Assessment of Environmental Effects for the Discharge of Wastewater to Land

Prepared for

RCL Homestead Bay Limited

Prepared by

LOWE Environmental Impact

April 2025

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Resource Consent Application and Assessment of Environmental Effects for the Discharge of Wastewater to Land

RCL Homestead Bay Limited

This report has been prepared for RCL Homestead Bay Limited (RCL) by Lowe Environmental Impact (LEI). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other parties.

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1 INTRODUCTION

1.1 Overview

RCL Homestead Bay Limited ('RCL') has purchased Lot 8 DP 443832 (163.46 ha) and Lot 12 DP 364700 (41.6 ha), summing approximately 205 ha in Homestead Bay, Queenstown. The intention is to subdivide this land for residential and commercial development. Consent is therefore sought to manage the discharge of wastewater from a large urban development.

Consent is sought for an average daily flow of 2005 m^3 of wastewater. This quantity was based upon 2673 dwelling equivalents (which was broken down to 2578 dwellings/residential units, plus a school and 2.1 ha of commercial space). These numbers underscored the consent design report prepared a few months before the subdivision application was finalised. The final anticipated development yield differs slightly with a marginally lower anticipated wastewater generation. The difference however is insignificant and the Applicant wishes to consent the right to accommodate 2005m^3 of wastewater per average day.

Additional information has been given in Appendix A (Consent Design Report).

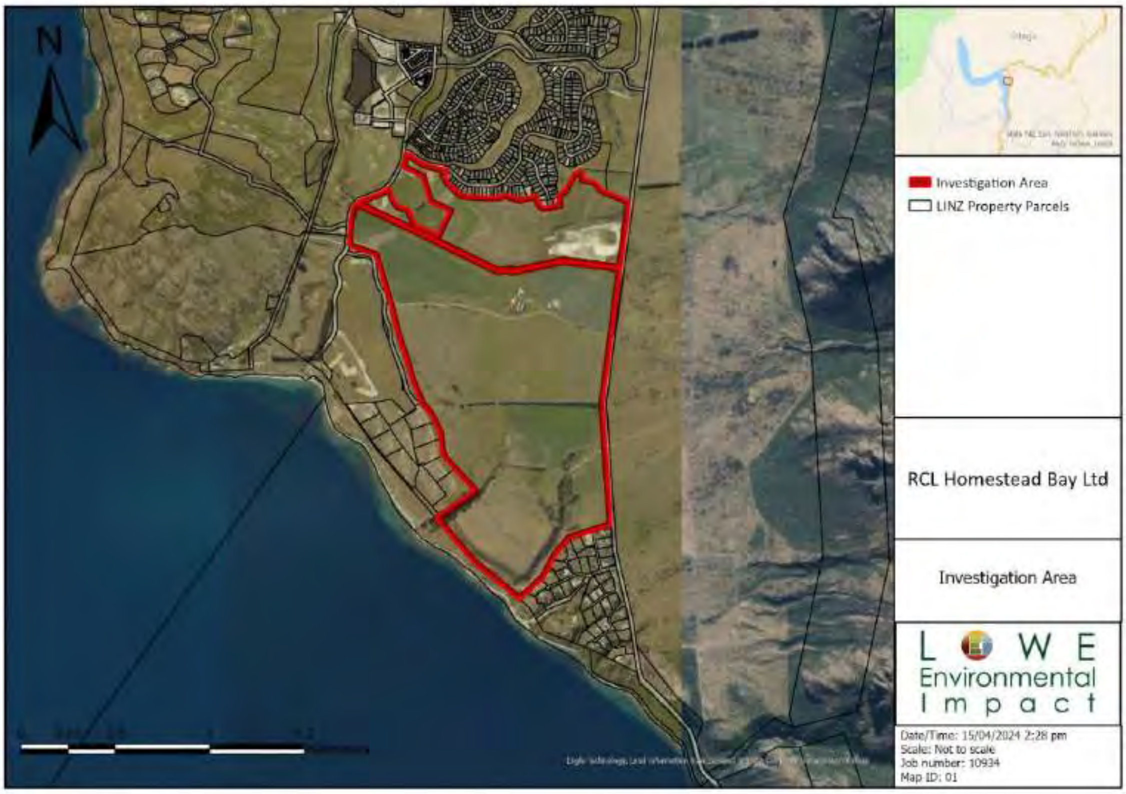


Figure 1.1: RCL Homestead Bay Limited Development Area

Café and retail activities are likely, and are assumed to occupy 10,700 m^2 for residents and outside visitors. The proposed activities include:

- Food retailing including supermarket and food and beverage services such as café, restaurants and bars;
- Retailing including personal accessories such as clothing and footwear, or recreational bike/ski service activities; and
- A school (600 students and 60 teachers).

1.2 Project Scope

Lowe Environmental Impact (LEI) has been engaged by RCL to undertake the following on their behalf:

- Site investigation of Homestead Bay land, to confirm suitability for the siting of a LTA (Land Treatment Area);
- Preparation of a conceptual LTA design;
- Prepare an Assessment of Environmental Effects in accordance with the Resource Management Act 1991 and the Fast Track Approvals Act 2024; and

This resource consent application has been prepared in accordance with the requirements of the Resource Management Act 1991 (RMA) and the Fast Track Approvals Act 2024 and sets out a consideration of the actual and potential effects of the proposed wastewater discharge on the environment.

The scope of this application is for the discharge of treated community wastewater to land (LTA) and its associated air discharge.

2 SITE CHARACTERISTICS

2.1 Locality and Surrounding Land Use

Homestead Bay development and associated investigation area (Figure 2.1 below) for the proposed activities is located within the Lake Wakatipu catchment, approximately 8.2 km from Queenstown (to the southeast) and 7.3 km away from Queenstown airport (to the south). This site is located on Kingston Road (State Highway (SH) 6).

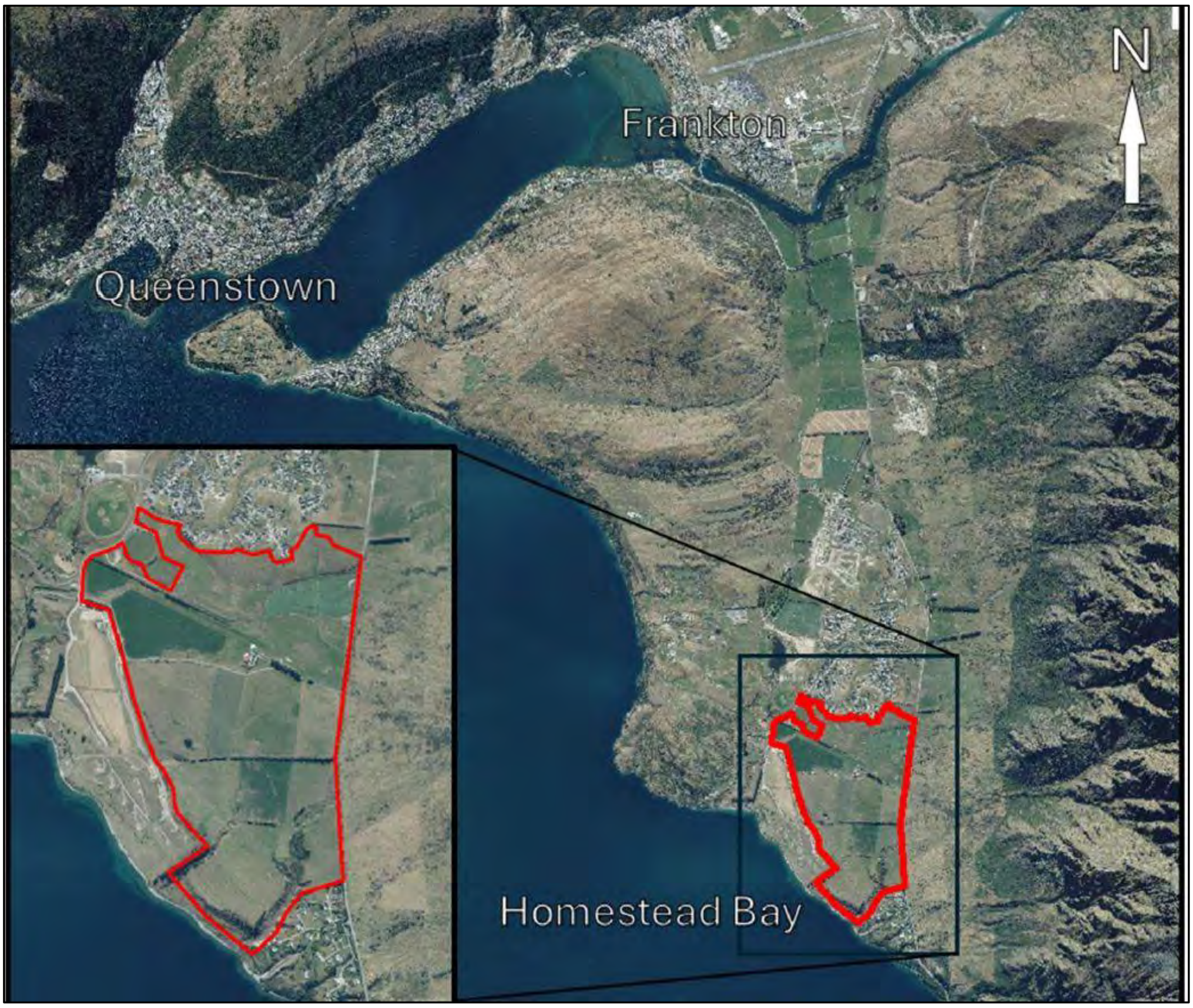


Figure 2.1: Site Location Plan (QLDC GIS. Image not to scale.)

The surrounding area is a mixture of rural and residential, with a large neighbouring subdivision (Jack’s Point) approximately north of the subject site and sharing borders.

2.2 Climate

Queenstown weather station (5446) is the closest station that has rainfall, temperature and PET (Potential Evapotranspiration) data that could be used to discuss the climate of the proposed site. The meteorological station has temperature, rainfall and PET records for the period 1970-2021. The data has been sourced from data.niwa.co.nz. The average annual rainfall, evapotranspiration and precipitation data by month have been presented in Table 2.1 below. The temperature data has been shown in Figure 2.2.

2.2.1 Rainfall and Evapotranspiration

The data shows an average total annual rainfall of 889 mm, with the highest average monthly rainfall observed in May (90 mm) and the lowest in February (59 mm). The average total potential evapotranspiration (PET) is 612 mm, peaking in January (118 mm) and December (115 mm), while dropping to near zero in June and July. The surplus/deficit column highlights periods of water deficit, particularly in January (-40 mm), February (-31 mm), November (-28 mm) and December (-42 mm), driven by higher PET than rainfall. In contrast, surpluses are observed from April to September, with the largest surplus in May (88 mm).

Table 2.1: **Average Annual Rainfall, Evapotranspiration and Surplus/Deficit by Month (1970-2021) (data.niwa.co.nz)**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	78	59	69	68	90	77	69	72	80	86	68	74	889
PET (mm)	118	89	58	21	3	0	0	9	34	68	96	115	612
Surplus/ Deficit (mm)	-40	-31	10	47	88	77	68	63	46	18	-28	-42	

2.2.2 Temperature

Figure 2.2 below shows the monthly mean temperatures follow a seasonal trend, as expected, with a mean temperature of 17 ºC in January (mid-Summer), and dropping to a low of 4.4ºC in July (mid-Winter).

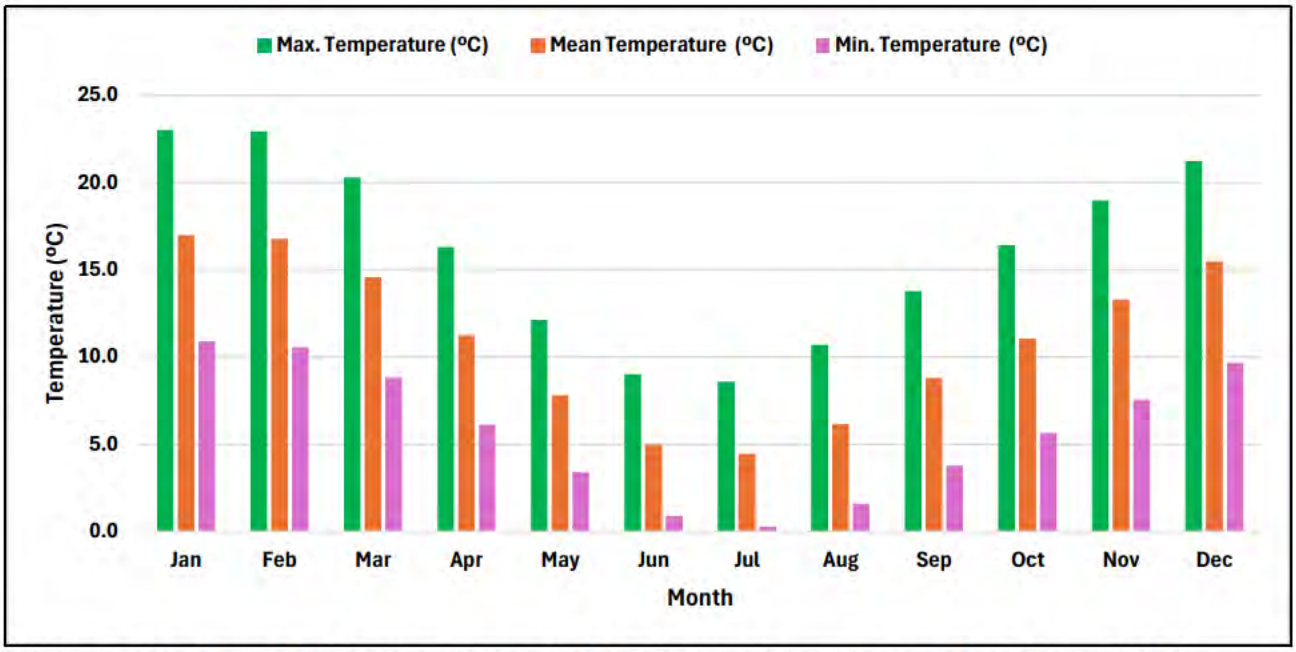


Figure 2.2: Annual Minimum, Mean and Maximum Temperature Data from 1970-2018 (Source: Data.niwa.co.nz).

2.2.3 Wind

Mean annual wind frequencies (%) of surface wind directions and strengths from hourly observations at Queenstown station (Macara, 2015) are shown in Figure 2.3 below. The plot shows the directions from which the wind blows.

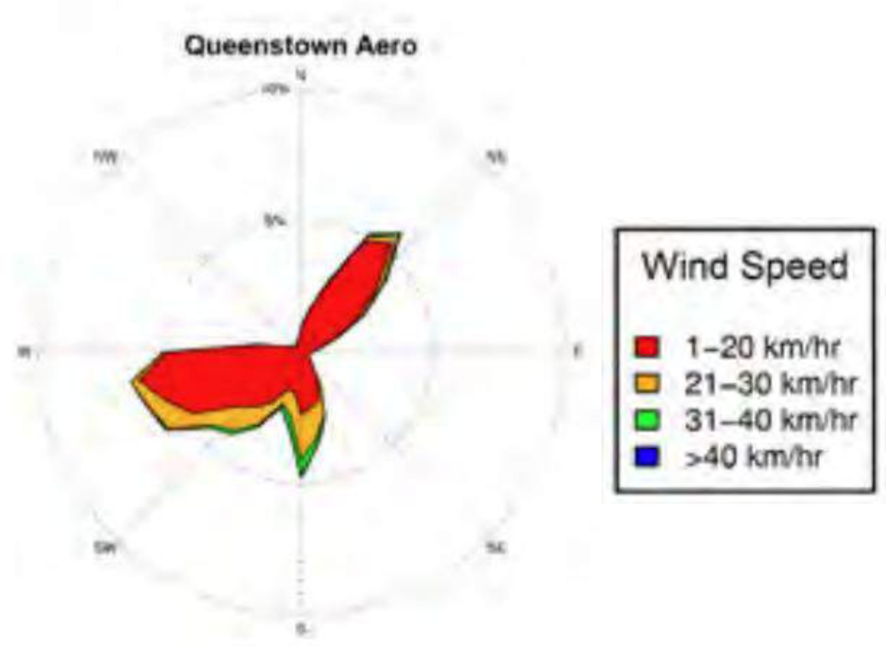


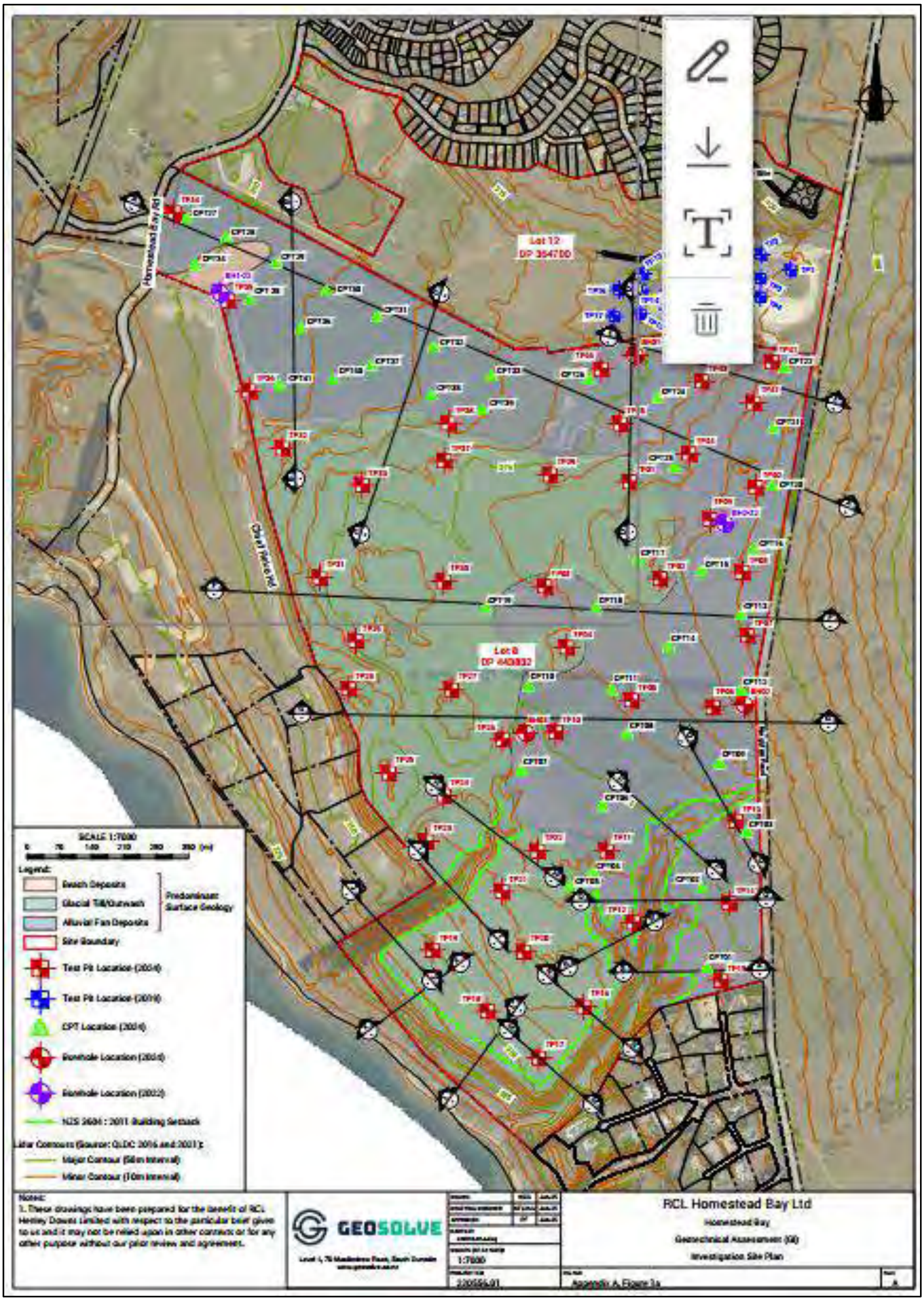
Figure 2.3: Mean Annual Wind Frequencies and Directions in Queenstown (Macara, 2015)

The wind rose indicates that the predominant wind directions at Queenstown Aero are from the west and northeast, as shown by the longer segments in those directions. These directions experience the highest frequency of winds across various speed ranges, particularly moderate wind strengths between 1–30 km/hr.

2.3 Geology, Geomorphology and Hydrology

2.3.1 Geology

The site is situated within the Wakatipu Basin, a landform shaped by successive glaciations during the late Quaternary, reaching its peak around 18,000 years ago (Barrell et al., 2011). As the ice retreated, it left behind deposits of moraine, till, outwash gravels, and pond sediments over ice-scoured schist bedrock. In the northwestern part of the site, lake sediments and beach gravels were deposited during periods of higher lake levels in the post-glacial era. These lake deposits are overlain by younger alluvial fan materials, sourced from the adjacent Mountains or reworked glacial outwash. The eastern and northern areas of the site are covered by alluvial fan deposits, whereas older glacial deposits remain exposed in the elevated western regions. The site's stratigraphy generally consists of alluvial fan deposits, beach sediments, lake sediments, unconsolidated fill, loess, colluvium, glacial pond deposits, glacial till, and outwash sediments. The predominant surface geology of the Site and bore location to understand the groundwater depth have been shown in Figure 2.4. A clearer image and additional discussion of the Site related to geology, geomorphology and groundwater have been given in the Geotechnical Report of the Homestead Bay development (Attached as Appendix B).



Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Figure 2.4: Predominant Surface Geology and Location of Bores (details in Appendix B)

2.3.2 Geomorphology and Hydrogeology

The site topography can be generally separated into three distinct geomorphological Environments as the following topographic zones (Geotechnical Report 2025, Appendix B) shown in Figure 2.5.

- Zone A – Elevated eastern areas, alluvial fan geomorphology.
- Zone B – Lower lying northwestern area, alluvial fan and historic lake environment.
- Zone C – Elevated western area with Glacial materials and geomorphology.

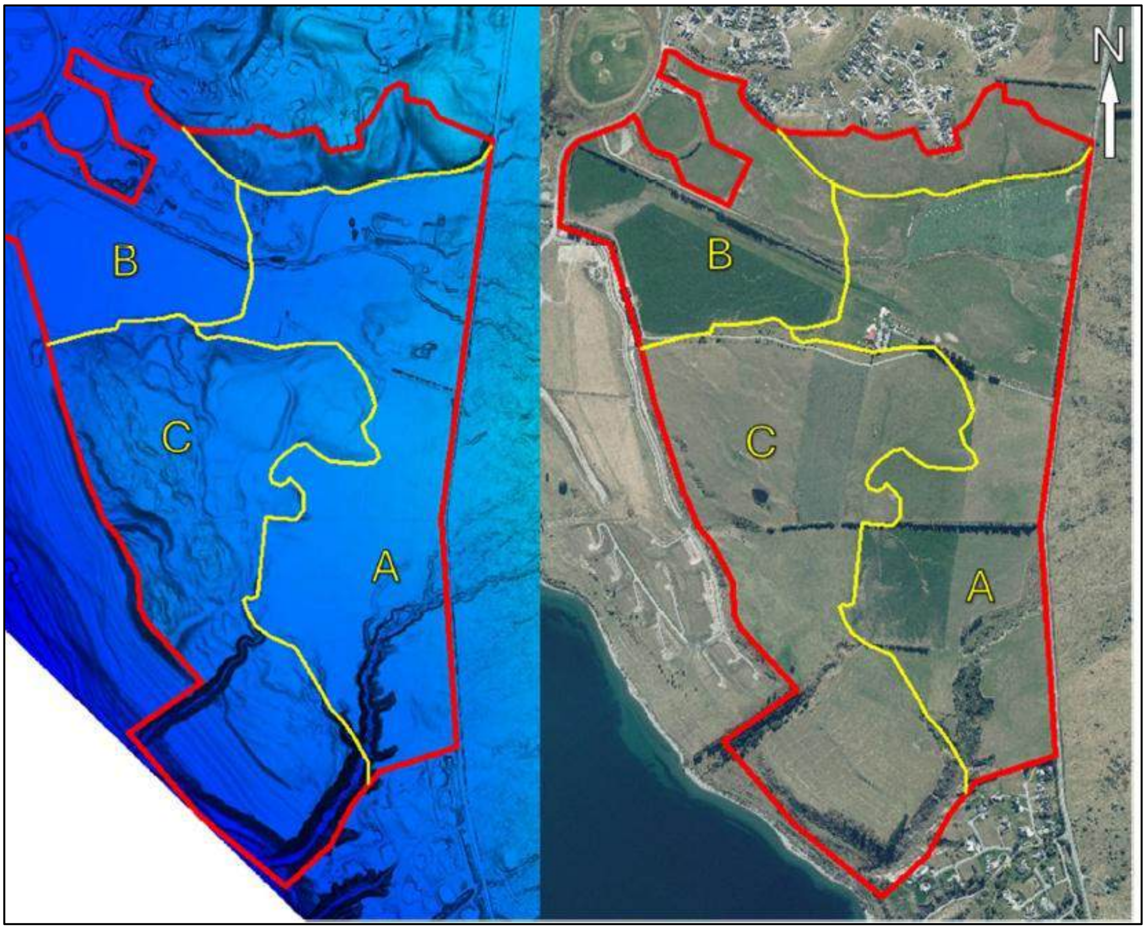


Figure 2.5: Generalised Topographic/Geomorphic Zones (Yellow) and Site Boundary (Red).

Zone A – Alluvial Fan

The eastern and southern portion of the site is located on an elevated, gently inclined slope comprising distal fan alluvium (Figure 2.6). The fan alluvium originates from the western slopes of the Remarkables Mountain Range, and immediate area.

Figure 2.6: A-Alluvial Fan Looking East Towards the Remarkable Range and the Head of the Fan

Zone B – Low Lying Northwestern Area

Zone B is located in the north-west portion of the site. The ground surface is near flat to sloping very gently towards the west. Investigations in this area encountered laminated silt (lake sediments) and beach deposits at shallow depths indicating the depositional environment has been influenced by the historically higher level of Lake Wakatipu.

Zone C – Glacial Till/Outwash Deposits

Zone C runs along the elevated western portion of the site with surface topography comprising of undulating, irregular hummocky features (see Figure 2.7 below). The deposition environment and geomorphology are glacial in origin.

Figure 2.7: Zone C Characterised by Locally Elevated Irregular and Undulating Hummocky Topography

From Figure 2.8, the investigations indicate that a part of the site comprises perched groundwater zones and unconfined aquifers due to the presence of the deposited materials, such as Alluvial Fan Deposits and Beach Deposits. Additional information is available in the attached Geotechnical Report 2025 (Appendix B).

