, fractured SANDSTONE. Moderately strong. Discontinuities; very closely spaced closed joints, cross-cutting and sub-vertical, rough to smooth planar.		5		60+	27// 51/9 for 5mm	MS	SW		J70 J60	5.30m - J, 70° 5.40m - J, 60°	SPT	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		50 mm blank pipe (1.0 m L) 9/11/2022 9/03/2023 50 mm slotted pipe (9.0 m L)
	5.60-5.70m - Highly fractured zone. Weak.						W	HW	EC			RC	100	0				
		20	6				MS	SW	VC	J60 J70	6.00m - J, 60°							
	6.10-6.15m - Crushed zone. Recovered as: sandy medium GRAVEL with minor silt. Subrounded.						VW	HW	EC		6.10m - CZ							
									VC		6.11m - J, 70° 6.15m - J, 70°	RC	100	0				
			7				MS	SW	C	J50 J70 J50	6.60-6.70m - Core broken during removal from catcher. 6.85m - J, 50° 6.85m - J, 70°							
	7.20-7.90m - Highly fractured zone.									J40	6.95m - J, 50° 7.20m - J, MN, silica coated	RC	100	8				
										J30 J30	7.30m - J, 40° 7.60m - J, 30°							
							W	MW	VC		7.75m - J, 30°							
	7.90-8.50m - Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; angular to subangular, weak to very weak. 8.20-8.30m - Well-rounded coarse sized gravel.	18	8								7.90-8.80m - Disturbed on removal from core catcher.							
												RC	75	0				
	8.60-8.80m - Crushed zone. Recovered as: GRAVEL with some sand and minor silt. Gravel; fine to medium, subangular.						EW	CW	EC		8.60m - CZ							
	Core loss.		9								9.00m - B, PL, silica coated							
	Slightly weathered, light and dark grey fractured and indistinctly bedded SILTSTONE. Moderately strong.						MS	MW	VC									
	9.50-9.60m - Crushed zone. Recovered as: GRAVEL with some sand. Gravel and sand; fine to coarse, subangular.									J45	9.50m - CZ 9.51m - J, 45°	RC	95	0				
	9.60-9.85m - Dark grey. Green and white vein						S	SW	C		9.70m - B, ST, limonite stained							
			16															

Notes:

SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started: 28/10/2022 *Finished:* 31/10/2022
Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track
Logged by: C. Hall *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 10 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
	precipitation. Defects are subvertical. Core loss.																	
	END OF BOREHOLE AT 10m - Target Depth Reached																	

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started: 28/10/2022 *Finished:* 31/10/2022
Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track
Logged by: C. Hall *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	10 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m	*Inclination:*	Vertical
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH10.1
BH10 Box 1: 0.0m to 2.5m

Photo BH10.2
BH10 Box 2: 2.5m to 5.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started:	28/10/2022	*Finished:*	31/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	10 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m	*Inclination:*	Vertical
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH10.3
BH10 Box 3: 5.0m to 7.2m

Photo BH10.4
BH10 Box 4: 7.2m to 10.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started:	28/10/2022	*Finished:*	31/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Appendix D

Laboratory Testing Results and Chain of Custody

ENVIRONMENTAL TESTING:

CHAIN OF CUSTODY

22-45837

ANALYTICA LABORATORIES

CLIENT INFORMATION				Lab ID (Lab use only)	22-45837	Registered By	DR	Date Registered	16/12/22
Client	WSP								
Address	Opus House 197 Rattray Street Dunedin								
Project Leader	Scott Kvick								
Project ID	6-CO082.00	PO Number							
Site	Mt Cooee Landfill								
Sampler	Scott Kvick								
Phone	021 243 6828								
Email	scott.kvick@wsp.com								
Invoice Email	NZ.AP@wsp.com								

CLIENT REQUESTS (Please Tick)											
Routine	X	Priority		Urgent		ESDAT		QC Report		Drinking Water	

TESTS REQUESTED												
	Sample ID	Depth	Sampling Date	Time	Matrix (Please Circle)	Analysis Requests/Suites [Enter Test Code Below]					Sample Comments (ie: extra test requests,high odour, bulk material)
						PAH	8 HM				
1	BH01	0.5	14/12/2022	9am	S	x	x				
2	BH01	1	14/12/2022	9am	S	x	x				
3	BH01	1.5	14/12/2022	9am	S	x	x				
4	BH01	2	14/12/2022	9am	S	x	x				
5	BH06	0.4	14/12/2022	9am	S	x	x				
6	BH10	0.5	14/12/2022	9am	S	x	x				
7	BH10	1	14/12/2022	9am	S	x	x				
8	BH10	1.5	14/12/2022	9am	S	x	x				
9	BH10	2	14/12/2022	9am	S	x	x				
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											

Matrix Key	S (Solids)	CW (Clean Water)	SW (Saline Water)	WW (Waste Water)
	All soils, sediment, sludge	Potable, Ground, Bore, Surface, Fresh	Sea Water, Geothermal	Effluent, Trade Waste, Leachate

Sender Name	Scott Kvick	Received by (Lab Staff)	SJL	Courier company		Courier #	JDQ000101S5
Date Sent	14/12/2022	Time sent	am : pm	Date Received	15/12/22	Time Received	am : pm

Seal Status | Sample Chilled

Page 1 of 1

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Certificate of Analysis

WSP New Zealand Limited
Opus House 197 Rattray Street
Dunedin

Attention: Scott Kvick
Phone: 021 243 6828
Email: scott.kvick@wsp.com

Sampling Site: Mt Cooee Landfill

Lab Reference: 22-45837
Submitted by: Scott Kvick
Date Received: 16/12/2022
Testing Initiated: 16/12/2022
Date Completed: 6/01/2023
Order Number:
Reference: 6-CO082.00

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.
Specific testing dates are available on request.