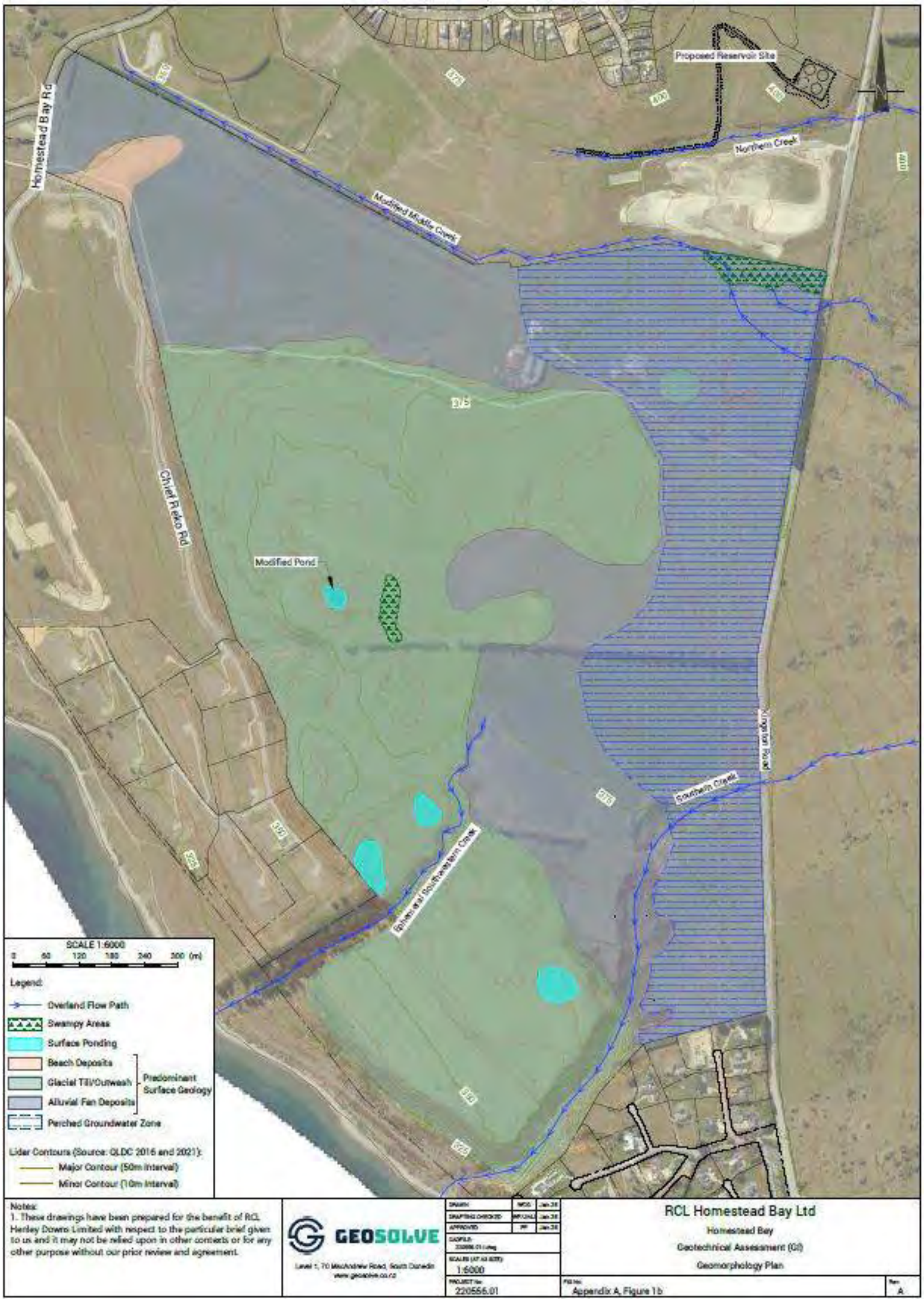


Figure 2.8: Indicative Hydrogeology (Details in Appendix B)

The Geosolve borehole investigations (RDAgritech Report, 2017) for the Henley Downs area encountered groundwater at or slightly above the glacial till contact, with initial groundwater levels dropping to dry or near the contact within a short monitoring period. Fan Alluvial Deposits and Lacustrine deposits overlie the Glacial Till in discontinuous and chaotic depositional patterns. The Lacustrine deposits are typically wet to moist, while the Fan Alluvium is dry to moist. Test pit investigations penetrating the alluvial fan to Lacustrine deposits revealed variable groundwater flow or dry conditions at the contact (RDAgritech Report, 2017). According to the RDAgritech report, below 7 m, soils were found to be medium dense to dense due to glacial compression, significantly reducing hydraulic conductivity and transmissivity compared to the less compact post-glacial deposits. The explanation of the typical groundwater regime parameters for geological units have been given in Table 2.2 (Table 1 in RDAgritech Report, 2017).

Table 2.2: Typical Groundwater Regime Parameters for Geological Units

Unit	Unit Grading Texture/Structure	Relative Aquifer Permeability	Relative Transmissivity	Relative Hydraulic Conductivity	Saturated or Unsaturated Zone	Likely Anoxic or Aerobic Condition
Flood and alluvial silt deposits	Silts and fine to medium sands; massive/loamy	Poor	Moderate to poor	Poor to moderate	Unsaturated; typically potentially saturated under the LAA fields	Aerobic
Alluvial fan	Interbedded well to poorly graded gravels, sands, and silty layers; subhorizontally dipping parallel to topography	Very high	Very high	Very high to high	Unsaturated except in transmissive groundwater flows	Aerobic
Glacial Outwash – gravels and sands	Thin to thick interbedded gravels/sands of varying silt content; bedded structure, sandy gravel texture	Good	High	High	Unsaturated except in water-bearing horizons	Aerobic in upper 2 to 3 m; anoxic below 3 m
Lacustrine laminated silts/sands	Fine sands/silts; rare clay; laminated bedding; clay loam	Poor	Moderate to poor	Poor to very poor	Saturated	Anoxic
Lacustrine sands	Interbedded massive sands; sand texture	Moderate to poor	Moderate	Moderate	Unsaturated; anoxic below 3 m	Aerobic in upper 2 m; anoxic below 3 m
Glacial Till	Massive well-graded gravels and sands with varying silt content matrix	Very poor to poor	Poor to very poor	Very poor	Saturated; anoxic below 2 m	Aerobic in upper 2 m; anoxic below 2 m

The probable groundwater movement scenario and the geological composition of the area are shown in Figure 2.9.

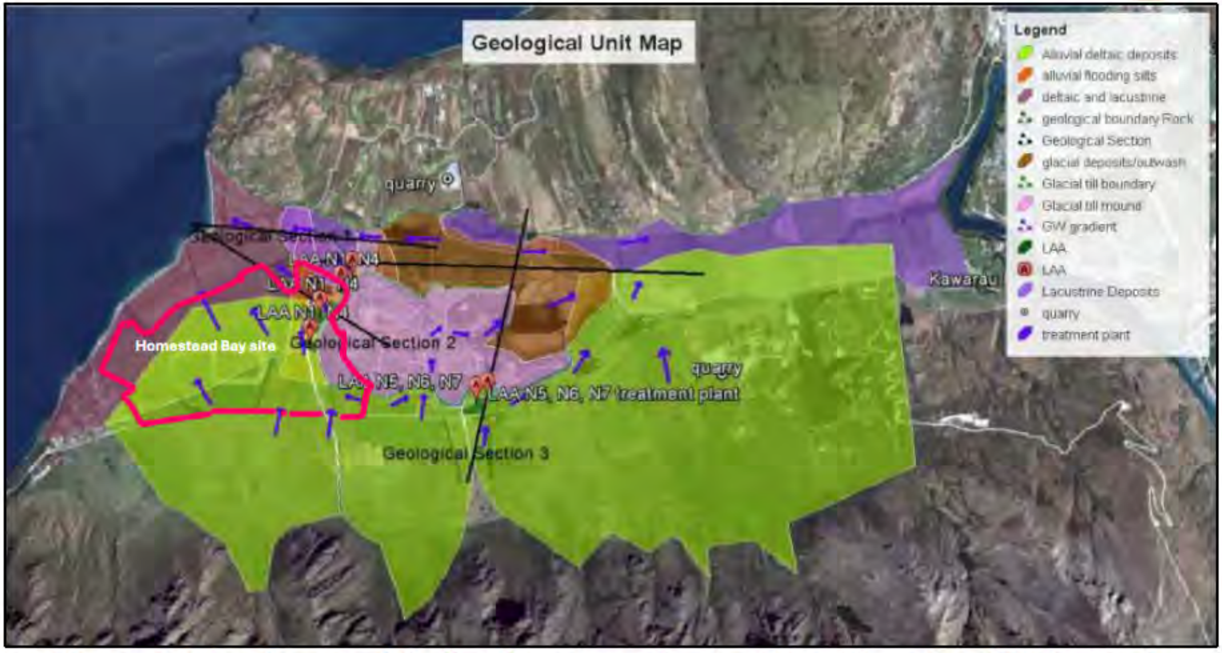


Figure 2.9 Geology and Indicative Groundwater Flow Direction (RDAgritech Report, 2017)

2.3.3 Groundwater

Relevant to this site is Geotechnical Report 2025 (Appendix B), LWP Memo (Appendix C) and RDAgritech Report, 2017. Eastern part of the property has a perched ground water aquifer whereas the rest of the property has unconfined groundwater layer which is evident from Figure 2.8. Additional information about groundwater of the Site could be found in Appendix B and Appendix C. Alluvial Fan deposits comprise northern, eastern and southeastern side in the property whereas Glacial till/outwash comprises rest part of the property. The origin of the materials implies that due to the presence of alluvial fan and glacial till, the hydraulic conductivity of the soils will be high. The groundwater wells CC11/0151 and CC11/0151P are located inside the property boundary on the southwest part of the Homestead Bay development property (Otago map). Table 2.3 details the characteristics of wells and bores near to the Homestead Bay development area as found in Otago Maps.

Table 2.3: Wells/Bores Characteristics in and Around the Homestead Bay Development (Otago map)

Items	**Property of Different Wells Surrounding the Homestead Bay Site**							
Well Number	*CC11/0151	*CC11/0151P	F42/0100	CC11/0152	F41/0589	F41/0324C	F42/0150	F42/0150A
Well Name	Unknown	Unknown	Unknown	Unknown	Unknown	Hole 3	Murphys Developments Bore	Murphys Developments Piezo
Well Status	Existing	Existing	Existing	Not Drilled	Existing	Existing	Existing	Existing
Well Type	Well/Bore	Piezometer	Well/Bore	Well/Bore	Piezometer	Piezometer	Well/Bore	Piezometer
Depth (M)	94.38	94.15	55	0	36	30	35.76	35.67
Drill Date	11-Jul-24	18-Jun-24	5-Jan-93		15-Jan-02	19-Oct-05	8-Jul-17	17-Jul-17
Owner	RCL Homestead Bay Limited	RCL Homestead Bay Limited	Carlin K	RCL Homestead Bay Limited	Jacks Point Limited	Jacks Point Limited	Homestead Bay Trustees Limited	Homestead Bay Trustees Limited
Northing	4997248	4997243	4997067	4997512	4999110	4999555	4998187	4998193
Easting	1265446	1265455	1265917	1265158	1264477	1264914	1264612	1264607
Use Type	Domestic	Groundwater Monitoring	Domestic	Domestic	Groundwater Investigation/Groundwater monitoring	Groundwater Monitoring	Community Drinking Water Supply	Groundwater Monitoring
Bore Consent Number	RM24.110.01	RM24.110.01	93149	RM24.110.01	-	-	RM17.173.01	RM17.173.01

*(Inside the Homestead Bay development Site boundary)

The regional groundwater table was measured using standpipe piezometers installed in boreholes (BH1 - BH3 and BH1-22 – BH2-22). The locations of these boreholes are shown in Figure 2.4 (a clearer picture is presented in Appendix B, Figure 1a). A summary of the measured groundwater levels is provided in Table 2.4 below.

Table 2.4: Site Groundwater Levels as Observed in Borehole Piezometers (Appendix B)

Piezometer	Date Measured	Groundwater Depth (m BGL)	Groundwater (m RL, NZVD2016)
BH1-22	2nd September 2022	14.8	339.2
	16th December 2024	13.4	340.6
	17th January 2024	15.4	338.6
BH2-22	2nd September 2022	5.1	386.9
	17th January 2024	4.3	387.7
BH1	16th December 2024	13.1	360.9
	17th January 2024	14.4	360.5
BH2	17th January 2024	10.5	380.5
BH3	17th January 2024	Dry	-

Groundwater seepages were observed in several test pits in the eastern area of the site. All test pits where groundwater seepages were encountered are within elevated areas of the alluvial fan, adjacent to the eastern site boundary. Additional information about the bores' properties has been given in Appendix B: Geotechnical Report, 2025.

2.3.4 Surface Water

This catchment is identified on Otago Maps as being within the Clutha Mata-Au Freshwater Management Unit (FMU) and within the Upper Lakes Rohe. The nearest surface water body to the subject site is an unnamed tributary of Lake Wakatipu, approximately 30 metres on the immediate east of the site and 400 metres west of the site. Lake Wakatipu itself is approximately 250 metres south of the site, but the site is approximately 30 metres above the lake level (elevation), with incised gullies cutting down to where water flows from the mountainous areas into Lake Wakatipu. There are two ephemeral watercourses flowing through the LTAs, and Māori Jack Stream downstream of the LTAs which flows directly into Lake Wakatipu. More details including figures have been given in Appendix C of this Application.

A wetland assessment for Homestead Bay was undertaken by Wildland Consultants Ltd (Wildlands) and is attached as Appendix H. Wildlands determined there were six wetlands that meet the definition of a 'Natural Inland Wetland' under the National Policy Statement for Freshwater Management 2020.

A map showing the surface water catchments, tributaries, and delineated wetlands within the property boundary is given in Figure 2.10 below.

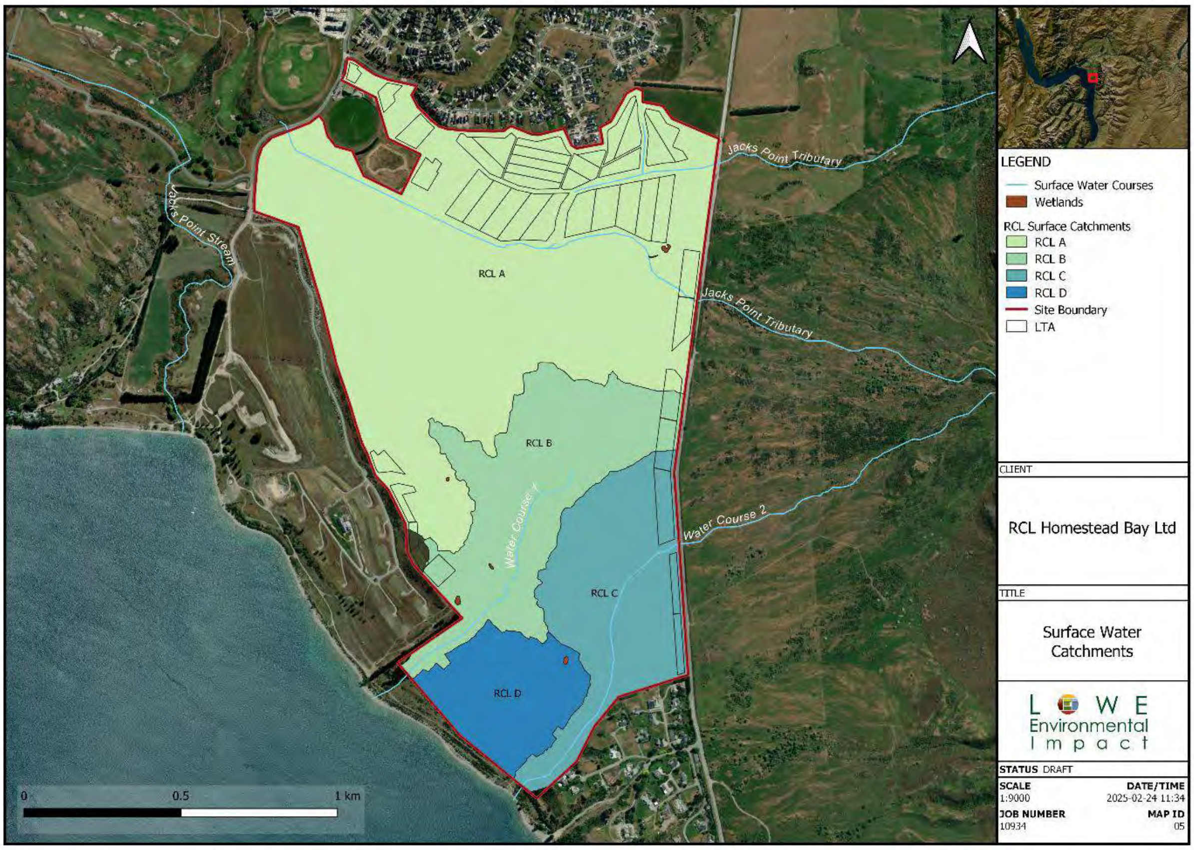


Figure 2.10: Surface Water Features

2.3.5 Unnamed Water Courses 1 and 2

Current State

The two unnamed ephemeral watercourses (Water Course 1′ and Water Course 2′) flow through the Homestead Bay development site (Figure 2.11).

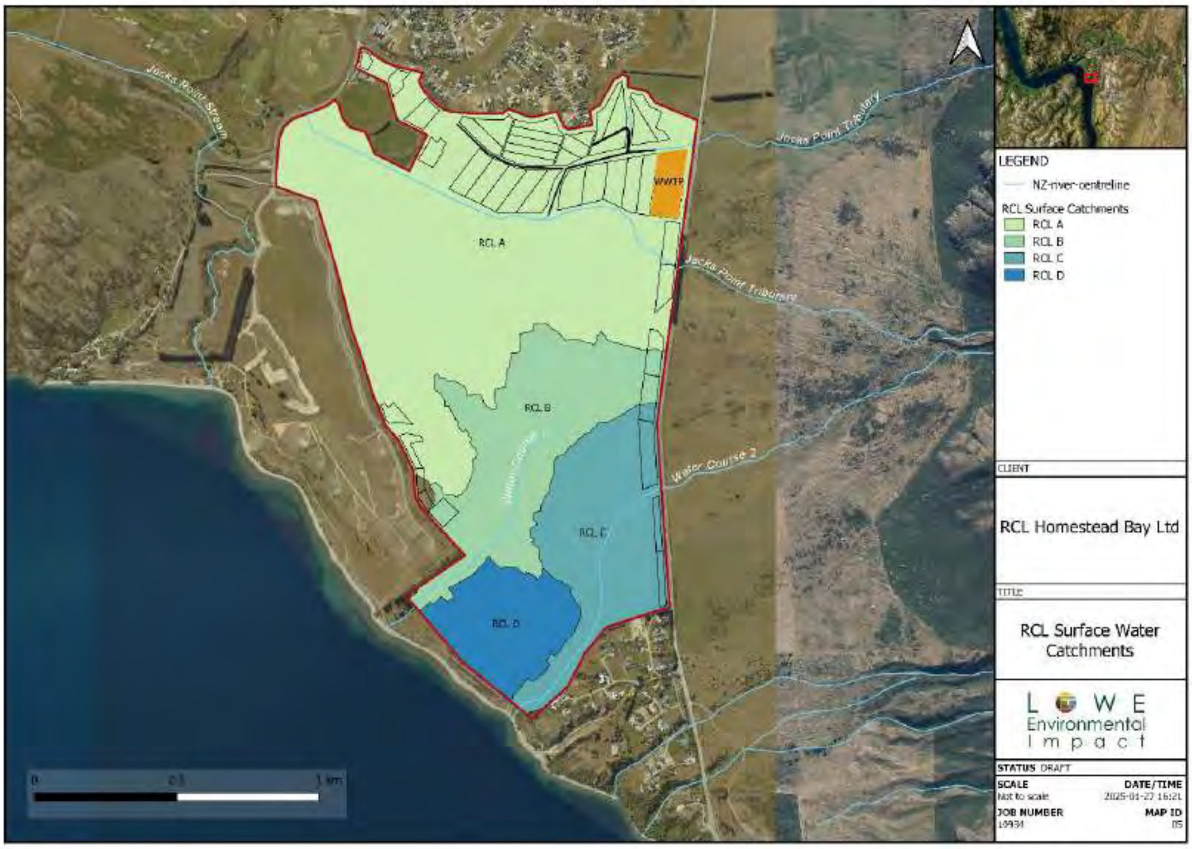


Figure 2.11: Location plan (approx.) showing outline of Homestead Bay, Two U**nnamed water courses, Māori Jack Stream (Jacks Point Stream) and Lake** Wakatipu

Both Unnamed water courses in the southern section of the site have value as channels that carry flood waters directly to the lake rather than over adjacent usable land.

Waterways Consulting completed a site visit in March 2023 and provided an aquatic assessment for the Homestead Bay Development. The channels were found to be generally well vegetated with terrestrial shrubbery. Stream 1 had minimal wetted habitat and it is expected that the stream only flows during and after heavy rainfall and dries again very quickly. Stream 2 had no evidence of any permanent water but does experience high flow events that have scoured an obvious and deep channel along the canyon valley floor. Neither of the streams support any fish or stream macroinvertebrates. Therefore, neither stream has aquatic ecological value.

Photos of these streams are given in Figure 2.12 and Figure 2.13 below.

Figure 2.12: Water Course 1

Figure 2.13: Water Course 2

2.3.6 **Māori Jack Stream**

Current State

A report has been prepared by E3Scientific Limited (E3S) titled "*Jacks Point Freshwater Ecological Assessment*" (E3S 2022) for the Jacks Point Residents and Owners Association as part of a requirement of their wastewater discharge permit conditions set by ORC (Permit 2009.312). That report presents the results of the required "*freshwater ecological baseline study*", including water quality and macroinvertebrate sampling and site observations of Māori Jack Stream and near-shore conditions of Lake Wakatipu in that vicinity by a recognised freshwater ecologist.

In summary the E3S (2022) report describes Māori Jack Stream as (Appendix D):

- A perennial, partially subterranean stream, with (at that time) only the lower reaches having visible, slow-flowing surface water on the western side of Māori Jack Road, roughly 600 m upstream from the edge of Lake Wakatipu.
- Having no surface connectivity to the lake (at that time) but flows beneath the sand/cobble shoreline approximately 20 m from the lake edge in Homestead Bay.
- Supporting macroinvertebrate communities with health indices indicative of 'fair' to 'poor' water quality. (The soft-bottomed MCI scores ranged from 68 to 92 and EPT % abundance from 0% to 11%: In NPSFM (2022) terms these results indicate a current state of C to D band).
- Supporting some slight periphyton growth and very little macrophyte growth.
- Having no records of fish held on the New Zealand Freshwater Fish Database (although the presence of habitat suggests fish could be present and common bullies were observed in the lake near shore).
- Having 'fair' to 'poor' water quality as evidenced by macroinvertebrate sampling and water quality results.

A photo of Māori Jack Stream is given in Figure 2.14 below.

Figure 2.14: Māori Jack Stream Lower Reach

2.3.7 Surface Water Regulatory Objectives or Standards

Unnamed Water Courses

It is debatable whether any regulatory water quality objectives or standards apply to these unnamed water courses given their limited flow and aquatic stream ecological value. It is conceivable that such objectives could apply if a discharge via land and groundwater re-emergence was to create permanent wetted aquatic stream habitat sufficient to support macroinvertebrates and/or fish. In that event the concentration limits set in Schedule 15 of the RWP may apply for nitrate-nitrogen (0.075 mg/L), ammoniacal nitrogen (0.01 mg/L), *E. coli* (50 cfu/100 ml), dissolved reactive phosphorus (0.005 mg/L) and turbidity (3 NTU) (Appendix C: LWP Memo).

Māori Jack Stream

The operative RWP sets concentration limits for tributaries to Lake Wakatipu as follows (Table 2.5):

Table 2.5: Limits for Tributaries of Lake Wakatipu in RWP Schedule 15 (Table 15.2.3)

Parameter	Limit
Nitrate-nitrogen	0.075 mg/L
Ammoniacal nitrogen	0.01 mg/L
Dissolved reactive phosphorus	0.005 mg/L
E. Coli	50 cfu/100 ml
Turbidity	3 NTU

These limits are deemed to be achieved when "*…80% of samples collected at a site, when flows are at or below median flow, over a rolling 5-year period, meet or are better than the limits*".

Further to these regional plan limits, the Jacks Point Discharge Permit (which is comparable in location, scale and activity type; being a subdivision development on neighbouring land) sets out monitoring conditions which are relevant to consider here. Condition 20(c)c and 20*c)d of their Permit sets concentration limit triggers for Māori Jack Stream, as follows (Table 2.6 and Table 2.7)

Table 2.6: Triggers Defined for Māori Jack Stream in Jacks Point Consent Condition 20(c)c

Parameter	Limit
E. Coli	10 cfu/100 ml
Total phosphorus	0.005 mg/L
Total nitrogen	0.1 mg/L

Table 2.7: Calculated Triggers for Māori Jack Stream in Jacks Point Consent Condition 20(c)d

Indicator	Median baseline result from the e3S 2022 report	Condition 20(c)d triggers (median baseline e3S +20%)
E. coli	12 cfu/100 ml	14 cfu/100 ml
Total phosphorus	0.116 mg/L	0.1392 mg/L
Total nitrogen	0.53 mg/L	0.636 mg/L

More information is provided in Appendix C.

2.3.8 Lake Wakatipu

Lake Wakatipu has an area of 291 km^2 with an average depth of 230 m. The total volume of the lake is 66,930 million cubic metres. All forms of recreational boating are undertaken on the lake. The shores of the lake are popular for picnicking, swimming, fishing and passive recreation.

Lake Wakatipu's water quality readings have been collected form many years at the lake outland and since 2 2016 at a site called "*Lake Wakatipu Open Water 10m*" located near the middle of the lake out from Homestead Bay.

Lake Wakatipu water quality is very good. In the simple 'state band' terms of the NPSFM (2022) it is currently well into 'A band' for every compulsory lake attribute monitored (Table 4). Lake Wakatipu has a Trophic Level Index (TLI) score of 1.4 (microtrophic) or "Very Good" on the LAWA website (accessed 11 December 2024 (LWP 2025)

The current TLI of the Lake Wakatipu in 2022 is microtrophic (LAWA data, 2022). It appears that the TLI of Lake Wakatipu is in a stable state near the microtrophic- oligotrophic boundary. Figure 2.15 presents the annual average TLI using TN, TP and Chlorophyll 'a' data from the lake outlet data. Minor variation of TLI from year to year is expected due to the slight variation of weather conditions from year to year.

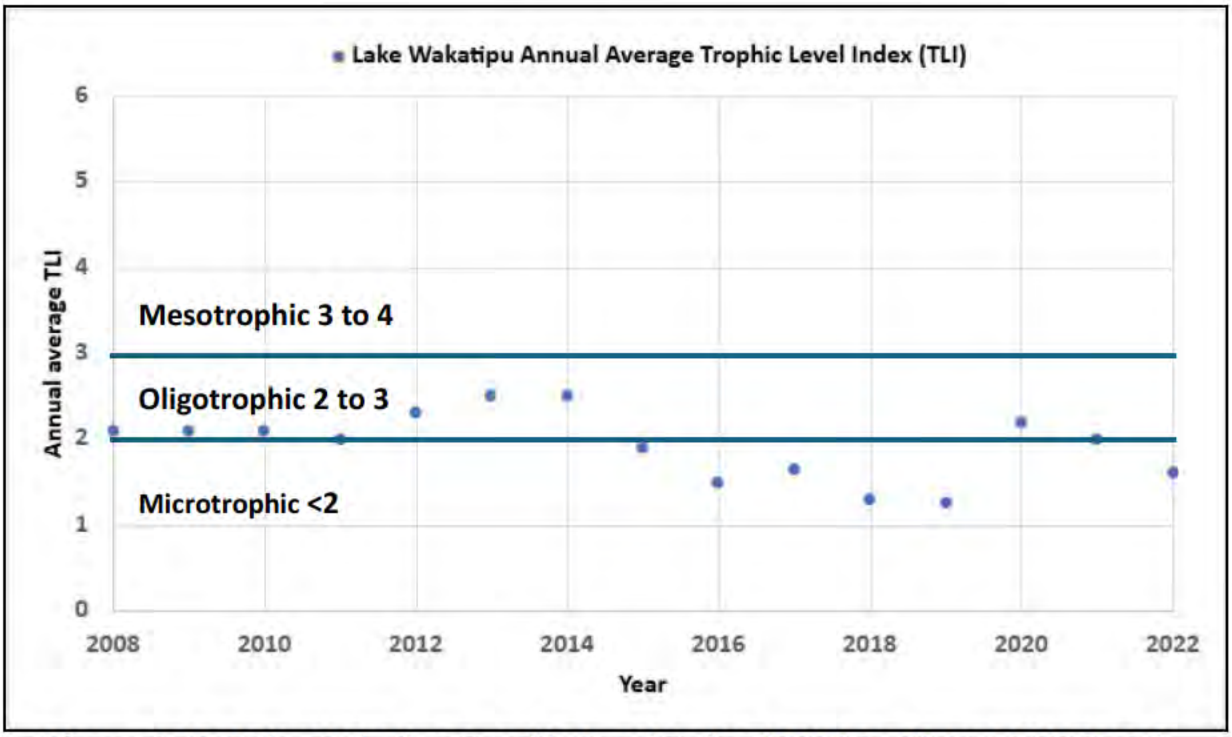


Figure 2.15: Lake Wakatipu Trophic Level Index (2008 to 2022, LAWA Data)

The E3S (2022) report also provided a "*freshwater ecological baseline study*" of the near-shore conditions of Lake Wakatipu in the vicinity of where Māori Jack Stream meets Homestead Bay.

In summary the E3S (2022) report made by LWP 20205 is repeated here:

- Very good water quality at the three sites they sampled 5 m out from the lakeshore at 0.5 m depth. The TN, TP and chlorophyll *a* concentration at these lake edge sites (median TN and TP of 110 and 2 mg/m3 respectively) are all a little higher than for the mid lake monitoring site, but still within 'A band' state.

- Lake TLI scores calculated ranging from 1.33 to 2.47 across the four sampling occasions (November 2021, December 2021, January 2022, February 2022) for each of the three lake-edge sample sites. These results reflect microtrophic to oligotrophic conditions or "very good" lake health – similar to the TLI score of 1.7 referenced from the LAWA site for 2020 as reported in E3S (2022) and similar to the TLI of 1.3 sourced from the LAWA website in December 2024.

- No periphyton or macrophyte growth at any of the sample locations. They commented that: "*This is most likely due to the higher wave energy that this area absorbs in these shallow (<1 m) depths. During southerly winds, a substantial fetch can be produced with increased wave energy along this stretch of shoreline. Because of this, much of the near-shore substrate along the margins is clean and bare with the continual movement.*" The E3S (2022) photographs at the monitoring locations show exceptionally clear water and clean gravel and cobble bed substrate.

- While no macrophytes were observed in the shallow margins, unsurprisingly given the described exposure of the margins to wind-driven waves, the E3S report did also comment that: "*Previous studies have shown that in the deeper water of the sample area, large areas of macrophyte beds are present (Miller, 2018). These beds include native milfoils (which were observed floating) and 8 species of native/endemic plants, one of which is the quillwort (Isoetes kirkii), listed as 'endemic, at risk – declining' (Miller, 2018).*"

- Several native fish were recorded as present in the lake on the NZFFD including longfin eel/ tuna (*Anguilla dieffenbachii*), kōaro (*galaxias brevipinnis*), and common bully/pako (*Gobiomorphus cotidianus*). Exotic fish species are also present including the rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and Chinook salmon (*O. tshawytscha*) (NIWA, 2022; ORC, 2016). No formal assessment was made of fish at the sites by E3S (2022) but they observed a common bully (*Gobiomorphus cotidianus*) in the shallows.

ORC recently commissioned a report to assess the condition of macrophytes in three Otago lakes including Lake Wakatipu (Winton and David, 2024). They found that:

- Lake Wakatipu had decreased slightly from an "excellent" ecological condition in 2020 to a "high" condition in 2024 (with a Lake SPI Index score of 72.8% in 2024).
- Lake Wakatipu possessed a diverse native vegetation (Native Condition Index 77%) but had moderate impacts from the invasive weed *Elodea canadensis* (Invasive Impact Index 29%).

Additional information can be found in the LWP Memo provided in Appendix C of this application.

Lake Wakatipu Regulatory Objectives or Standards

The operative RWP sets concentration limits for Lake Wakatipu as follows (Table 2.8):

Table 2.8: Limits for Lake Wakatipu in RWP Schedule 15 (Table 15.2.5)

Parameter	Limit
Total nitrogen	0.1 mg/L
Ammoniacal nitrogen	0.01 mg/L
Total phosphorus	0.005 mg/L
E. coli	10 cfu/100 ml
Turbidity	3 NTU

These limits are deemed to be achieved when "*…80% of samples collected at a site, over a rolling 5-year period, meet or are better than the limits*".

2.4 Stormwater

There are three significant drainage channels present on the site, as shown in Figure 2.16 below from Geosolve 2025. All three channels, along with an additional south-western channel, ultimately discharge into Lake Wakatipu.

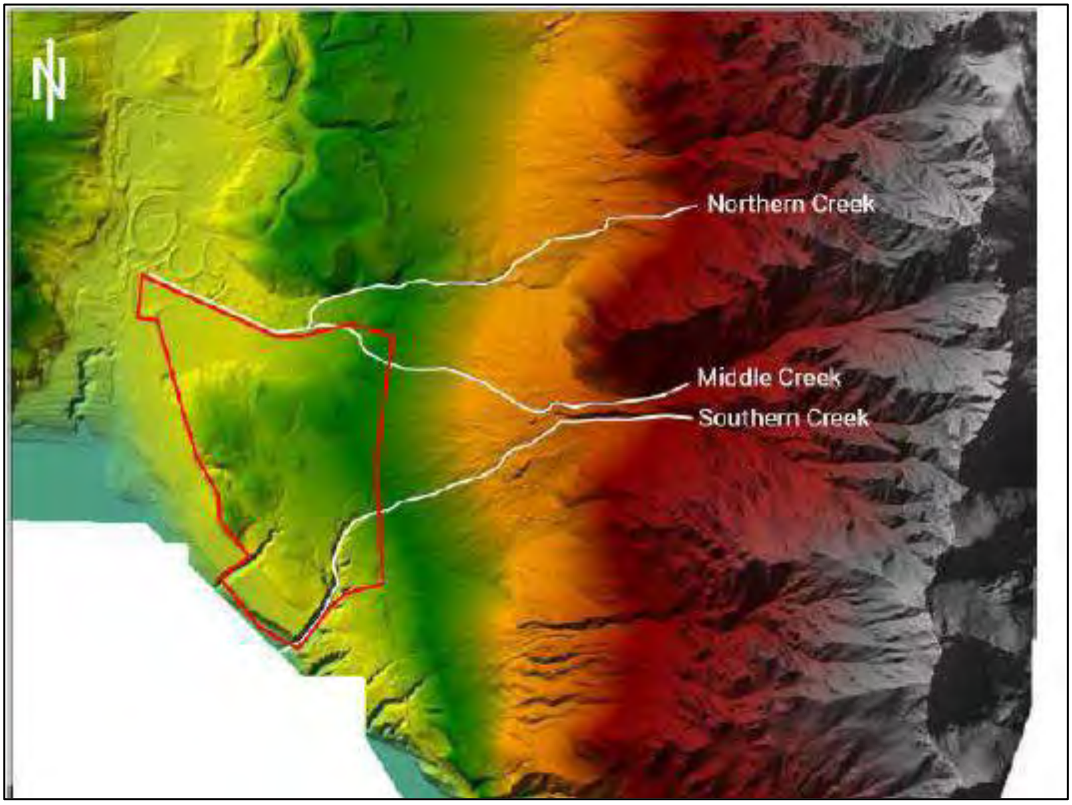


Figure 2.16: Northern, Middle, and Southern Drainage Channels that Dissect the Site (Geosolve 2025)

The principal routes for stormwater discharge from the development will be through existing drainage channels leading into Lake Wakatipu. Flood and stormwater treatment systems will be designed to control flows and maintain water quality.

A preliminary stormwater management scheme has been developed, outlining preferred treatment approaches for different parts of the site. With the application of industry best practices, minimal adverse effects from urban stormwater runoff are anticipated. This has been carried out by others and is not part of this scope.

Overall, the servicing of the proposed development will be undertaken in accordance with the QLDC Land Development and Subdivision Code of Practice as well as requirements of the Regional Planning documents.

2.5 Ecosystem

Terrestrial Ecosystem have been undertaken for the development site by Water Ways Consulting and Beale Consultants, respectively. A wetland assessment and ecological effects assessment for Homestead Bay was undertaken by Wildland Consultants Ltd (Wildlands).

The Aquatic Ecology report (Appendix D) identifies that there are two watercourses (discussed earlier) and a pond within the subject site. The report concludes that the pond is an artificial waterbody with only a few winged insect species and very limited aquatic ecological value.

The Terrestrial Ecological Assessment identifies small remnant patches of matagouri shrubland on the terrace risers near the western boundary of the property, with some areas supporting tree daisy, mingimingi, and porcupine shrubs. Additionally, in the two gullies and across the lakeside face, there is a mixed indigenous/native shrubland (Figure 2.17).

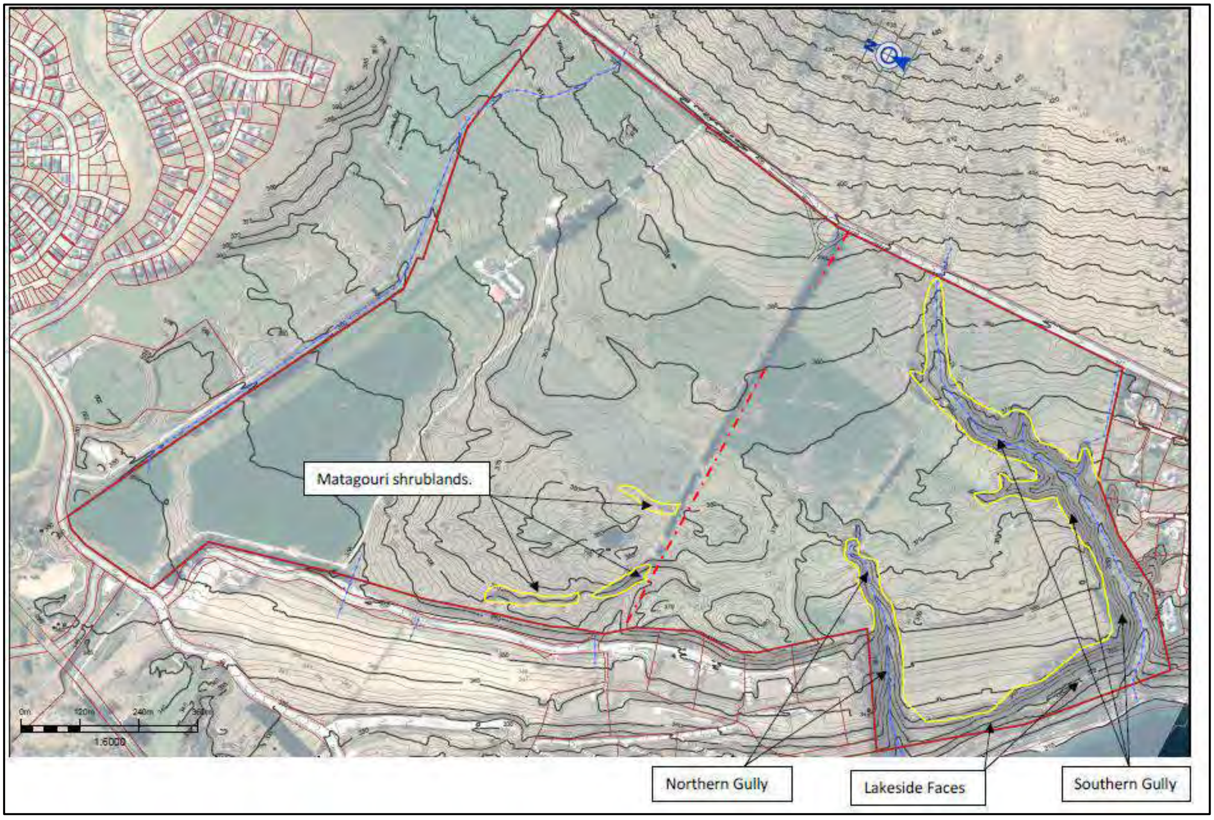


Figure 2.17: Location of the Indigenous Vegetation (Beale Consultants)

2.6 Soils and Plants

2.6.1 Overview

Through desktop and site soil investigations, there are three soil types (soil siblings) identified across the development site (and adjacent QEII land) known as Wakatipu, Barhill and Pigburn soils. The S-Map soil type data is overlain with the test pit sites for this application in Figure 2.18 below.

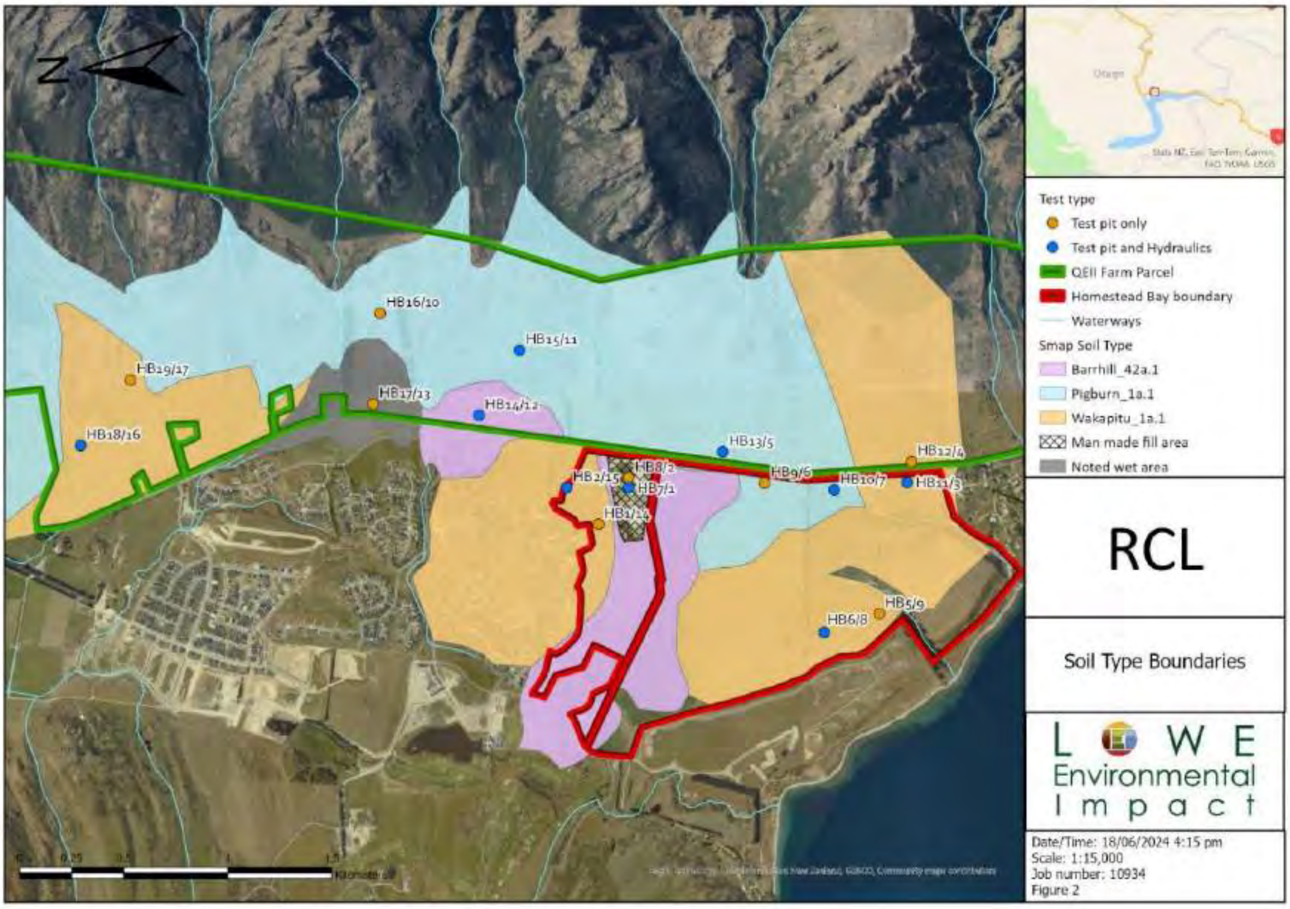


Figure 2.18: Soil Types in the Area and Test Pit Locations

The adjacent QEII land also contains the same soil types as the subject land, therefore soil sampling included QEII land to support the investigations for this site.

RCL land soils consist of a mixture of all three soil types, but predominantly Barhill and Pigburn soils in the most probable LTA locations (discussed later in this report). Pigburn is a weathered fluvial soil which is well-drained and has moderate nitrogen leaching potential. Barhill soils are Pallic soils which are moderately well-drained with low nitrogen leaching potential.

A detailed soil investigation memo has been provided in Appendix E of this Application, and the key points will be discussed further below. The soil investigations informed the Design Irrigation Rates which the LTA area can assimilate on a continuous basis across each soil type. These rates are given in Table 2.17.

2.6.2 Desktop Soil Characteristics

A desktop soil assessment was completed to ensure consistency with the on-site soil investigations. The findings are provided below.

Landcare Research Soils Map (S-map) information

The Homestead Bay residential zoned area occupies sloping topography from the east down to the flats of the central plain area south of the Jacks Point development. In the S-map assessment of the soils from Homestead Bay Development, the land consists of three main soil types (Table 2.9).

Table 2.9: Soil Information

Soil Family	**Characteristics (S-Map)**	**Irrigation Suitability**
Wakatipu	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be **dry in summer and wet in winter**. It is formed in a blanket deposit of silt sized windblown materials overlying poorly stratified poorly sorted gravel sand and mud deposited from glacial ice or meltwater, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth is 20 - 45 (cm), due to densely packed gravels that mechanically impedes root growth. Generally, the soil is **well drained with moderate vulnerability of water logging in non-irrigated conditions** and has moderate to low soil water holding capacity. Inherently these soils have a high structural vulnerability and a **moderate N leaching potential**, which should be accounted for when making land management decisions.	Subsoil infiltration limitation; Year-round irrigation possible
Pigburn	This soil belongs to the Recent soil order of the New Zealand soil classification. Recent Soils are weakly developed, showing limited signs of soil-forming processes although a distinct topsoil is present, a B horizon is either absent or only weakly expressed. It is formed in alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is slightly stony. The subsoil has dominantly loam textures, with very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally, the soil is **well drained with very low vulnerability of water logging in non-irrigated conditions** and has moderate to high soil water holding capacity. Inherently these soils have a high structural vulnerability and a **moderate N leaching potential**, which should be accounted for when making land management decisions.	Limited to nil Subsoil infiltration limitation; Year-round irrigation possible
Barrhill	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic Soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be dry in summer and wet in winter. It is formed in a blanket deposit of silt sized windblown materials overlying alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with gravel content of less than 3%. The plant rooting depth extends beyond 1m. Generally, the soil is **moderately well drained with very low vulnerability of water logging in non-irrigated conditions** and has high soil water holding capacity.	Some subsoil infiltration limitation; Year-round irrigation possible

Soil Family	Characteristics (S-Map)	Irrigation Suitability
	Inherently these soils have a high structural vulnerability and a **low N leaching potential**, which should be accounted for when making land management decisions.	

These soils generally align with those seen at Homestead Bay across both the RCL and QEII sites, and contain the following soil types:

- Wakatipu soils – cover the greatest area and are typically flat to gently sloping soils, which are formed in glacial deposits;
- Barrhill soils – are soils located in the central valley and also east of Jacks Point on the QEII property; and
- Pigburn soils – occupy a large area of the QEII property and are typically characterised as being a recent soil which is weakly developed.

Homestead Bay Soil Investigations on Site

A comprehensive soil investigation was undertaken by LEI on behalf of RCL between 4 to 7 July 2024. It comprised of machine excavation of 17 test pits (Figure 2.19 below), nine of which also included hydraulic testing, as shown in Figure 2.19. These test pits were excavated to a depth of approximately 2 m, with hydraulic testing completed at a depth of 0.2 m. The test pits allowed for further investigation of the three soil types relevant to this application; Barhill, Pigburn and Wakatipu. The soil investigation memo is attached to this application which discusses the sampling methodology, individual profiles and findings of each sampling location (Appendix E).

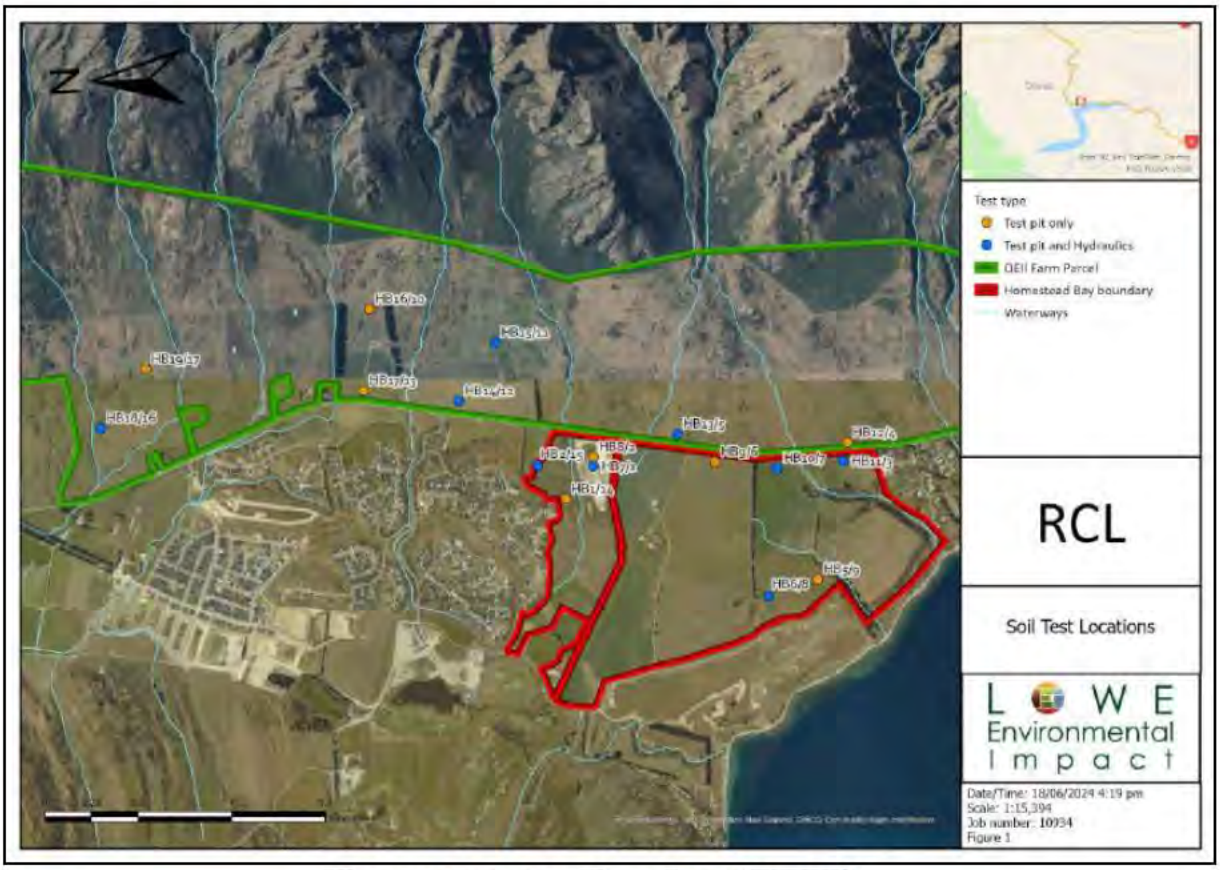


Figure 2.19: Location of Soil Test Pits

The summary of average soil profiles for each soil type is supplied in Table 2.10 below. The soil profiles typically comprised of 0.35 m of weathered topsoil (organic silt) with roots throughout, underlain by a silt subsoil down to alluvial or colluvial gravels at depth.

These soil logs show a consistent silt loam down to 0.9 m, with ranging stratification of gravels below this. Soil Categories′ 2 and 3 within AS/NZS 1547:2012 are representative of sands and loams.

Table 2.10: Averaged LEI Test Pit Logs by Soil Family

m bgl	**Pigburn**	**m bgl**	**Wakatipu**	**m bgl**	**Barrhill**
SMap class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0 - 0.3	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is weak and friable. Common fine roots. Boundary is abrupt and smooth.	0-0.35	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Common fine roots. Boundary is distinct and occluded.	0-0.40	Moist, 10YR 4/2 (dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.
0.3-0.9	Moist, 10YR 6/2 (light brownish grey) coloured soil. **No gravels**. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth. Some occlusions.	0.35-0.6	Moist, 10YR 5/8 (yellowish brown) coloured soil. **Slightly gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. Few fine roots. Boundary is sharp and smooth.	0.4-0.9	Moist, 10YR 5/4 (yellowish brown) coloured soil. **Very slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is firm, aggregate strength is weak and brittle. Few fine roots. Boundary is sharp and smooth. Oxide staining layers throughout the b horizon.
0.9-1.1	Moist, 10YR 6/3 (pale brown) coloured soil. **Very gravelly**, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth.	0.6-1.8+	Slightly moist, 10YR 7/3 (very pale brown) coloured soil. **Extremely gravelly**, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain. Soil strength is firm, aggregate strength is slightly firm and brittle. No roots. Concreted	0.9-1	Slightly moist, 10YR 5/4 (yellowish brown) coloured soil. **Extremely gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. No roots.

m bgl	**Pigburn**	**m bgl**	**Wakatipu**	**m bgl**	**Barrhill**
SMap class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
			texture but water soaks away.		Boundary is sharp and smooth.
1.1-1.45	Moist, 10YR 6/1 (grey) coloured soil. **Slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. Few fine roots. Boundary is sharp and smooth.			1-1.4	Moist, 10YR 6/3 (pale brown) coloured soil. **No gravels**. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is weak and brittle. Organic staining from roots. Boundary is sharp and smooth.
1.45-1.8+	Moist, 10YR 6/1 (grey) coloured soil. **Very gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. Few fine roots. Mixture of size class gravels.			1.4-1.7+	Moist, 10YR 6/3 (pale brown). **Extremely gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. No roots. Mixed size of gravels and sand.