Heavy Metals in Soil

	Client Sample ID		BH01 0.5	BH01 1	BH01 1.5	BH01 2	BH06 0.4
	Date Sampled		14/12/2022	14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-1	22-45837-2	22-45837-3	22-45837-4	22-45837-5
Arsenic	mg/kg dry wt	*0.125*	13.8	11	13.4	14.2	2.7
Cadmium	mg/kg dry wt	*0.005*	0.046	0.061	0.049	0.023	0.013
Chromium	mg/kg dry wt	*0.125*	21.7	24.0	26.9	17.4	24.6
Copper	mg/kg dry wt	*0.075*	30.4	28.6	36.3	25.3	20.2
Lead	mg/kg dry wt	*0.25*	37.3	54.7	31.0	15.8	7.43
Mercury	mg/kg dry wt	*0.025*	0.092	0.12	0.12	<0.025	0.96
Nickel	mg/kg dry wt	*0.05*	21.8	21.1	25.0	18.0	11.3
Zinc	mg/kg dry wt	*0.05*	80.5	75.9	80.4	65.7	49.2

Heavy Metals in Soil

	Client Sample ID		BH10 0.5	BH10 1	BH10 1.5	BH10 2
	Date Sampled		14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-6	22-45837-7	22-45837-8	22-45837-9
Arsenic	mg/kg dry wt	*0.125*	6.4	3.5	3.3	3.8
Cadmium	mg/kg dry wt	*0.005*	0.065	0.034	0.034	0.044
Chromium	mg/kg dry wt	*0.125*	30.0	31.5	37.4	39.1
Copper	mg/kg dry wt	*0.075*	20.7	48.7	50.1	50.0
Lead	mg/kg dry wt	*0.25*	13.8	8.91	6.41	6.44
Mercury	mg/kg dry wt	*0.025*	0.19	0.13	0.15	0.17
Nickel	mg/kg dry wt	*0.05*	20.6	22.7	26.1	22.0
Zinc	mg/kg dry wt	*0.05*	72.6	88.4	91.2	92.3

Polycyclic Aromatic Hydrocarbons - Soil

		Client Sample ID	BH01 0.5	BH01 1	BH01 1.5	BH01 2	BH06 0.4
		Date Sampled	14/12/2022	14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-1	22-45837-2	22-45837-3	22-45837-4	22-45837-5
1-Methylnaphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
2-Methylnaphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Acenaphthene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Acenaphthylene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Benz[a]anthracene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo[a]pyrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Benzo[b]&[j] fluoranthene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo[g,h,i]perylene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo[k]fluoranthene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Chrysene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Dibenz(a,h)anthracene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Fluoranthene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
Fluorene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Indeno(1,2,3-cd)pyrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Naphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Phenanthrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Pyrene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.03*	0.030	0.030	0.030	0.030	0.030
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010	<0.010
Anthracene-d10 (Surrogate)	%	*1*	91	92	90	90	89

Polycyclic Aromatic Hydrocarbons - Soil

		Client Sample ID	BH10 0.5	BH10 1	BH10 1.5	BH10 2
		Date Sampled	14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-6	22-45837-7	22-45837-8	22-45837-9
1-Methylnaphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
2-Methylnaphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Acenaphthene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Acenaphthylene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Anthracene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Benz[a]anthracene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020
Benzo[a]pyrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Benzo[b]&[j] fluoranthene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020
Benzo[g,h,i]perylene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020
Benzo[k]fluoranthene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Chrysene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Dibenz(a,h)anthracene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Fluoranthene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020
Fluorene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Indeno(1,2,3-cd)pyrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Naphthalene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Phenanthrene	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Pyrene	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.03*	0.030	0.030	0.030	0.030

Polycyclic Aromatic Hydrocarbons - Soil

	Client Sample ID		BH10 0.5	BH10 1	BH10 1.5	BH10 2
	Date Sampled		14/12/2022	14/12/2022	14/12/2022	14/12/2022
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.01*	<0.010	<0.010	<0.010	<0.010
Anthracene-d10 (Surrogate)	%	*1*	87	88	91	110

Moisture Content

	Client Sample ID		BH01 0.5	BH01 1	BH01 1.5	BH01 2	BH06 0.4
	Date Sampled		14/12/2022	14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-1	22-45837-2	22-45837-3	22-45837-4	22-45837-5
Moisture Content	%	*1*	24	20	26	19	19

Moisture Content

	Client Sample ID		BH10 0.5	BH10 1	BH10 1.5	BH10 2
	Date Sampled		14/12/2022	14/12/2022	14/12/2022	14/12/2022
Analyte	Unit	*Reporting Limit*	22-45837-6	22-45837-7	22-45837-8	22-45837-9
Moisture Content	%	*1*	27	24	28	20

Method Summary

Elements in Soil

Samples dried and passed through a 2 mm sieve followed by acid digestion and analysis by ICP-MS. In accordance with in-house procedure based on US EPA method 200.8.

PAH in Soil

Solvent extraction, silica cleanup, followed by GC-MS analysis.
Benzo[a]pyrene TEQ (LOR): The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH.
Benzo[a]pyrene TEQ (Zero): The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation.
Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to *'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'*. Ministry for the Environment. 2011. (In accordance with in-house procedure).

Moisture

Moisture content is determined gravimetrically by drying at 103 °C.

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