2.7 Hydraulic Conductivity Tests

Understanding water movement through soils provides insight into how plants benefit from water applied to the soil (Brady & Weil, 2008; McLaren & Cameron, 1996). Saturated and unsaturated hydraulic conductivity tests were undertaken at nine test pits at a depth of 0.2 m using a combination of double-ring infiltrometers and unsaturated plate permeameters.

Table 2.11 presents the saturated hydraulic conductivity (total flow through the soil, including macropores, such as root and wormholes) for the sampling locations, while Table 2.11 presents the unsaturated hydraulic conductivity (represents the flow through meso and micropores, i.e. full matrix flow through the soil) for the nine sampling locations.

The saturated tests are likely to provide a more representative result of the gravity drainage through the larger macropores. The faster draining soils in the saturated tests are the Wakatipu soils, which all displayed an extremely gravelly, concreted type soil beyond around 0.6 m depth. This natural concreted type layer quickly wicked away water when applied, indicating a high infiltration rate.

Table 2.11: Soil Saturated Hydraulic Conductivity (K_{sat}) on RCL Land

Test Pits	Soil Type	Topsoil Average K_{sat} (mm/day)
HB2-15	Wakatipu	1,440
HB6-8	Wakatipu	3,960
HB7-1	Manmade	114
HB10-7	Pigburn	720
HB11-3	Wakatipu	1,044
HB13-5	Pigburn	*Too gravelly to conduct testing
HB14-12	Barrhill	720
HB15-11	Pigburn	920
HB18-16	Wakatipu	720

Field tests using the plate permeameters ($K_{-40\ mm}$) found that the rate moving through the soil indicated a strongly unified soil texture which showed only small increments of change across the different pressures. The unsaturated tests are well grouped between the soil types, with the faster draining soils being the Pigburn, compared with the slower draining Wakatipu and Barrhill.

Table 2.12: Soil Unsaturated Hydraulic Conductivity ($K_{-40\ mm}$) on RCL Land

Test Pits	Soil Type	Topsoil Average K_{-40} (mm/day)
HB2-15	Wakatipu	22
HB6-8	Wakatipu	30
HB7-1	Manmade	53.5
HB10-7	Pigburn	123
HB11-3	Wakatipu	11
HB13-5	Pigburn	73
HB14-12	Barrhill	37
HB15-11	Pigburn	110
HB18-16	Wakatipu	25

The hydraulic results based on soil distribution are shown below in Figure 2.20. The distribution of these rates support the proposal to irrigate based on soil type.

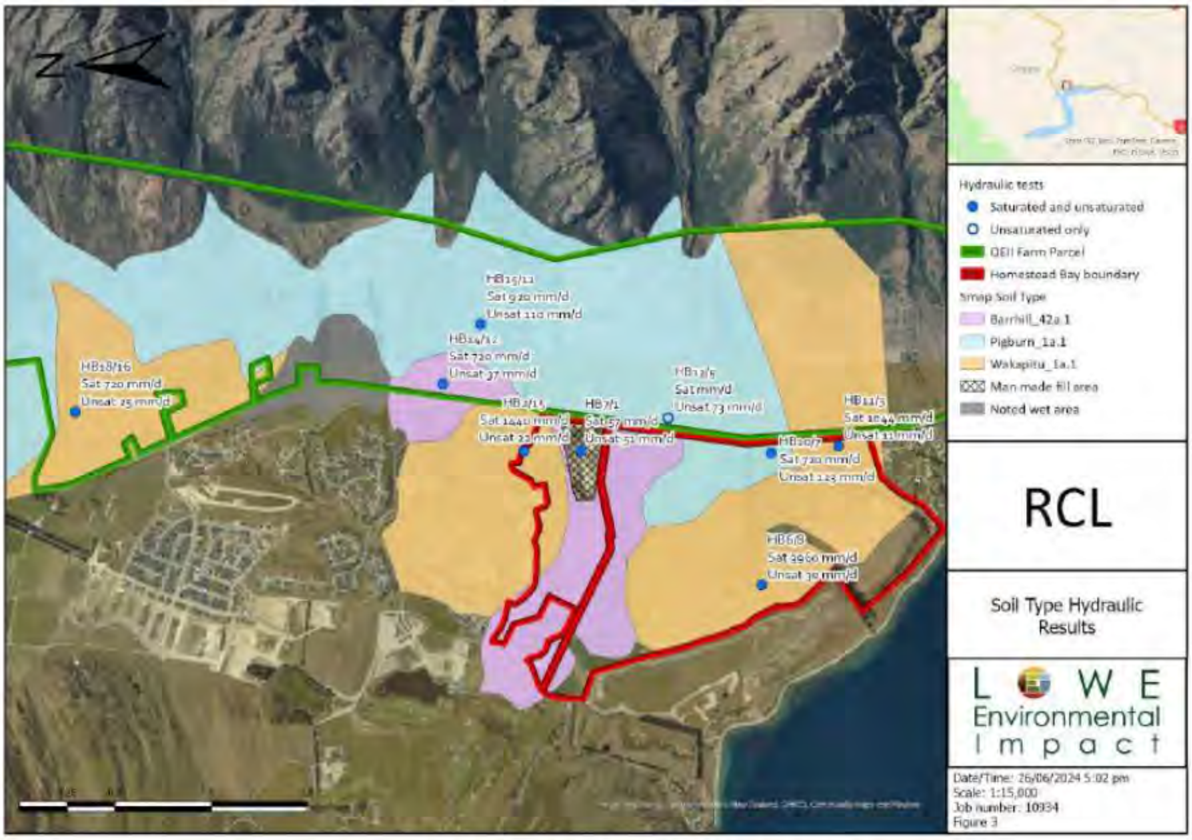


Figure 2.20: Soil Hydraulic Distribution

Field measurements typically only observe clean water effects, but the impact of wastewater constituents must also be considered. Organic material, solids and nutrients in the wastewater can allow the development of microbial growth, commonly referred to as biofilm, which in turn can result in a 'clogging' effect of the soil pores, particularly near the irrigation line outlets. This can reduce the soil's infiltration capacity. In addition, the salt concentration will influence the soil wetting by altering the water tension. Crites and Tchobanoglous (1998) recommended a value of 10% of the K_{sat} or 30% of the K_{unsat} to select a DIR for wastewater application on lands. LEI has conservatively adopted the lowest value between the 10% of the K_{sat} and 30% of the K_{unsat} to provide a DIR.

Due to the previously mentioned grouping by soil type, the design application rates have been considered separately for Barrhill, Pigburn, and Wakatipu soil types. These are shown below in Table 2.13, Table 2.15 and Table 2.16 respectively below.

The Barrhill soil DIR is calculated from on-site measurements and from past investigations on the neighbouring Jacks Point development.

Table 2.13: Barrhill Design Irrigation Rate

	Saturated (K_{sat})	**Unsaturated (K_{-40})**
Field Measurement low permeability subsoil (mm/day)	720	37
Adjustment (%)	10	30
DIR (mm/day)	72	11.0

The DIR recommended by the investigation is up to 11 mm/day for Barrhill soils.

The Pigburn soils dominate the higher elevations of the QEII site and part of the RCL site. These soils show a high saturated infiltration rate and unsaturated rate.

Table 2.14: Pigburn Design Irrigation Rate

Items	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	820	137
Adjustment (%)	10	30
DIR (mm/day)	82	41

The DIR recommended from the investigation is up to 41 mm/day for Pigburn soils.

Wakatipu Soils

The Wakatipu soils experience higher saturated infiltration rates due to the rapid infiltration at around 0.6 m depth. The lower unsaturated infiltration rate is similar to that of the Barrhill soils, which are also pallic soils.

Table 2.15: Wakatipu Design Irrigation Rate

Items	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	1,791	24.2
Adjustment (%)	10	30
DIR (mm/day)	179	7.3

The DIR recommended from the investigation is up to 7 mm/day for Wakatipu soils.

Manmade Soils

The manmade soils were imported as clean fill of unsuitable construction foundation material from the nearby Hanley's Farm development. The saturated and unsaturated hydraulic conductivity of these soil has been given in Table 2.16.

Table 2.16: Manmade Design Irrigation Rate

Items	Saturated (K_{sat})	Mean Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	114	53.5
Adjustment (%)	10	30
Maximum DIR (mm/day)	11.4	16.1

A summary of this work concluded a design irrigation rate (DIR) for each of the site's dominant soils, which the LTA area can assimilate on a continuous basis. These rates are given in Table 2.17.

Table 2.17: Design Irrigation Rate for each Soil Type

Soil Type	DIR (mm/day)
Barrhill Soils	11
Pigburn Soils	41
Wakatipu Soils	7
Manmade Soils*	11

These DIR rates represent a percentage of the soil's saturated and unsaturated hydraulic conductivity rate and inform the system design along with the nutrient loading rate.

*Manmade soil refers to the area of RCL land which has received surplus soil material from the development at Hanleys Farm.

2.7.1 **Soil's Physical** Properties in Relation to Hydraulic Conductivity

The soil physical properties across the 17 sampling locations, with test results provided by Landcare research laboratory.

The parameters considered relevant to this application are particle density, dry bulk density, total porosity, macro-porosity, and micro-porosity. These are essential in understanding the soil's ability to retain water, support plant growth, and allow for air and water movement through the soil profile. The testing details of soils physical properties and its implications have been given in the soils investigation memo which has been attached as Appendix E. All sites had physical properties which will support active plant growth and hydraulic assimilation of applied wastewater.

2.8 Phosphorus sorption in soils

2.8.1 Maximum Phosphorus (P) Sorption Capacity of Soils Calculated from Landcare Research Tests Data

High phosphorus adsorption is particularly important in preventing environmental issues such as eutrophication. Several factors influence phosphorus retention in soils, including soil texture, pH, organic matter content, and mineral composition. The P sorption capability in soils is a key indicator of how effectively a soil can adsorb and hold phosphorus, a critical nutrient for plant growth.

The Maximum Phosphorus Sorption Capacity (MPSC) (mg/kg) in soil samples ranged from 1,887-8,507 mg/kg soil (Table 2.18) which has been calculated by using the data from Landcare Research.

The highest MPSC was observed at sampling location HB 5/9 (Wakatipu soil), with a value of 8,507 mg/kg, suggesting a superior ability to adsorb phosphorus, which could be attributed to factors such as high clay content, organic matter, or the presence of minerals like iron and aluminium oxides known for high phosphorus sorption. A detail of the MPSC has been given in the soil investigation memo in Appendix E.

Table 2.18: Maximum Phosphorus Sorption Capacity (mg/kg) of Soils in different Sampling locations

Soil type	Sampling Locations	Maximum Phosphorus Sorption Capacity (mg/kg)
Manmade	HB 7/1	4,175
Manmade	HB 8/2	4,429
Pigburn	HB 11/3	1,887
Pigburn	HB 12/4	4,380
Pigburn	HB 13/5	2,534
Pigburn	HB 9/6	1,958
Pigburn	HB 10/7	2,769
Wakatipu	HB 6/8	5,097
Wakatipu	HB 5/9	8,507
Pigburn	HB 16/10	4,035
Pigburn	HB 15/11	3,499
Barhill	HB 14/12	4,764
Barhill	HB 17/13	5,881
Wakatipu	HB 1/14	6,575
Wakatipu	HB 2/15	6,248
Wakatipu	HB 18/16	5,324
Wakatipu	HB 19/17	4,464

2.9 Natural Hazards

Geosolve has conducted a natural hazards assessment for the proposed development (Appendix B). The risk and tolerability of hazards has been evaluated in accordance with the Otago Regional Council (ORC) Proposed Regional Policy Statement (RPS) process. The report has the following key findings:

- No evidence of shallow or deep-seated slope instability, except in the southern creek channel, where setback recommendations are provided.
- The risk of slope instability and inundation from landslides originating from the Remarkables mountains is assessed as unlikely.
- No features indicating alluvial fan activity have been observed on the site.

2.10 Flooding

Flood modelling has been undertaken by Geosolve. This has included the simulation of a 1% AEP storm event (QLDC required level of assessment). The majority of the development has been assessed as having an Acceptable to Tolerable Risk of an alluvial fan hazard with Significant Risk only being identified within the incised channels. It is noted that the channels are excluded from the development areas.

The report concludes that engineering solutions are available for the Tolerable Risk areas to be incorporated into the development as defences to convey floodwater away from the proposed development areas and towards outfalls to the lake. Furthermore, engineers' defences can be designed to match pre-development discharges to the lake.

2.11 Contamination

A Preliminary Site Investigation (PSI) has been conducted by WSP for the applicant's land.

The PSI confirms that areas of the site have possibly been subject to HAIL (Hazardous Activities and Industries List) activities, particularly associated with the existing airstrip and past agricultural activities. Areas where HAIL activities have been noted are assessed to pose a moderate to high risk to human health, while the remainder of the site has been assessed as low risk.

2.12 Heritage and Archaeology

As part of the wider area, Origin Consultants have undertaken a Heritage and Archaeological Assessment of the subject site. The assessment identifies the earliest human occupation of the Otago region by Polynesian settlers around 1280 AD and highlights the importance of Lake Wakatipu and the surrounding area for food gathering and resource collection, as recorded in the Ngāi Tahu Claims Settlement Act 1998. However, Homestead Bay is understood to have not been intensively used by Māori, due to its distance from the lake's edge and the lack of natural shelter nearby. There are no archaeologically recorded Māori sites in the area. Additionally, the Kā Huru Manu Atlas does not identify any points of interest within or near the site.

From the mid-1800s, the area was farmed as part of a large sheep station, a practice that continued until the recent construction of urban developments such as Jacks Point, Lakeside Estates, and Hanleys Farm. Several archaeological assessments have been conducted for these developments, and no historical or archaeological sites have been identified within the subject site.

Overall, the assessment concludes that while the site has some intangible values due to its connection to the Ree's Homestead at Woolshed Bay and contextual value linked to the construction of the state highway, these are not considered significant.

2.13 Anticipated Climate Change

Warming of the global climate system is unequivocal, and since the 1950s, many of the observed climate changes are unprecedented over both short and long timescales (decades to millennia) (IPCC, 2013). The atmospheric concentrations of carbon dioxide have increased to levels unprecedented in at least the last 3 million years (Willeit et al., 2019). Carbon dioxide concentrations have increased by at least 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land-use change emissions (IPCC, 2013). Due to the influence of greenhouse gases on the global climate system, it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC, 2013; IPCC, 2018).

Otago's climate is undergoing significant changes, and these trends are projected to continue into the foreseeable future, driven primarily by human-induced greenhouse gas emissions. The Otago Regional Council commissioned NIWA to analyse future climate projections for the region, utilizing climate model simulations from the IPCC Fifth Assessment Report and assessing hydrological impacts. Key findings include:

- Projected temperature increases, with annual average warming of 0.5-1.5°C by 2040 and 0.5-3.5°C by 2090, depending on emissions scenarios.

- Extreme hot days (>30°C) are expected to rise significantly, particularly in Central Otago, with an additional 30-40 such days by 2090, while frost days (<0°C) are projected to decline by 10-15 days by 2040 and up to 40 days by 2090 in inland areas.

- Annual rainfall is anticipated to increase slightly (0-10%) by mid-century, with larger increases (10-20%) by 2090, especially in western Otago, accompanied by a rise in extreme rainfall event severity, such as a 35% increase in the intensity of a current 1:100-year event by 2090.

- The number of dry days is projected to decrease in some coastal and central areas but increase in others (Macara et al., 2019).

3 BACKGROUND

3.1 Current Land Use and Permitted Baseline Loss

The existing land use of the application site is grazed pasture/lucerne, cropping and dryland animal grazing, wastewater discharge to land and aviation activities.

The current farming system area of 201 ha within the site area of 205 Ha has been estimated to leach an average of 9 kg N/ha/yr as detailed in Overseer farm system modelling in Appendix F.

3.1.1 Wastewater systems

The Otago Regional Council (ORC) manages small-scale discharges from small-scale septic tanks, wastewater systems (discharge of less than 2000 litres per day) and long drops using Permitted Activity Rules 12.A.1.1 to 12.A.1.4 in the Regional Plan: Water for Otago (RPW) Plan. These permitted activity rules allow discharge of effluent, provided certain conditions are met. Within the permitted activity rule, the lot size is not a condition of the rule.

3.1.2 Application of Nitrogen

A landholding's diffuse N loss is managed under the RPW. Under Rule 12.C.1.3 (a) (i) and Map H6 of the RWP, from 1 April 2026 it will be a permitted activity to apply nitrogen or use land in a way (across the total area of land managed by a landholder) that leaches up to 15 kg N/ha/yr. The nitrogen application rate is not limited under the rule, provided the residual leaching rate is less than 15 kg N/ha/yr modelled using Overseer® version 6 or later.

By way of comparison, this permitted N loss of 15 kg N/ha/yr across the proposed housing development area and Land Treatment Areas (LTA) could plausibly occur under a more intensive cropping and dry stock operation on this land. It is, therefore, a useful comparison of the proposal against what would be permitted by the RPW.

The permitted activity rule sets the landholding's permitted nitrogen mass that can be lost without consent. This means that the currently permitted leaching equates to a mass of 3,015 kg N/yr, being (201 ha x 15 kg/ha/yr) from lots 8 and 12 (being the new subdivision and LTA area).

In relation to this proposal, this mass can be allocated between the loss associated with the new subdivision area and the loss from areas used for LTA.

3.2 Productive Land

The rural-zoned portion of the subject site is classified as LUC-Class 3 highly productive land, according to Manaaki Whenua / Landcare Research GIS mapping. However, since the Queenstown Lakes Spatial Plan 2021 designates the site for future urban development (see Figure 3.1), the National Policy Statement (NPS) for Highly Productive Land does not apply, as per Section 3.5(7) of the NPS.

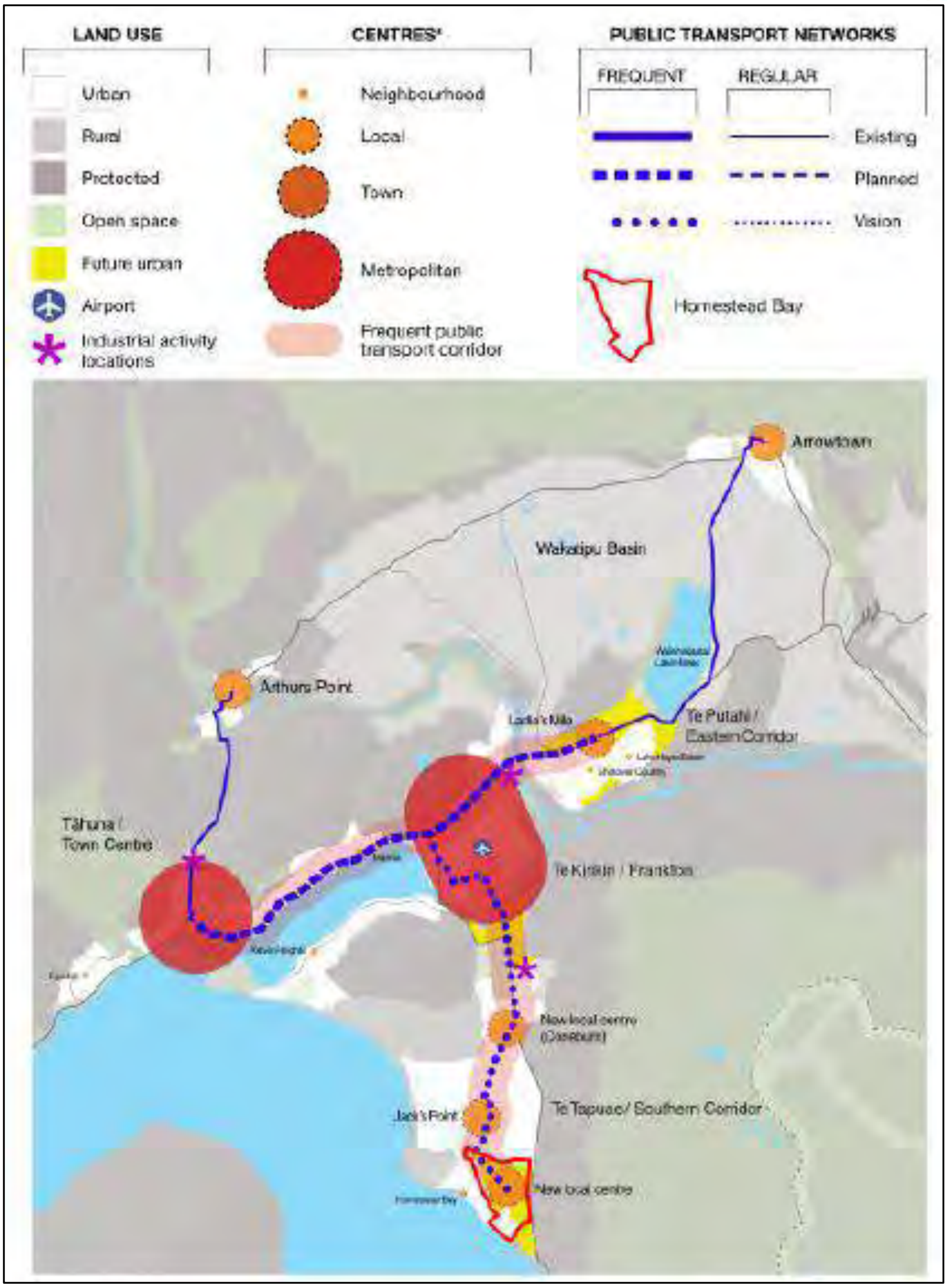


Figure 3.1: The Queenstown Lakes Spatial Plan - Future Urban as Signified by Yellow Shading

The remainder of the site is already included within the Urban Growth Boundary and is not zoned Rural and therefore the NPS also does not apply to this land.

3.3 Existing Consents

Consents currently exercised on the Applicant’s land include:

Land Use Consent RM24.110.01: Held by RCL Homestead Bay Limited to construct two bores for the purpose of accessing groundwater. Bores CC11/0151 and CC11/0151P are operational. CC11/0151 is a well/bore used for domestic purposes with a depth of 94.38 m, drilled on 11-Jul-24, while CC11/0151P is a piezometer for groundwater monitoring with a depth of 94.15 m, drilled on 18-Jun-24.

Discharge Permit RM13.334.01: Held by BP Oil New Zealand Limited to discharge contaminants to land for the purpose of disposing of treated stormwater from a refuelling pad. Expires 2033.

Discharge Permit 2009.312.V1: Held by Jacks Point Residents & Owners Association Incorporated to discharge treated domestic and commercial wastewater to land for the purpose of disposal of wastewater from a residential resort development. Expires March 2045.

Water Permit 2005.447: Held by Jacks Point Development Limited to divert part of an unnamed tributary of Lake Wakatipu to a new alignment, for the purpose of improving the direction of flow within the watercourse and to control the flow of water in the watercourses. Expires March 2041.

The Homestead Bay Trustees Limited holds Land Use Consent RM17.173.01 (on neighbouring land) for the construction of a bore. F42/0150 is a well/bore used for community drinking water supply, with a depth of 35.76 m, drilled on 8-Jul-17.

3.3.1 Surface Water Permits

There is a consented surface water take from Lake Wakatipu relevant to the site (Consent Number 2004.724) held by Jacks Point Land Limited, to take and use surface water for purpose of irrigation of golf course and open space and community water supply. Additionally, there is a groundwater take permit (Consent Number RM11.151.01.V1) held by Lakeside Estates Home Owners Association Incorporated, to take and use groundwater for the purpose of communal domestic supply and irrigation. The surface water take is approximately 800 m west of the nearest LTA (LTA L), and the groundwater take is approximately 620 m south of the nearest LTA (LTA I – 2) as shown in

Figure 3.2.

Figure 3.2: Distance of LTA from the Nearest Surface Water and Groundwater Takes

3.4 Other Consents Required

RCL also require consent(s) for other activities associated with the Homestead Bay development. These include:

- Various Queenstown Lakes District Council consents for the subdivision and construction required, and associated activities i.e., earthworks, transport, energy, utility and noise.

- Various Otago Regional Council consents for the subdivision development including residential earthworks, stormwater discharge, bed disturbance, diversions, bridges/structures, and water takes.

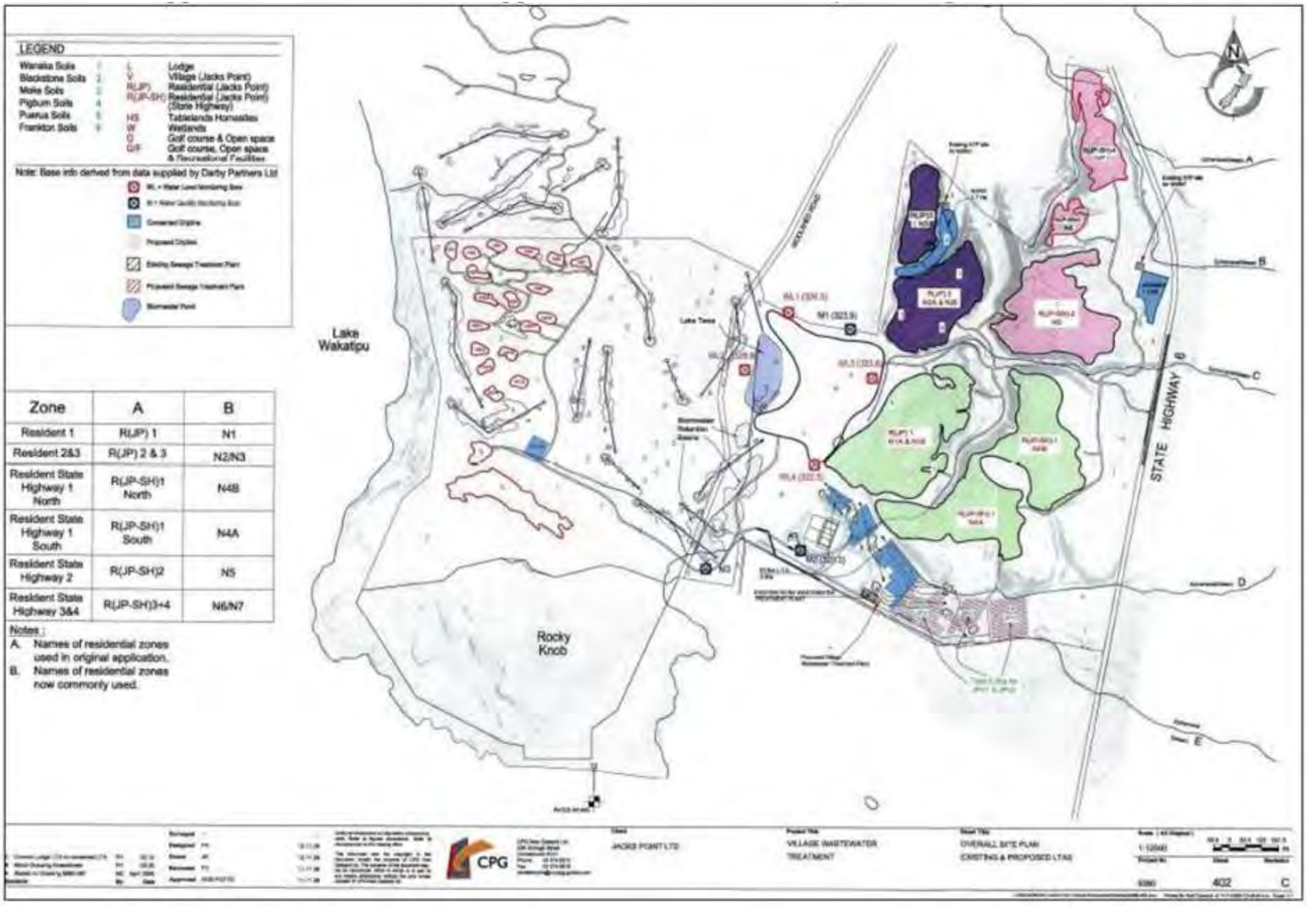
- Wildlife Act approval in relation to lizards and their habitat.

3.5 Nearby Jack's Point Consent Conditions

The adjacent Jack's Point community is comparable to the proposed development site as a recently authorised residential development with treated wastewater disposed to LTAs. Therefore, it is considered relevant to consider throughout the application, to ensure consistency across the catchment, considering nutrient limits and cumulative effects.

Relevant considerations from their authorised consent conditions relate to groundwater and surface water monitoring requirements. The conditions have established a catchment monitoring programme, along with a series of trigger and response conditions. These conditions and their suitability are discussed in detail in the LWP memo (Appendix C). The monitoring programmes proposed with this application incorporate the LWP advice. The cumulative effects of the discharges within Lot 12 are described in Section 7.12.

Figure 3.3 shows the location of the Jack Point Land treatment areas.



Zone	A	B
Resident 1	R(JP) 1	N1
Resident 2&3	R(JP) 2 & 3	N2/N3
Resident State Highway 1 North	R(JP-SH)1 North	N4B
Resident State Highway 1 South	R(JP-SH)1 South	N4A
Resident State Highway 2	R(JP-SH)2	N5
Resident State Highway 3&4	R(JP-SH)3+4	N6/N7

Notes :
A. Names of residential zones used in original application.
B. Names of residential zones now commonly used.

Figure 3.3: Jacks Point Relevant Consented Land Treatment Area by Discharge Permit 2009.312.V1

4 DESCRIPTION OF PROPOSED ACTIVITY

4.1 Introduction

Consent is sought for the discharge of treated community wastewater to land associated with the planned Homestead Bay subdivision development of approximately 2500-2600 dwelling equivalents. The proposed development will include:

- Residential housing ranging from apartment blocks to low-density housing; and
- Light commercial activities for residents and outside visitors including:
  - Food retailing, including supermarket and food and beverage services such as cafes, restaurants and bars; and
  - Retailing, including personal accessories such as clothing and footwear or recreational bike/ski service activities; and
- A school is also a prospect (typically 600 students and 60 teachers).

Treated wastewater will be discharged to land via subsurface pressure compensating drip irrigation (PCDI) at an average Design Irrigation Rate (DIR) of 7.1 mm per day across the Land Treatment Areas (LTAs).

It is proposed that the LTA management be a combination of cut and carry system, cut and leave system, light sheep grazing and native vegetation plantation to allow for nutrient management.

The total proposed dry weather wastewater flow is 2,005 cubic metres per day based on calculations given in Section 4.3.3. However, the capacity of wastewater treatment plant will be designed for flows of up to 3,974 cubic metres per day to account for wet weather.

It is envisaged that there will be several Land Treatment Areas (LTAs) which will progressively be constructed as the wastewater flows increase (as the subdivision development progresses). The total LTA is proposed to be 28.5 ha. Conditions will allow for the staged construction of infrastructure as demand increases and subdivision stages are completed. Detailed engineering design will proceed each stage of construction and be subject to Council approval. The exact area and layout of the LTA is not currently finalised, however there is 29.5 Ha of land that could be developed for LTAs and an example LTA layout is shown in Figure 4.1 below.

The selected and proposed design combines population density, reticulation type, treatment level, and land application area to configure a scheme that minimises environmental effects.

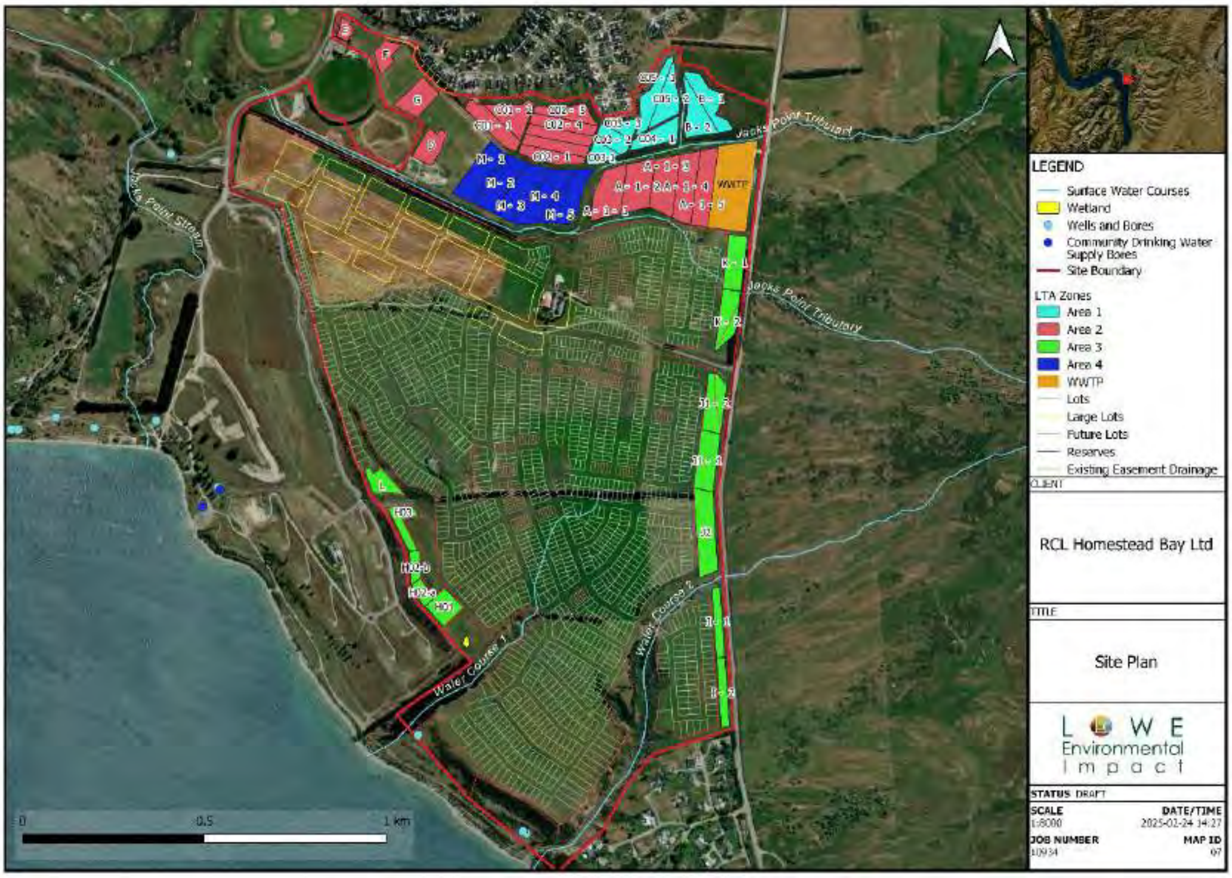


Figure 4.1: Indicative Land Treatment Areas and Key Site Features

4.2 Scope of Application

The scope of this assessment is to accompany a resource consent application to discharge treated wastewater from a community wastewater treatment plant (WWTP) to land. The preferred type and supplier of the wastewater treatment plant (WWTP) will be determined following confirmation of the consented treatment standard, LTA area and development rate of wastewater flows. The development will be staged, but consent is sought based on capacity for the full completed development.

4.3 Basis of Design

4.3.1 Wastewater Influent Quality

Wastewater generation at this site will predominantly be from residential toilets, showers, laundry and kitchen facilities and will therefore have the characteristics of conventional domestic sewage. However, there will also be wastewater sourced from some commercial areas including cafes, which will be a stronger waste similar to blackwater. Non-residential buildings will require an additional grease trap.

Based on the above, the typical urban influent wastewater constituents are expected to have Biochemical Oxygen Demand (BOD_5) 180 - 400 mg/L, Suspended Soils (TSS) 180 - 400 mg/L, Total Nitrogen (TN) 60 - 70 mg/L and Total Phosphorus (TP) 10 - 12 mg/L.

4.3.2 Wastewater Discharge Quality

With the proposed tertiary treatment, the proposed full development final annual average treatment effluent quality for the WWTP options is $cBOD_5$ 20 mg/L, TSS 20 mg/L, TN 7.5 mg/L, TP 2.5 mg/L, and *E.coli* 1000 MPN/100 mL.

Annual average treatment quality parameters will be proposed for consenting, as this allows some reduction in treatment efficiency during colder weather conditions.

4.3.3 Wastewater Flows

At completion, the total average daily inflow for the WWTP is proposed to be capped at 2,005 m^3/day of wastewater. This consent design report (Appendix A) explains how this number was arrived at, based on assumed land uses at the time the consent design report was prepared in late 2024.

Updated land use assumptions based in the final application are now as follows Table 4.1:

Table 4.1: Estimated Population and Average Wastewater Volume (QLDC COP)

Category	Number of lots	Estimated number of residential units	Estimated daily residential population	Estimated wastewater generation per day (m3)	Land Area
Low density residential	1438	1438			
Medium density residential	22	203			
High density residential	14	890			
Total residential units		2531	7593	1,898	
Commercial	3			43	2.5 Ha
Total				1,941	

The above calculations are based on the QLDC code of practice 2024, assuming 3 people per residential unit and 250 litres per person per day. This may in time prove to be an overestimate. As covered in the consent design report (Appendix A) there are plausible scenarios whereby the flows per dwelling end up being lower than the QLDC Code of Practice indicates including:

- Based on preliminary monitoring received from parts of the QLDC network, there is a strong prospect that that the per person flow rate is over stated
- The average number of people per house may be lower than 3 people, particularly in the higher density areas if a lot of apartments are built
- For the purposes of these calculations, commercial activity has been presumed to occur 365 days a year

This illustrates the value of a robust monitoring regime for the proposed scheme and to maintain some flexibility to adjust the size and staging of the scheme if wastewater flows prove to be lower.

For the assessment of flows, the proposed activities include cafés and retail activities and school, flows are treated as a separate wastewater source. The QLDC Code of Practice 2024 incorporates New Zealand Standard 4404:2010 flow rate of 0.4 L/s/ha for the 12-hour operational period over the 2.5 ha of commercial land has been used. Note that this rate includes peaking factors, so no additional flow needs to be added for inflow and infiltration (I/I), or diurnal peaks.

The scheme will also require capacity to receive intermittently higher flows up to the Peak Wet Weather Flow (PWWF), which can occur during times of wet weather. It should be noted that the flow associated with diurnal variations will be stored and balanced as part of the WWTP.

The total assumed daily average of wastewater generated of 1941m^3 per day is of course lower than the 2005m^3 sought to be consented. It is considered by the Applicant useful to maintain some contingency to receive more wastewater than is projected to be generated within the development, for example from neighbouring smaller developments or from community facilities that may be built within or near the development.

4.3.4 Determinant Loading

Treated wastewater will be applied to the land through subsurface pressure-compensating drip irrigation (PCDI) at an average Design Irrigation Rate (DIR) of 7.1 mm per day across the designated Land Treatment Areas (LTAs). The design application depths across the proposed LTA areas ranges between 5 - 8 mm/day for the PCDI system adopted.

The soil investigation has indicated that all of the site's soils have a high hydraulic capacity to assimilate the wastewater.

The DIR of an average 7.1 mm/day has been selected considering the potential capability of the soils to assimilate water which has been given in Table 4.2.

Table 4.2 Proposed Design Application Rate

	Proposed DIR (mm/day)
Barrhill Soils	7 to 11
Pigburn Soils	7 to 41
Wakatipu Soils	7
Manmade Soils	7 to 16

Although some soil types had higher capability to assimilate water (i.e. the ability of soil to percolate water which is known as soil's saturated and unsaturated hydraulic conductivity), a lower average DIR has been proposed as the wastewater application rate will also depend on rate of nutrient applied.

4.3.5 Land Treatment Areas

Considering the total area of Homestead Bay development, suitable areas for LTA have been identified. Considering the nitrogen loading, total volume of wastewater generated, soil's saturated and unsaturated hydraulic conductivity, an LTA area of 28.5 ha has been selected as seen in Figure 4.1.

Table 4.3: Areas of Discharge and Discharge Application

Overseer Block Groups	**Land Treatment Area Label**	**Area (ha)**	**Average Discharge Application (mm/d)**	**Design Flow Rate (m^3/day)**	**Annual Flow Rate (m^3/year)**
Area 1	B, C3, C4, C5	4.5	5.4	250	89,089
Area 2	C1, C2, A, D, E, F, G	11.5	7.1	820	299,554
Area 3	H, I, J, K, L	7.2	7.1	515	187,716
Area 4	M	5.2	8.0	420	152,005
Total		**28.5**	**7.1**	**2,005**	**728,364**

The design irrigation rates for the LTA sites are derived from the LEI's soil investigation memo (Appendix E), and the proposed land use potential to remove nutrients.

It is emphasised that the areas (Figure 4.1) are at this stage indicative only. They have been nominated to create a plausible scenario using land owned by the Applicant that would not otherwise be developed. Over time, some areas may not be needed (for example because the more conservative discharge rates are not observed) and there may be some reconfiguring of the size and locations of the LTAs through detailed design and through working with neighbouring landowners and disposal schemes. It is therefore sought that any resource consent issued not be specific as to the precise locations of the LTAs, to allow pragmatic decisions to be made in the implementation of the scheme. Certainty of the consented activity scope is achieved with the specification of maximum irrigation rates, maximum nitrogen loading rate per ha and a minimum land treatment area. These parameters are set out in the proposed consent conditions.

4.3.6 Nutrient (Nitrogen and Phosphorus) Loading in the LTA

Using the wastewater effluent concentrations discussed in Section 4.3.2, the site nutrient loading for the development is assessed in Table 4.4.

Table 4.4: LTA Nutrient Loading

Items	**Average daily flow (m^3/day)**	**Total nitrogen** (kg/yr)	**Total phosphorous** (kg/yr)
Total Average Daily Flow and Annual Loading	**2,005**	**5,490**	**1,830**
Land Treatment Area Selected			
LTA (ha)	**28.5 (Hectares)**		
Average Loading rate	7.1 mm/d	193 kg/ha/yr	64 kg/ha/yr

4.3.7 Nutrient (N and P) Management Through Plants

Plant and microbial removal and the soil cation exchange capacity are the primary mechanisms for the assimilation of nutrients and water by land application systems. The plant system's total assimilative capacity depends on the land area utilised, with the loading rate refined based on the crop type and its management. Table 4.5 provides examples of nutrient uptake rates for different crop types.

Table 4.5: Crop Nutrient Uptake

Crop / Land use	N uptake (kg/ha/year)	P uptake (kg/ha/year)	Reference
Pasture – irrigated, cut and carry	**500 - 600**	**130 – 160**	Morton *et al.* (2000)
Pastoral – irrigated grazed system	200 - 240	52 – 64	FLRC (2009), Williams and Haynes (1990)
Standard Rotation Forestry – Pine	100 (kg/ha/year)	30 (kg/ha/year)	Nicholas (2003)
Standard Rotation Forestry – Eucalypt	50 (kg/ha/year)	10 (kg/ha/year)	Myers *et al.* (1999)
Native planting	100 - 200	35	Ongoing research by ESR and Canterbury University, initial findings that it is similar uptake to grazed pasture

The current land use in the development area includes grazed pasture, lucerne cultivation, cropping, dryland animal grazing, and aviation activities.

Land use of the communal LTA is generally one of the following three methods stated in the order of preference for nitrogen renovation:

1. Cut and Carry (including complementary farming activities (cropping));
2. Sheep grazing; and
3. Landscaped areas or cut and leave (including community green spaces and indigenous vegetation planting (biodiversity restoration)).

Cut and Carry

"Cut" refers to mowing grass or grass-type crops, tree felling (replanting with juvenile plants) or pruning vegetation back to stimulate regrowth; "carry" refers to removing all dry matter from the site for sale or grazing elsewhere. If vegetation is not removed off-site, biological decay will result in the transfer of nutrients from the plant back into the soil matrix, with zero net plant uptake.

Sheep Grazing

Sheep grazing removes dry matter (and thus nutrients) but recycles some back to the soil store; the net input of nutrients from sheep urine and faeces back to the soil will be less than that eaten by the sheep and turned into meat, wool and energy. Sheep are generally rotated around the site to optimise grazing and vegetation removal.

Landscaped or Cut and Leave

This option is suitable if the lawn and landscaped areas are managed for aesthetic reasons for which vegetation growth and removal are undesirable. The net result is limited nutrient removal off-site if the clippings are not collected; the plant life cycle of regeneration and decay will inevitably result in most nutrients taken up by the plants re-entering the soil matrix during the decay phase. However, plant uptake will slow the rate of nutrient leaching, and nitrogen losses occur due to denitrification and microbe use. In addition, evapotranspiration will reduce hydraulic pressure on the soil. Some landscaping plants, such as Manuka, appear to have other benefits in wastewater LTAs. If Manuka or similar plants are added to the site, these are going to not only accumulate N and P but also have been shown to emit nitrification inhibiting and bactericide chemicals, reducing N_2O emission and killing harmful pathogens while enhancing native ecosystems.

LTA Management Summary

The proposed Land Treatment Area (LTA) will be managed through a combination of land uses, ensuring wastewater application and timing align with vegetation needs. "Cut and Carry" systems with lucerne or pasture will be implemented in areas suitable for harvesting machinery to provide supplementary animal feed. Additionally, light grazing with sheep and irrigating regenerative vegetation will be incorporated as viable management strategies.

The proposed PCDI system is expected to enhance nutrient treatment within the plant root zone. It will also significantly reduce total suspended solids (TSS) and biochemical oxygen demand (BOD_5), two key wastewater indicators, while effectively removing pathogens.

The flow estimates for the development have been determined based on the guidelines outlined in NZS 4404:2010 and the Queenstown Lakes District Council (QLDC) Code of Practice, ensuring a robust and consistent methodology. These flows are considered conservative providing an additional margin of safety. The adopted design LTA include a dry weather flow (DWF) of 2,005 m^3/day at full development, and a peak wet weather flow (PWWF) of 3,974 m^3/day, which accounts for additional contributions from rainfall.

Soil assessments have arrived at an average design loading of 7.1 mm/day with a range of 5 – 8 mm/d, depending on soil type and slope. The application rate is approximately 2.67 mm/hr, which is well below the soils′ infiltration acceptance rates. Although the LTA design has been developed based on the dry weather flow, the system has the capacity to assimilate peak flows as well. This is because the design irrigation rates (DIR) have been selected considering saturated hydraulic conductivity and unsaturated hydraulic conductivity in such a way so that the double volume of water than the dry flow volume (in peak season) could be managed by soil layers.

The WWTP technology is readily available to produce high-quality effluent with levels of approximately $cBOD_5$ 20 mg/L, TSS 20 mg/L, TN 7.5 mg/L, TP 2.5 mg/L, and E. coli 1000 MPN/100 mL. The WWTPs and the land treatment area (LTA) can be developed in phases to accommodate the progression of the development.

The groundwater depth is sufficient to prevent mounding at the proposed application rates. The entire site ultimately drains into Lake Wakatipu, which has a very low trophic index of 2–3 (oligotrophic), indicating minimal nutrient levels. The proposed design aims to preserve this exceptional water quality.

Nitrogen loading varies based on land management practices, with an average of 193 kg N/ha/year being discharged to land, assuming a WWTP discharge quality of 7.5 mg/L. The land management approaches include cut-and-leave, native planting, and cut-and-carry (harvesting) systems, each influencing the nitrogen dynamics differently.

The current farming system across 205 hectares has been estimated to leach an average of 9 kg N/ha/year. Modelling of the proposed system, which includes urban development and wastewater treatment, using the Overseer model indicates an average nitrogen leaching rate of 10 kg N/ha/year. This remains well within the permitted limit of 15 kg N/ha/year for agricultural use as outlined in the ORC Regional Plan. Additionally, the total nitrogen leaching into Lake Wakatipu is projected to be 31% lower than the allowable limit specified in the Regional Plan.

Phosphorus discharge from the treatment plant is modelled to average 64 kg P/ha/year across the LTA, based on an effluent quality of 2.5 mg/L from the WWTP. After accounting for plant uptake and removal, the additional phosphorus generated compared to the current farming system is estimated to be 30 kg P/ha/year. Given the soil's phosphorus retention capacity, it is expected that this phosphorus will be retained within the soil. Modelling indicates that it would take at least 135 years of treated effluent application for phosphorus to exceed the soil's retention capacity and begin leaching beyond a 1-metre depth (well beyond the anticipated duration of the consent). More details have been given in Section 6 below.

4.4 Hydraulic Loading

Wastewater is proposed to be applied via drip lines installed at approximately 200 to 300 mm depth, to prevent freezing during the winter months while still discharging the water within the plant root zone. The exact requirements for the dripline design will be determined during the detailed design and procurement phase. The drip lines will likely be placed a maximum of 1 m apart, with the drippers spaced at approximately 500 - 600 mm intervals. The drippers will likely have an average discharge capacity of 1 to 2 L/hour depending on the type.

Based on the concept design, it is expected that the area will be divided into several 'irrigation blocks' and each will have a number of zones irrigated together. It is likely that application return will vary depending on inflows and the ultimate design dose volume. There will be capacity within the subsurface irrigation system to irrigate all zones within one day if needed during peak wet weather flows. The irrigation at 21 mm/day, 3 times the average rate on any one day allows flexibility within the system to manage the application from daily to up to a 3-day return period at time of peak flow.

4.5 Wastewater Treatment Plant

There are numerous options for communal WWTPs suitable for this scheme. The consent level design report (Appendix A) provided detail on the technology examples considered and there is also discussion on options within the Stantec Engineering report.

The Applicant has not yet selected the specific plant, the preferred WWTP type and supplier are likely to be determined following confirmation of the consented treatment standard, the LTA area, the development rate of wastewater flows (i.e. how modular the WWTP needs to be). Nonetheless, there is certainty in the proposed wastewater flows, tertiary treatment, and ability to meet high quality treatment limits.

The WWTP treatment plant and LTA are considered an integrated treatment train for the wastewater. The land treatment system provides further nutrient and bacterial removal from the wastewater.

4.5.1 Staged Development

Adopting a staged approach to the WWTP and LTA based on flow is proposed. Potential treatment standards and scenarios for staging the WWTP capacity and land treatment area are outlined in Table 4.6.

Stage 1 of the wastewater scheme (up to 500 m^3/day) accommodates the plant's much lighter loading and the difficulty of operating an extensive, activated sludge treatment system with less than 50% design capacity compared to its final expected load. Stage 1 has options for higher BOD and N up to 500 lots, while future stages have a lower BOD and nitrogen concentration for flows up to the design dry weather flow peak of 2,005 m^3/day.

Table 4.6 demonstrates possible scenarios, with differences in the number of lots, wastewater loading rate, wastewater nitrogen concentration and LTA area. This illustrates the options the Applicant has to invest in the wastewater treatment plant, to improve wastewater quality or to retain a lower level of nutrient removal treatment and increase the land treatment area.

Table 4.6 also demonstrates the full development scenario with an application area of 28.5 ha.

Table 4.6: Potential Development Scenarios

WWTP	Stage 1	Stage 2		Stage 3		Stage 4		Stage 5	Stage 6
Lots connecting	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,578
Design Flow Rate (QLDC CoP) (m³/day)	375	563	750	938	1,125	1,313	1,500	1,688	2,005
Expected flow 520 L/lot (m³/day)	260	390	520	650	780	910	1,040	1,170	1,390
Nitrogen concentration at WWTP (mg/L)	20	15	10	12	10	7.5	7.5	7.5	7.5
Nitrogen mass (kg/yr)	2,738	3,080	2,738	4,106	4,106	3,593	4,106	4,620	5,488
Area required to meet 220 kg N/ha	12.4	14.0	12.4	18.7	18.7	16.3	18.7	21.0	24.9
Hydraulic loading mm/day at minimum area	3.0	4.0	6.0	5.0	6.0	8.0	8.0	8.0	8.0
Likely area development scenario	14.2	14.2	14.2	19.7	19.7	19.7	19.7	21.5	28.5
Possible scenario loading (mm/day)	2.6	4.0	5.3	4.8	5.7	6.7	7.6	7.8	7.0
Consent hydraulic limit (PWWF)	5	8	11	10	11	13	15	16	14
Possible scenario nitrogen loading rate kg N/ha/yr	193	217	193	208	208	182	208	215	193
Proposed Consent limits (kg N/ha)	220	220	220	220	220	220	220	220	220

Note that stages described above are reference to staged upgrades of the wastewater scheme, and do not directly correspond with the scale of stages anticipated in the subdivision.

By proposing a 220 kg N/ha/yr nutrient limit and a maximum hydraulic loading rate, the Applicant is seeking development flexibility by treating the WWTP and LTA area as a treatment train which can be built in stages in response to the speed of housing development occupation. This allows RCL to either improve wastewater treatment quality or increase LTA size as development occurs. Having a fixed input standard to the LTA for total nitrogen loading of 220 kg N/ha/yr and maximum hydraulic loading rates provides certainty about the standard of effluent (both quality and quantity) from the WWTP part of the treatment train, to both ORC as the regulator and to the owner and operator of the WWTP system.

4.6 WWTP Management and Servicing

The WWTP will be designed to mitigate aesthetic effects including earth mounding, fencing and planting to visually screen and to limit access to maintenance and monitoring staff.

Remote Telemetry Control (TCOM) will allow various functions, including remote monitoring capability, electronic logging of effluent flows, pump run times and alarm logs with audible and visual alarm features.

The proposal also includes a robust surface and ground water monitoring plan which has been given in Appendix G.

5 CONSIDERATION OF ALTERNATIVES

A range of alternative options have been investigated for the discharge of community wastewater from the Homestead Bay development. These are explained as follows:

5.1 Discharging to an Existing Community Network

The subject site is not currently serviced by a reticulated wastewater disposal system. QLDC is currently upgrading the Shotover Treatment Plant to accommodate expected population growth to 2048 QLDC Notice of Requirement to alter Designation 46 (RM220696). However, discussions with QLDC have highlighted operational challenges at the treatment plant and riverbank infiltration, raising uncertainty about whether wastewater from Homestead Bay can be accommodated in a timely manner.

As a result, RCL commissioned additional feasibility studies from Lowe Environmental Impact, which have confirmed the viability of treating and disposing of wastewater on-site.

As part of the wider Southern Corridor south of Kawarau River, around Hanley's Farm, Jack's Point, and Homestead Bay, QLDC have discussed with RCL the potential for having a WWTP in the Southern Corridor.

The proposed on-site disposal system eliminates the need for a connection to the existing QLDC wastewater network. It is considered that the proposed WWTP facilities detailed in this AEE at the RCL property could positively contribute to the southern corridor infrastructure.

5.2 Individual On-Site Wastewater Treatment and Discharge

The first option considered for the Homestead Bay development was individual on-site wastewater systems with land treatment areas for each lot. However, this option was not pursued further due to the high treatment and LTA costs, estimated at approximately $25 - 30,000 per lot, with the entire expense falling on the purchasers and some lots have restricted access to disposal areas. Additionally, the cumulative effect of the systems is expected to be higher as the treatment standards are lower for this small system, and there will be a number that are poorly maintained. The increased community cost and operational uncertainties of these systems make individual on-site solutions unsuitable as best practice for a subdivision of this scale.

5.3 Alternative Land Area

Suitable land treatment areas for receiving treated wastewater were identified, including the QEII Remarkables Station to the east of the State Highway. This land covers both the Kawarau River and Lake Wakatipu catchment but is not owned by the applicant. While the prospect of utilising QEII’s land for LTAs was discussed with them, it was unclear that an agreement could be reached. This option is not being pursued at this time, given sufficient land for discharge is within RCL’s site.

The golf course at Jacks Point land is a potential option (subject to agreement with that landowner) but due to challenges in integrating the LTA into the existing course while avoiding trees, tees, and greens and gaining approval to use this land is expected to be a complex process and is likely to contribute nutrients into the same catchment as the current proposed system.

The necessary land is available within RCL's ownership and for these reasons, alternative LTA locations were not pursued further.

5.4 Alternative Discharge to Land Options

LEI considered the suitability of several discharge to land options, including:

- Infiltration trenches (LPED-T);
- Via infiltration beds (LPED-B);
- Via mounds (LPED-M);
- Via evaporation assisted beds (LPED-ETA);
- Via surface irrigation methods (LT-S);
- Via subsurface drip irrigation (LT-SS); and
- Via a combination of drip and surface spray.

In selecting the proposed subsurface drip irrigation method, several factors were taken into account such as soil type and soil profile, soil permeability, cultural values, consenting feasibility and the quality of the effluent from the treatment plant.

Tables K1 and K2 in AS/NZS 1547:2012 summarises common site and soil constraints and provide guidance on the suitability of land application systems. Table 5.1 below is a modified extract from Tables K1 and K2 of AS/NZS 1547:2012.

Table 5.1: Summary of Common Site and Soil Constraints
(Modified extract of Tables K1 & K2 AS/NZS 1547:2012)

Land Application System	**Slope (%)**	**Soil Depth (m)**	**Soil Category Number**	**Comments – Suitability of System at the Applicants Site**
Infiltration Trenches	<15%	> 1.2	1 – 4	These methods allow for a high design loading rate (DLR). While they do provide treatment through a sand profile the hydraulic loading rate is such that nutrient removal is poor. These systems are primarily designed for the disposal of wastewater rather than wastewater dispersal and soils treatment. Overall, the treatment outcomes are not as high as for subsurface drip irrigation. Phosphorus discharge would be significantly higher.
Infiltration beds and evaporation beds	< 10%	> 1.2	4 – 6	
Mounds	< 15%	Not Important	1 – 6	
Surface irrigation systems	< 10%	> 0.4	Any	This is likely a cheaper system to install, but surface irrigation will require more land to account for larger buffer distances due to spray drift than subsurface and an additional disinfection step may be required. Issues can also result due to snow cover or surface freezing. The irrigation equipment can also create a visual effect on the landscape
Subsurface drip irrigation	< 30%	> 0.4	Any	This system is considered for the land application of domestic wastewaters as it provides public protection from pathogens and does not limit land use. The buried drip line is also not prone to freezing but care is required with land management, cultivation and harvesting equipment. The buried nature of the irrigation lines avoids any visual effects from the infrastructure.
Combined spray and drip	As above	> 0.4	Any	This system can use drip irrigation in the buffer areas and at times of high winds, frost and snow lie and the lower cost and better distributed spray at other times. The combination does not fully mitigate the potential visual effects and freezing effects on above ground infrastructure.

Table 5.1 indicates that the subsurface drip irrigation system is the most suitable system to use for the proposed discharge at the proposed locations because it is well-suited to the site's soil conditions and ensures a high level of treatment and public safety compared to other methods. Subsurface drip irrigation offers several advantages for the safe and efficient application of effluent. By placing the irrigation system underground, it minimises the risk of pathogens coming into contact with humans and animals, thereby enhancing public health. This design also prevents

the generation of unpleasant odours, as the effluent is directly injected into the soil, avoiding surface exposure. Additionally, the soil's natural microbial ecosystem plays a crucial role in further reducing pathogens. Beneficial soil microbes outcompete and neutralize harmful microbes, providing an additional layer of treatment.

Subsurface drip irrigation is therefore considered the most suitable method for discharging Homestead Bay Development’s wastewater.

5.5 Discharge to Surface Water

The discharge to surface water or directly into Lake Wakatipu as an alternative receiving environment was not considered due to being deemed unacceptable to the community and iwi.

5.6 Overall

A range of wastewater treatment and discharge options for the Homestead Bay Development were evaluated. Individual on-site treatment was ruled out due to; increased environmental effects, low land availability per lot, high costs and operational challenges, alternative community-based land treatment areas were dismissed due to the complexity of land access and the discharges largely remaining within the same groundwater and surface water catchment and do not provide an alternative receiving environment option.

Among the land discharge methods considered, subsurface drip irrigation was identified as the most effective; offering reliable treatment, public safety, and minimal environmental impact. Connecting to an existing wastewater network was not feasible due QLDC infrastructure limitations, and discharge directly into surface water was deemed unacceptable.

As a result, subsurface drip irrigation was selected as the most suitable and sustainable wastewater management solution for the development.

6 STATUTORY FRAMEWORK

6.1 Introduction

The Resource Management Act (RMA) 1991 and Fast Track Approvals Act 2024 sets out a statutory framework for consideration of resource consent applications which includes National Environmental Standards, National Policy Statements, Regional Policy Statements and Regional and District Plans. An assessment of the proposed activity against the RMA and relevant standards, statements, policies and plans are given below.

The Otago Regional Policy Statement (ORPS) is the dominant regional planning policy document for the Otago Region. It became operative on 01 October 1998 and is currently in the process of being reviewed. An assessment of the objectives and policies of the ORPS will be provided later in this application document.

The relevant operative regional plans are the Regional Plan: Water for Otago (ORPW) and the Regional Plan: Air for Otago (ORPA). These two regional plans include the rules governing the discharges of contaminants into water or air and will be discussed further below.

In addition to these regional documents, the National Environmental Standards (NES) for Sources of Human Drinking Water Regulations 2007, National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health, and the National Environmental Standard for Air Quality Regulations 2004 may have an influence on this resource consent application.

6.2 National Environmental Standards

There are three National Environmental Standards that are relevant to this resource consent application:

- The Resource Management (National Environmental Standards for Air Quality) Regulations 2004; and
- The Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations; and
- The Resource Management (National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health 2011.

6.2.1 NES for Air Quality

The NES for Air Quality includes standards governing ambient air quality, via the imposition of standards for five priority air pollutants (fine particles (PM10), sulphur dioxide, ozone, carbon monoxide, nitrogen dioxide). The standards apply in open air everywhere where people may be exposed in all regions of New Zealand. They do not apply to sites to which resource consents apply, to indoor air or air in tunnels.

The NES also requires air shed definition. ORC has gazetted defined air sheds within the Otago Region. The LTA and WWTP site lie within Air Zone 3 and is not within an identified air shed. The priority pollutants do not include odour or aerosols, which are the primary pollutants of interest in this assessment.

The scope of this application is for the discharge to land of wastewater and associated discharges to air. The air discharge is assessed as a discretionary activity as detailed in Section 6.3.2 below.

Given the above, on this basis, no consent is required under the NES for Air Quality.

6.2.2 NES for Sources of Human Drinking Water

The NES for Sources of Human Drinking Water includes standards governing monitoring of water supplies and protection of abstraction points, water treatment plants and distribution networks. These standards tie in closely with the Drinking Water Standards for New Zealand.

Regulations 7 and 8 apply to an activity that has the potential to affect a registered drinking-water supply that provides no fewer than 501 people with drinking water for not less than 60 days each calendar year.

The neighbouring Jacks Point development would be the nearest registered drinking water supply, which is located potentially downgradient of the Applicant's site and will be near the lake. Therefore, Regulations' 7 and 8 apply to the activity.

Regulation 7 states that the Regional Council must not grant a water permit or discharge permit for an activity that will occur upstream of an abstraction point where the drinking water concerned meets the health quality criteria if the activity is likely to-

(a) Introduce or increase the concentration of any determinands in the drinking water, so that, after existing treatment, it no longer meets the health quality criteria; or
(b) Introduce or increase the concentration of any aesthetic determinands in the drinking water so that, after existing treatment, it contains aesthetic determinands at values exceeding the guideline values.

The drinking water concerned meets the health quality criteria and so the proposed discharge to land must not result in (a) or (b).

Regulation 8 only applies if the drinking water is not tested in accordance with compliance monitoring procedures in the drinking-water standard. Assumptions have been made that testing is undertaken and that Regulation 7 applies.

The location of the drinking water supplies has been taken into account in the Assessment of Environmental Effects (Section 7.4.5 of this report).

Based on the assessment in Section 7.4.5, a discharge consent is not precluded from being granted and no other consents are needed under the NES.

6.2.3 NES for Assessing and Managing Contaminants in Soil

The NES for Assessing and Managing Contaminants in Soil to Protect Human Health 2011 is relevant to applications to subdivide or change the use of land that is identified on the Hazardous Activities and Industries List ('HAIL'). An assessment of the Site has been completed. This assessment has determined that there have been HAIL activities undertaken on the property land parcel but not on the specific proposed LTA areasNo disposal infrastructure will be installed at any identified HAIL site without the land first being remediated under a Remedial Action Plan.

6.3 Otago Regional Plans

The Operative Regional Plan for water quality and air quality in the Otago Region is the Otago Regional Plan: Water (ORPW) and the Regional Plan: Air for Otago (ORPA) respectively.

6.3.1 Regional Plan: Water for Otago

The purpose of the ORPW is to provide a framework for the integrated and sustainable management of Otago's water resources.

The relevant sections are Section 12.A – Discharge of Human Sewage and Section 12.B which includes discharges from specified contaminants and stormwater; and discharges from industrial or trade premises

Rule 12.A.A.1 states:

"The discharge rules in section 12.A apply where a discharge contains human sewage"

Rules 12.A.1.1 to 12.A.1.3 pertain to existing long drops and existing on-site wastewater treatment systems.

Rule 12.A.1.4 states:

"The discharge of human sewage through any on-site wastewater treatment system, installed after 28 February 1998, onto or into land is a permitted activity, providing:

1.1.1.1.1 The discharge does not exceed 2000 litres per day (calculated as a weekly average); *Cannot comply*

1.1.1.1.2 The discharge does not occur within the A zone of any Groundwater Protection Zone, as identified on the C-series maps, nor in the area of the Lake Hayes catchment, as identified on Map B6; and *Complies*

1.1.1.1.3 The systems disposal field is sited more than 50 metres from any surface water body or mean high water springs; and *Cannot comply*

1.1.1.1.4 The systems disposal field is sited more than 50 metres from any bore which:

1.1.1.1.4.1.1.1.1 Existed before the commencement of the discharge activity; and *Complies*

1.1.1.1.4.1.1.1.2 Is used to supply water for domestic needs or drinking water for livestock; and *Complies*

1.1.1.1.5 There is no direct discharge of human sewage, or effluent derived from it, to water in any drain or water race, or to groundwater; and *Complies*

1.1.1.1.6 Effluent from the system does not run off to any other person's property; and *Complies*

1.1.1.1.7 The discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage." *Complies*

The proposal will not comply with (a) because the average flows will be 2,005 litres per day, and (c) because the LTAs will be 10 metres setback from streams in some areas.

Rule 12.A.2.1 states:

"Except as provided for by Rules 12.A.1.1 to 12.A.1.4, the discharge of human sewage to water, or onto or into land in circumstances where it may enter water, is a discretionary activity."

The discharge of treated effluent into land from the proposed Homestead Bay community WWTP is therefore deemed to be a discretionary activity.

Rule 12.B.A.2 states that the discharge rule in 12.A applies in addition to 12.B where a discharge contains human sewage.

Rules 12.B.4.1 is the most relevant rule in Section 12.B and it states:

"The discharge of water (excluding stormwater) or any contaminant from an industrial or trade premises or a consented dam to water or to land is a discretionary activity, unless it is permitted by Rule 12.B.1.6, 12.B.1.7, 12.B.1.10 or 12.B.1.11".

The proposed discharge is deemed to be a discretionary activity under Rule 12.B.4.1 given there will be some café's and/or other similar trade premises contributing to the wastewater discharge.

6.3.2 Regional Plan: Air for Otago

The purpose of the ORPA is to seek the avoidance, remediation, or mitigation of adverse effects resulting from discharges of contaminants into air.

The following rules from the plan are considered to be applicable to this application:

Table 6.1 provides an assessment against Rule 16.3.7.1 – Discharges form the storage, transfer, treatment and disposal of liquid borne municipal, industrial or trade water.

Table 6.1: Assessment of Compliance with Rule 16.3.7.1

Condition	Description	Compliance	Assessment
n/a	The discharge of contaminants into air from the storage, transfer, treatment or disposal (including land application of treated effluent and sludge, but excluding the burning of sludge and associated solids) of liquid-borne municipal, industrial or trade waste, where the influent liquid waste does not exceed a BOD_5 of 850 kg per day;	**Applicable**	The expected influent BOD_5 is 180 - 400 mg/L (0.2 - 0.4 kg/m^3); therefore, based on a regular flow of 2,005 m^3/day the BOD_5 will not exceed 802 kg/day considering the highest concentration of BOD_5. As covered in the Stantec Engineering Assessment, preliminary design work indicates a total BOD_5 in the order of 440kg per day.
(a)	Ponds constructed after 1 January 2002 are located at least 150 metres from the closest part of the boundary of the property; and	**n/a**	n/a
(b)	Land application does not occur within:		
	150 metres from any residential dwelling on a neighbouring property or from a building used for employment purposes on a neighbouring property; and	**Cannot comply**	There will be residential dwellings within 150 metres of the land application.
	20 metres from a formed public road; and	**Cannot comply**	There is a formed public road within 20 m.
	150 metres from any public amenity area or place of public assembly, excluding formed public roads, and	**Cannot comply**	There is a community park amenity area and area of public assembly within 150m.
(c)	Any discharge of odour, particulate matter, droplets or gases is not noxious, dangerous, offensive or objectionable at or beyond the boundary of the property.	**Complies**	Subsurface drip irrigation will ensure no odour or contaminants leave the application field border. The wastewater treatment plant will be enclosed and can be fitted with carbon/or similar filter if required.

The proposed treatment and land application of effluent from Homestead Bay Development comply with all relevant conditions of Rule 16.3.7.1 except condition (b) because there will be residential dwellings, community park and public assembly area within 150m proximity to the LTAs and a public road within 20m (even though there is not expected to be discharge to air from the LTAs themselves). Therefore, the air discharge is assessed as a **discretionary** activity under Rule 16.3.7.3.

However, it should be taken into account that the fact that the LTAs are within 150m of residential properties or public areas is not resulting in a discharge to air because the dripper lines are below ground. It is asserted that a permitted baseline is the same scheme reconfigured to locate dripper lines away from property boundaries such that it is compliant with the rule. That discharge to air would be no lesser than the scheme as proposed. It is requested that this permitted baseline be taken into account for the assessment.

6.3.3 Conclusion

The discharge of contaminants relating to wastewater treatment and application to land is considered a discretionary activity pursuant to the Otago Regional Plan: Water under Rules 12.A.2.1 and 12.B.4.1.

The discharge of contaminants to air is considered a discretionary activity pursuant to Rule 16.3.7.3 of the Otago Regional Plan: Air.

7 ASSESSMENT OF ENVIRONMENTAL EFFECTS

7.1 Overview

This assessment of environmental effects has been prepared in accordance with the requirements of Section 127 and the Fourth Schedule of the Resource Management Act ("the Act"). Section 127 requires an application for resource consent to include an assessment of environmental effects in such detail that corresponds with the scale and significance of the effects the activity may have on the environment.

The potential adverse effects that may arise from the proposed discharge of treated effluent to land and contaminants to air are:

- Effects on soils and plants;
- Effects of ground and surface water quality;
- Effects on ecology;
- Climate change effects;
- Effects on existing water takes;
- Effects on amenity values;
- Effects on public and community;
- Effects on Air Quality;
- Effects on Tangata Whenua Values; and
- Cumulative effects.

The application includes a robust surface and groundwater monitoring plan, which has been given in Appendix G.

Appendix C of this application is a memo from LANDWATERPEOPLE assessing the environmental sensitivity and risks from the proposal, confirming that the waterways which could potentially receive treated wastewater include groundwater, two unnamed surface watercourses, Māori Jack Stream and Lake Wakatipu. The assessment on these waterbodies provided in the memo is adopted for the purposes of this assessment, and the assessment provided below can be considered supporting information which takes into account the refined system design and management proposed.

It is considered relevant to take into account the permitted baseline provided by Rule 12.C.1.3 (a) (i) and Map H6 of the RWP, for the loss of nitrogen from a property. Consent is required because the discharge will exceed the permitted volume of 2,000 litres per day in total across all properties together, and the disposal field is sited less than 50 metres from some of the streams flowing through the property. The proposed land use discharge of nitrogen to the environment is below that permitted, while the proposed change in landuse there is an increase on that current predicted for the current farming system i.e., the current land use nitrogen loss could be more intensive and a permitted activity.

In respect of the discharge to air, it is also requested that the permitted baseline of the same scheme reconfigured to locate underground LTAs further from residential properties should also be taken into account.

Therefore, the effects of concern are essentially limited to nutrient loss after the application of wastewater discharge compared with the current land use and the effects of the LTAs being within 50 metres of ephemeral surface water bodies. A full assessment of effects of the wastewater application to land activity is still provided below, however the Applicant requests that the permitted baseline is taken into account when considering this application.

7.2 Effects on Soils and Plants

The proposed land application of treated wastewater is expected to be beneficial for plant growth. However, an assessment of effects is given below discussing how the proposal will avoid any potential detrimental effects on soil.

7.2.1 Effects on Soils

Hydraulic Loading

Comprehensive soil investigations were undertaken to understand the soils hydraulic conductivity and select an appropriate hydraulic loading rate for the receiving environment. The proposed peak day average hydraulic loading rate of 7.1 mm/d is far less than the topsoil assimilative (absorption) capacity. S-maps (Landcare Research, 2025) suggests the lowest available water holding capacity (WHC) of 52 mm per 30 cm (between 0 – 30 cm depth) for Barrhill soils, which is the lowest among the three soils.

Direct drainage losses are likely when the soil's moisture content is above field capacity and close to soil saturation (-1 KPa) when all soils exhibit a greater degree of preferential flow through large water conducting pores >300 µm (Jarvis, 2007; Silva et al, 2000) or if application depth exceeds the soil's water holding capacity. It is good practice to apply less than half of the water holding capacity in any application to maintain matrix flow, thus a loading of <26 mm/application is desirable. The low application rate proposed will allow the topsoil to assimilate the irrigation demand via plant uptake/transpiration and evapotranspiration, without reaching saturation (Additional information has been given in Section 4.4).

The significance of the soil moisture deficit is such that given appropriate irrigation methods, potential excess water (drainage) to potential groundwater may be minimised for summer periods of the year. Soil moisture retention within the root zone also aids to reduce nitrogen losses to groundwater by making the nitrogen more bioavailable for plant and soil micro-organisms.

Overseer modelling takes into account climate, soils and the application rate when it calculates soil drainage and associated N loss. The model predicts that nitrogen leaching will occur from April to November. The N leaching rate reported by Overseer takes drainage within each month into account and the potential effects of this N loss have been assessed in Section 7.4.2 below.

The LTA will be mostly managed as a cut and carry system. This means that grass or lucerne will be grown and regularly harvested to increase the removal of nutrients. Regular harvest events of dry matter have been modelled, with this grass material will being exported from the site. There will also be some LTAs managed as native plantation, and possibly cut and leave and light sheep grazing in the proposed site with modelled lower rates of nutrient removal.

Overall, the proposed loading rates are appropriate for the soils and any effects of the hydraulic loading rate are expected to be low.

Nutrient Loading

The wastewater applied to land will contain macro nutrients—nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), and magnesium (Mg)—as well as essential micronutrients for plants, including boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). These nutrients will enhance soil health by improving its fertility and productivity, thereby supporting long-term soil sustainability. Additionally, wastewater application will promote a thriving soil ecosystem by enhancing microbial diversity and activity.

The presence of organic matter and nutrients will support beneficial microorganisms, such as beneficial mycorrhizal fungi, which contribute to nutrient cycling and plant growth. A well-balanced soil microbiome will improve soil structure, increase organic matter decomposition, and enhance disease suppression, further benefiting overall soil health.

Further treatment

Land treatment of wastewater will assimilate BOD_5, Total Suspended Solids (TSS), Total Nitrogen (TN), Phosphorus (P) and pathogens contained in the wastewater, and this is discussed in more details below.

TSS

The treated effluent will be low in TSS (20 mg/L) after treatment. These solids will be further reduced via a fine tertiary filter at the WWTP and then further filtered by the rubber diaphragm in the dripper filter to prevent the drippers from blocking. Any residue at the drippers is flushed out during the routine system maintenance. Therefore, the TSS entering the soil matrix will be very low and will not cause soil pore blockages. Any TSS that may enter the soils will have a less than minor effect on the soils as the soil has the ability to assimilate moderate TSS loads as the solids are incorporated into the soil matrix along with humus.

BOD

A healthy soil environment can assimilate up to 600 kg BOD_5/ha/d (NZLTC, 2000). The fully developed discharge field covers a proposed area of at least 28.4 ha (17,040 kg BOD_5/day allowable). The effluent BOD_5 concentration, after treatment, will be on average 20 g/m^3 prior to tertiary filtration and the average flow is estimated as be 2,005 m^3/day. Therefore, the BOD_5 in the effluent in full development is 40.1 kg BOD_5/day which is very low compared to the 17,040 kg BOD_5/day the soil can assimilate. Therefore, the LTA has the required capacity to assimilate BOD_5 and the effects of BOD_5 and risk of anaerobic soil conditions from the discharge on soils will be less than minor.

Drainage and Runoff

The hydraulic loading rate will increase drainage through the soil profile; however, ponding is not expected to be a concern given the low application rate in comparison to the soil's saturated and unsaturated hydraulic conductivity capacity, along with the soil's drainage status. Subsurface drip irrigation will also be located 200 mm below the topsoil. Therefore, no surface runoff is expected from the site as a result of the drip irrigation. Incorporated within area B and C are subsurface French drains which will intercept potential lateral drainage and discharge that drainage water to the subsoil. The French drains will eliminate the potential for overland flow to or from the neighbouring JPROA land treatment areas.

From the NZ Guidelines for the Utilisation of Sewage Effluent on Land (NZLTC, 2000), the sodium adsorption ratio (SAR) is likely to be in the order of 4 – 7. The SAR is the ratio of sodium ions to calcium and magnesium ions in the soil. When the SAR is greater than 9, the soil's infiltration rate can be affected due to dispersion of clay particles. As the expected SAR ratio is less than 9, it is expected that the soil's drainage capability will not be affected by the discharge.

Heavy Metals

The accumulation of heavy metals or pesticides within the soil profile will not be an issue of concern as the wastewater is domestic in origin. Heavy metals and pesticides are not found in significant quantities in domestic wastewater that has no significant industrial component. Moreover, the small-scale commercial activities in the Homestead Bay Development are not going to generate any notable heavy metals as no heavy metals will be used in any activities in the whole development area to a level that can create high concentration of heavy metals in the wastewater.

Overall

Overall, any effects of the proposal on soils will be low and for some matters positive.

7.2.2 Effects on Plants

At the site, grasses and native plants will be grown based on the required nutrient removal. The LTA will be managed through cut and carry, and native planting, and potentially cut and leave and light sheep grazing.

The proposed discharge of treated wastewater to land will be controlled by a suitable wastewater management plan (details in Section 4.3), taking into consideration the hydraulic and nutrient limitations of the soils and climatic fluctuations within the region. The wastewater application on land has the potential to have both positive and negative effects on plants, which have been discussed below.

The controlled application of treated wastewater at the LTA sites can benefit plant growth by providing essential nutrients, such as nitrogen and phosphorus, which support healthier and more robust vegetation. The organic matter in wastewater can improve soil structure, enhancing water retention and fostering beneficial microbial activity, which in turn aids root development and improving soil structure that will allow exchanges between soil air and atmosphere allowing more oxygen for the root respiration. Over time, these improvements contribute to increased plant productivity, improved biodiversity, and a more resilient and sustainable ecosystem.

Despite its benefits, wastewater application must be carefully managed to prevent potential adverse effects on plant health. Excessive nutrient accumulation can lead to imbalances that may negatively impact plant growth, causing nutrient toxicity or deficiencies. The buildup of salts or contaminants from wastewater can affect plant physiology, leading to reduced water uptake, stunted growth, or even plant mortality. Additionally, waterlogging in the rootzone can alter root development and nutrient availability. Climatic fluctuations, such as heavy rainfall or prolonged dry periods, may further influence plant responses to wastewater, necessitating careful monitoring and adaptive management to minimize risks.

The proposed hydraulic and nutrient loading rates for a cut and carry, light sheep grazing, cut and leave and native plantation regime are within the soil and plant assimilation capacities (Section 4.3). The cut and leave management of the grasses will increase the organic matter in soils and also increases the biota in the soil enriching soil ecosystem. The native plantation will allowing a healthy ecosystem, and certain native plants have been shown to decreasing harmful pathogens.

It is assessed that the application of wastewater to land has the potential to improve soils allowing increased plant growth. Therefore, the potential negative effects on the soils and plants will be acceptable.

7.3 Effects on Natural Inland Wetland

The proposed LTAs are at the closest point 60 metres from the delineated natural inland wetland to be retained, therefore any effects of the discharge to land are considered acceptable given the permitted baseline in Rule 12.A.1.4 allows for discharges of human sewage into land provided there is a 50-metre setback from surface water bodies. In addition to this, the proposal is to manage human effluent by treating to a high quality and discharging subsurface at a conservative (low) application rate. The soils will provide further treatment through natural soil processes and overall effects on the natural inland wetland will be negligible and acceptable.

The other five existing delineated natural inland wetlands will be removed to allow for the residential development and therefore effects on these are not assessed. Relevant consents will be obtained to remove these wetlands.

7.4 Effects on Ground and Surface Water Quality

7.4.1 Microbial Contaminants

The effluent discharge from the WWTP is designed to have low concentrations not exceeding 1000 MPN/100 ml *E.coli*. The protection of groundwater and surface water is ensured by further treatment of the treated wastewater within the soil profile through the mechanisms of filtration, absorption and natural attrition. When this wastewater is applied to soils at a depth of around 200 mm, the soils continue to reduce the number of *E.coli* to negligible amounts due to the competition of the *E.coli* with the native microbes in soils.

The USEPA defines these processes as:

Slow rate land treatment "the application of wastewater to a vegetated soil surface. The applied wastewater receives significant treatment as it flows through the plant root/soil matrix. Solids removal generally occurs at the soil surface and biological, chemical and additional physical treatment occurs as the wastewater percolates through the plant root/soil matrix"

According to a study by the Florida University (IFAS)

"when at least two feet of unsaturated soil exists between the infiltration system and the water table, BOD_5 removals of >90%, TSS removals of >95% and faecal coliform reductions of > 99% can be expected for a functional and properly maintained septic tank. Bacteria and viruses are effectively removed by adsorption and sorption processes in the groundwater and are not transported far from the source"

In addition to the IFAS study noted above, a number of studies also show that passage of treated wastewater through the soil at a low rate and applied intermittently will enhance the natural pathogen die-off and reduce the number eventually transported into ground/surface water.

The main mechanisms that operate within the soil matrix to ensure pathogen removal are filtration, adsorption and natural attrition. Results from various studies show virus reductions of 99.99% through 0.6 m of 0.12 mm diameter sand and bacteria reductions of 99.998% through 0.9 m of 0.15 mm diameter dune sand, with 92 to 97% reduction occurring in the top one centimetre. In addition, Rubin (2009) (an author of many USEPA publications) in his recent decentralised wastewater workshops in New Zealand stated that they conservatively use one log reduction of bacteria per 150 mm of travel through the soil and subsoils. Therefore, a high level of pathogen removal will be achieved before such drainage travels through the glacial till soil matrix to reach the groundwater and potentially Lake Wakatipu.

The above studies relate to Low Pressure Effluent Dosing (LPED) systems; however, the Homestead Bay Development WWTP will be applying treated effluent over a large land area at a low rate. Therefore, it can be expected that the method of land application within the LTA will produce better results over the discharge area as a whole.

A study by Bohrer and Converse (2000) was conducted in Wisconsin which evaluated six drip irrigation systems for the treatment of wastewater by septic tanks and aerobic units in soils that ranged from coarse sand to clay loam. They found that beyond approximately 450 mm of soil depth the faecal coliform count was below detection limits. At 150 to 300 mm soil depth the coliform count ranged from 2 to 24 MPN per gram of soil.

Therefore, as a result of the combination of the proposed tertiary treatment plant, the low application rate and the large depth of soil and subsoil; it is considered that the effect of microbes on any potential receiving groundwater and surface water will be minimal. Thus, the effects of wastewater application through microbial processes on the LTA and the environment are assessed to be negligible and acceptable.

7.4.2 Nitrogen

Nitrate-nitrogen is mobile through the soil and has the potential to adversely affect human health if present in high concentrations in drinking water. The Drinking Water Standards for New Zealand (Water Services Regulations, 2022) specify a maximum acceptable value of nitrate-nitrogen at 11.3 mg/L. The treated wastewater will have a total nitrogen concentration of 7.5 mg/L before application intro the soil. The total nitrogen in wastewater consists of organic nitrogen from organic matter, nitrite-nitrogen, nitrate-nitrogen, ammonium nitrogen, etc. Nitrate-nitrogen is a component of total nitrogen in wastewater.

Moreover, when wastewater containing 7.5 mg/L of total nitrogen is applied 200 mm below the surface, a significant portion of the nitrogen will be taken up by plants. Additionally, denitrification will occur, removing a major amount of nitrogen from the wastewater. This process implies that the concentration of nitrate-nitrogen in groundwater will be much lower than the prescribed limit for drinking purposes.

As discussed in Section 4.3.6, the LTA sites average nitrogen loading rate of 193 kg N/ha/yr is within the range of plant uptake capacity for a cut and carry, cut and leave, light sheep grazing and native plantation system. Therefore, nitrogen applied to the soils will provide a beneficial nutrient for plant growth and most nitrogen will undergo plant assimilation, immobilisation within the soil matrix or denitrification prior to potential leaching to ground of any surplus. The effects of nitrogen loading scenario has been discussed below under the specific headings.

Current Land Use and Permitted Baseline Loss

Wastewater systems

The Otago Regional Council (ORC) manages small-scale discharges from small-scale septic tanks, wastewater systems (discharge of less than 2000 litres per day) and long drops using Permitted Activity Rules 12.A.1.1 to 12.A.1.4 in the Regional Plan: Water for Otago (RPW) Plan. These permitted activity rules allow discharge of effluent, provided certain conditions are met. Within the permitted activity rule, the lot size is not a condition of the rule.

Application of Nitrogen

A landholding's diffuse N loss is managed under RPW. Under Rule 12.C.1.3 (a) (i) and Map H6 of the RWP, from 1 April 2026 it will be a permitted activity to apply nitrogen or use land in a way (across the total area of land managed by a landholder) that leaches up to 15 kg N/ha/yr. The nitrogen application rate is not limited under the rule, provided the residual leaching rate is less than 15 kg N/ha/yr modelled using Overseer® version 6 or later.

By way of comparison, this permitted N loss of 15 kg N/ha/yr across the proposed housing development area and Land Treatment Areas (LTA) could plausibly occur under a more intensive cropping and dry stock operation on this land. It is, therefore, a useful comparison of the proposal against what will be permitted by the RPW.

The permitted activity rule sets the landholding's permitted nitrogen mass that can be lost without consent. This means that the currently permitted leaching equates to a mass of 3,015 kg N/yr, being (201 ha x 15 kg/ha/yr) from the new subdivision and LTA area.

In relation to this proposal, this mass can be allocated between the loss associated with the new subdivision area and the loss from areas used for LTA.

The subdivision area is expected to leach 0 - 3 kg N/ha/yr from stormwater and gardens; for this development, the area is 172 ha equalling up to 517 kg N/yr, the remaining nitrogen mass of 2,498 kg N (3,015-517) can be applied to the LTA area of 28.4 ha LTA, allowing a permitted leaching rate from the LTA's of 87.9 kg N/ha/yr.

Table 7.1 shows the proposed loadings and N losses using OverseerFM modelling.

Overseer Outcomes

In addition to looking at the existing and permitted nutrient loss for the area, nutrient modelling using OverseerFM was undertaken. The current landuse nutrient budget and proposed system LTA nutrient budget were produced to indicate the potential leaching from the proposed application of treated wastewater on the LTAs. The input Nitrogen loading was applied at a rate of 149 to 220 kg N/ha/yr evenly across the year.

Nitrogen loading was applied as a soluble fertiliser, such as nitrate, to 28.4 ha of blocks. Using nitrate is conservative, as some of the WWTP effluent nitrogen will be in an ammoniacal form that is more tightly adsorbed onto soil cation exchange sites than soluble nitrate.

In the proposed LTA system, OverseerFM modelling applied the wastewater as irrigation in the form of drip irrigation. The total application depth modelled varied evenly across the year from 2,064 mm to 3,060 mm. There is no seasonal variability in the modelled irrigation depth.

A cut and carry system involve removing cut pasture and removing it off the site, which is applied to 24 ha of the land treatment area, with the remaining 4.4 ha modelled as lightly grazed by stock. The sheep grazing is to replicate irrigation of native plantings, and this cannot be modelled in OverseerFM.

The cut and carry is modelled as baleage or similar. For the OverseerFM model, 10 t DM/ha/yr of pasture silage was cut and exported off the 24-ha irrigated block. This model shows the effects of a typical cut-and-carry system, which could be conventional baleage or collected pastoral or turf grass cuttings.

The OverseerFM nutrient budget shows a total leaching value for the 4 different LTA areas to range from 68 to 86 kg N/ha/yr. This leaching is dominated by winter losses, as is to be expected, as irrigation is applied all year round (the nitrogen loss profile is similar to summer vs winter loss with the current farming operation). The total leaching value for phosphorus is 1.4 to 2.1 kg

P/ha/yr. Table 7.1 presents a summary of the RCL OverseerFM modelling. Additional Overseer modelling is presented in Appendix F.

Table 7.1: Nitrogen and Phosphorus Leaching - RCL LTA Scenario Summary

Scenario	Description	N added or removed	(Kg/ha/yr)	P added or removed	(Kg P/ha/yr)
LTA	RCL Land Treatment Area (28.4 ha)	N Added:	193	P Added:	64
		N removed as supplements:	185	P removed as supplements:	30
		N lost to water:	62	P lost to Water (overland flow)	1.8
Balance of the land holding	Lot 8 and 12 housing area (172 ha)	N lost to water:	2.2	P lost to Water (overland flow)	<0.1
Total Land Area Summary	201 ha	Total Development Area Average	10.2	Area Average	0.3

The calculation of Nitrogen loading pre and post proposed development are presented in Table 7.2. During the initial development period, as stages of the new subdivision are developed, the net reduction is expected to be greater.

Table 7.2: Nitrogen Budget Pre and Post-Development Nitrogen Leaching Estimate Land Use Area (ha) N Leached (kg/ha/yr) (kg/yr)

Pre-Development Nitrogen Leaching Estimate			
Land Use	**Area (ha)**	**N Leached (kg/ha/y)**	**(kg/y)**
Farmed area of subdivision and LTA permitted	201	15	3,015
Current landuse uses	201	9.1	1,839
Post-Development Nitrogen Leaching Estimate			
Land Use	**Area (ha)**	**Overseer estimated N Leached (kg/ha/yr)**	**(kg/yr)**
LTA (now including town and new housing development)	28.4	72	1,656
New housing development and recreational areas	172.6	2	**395**
Total Post-development	**201**		**2,051**

OverseerFM also presented the drainage nitrogen concentration associated with leaching. In the current farming system the drainage volume represents the balance between rainfall and evaporation. The concentration of N is reported to decrease with the LTA development due to increased drainage from the irrigation, adding to the water balance.

With the development of the WWTP and LTA's, there will be a potential increase of 212 kg nitrogen from what is currently occurring, and a reduction of 964 kg N able to enter the environment every year compared with the RPW allowable N loss. This equates to an 11 % increase over current landuse, and a decrease of 31% compared to the RWP "baseline" leaching[1].

Nitrogen Mass Balance Approach

An alternative analysis (to OverseerFM) to estimate leaching from the LTA is to consider research undertaken by Beggs et. al. (2011). Beggs explains that wastewater applied to land undergoes further biological processes, with research trials indicating that the concentration of nitrogen applied to the soil by wastewater treatment systems via subsurface drip irrigation is not 100% lost via leaching.

In the soil, many processes utilise nitrogen. Subsurface drip irrigation is considered more effective at removing nitrogen as it is located around 200 mm below ground and applies around 7 mm of treated wastewater per day to the active subsoil layer. Biological processes can further break down the nitrogen in the sub-surface layer, taken up by plant roots for growth, and exported by cut and carry harvesting systems.

The soils of the proposed LTA are considered to be equivalent to a silt loam soil (Loam). Based on the findings of Beggs et. al., (2011) (see Figure 7.1 below), the fate of wastewater nitrogen applied to land via subsurface drip irrigation in a Loam soil is:

- 0 – 32% via root uptake from plants;
- 40 – 62% lost via Denitrification; and
- 30% lost via leaching

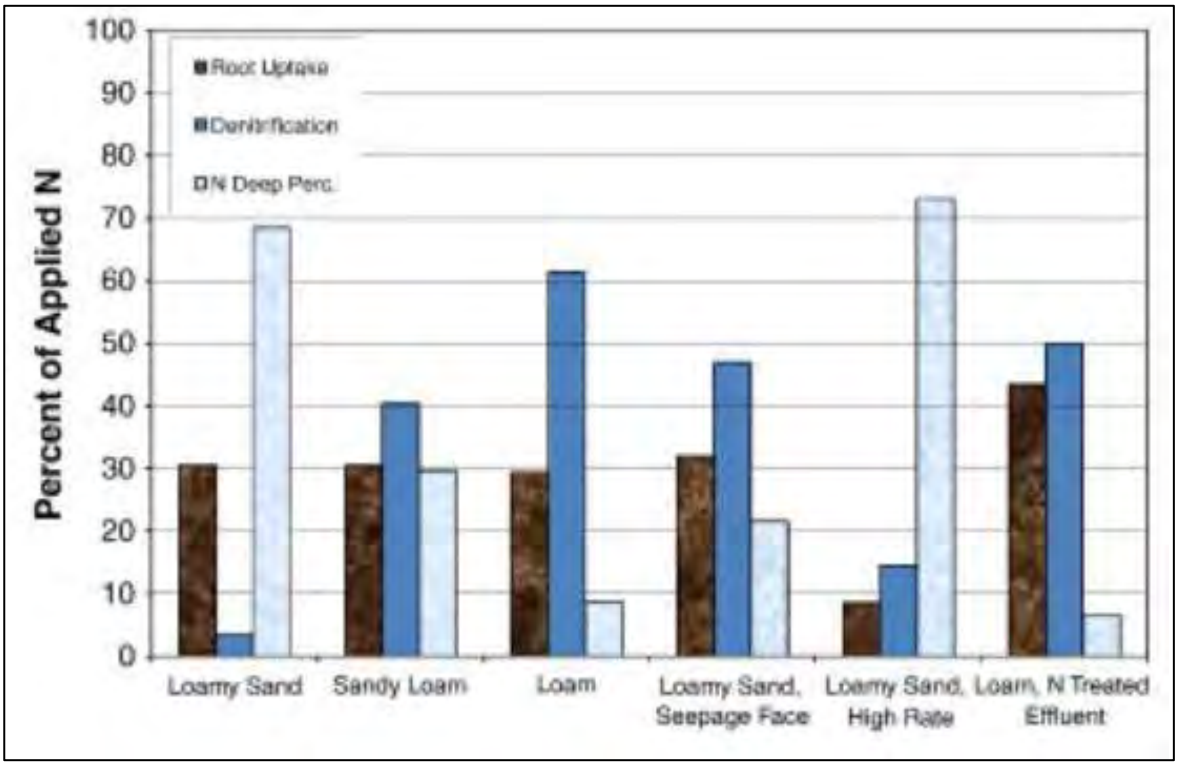


Figure 7.1: Fate of Nitrogen in Wastewater Effluent Applied to Land (Beggs, et. al., 2011)

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[1] ORC Regional Water Plan permits leaching of 15 kg N/ha/yr for land in nitrate sensitive catchments

For the proposed LTA system, if 193 kg N/Ha/yr is applied to 28.4 ha LTA, using Beggs et al., (2011), 8-30% estimation being leached below the root zone equates to 15-57 kg N/ha/yr. This is comparable to the OVERSEER® estimate in the section above for cut and carry of 72 kg N/ha.

Based on the preceding analysis, the potential for N leaching to ground or surface waters and any potential effects are likely to be the same as the status quo and considered acceptable.

7.4.3 Phosphorus

As previously discussed in Section 4.3.6 and 4.3.7, the proposed application rate will be approximately 64 kg P/ha/yr. This rate is less than the suggested phosphorus plant uptake capacity of 130 kg P/ha/yr – 160 kg P/ha/yr (Morton et al., 2000) for a cut and carry regime but greater than estimated for the current farming operation by OVERSEER® of 34 kg P/ha/yr.

The soil's P retention properties were investigated to assess the fate of the surplus P (30 kg P/ha if using the 34 kg/ha uptake from OVERSEER®). Phosphorus is not very mobile within the soil profile. The soil test analysis shows that the proposed LTA soil profile can retain large amounts of added P before the P migrates further down the soil/subsoil profile. In Table 7.3, the P retention has been calculated for the first 1.5 m of the soil/subsoil profile based on the Landcare Research laboratory analysis. Using 1.5 m is considered conservative, and depending on the depth of groundwater, there is a potentially greater subsoil depth for P storage.

The P retention analysis suggests that P supplied over 135 years at full loading rates can be stored within the first 1.5 m of the soil profile before significant P migration to layers beneath 1.5 m. This storage potential is much greater than the proposed consent duration of 35 years.

Table 7.3: Phosphorus Storage Capacity

Parameter	Manmade Soil	Pigburn (Sites: HB 8/2, HB 9/6, HB 10/7)	Wakatipu (Sites: HB 6/8, HB 5/9, HB 1/14, HB 2/15)
Bulk Density (kg/m³)(1)	1,300	1,300	1,300
Average P Sorption (mg/kg)	321	235	508
Treatment Soil Depth (m)	1	1	1
P Storage Capacity (kg P/ha)	4,175	3,052	6,607
Design P Storage Capacity (kg P/ha)	4,611		
P Loading Rate less DM export (kg P/ha/yr)	34		
Site Life (years)	135		

Based on the above, the leaching/runoff of total phosphorus off the LTA is expected to be low given:

- The conservative average hydraulic rate application rate (average 7 mm/d);
- The large P retention capacity of the soil;
- The added wastewater P is the primary source of phosphorus for the plant uptake; and
- There is a considerable vertical distance to any ground or surface water.

There is a low potential for phosphorous leaching to groundwater due to the large depth of soil matrix before any potential groundwater, and most (if not all) phosphorous will be retained within the soil profile and not be leached to groundwater.

Based on the preceding analysis, the potential for P leaching to ground or surface waters and any potential effects are expected to be negligible.

7.4.4 Direct Effects on Groundwater

As stated in Appendix C, the groundwater beneath and flowing downgradient of the site is not especially sensitive, the main risk is potentially contaminated groundwater flowing and re-emerging in streams and/or Lake Wakatipu.

The OverseerFM nutrient budget indicates a total nitrogen leaching rate of 68 to 86 kg N/ha/year across the 28.4 ha land treatment area, with winter losses being the most significant due to year-round irrigation, similar to the current farming operation. Phosphorus leaching is estimated at 1.4 to 2.1 kg P/ha/year. A summary of the RCL OverseerFM modelling is provided in Table 7.1, with additional modelling details available in Appendix F.

The development of the treatment plant and LTA is expected to see a slight increase in the mass of nitrogen entering the environment by 212 kg annually (considering the current land use of farming), representing a 11% increase compared to the current landuse. It is however predicted that there will be a dilution effect on the groundwater nitrogen due to the increase in water added to the shallow groundwater system associated with the wastewater.

Taking into account the underlying geology and depth of soil matrix prior to any potential groundwater abstraction and given the distance to the closest operative bore is over 600 m it is considered that the effects of wastewater land application on groundwater will be low.

7.4.5 Direct Effects on Surface Water

It is considered that the proposed discharge to land within the LTA has been designed in accordance with industry best practices and is the best practicable option for managing community wastewater to minimise adverse effects on surface water.

The proposed hydraulic loading rate over the 28.4 ha LTA will average 7.1 mm/day, which is significantly below the calculated topsoil’s saturated and unsaturated hydraulic conductivity. Therefore, the hydraulic loading over the application area will be such that the wastewater will assimilate into the soil profile without surface run-off or ponding. It is expected that the majority of the treated effluent applied (irrigated) to the land over the summer period is likely to be taken up via evapotranspiration (plant transpiration and soil evaporation) alone.

Consideration is given to the potential for surface run-off resulting from either a system failure or excessive rainfall beyond normal expectations causing the soil to become saturated and wastewater to be forced to the surface. This is unlikely as the soil saturated hydraulic conductivity is tested to be around 2 m per day, however, in the event of such an occurrence, any run-off would be significantly diluted, having filtered up through the soil and then percolating across a vegetated surface that has the ability to remove any remaining suspended contaminants.

Surface emergence of any applied wastewater is very unlikely due to the soil matrix and 200 mm depth of the emitter lines. For those ephemeral surface water features that are located near the LTA areas, a 10 m buffer has been provided to separate the subsurface irrigation and minimise the risk of contaminants entering the streams.

All watercourses on the site and near the LTA are ephemeral and therefore unlikely to deliver contaminants to Lake Wakatipu from subsurface applied effluent. The main vector for treated wastewater to enter relevant surface water features (such as the unnamed tributaries), is receiving water through groundwater discharging into it. For nutrients that do emerge in the lake, the net reduction in nitrogen concentration from the current situation and further mixing and dilution means that the Lake Wakatipu water nutrient concentrations will maintain at very low levels. The proposed change in land use with a community wastewater treatment system and the land management will have little to no effect on or cause additional surface water runoff as the land treatment method is via subsurface drip irrigation.

The LWP memo (Appendix C) assess the nitrogen and phosphorus loading assessment detailed in Sections 4.3 and 7.3 and provides a detailed assessment of the potential impact on all surface water features associated within and surrounding the development site. The overall conclusions of the report's author in that assessment of the likelihood that treatment systems laid out in the consent level design report (LEI 2025) can meet the RWP Schedule 15 limit for TN of 0.1 mg/L in samples taken 5 m from the lakeshore is:

i) *I am moderately confident of meeting the 0.1 mg/L limit in 80% of samples collected at 5 m (as is the RWP stated requirement). I wouldn't be surprised if the odd sample exceeds 0.1 mg/L before sufficient mixing has occurred during brief calm periods. However, I don't think that situation would give rise to any discernible adverse effects.*

ii) *I am very confident that the 0.1 mg/L limit would almost always be met within a distance of 25 m from the shoreline.*

The risk of benthic cyanobacterial blooms (i.e., those that grow attached to the lake-bed), or for that matter any nuisance periphyton (e.g., attached algae) or fungus growths near the shore in Homestead Bay, is considered low due to the frequent wind-driven wave action, as evidenced by observation of very clean gravels and cobbles in that area as described in LWP Memo (Appendix C).The risk of nuisance benthic growths would increase if there were extended calm periods in Homestead Bay.

Accounting for the low expected concentration of N and nil additional contribution of P combined with the volatility of the catchment hydrology means that the risk of nuisance periphyton is expected to be very low.

7.5 Effects on Ecology

The two unnamed tributaries flowing through the LTAs contain little to no ecological value. Therefore, given this and the good management proposed, including subsurface application at a low loading rate, and a 10-metre setback from waterways, any effects on ecological value of these tributaries will be negligible. Māori Jacks Stream and Lake Wakatipu hold ecological value, however the only potential effects on ecology from the proposed subsurface discharge of wastewater to land would be contaminants entering the waterbodies and degrading water quality. However, as discussed in Section 7.4, effects of the proposal on surface and groundwater quality will be low, therefore effects on ecology will also be very low. Water quality monitoring conditions are also proposed (Section 9) to ensure there are no unforeseen effects.

7.6 Climate Change Effects

Climate change presents both challenges and opportunities for wastewater application in the LTAs, requiring adaptive strategies to enhance resilience and sustainability. Projected temperature increases of 0.5–1.5°C by 2040 and up to 3.5°C by 2090, along with a reduction in frost days, may extend the growing season, allowing for increased biomass production and improved plant uptake of nutrients from wastewater. While extreme hot days (>30°C) will become more frequent, requiring more water application to soils and assimilation in the environment. The anticipated increases in annual rainfall (up to 10% by mid-century and 20% by 2090) will allow the groundwater dilution of wastewater irrigation during wetter periods.

Moreover, the addition of treated wastewater to land will bring benefits which will positively impact upon mitigating Greenhouse Gas Emissions (GHG) and climate change.

1. The beneficial reuse of wastewater on land will supply water and nutrients to plants which will increase the photosynthesis in that area. The increased photosynthesis will enhance the removal of carbon from atmosphere and help to mitigate climate change.
2. The land application will allow the cycling of nutrients to plants from wastewater, and this will reduce the need for chemical fertilizers (e.g. P and N). This will indirectly reduce the use of energy to manufacture these fertilizers and will reduce the emission of GHGs from industries.
3. The near surface application in an oxidised condition will decrease the chances of producing N_2O and CH_4 which have at least 300 and 28 times more potent in global warming than CO_2.
4. The supply of nutrients and organic matter will allow the use of organic matter to sustain plants and microbe life while allowing to attain a circular bioeconomy.
5. The land application will allow the soil to act as a natural buffer and manage the harmful microbes (if there is any) naturally instead of using additional harmful chemicals.

Thus considering the above discussion, it is considered that any potential impacts of climate change will be acceptable.

7.7 Effects on Existing Water Takes

Jacks Point Land Limited take surface water from Lake Wakatipu, downstream of the Homestead Bay Development site near Māori Jack Stream, for community water supply. This is a registered drinking water supply servicing a population of 1,750 people at the neighbouring Jacks Point subdivision. Therefore, it is important to consider the risk of contaminants from the wastewater discharge affecting this water supply.

As discussed above, the proposal is for subsurface drip irrigation at a low application rate, with further treatment occurring through natural soil processes. The depth to groundwater at the site ranges from approximately 4-15 metres below ground level. The 10 metre setbacks will be maintained between the LTAs in the northern area of the site and the ephemeral streams. However, even if contaminants were to enter the streams, it is considered highly unlikely that these ephemeral streams would transport the nutrients hundreds of metres downstream to Lake Wakatipu or other streams.

Even in the event that the streams are flowing due to stormwater and rainfall runoff, any nutrients transported to the lake would be at negligible concentrations given the soil treatment processes and significant dilution effects of the waterbody stormwater flows and the lake.

The possible LTAs at the south of the site, closer to the lake and other tributaries, theoretically may pose a greater risk. However, the LTA would be at least 150 metres from the nearest surface water body at this location, and potential effects are mitigated by the high treatment standards at the WWTP to below drinking water standards for nitrate and low bacterial concentrations before further treatment within the soil and subsoil matrices. The soils have high infiltration rates compared to the irrigation application rate. The times of flow will also always occur when there is significant wave mixing at the lake edge, as detailed in the assessment by LWP (Appendix C).

Overall, the proposal will not result in any detectable effect on the drinking water supply.

7.8 Effects on Amenity Values

The irrigation system within the proposed LTA will be buried and constructed to blend in with the surrounding environment to reduce visual effects.

A landscape assessment of the subject site and proposed development has been completed by Rough Milne Mitchell (RMM) Landscape Architects, who also contributed to the development of the masterplan as part of the project team. The Homestead Bay Development site is situated between Outstanding Natural Landscapes (ONLs); the Remarkables to the east, Lake Wakatipu to the south and west, and Jacks Point Hill and Peninsula Hill to the west and northwest. While the site contains some landscape features of value, such as hummocks and gullies, its predominant landscape values derive from the surrounding ONLs. However, the site itself is not located within an ONL.

The transformation of the land into an urban environment will align with existing developments on adjacent land, including Jacks Point and Hanleys Farm to the north and Lakeside Estates to the south. This development will contribute to a continuous urban corridor as envisioned by the Queenstown Lakes Spatial Plan.

Additionally, native planting will be carried out in gullies, along the lake escarpment, and within recreational areas to enhance the site's natural character.

The LTA’s will provide enduring open space areas around the development and there will be no visible built form or structures above ground. The only physical identifier of the location of the LTA’s will be ground surface valve boxes and in the drier months the LTA’s may appear greener than surrounding landscaped areas if irrigated, however the visual effect is unlikely to be stark nor out of place with the existing rural environment (which involves irrigation) nor the emerging urban context.

This is similar to the existing LTA areas within the neighbouring Jacks Point Residential area which does not have any notable visual effects and could be considered as a practical example of the negligible visual effects of managing wastewater in LTAs. Figure 7.2 and Figure 7.3 below are examples of typical LTA scenery. In these areas the dripper lines are buried as is proposed for the Homestead Bay scheme.

Figure 7.2: LTA Example Subsurface Drip Fields

Figure 7.3: Example LTA Subsurface Drip Irrigated Areas

In summary, it can be concluded that the proposed discharge of treated wastewater to land in the Homestead Bay development site will be subsurface and therefore will have negligible effects on amenity values given the wider residential development.

7.9 Effects on Public and the Community

It should be noted that currently, there is no community wastewater treatment scheme. It is considered that there will be minimal effects on the people in the wider community from the Homestead Bay Development effluent discharge because the proposed LTA and WWTP will be located on private property (Homestead Bay development). People will be alerted to the LTA by signage. The high-quality treatment of the community wastewater will ensure that the discharge prior to land treatment meets the equivalent of the Victoria Government Class B recycled water standard. There will be acceptable health effects arising from *E. coli* as a result of the application to land and public access. In the Jacks Point development, land treatment has been successfully integrated into the landscape with the LTA used for passive recreational activities.

Aerosols will not be produced from the wastewater treatment discharge as the application to land will be via subsurface irrigation. The treatment system will not be odorous when working correctly and robust monitoring and control devices will notify if any system fails or performs poorly. For these reasons, adverse effects resulting from the wastewater land application system are considered to be no more than minor.

7.10 Effects on Air Quality

The permitted baseline is applied to effects on air quality. Consent is required due to the LTAs being within 150 metres of residential dwellings and amenity areas, even though LTAs will be underground and will not create a discharge to air. As discussed above, aerosols will not be produced and there will be no noticeable odour from the discharge of wastewater to land because the application method is subsurface. Robust monitoring and control devices will notify if the system fails or is performing poorly. Therefore, any effects of the proposal from land disposal on air quality will be insignificant. The existing Jacks Point land treatment areas with subsurface drip are examples of this and demonstrate there is no identifiable air quality effects.

Discharges to the air from the treatment plant are addressed in the Stantec Engineering Assessment.

7.11 Effects on Tangata Whenua Values

As described in Kāi Tahu ki Otago Natural Resource Management Plan 2005 (IMP), Lake Wakatipu is an important source of freshwater that sustains many ecosystems important to Kai Tahu ki Otago. Wai Māori issues for this catchment include:

- a lack of reticulated community sewerage schemes
- existing sewage schemes not effectively treating the waste and do not have the capacity to cope with expanding population
- land use intensification
- increase in lifestyle farm units which increases the demand for water
- sedimentation of waterways from urban development

In specific reference to the management of wastewater, Pauling, C., and Ataria, J., (2010)[2] references the following provided to the 2001 New Zealand Land Treatment Collective Conference; "*Te Rūnanga o Ngāi Tahu's tribal policy opposes the direct discharge of wastewater, including effluent, to waterways. Discharges to land are generally encouraged… Agencies need to be aware that although discharges to water may be within*

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[2] Pauling, C., and Ataria, J., (2010)., Tiaki Para : a study of Ngāi Tahu values and issues regarding waste. Lincoln, NZ. Manaaki Whenua Press, Landcare Research.

acceptable biological or physical water quality standards, it may not be acceptable from a cultural perspective… It is not a question of the water being within national or international health standards – if water contains wastewater… then the mahinga kai that particular waterway sustains cannot be harvested and eaten."

Based on these cultural views and values, Te Rūnaka prefers wastewater to be treated (preferably land-based) before discharging into natural waterways or groundwater. Therefore, treatment to a high quality and application to land of treated effluent is an approach consistent with the resource management policies in both the Kāi Tahu ki Otago Natural Resource Management Plan 2005 and Te Rūnanka's Freshwater Policy. Treating wastewater and applying it to land at a sustainable rate minimises the impact of pollutants on soils and receiving groundwater.

Of concern to Te Rūnaka is the protection of sites of cultural significance such as Nohoanga sites (traditional camping sites associated with māhinga kai – food gathering), sites of wāhi taonga and tapu (sacred and treasured sites) and "silent files" which are unidentified areas of cultural and spiritual significance. Lake Wakatipu is a Statutory Acknowledgement Area (SAA) to Te Rūnaka which will be assessed further below. There have been no other sites identified as having cultural significance within the vicinity of the proposed LTAs. Nonetheless, the use of an accidental discovery protocol will be volunteered as a condition of consent (Section 9).

The proposed LTA has been selected on the basis of its location and ability to minimise effects on the environment, including on lake water quality. The proposal is for a high-quality, controlled community wastewater treatment system and therefore is not an activity that is expected to have any significant risk to tangata whenua values. By contrast, it is seemingly their preferred approach to wastewater management as opposed to onsite wastewater systems. The discharge of wastewater will be to land rather than water, with setbacks from surface water features and groundwater bores. As discussed, effects on Lake Wakatipu (and thus the SAA) from the proposed discharge will be negligible, and therefore given the above, it is anticipated that the proposed system design and management will not have any adverse effects which are unacceptable on cultural values.

7.12 Cumulative Effects

Although land treatment of wastewater has many beneficial effects, there are also potential negative impacts if wastewater application systems are not managed properly. The presence of E. coli, nitrogen, and phosphorus in concentrations higher than those found in ordinary groundwater and surface water increases the risk of contamination.

Most relevant to consider in this instance is the cumulative effects of both Jacks Point wastewater discharge and the proposed Homestead Bay wastewater discharge. Both residential developments are contributing contaminants to the same ultimate surface water catchment and groundwater system. Therefore, it is important to consider the effects of both sites on the receiving environment.

The LTA areas within Lot 12, areas A to G, are adjacent to or between the existing Jacks Point land treatment area. Area M is an area consented to and constructed for the Jack Point Village development but has not been commissioned, as the wastewater from the Village development is conveyed to QLDC Shotover WWTP. This casts doubt on the need for an ongoing easement right over this land. The Applicant intends in due course to work through this matter with interested parties.

The risk to JPROA authorised activities and consent compliance is avoided or effects are mitigated by the following design features and factors:

- The nitrogen and phosphorus loading rates are similar to the 2024 farming nutrient loss, not changing the current risk of cumulative nitrogen loading;
- The nitrogen loss following development is less than ORC RPW permitted for farming landuse;
- High levels of treatment by RCL wastewater will have a dilution effect on JPROA groundwater due to the following factors;
  - nitrogen treated to 7.5 mg/L compared with 15 mg/L for JPROA,
  - phosphorus treated to 2.5 mg/L compared to 12 mg/L,
  - irrigation rate of 8 mm/day vs 12 mm/day, and
  - French drains to capture lateral flow from areas B and C, avoid potential drainage and rainfall runoff moved off the RCL LTA to the JPROA LTA;
- Homestead Bay will be developed in stages with areas D to G and M able to be developed last;
- If lower flows per lot eventuate compared to the basis of design (in accordance with the QLDC Code of Practice, less treatment area would be required to accommodate the lower flows, enabling greater separation between the schemes; and
- The Applicant and the JPROA could work together on compliance monitoring.

Any mismanagement by either system could negatively affect either consent holder's compliance and, if significant, both local surface water and groundwater quality. Therefore, proper monitoring is essential to ensure that the entire wastewater treatment system is functioning effectively and that the discharged wastewater meet the proposed wastewater quality standards (discussed in Section 4.3.2).

If proper maintenance is conducted alongside effective treatment and monitoring of the wastewater treatment plant performance and monitoring of the Land Treatment Areas (LTA), no unacceptable adverse effects are anticipated. Thus, maintenance and monitoring of the wastewater management system, as well as regular assessment of treated wastewater at both the treatment plant and the land application site, along with its impact on the receiving environment, including at strategic locations designed to measure the effects of the LTAs proposed in this scheme, are crucial to achieving the positive effects of wastewater application to land.

Monitoring conditions have, therefore, been proposed to account for the joint contributions from the Jacks Point subdivision and RCL to the environment. It is considered appropriate to adopt similar conditions and take water quality samples from the same bores and monitor Lake Wakatipu's water quality at the same locations. The LWP assessment (Appendix C) provides recommended surface water quality conditions.

7.13 Summary and Cumulative Effects

With the development of onsite WWTP and LTAs, will allow the development of a significant area of residential housing and commercial land with nutrient and bacterial standards aligned within the current landuse and losses anticipated by the RPW for nitrogen while maintaining the very high water quality within Lake Wakatipu. During the initial period of the development, as stages of the new subdivision are developed, the net reduction in nutrients is expected to be greater, and grazing can be retired, allowing for areas to be used for grass harvesting.

The proposal contributes to the wellbeing of the community, amenity and cultural concerns.

The effects of the Homestead Bay Development proposed land application of treated effluent within the boundary of Homestead Bay Development has been assessed as having a very low impact on the receiving environment.

8 CONSENT DURATION

A consent term of 35 years is sought for the proposed discharge of wastewater onto land from the Homestead Bay residential development and the associated discharge to air.

The duration of the proposed consent provides for future community growth and the staged nature of the development. Other reasons that a 35-year term is appropriate for the proposed activity include:

- The WWTP system is new and therefore is within the expected lifespan of the system
- Wastewater discharged to land is of a high quality and will be under controlled conditions to ensure adverse effects are no more than minor
- The discharge to land will be undertaken in accordance with the Operations and Management Manual, and includes a robust monitoring programme
- Ongoing monitoring will ensure that any increase in level of effects beyond what is anticipated will be able to be remedied and actions taken to resolve the issue
- There is no alternative community system option available to the site i.e., council network, and is the best practicable option for a significant residential development. Therefore, a long-term consent will provide certainty and ensure wastewater will be appropriately managed
- There is no reason for a reduced consent duration given the staged development, high-quality treatment, controlled conditions, robust monitoring and recording programme, benefits to the community, and the community reliance on a reliable wastewater treatment system.

9 CONCLUSION

Given the above, it is considered that it is appropriate to grant consent to this application in terms for the following reasons.

The proposed Homestead Bay Development WWTP and land application scheme will provide a high-quality, controlled wastewater management system for a large residential development. Further to this:

- The proposed land treatment area will be no less than 5 ha during initial development, with a minimum of 28.5 ha at full development;

- The closest LTA area will be sited no less than 400 metres from Lake Wakatipu and 10 metres from ephemeral watercourses.

- The irrigation of wastewater to land will provide beneficial nutrients, to a nutrient deficient soil, allowing for improved plant growth.

- The proposed new scheme will allow QLDC to provide for the wastewater treatment needs of the Homestead Bay Development and housing developments in a sustainable manner including an adequate allowance for population growth.

- The proposed activity is consistent with the objectives and policies of the Otago Regional Plans.

- The applicant has undertaken a thorough assessment of alternative methods for the discharge and concludes that the proposal is the best practicable option, and the best suited wastewater treatment system will be selected to meet the future consented limits.

- The proposed activity will not, after reasonable mixing, result in the production of any conspicuous oil, grease films, scums, foams or floatable or suspended materials; conspicuous change in the colour or visual clarity of the nearby waterways, any emission of objectionable odour; render fresh water unsuitable for consumption by farm animals or have any significant adverse effects on aquatic life.

This assessment concludes that the proposal will promote the sustainable management of natural and physical resources while avoiding, remedying or mitigating adverse effects on the environment.

A term of 35 years is sought for the resource consent to allow the discharge of wastewater onto land from the proposed Homestead Bay Development WWTP.

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11 APPENDICES

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APPENDIX A

Consent Design Report

Homestead Bay Consent Level Design

Wastewater Land Application

Prepared for

RCL

Prepared by

LOWE
Environmental
Impact

March 2025

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Homestead Bay Consent Level Design Wastewater Land Application

RCL

This report has been prepared for the **RCL** by Lowe Environmental Impact (LEI). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other parties.

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1 EXECUTIVE SUMMARY

The purpose of this report is to present the consent-level design for the wastewater land treatment system for RCL's Homestead Bay development. The proposed development will include approximately 2,580 residential lots/units, a commercial village, and possibly a school. The system is designed to minimise adverse environmental impacts while meeting community expectations for cost-effective and efficient wastewater management.

The wastewater treatment strategy incorporates land treatment via a pressure-compensating drip irrigation (PCDI) system for treated effluent discharge to an area of approximately 28.5 ha. This land-based system aligns with sustainable water and nutrient reuse principles while maintaining compliance with environmental standards. The development will occur in staged phases, with wastewater flows and treatment capacities increasing alongside residential and commercial expansion.

The consent level design assesses:

- Wastewater discharge characteristics, including influent and effluent quality.
- Site conditions, such as soil composition, groundwater flow, and surface water dynamics.
- Operational regime and monitoring requirements to ensure system compliance.

The selected system combines advanced wastewater treatment with land treatment areas (LTAs) to optimise nitrogen and phosphorus management while reducing leaching and environmental risks.

The flows have been based on NZS 4404 and QLDC Code of Practice. It is considered that these flows are conservative as they are greater per dwelling than measured flows from similar developments in the region. The adopted design dry weather flow at full development is 2,005 m^3/d, with a peak wet weather flow of 3,974 m^3/d, based on a gravity reticulation.

Options for four likely wastewater treatment plants (WWTP) have been identified, which are all variations of the activated sludge process and capable of producing a high quality effluent with quality in the order of $cBOD_5$ 20 mg/L, TSS 20 mg/L, TN 7.5 mg/L, TP 2.5 mg/L, and *E.coli* 100 to <1,000 MPN/100 mL. These WWTPs and the LTA can be staged as the development progresses.

Soil assessments have arrived at conservative average design loadings of 5 – 8 mm/d, depending on soil type and slope, at an application rate of approximately 2.67 mm/hr, which is well below the soil infiltration acceptance rates.

There are several factors that can be changed to manage the environmental impacts of a development such as this. These can include the selection of the LTA locations, the wastewater flow assessment and expected loading at the WWTP, the level of treatment within the plant and the operation of the LTA.

For the case of RCL, there may be limited available area for the LTAs, so the treatment in the WWTP and the operation of the LTA have been optimised to meet the land area requirements and achieve TN leaching to meet defined receiving water standards.

Groundwater is at a depth where mounding will not be an issue at the application rates proposed. All of the site ultimately drains to Lake Wakatipu. This lake has a very low trophic index of 2 – 3

(Oligotrophic), meaning that it has very low nutrient levels, and the design proposed seeks to maintain this high quality level.

Nitrogen loading to the land treatment area's after the WWTP treatment varies depending on land management, with an average of 193 kg N/ha/yr discharged to land at a WWTP discharge average quality of 7.5 mg/l. Land management varies from cut and leave, grazing, native planting and cut and carry (harvesting).

The current farming system over the 201 Ha has been estimated to leach an average of 9 kg N/ha/yr. The proposed system, including the urban development and wastewater treatment, has been modelled using the Overseer model to leach an average of 10 kg N/ha per year. The predicted losses are estimated to be similar and within modelling error to the current land use leaching loss of 9 kg N/ha/yr and less than the permitted nitrogen leaching in the ORC Regional Plan of 15 kg/ha/yr. The total nitrogen leached into Lake Wakatipu is modelled to be 31% less than the amount permitted under the Regional Plan.

Phosphorus applied from the treatment plant is modelled to average 64 kg P/ha/yr, with plant uptake and removal from the sites, any surplus in phosphorus is estimated to be retained in the soil. The soil has the capacity to receive at least 135 years of treated effluent application before P is expected to exceed the capacity of the soil and for phosphorus to leach below the first 1m and deeper into the soil profile. Therefore, little, if any, phosphorus is expected to leach into Lake Wakatipu or other water bodies via the groundwater system.

The proposed system is considered to be sustainable long-term, and thus consentable.

2 INTRODUCTION

2.1 Purpose

This report provides the consent level design for the land treatment of the wastewater from RCL's Homestead Bay development. This report describes the design regimes and presents reasonable and appropriate systems to align with the proposed development to minimise adverse environmental effects. This report does not detail the effects of wastewater application on the environment. The environmental effects of the activities and mitigation methods will be addressed in the consent application. The proposed design allows wastewater treatment and discharge to best meet the new community's expectations while optimising the capital and operational costs. Where the design has been modified to avoid or mitigate potential adverse environmental effects known at the time of writing, those matters have been included in this report.

RCL is investigating the development of Lot 8 DP 443832 (163.46 ha) and Lot 12, DP 364700 (41.6 ha), upon which one inhabited building is currently erected (as seen in Figure 3.1). RCL has identified areas within Lot 8 and Lot 12 for the potential of land treatment of wastewater, as seen in Figure 3.1.

The proposed activities include residential housing with a mix of densities, from apartment blocks to low-density housing. This includes approximately 2,580 residential lots/units, a commercial village shopping area along with a potential school site.

Light commercial activities will likely occupy 2.16 ha. The proposed activities are likely to include:

- Food retailing, including supermarket and food and beverage services such as cafés, restaurants and bars;
- Retailing, including personal accessories and services such as clothing and footwear, recreational bike/ski service activities, personal care services such as hairdressers, dentists, physiotherapists and the like; and
- Small scale office spaces.

A potential primary school allowing for up to 600 students has also been factored into the assessment.

New Zealand Standard 4404:2010 has been used as the basis for flow rates for light industrial and commercial activities at 0.4 litre/second/hectare (L/s/ha) for the 12-hour operational period.

For the site, the options for reticulation, wastewater treatment, and discharge have been assessed, and the proposed system has been selected. Developing a land-based discharge system is the preferred option for RCL, with the option of including high-rate subsoil trench discharge for high-flow management in the future if appropriate. This Consent Level Design focuses on the proposed option of land application of all RCL's treated wastewater via pressure-compensating drip irrigation (PCDI) to allow for further treatment in the soil/plant/atmosphere system via a communal discharge of treated wastewater to land.

2.2 Background

The proposed PCDI allows for the development of the discharge area in progressive stages. These stages will meet the discharge volume for each stage up to the design average dry weather daily discharge of 2,005 m^3/d and wet weather flow up to 3,973 m3/d with communal discharge to several small land treatment areas (LTAs) within the RCL-owned parcels.

LEI has developed the land treatment design using flows adopted with Stantec (10 October 2024), using QLDC subdivision development Code of Practice wastewater flows, allowing for the development of the flow profile for the LTA design. These flows are conservative compared to measured flows from similar developments in the region.

2.3 Scope

This Consent Level Design report contains the following information:

- Section 3 characterises the wastewater to be discharged;
- Section 4 outlines the critical receiving environment properties to be addressed by the system design;
- Section 5 describes the discharge system and staging of the Project;
- Sections' 6 and 7 explain the operational regime; and
- Section 7 Conclusions.

As stated above, this report describes the system design of the Project. This report does not include details of the proposed activities effects on the environment and mitigation methods. These details will be included in the consent application.

Criteria and parameters adopted in this report are considered conservative, and there will be scope for refinement at the detailed design stage.

3 DISCHARGE CHARACTERISTICS

3.1 Project

A number of options have been considered for the project, and from investigations there are a number of WWTP systems, and proposed land treatment areas that can meet the sites environmental opportunities and constraints.

A site visit was completed to understand the soils onsite, with results presented in the Soil Assessment (Appendix A).

The wastewater treatment from the development is proposed to occur via a combined treatment plant and be discharged to land for further treatment via several LTAs within the RCL-owned parcels. This proposed system is designed for a dry weather discharge rate of 2,005 m^3/d and wet weather flow rate of 3,973 m3/d.

The construction of the LTAs is to be undertaken as the wastewater flow increases. The full development loading rate has been calculated with a LTA area of 28.5 ha, with the areas shown in Figure 3.1.

The proposed land treatment system design combines population density, reticulation type, treatment level, and land application area to configure a scheme that minimises environmental effects.

3.2 Basis of Design

3.2.1 Wastewater Influent Quality

Most wastewater generated will be from each Lot's toilets, showers, laundry, and kitchen facilities and will, therefore, have the characteristics of conventional domestic sewage. Wastewater from some of the commercial areas, such as cafés or restaurants, will be stronger, similar to blackwater. The cafés and restaurants will require an additional grease trap.

Therefore, the typical influent wastewater constituents[1] are expected to have Biochemical Oxygen Demand (BOD_5) 220 mg/L, Suspended Soils (TSS) 220 mg/L, Total Nitrogen (TN) 40 mg/L and Total Phosphorus (TP) 8 mg/L.

3.2.2 Wastewater Effluent Quality

All wastewater treatment units considered in this report can be configured to achieve advanced tertiary treatment quality, providing the necessary nutrient reductions. Annual average treatment quality parameters will be proposed for consenting, as this allows some reduction in treatment efficiency during colder weather conditions.

The effluent quality required from the WWTP will depend on the selected area to be irrigated. The expected final stage effluent quality for the WWTP options on an annual average basis is $cBOD_5$ 20 mg/L, TSS 20 mg/L, TN 7.5 mg/L, TP 2.5 mg/L, and *E.coli* 100 MPN/100 mL. From discusss with WWTP designers at Apex Water and Stantec, it was confirmed that the treatment quality standards proposed for the full design are considered realistic to achieve.

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[1] Metcalf and Eddy 3rd ed 1991

The WWTP is proposed to be configured to produce an effluent with low total nitrogen, i.e. 7.5 mg/L, and low total phosphorus, i.e. 2.5 mg/L, to match the annual application rate of up to 220 kg N/ha/yr and a maximum average application depth of 8 mm/day.

3.2.3 Wastewater Flows

For the calculation of wastewater flows, the proposed activities include cafés, retail activities and possibly a school, where flows are treated as a separate wastewater source. The New Zealand Standard 4404:2010 (Table 3.1) flow rate of 0.4 L/s/ha for the 12-hour operational period over the 2.16 ha of commercial space has been used. Note that this rate includes peaking factors, so no additional flow needs to be added for inflow and infiltration (I/I), or diurnal peaks.

The adopted design flows for the non-residential component of the development have not removed the peaking factors when looking at average daily flows or taken into account the working week only days for the commercial area and school. Therefore, the design dry weather daily flows for the commercial area could be reduced by a factor of 5 and the annual flow reduced by say 5.5/7. In the overall context of the development, removing the peaking factors will make little difference and have been left as they are to be conservative.

The design flow for the residential lots/units is based on a population density of three people/lot. The assessed population numbers are presented in Table 3.1. This based on the proposed subdivision layout design in October 2024.

Table 3.1: Estimated Population

Influent Location	Units	Population per day
General Activities		
School (600 students + 60 teachers/staff)		660
Subtotal (People/day)		**660**
Housing		
Apartments	592	1,776
Terraced Housing	764	2,292
Standalone Housing	1,222	3,666
Subtotal Housing (People/day)		**7,734**
Total		**8,394**

The design flow rates have been modified and calculated using standards relevant to domestic wastewater management using NZS 4404:2010 Land Development and Subdivision Infrastructure for communal systems incorporated into Queenstown Lakes District Council Land Development and Subdivision Code of Practice (2020) (QLDC COP) and NZS 1547:2012. Two methods of wastewater flow predictions have been used to assess the expected flows at RCL.

The first method (Method 1) uses the QLDC code of practice and requires the assessment to be undertaken using 3 people/house, with the Average dry weather flow of 250 L/p/d with standard fixtures.

The second method (Method 2) is based on the observed flows of similar subdivisions in the QLDC area. Some QLDC wastewater flow monitoring has been completed for Hanley's Farm and Shotover Country, which, are expected to be similar to the development proposed here. The figures LEI received indicated flows of 468 L/household equivalent/day (L/he/d) at Hanley's Farm and 513 L/he/d at Shotover Country, being somewhat below the QLDC COP assumption of 750 L/he/d (Queenstown Lakes District Council, 2024). It is understood that some of the measured flow data are provisional and that more data would be desired for a lower design flow to be broadly accepted for the basis of design. It is nevertheless LEI's view that the 750 L/he/d assumption is likely to prove conservative. The design and management of the Homestead Bay system will present an opportunity to verify actual flows over time.

Two methods can be applied to estimate the total flow from the proposed development. Method 1 is considered conservative with a blanket 250 L/p/d. Method 2 (of 520 L/he/d) is considered more likely to be a realistic flow for the development. Using a staged development the installed WWTP capacity and LTA area can be matched to the actual flows.

The wastewater flows have been derived using Method 1, based on QLDC COP are shown in Table 3.2, the LTA has been sized using the Average Daily Flow (ADF) of 2,005 m^3/day. While also having the capacity to receive intermittently higher flows up to the Peak Wet Weather Flow (PWWF), which can occur during times of wet weather. It should be noted that the flow associated with diurnal variations will be stored and balanced as part of the WWTP.

Table 3.2: Estimated Population and Average Wastewater Volume (QLDC COP 2020)

Influent Location	**Lots**	**Peak Population Numbers**	**Flow Rate (L/p/day)**	**Design Average Daily flow (m^3/day)**	**Design Peak Wet weather Flow (m^3/day)**
General Activities					
Commercial Flows (Light) (Incl. Cafés, Retail and other)	2.16 ha	0.4 L/s/ha of Commercial Space (12 hour period)		37	37
School (600 students + 60 teachers/staff)		660	53[2]	35	69
Total General Activity Flow				**72**	**106**
Lot Type		3 P/lot	250 L/p/d		
Apartments	592	1,776	250	444	888
Terrace Houses	764	2,292	250	573	1,146
Standalone Houses	1,222	3,666	250	917	1,833
Subtotal Housing	**2,578**			1,934	3,867
Total		**8,394**		**2,005**	**3,974**

For comparison, the wastewater flows calculated using Method 2 and based on 520 L/he/d are shown in Table 3.3.

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[2] The flow of 53 L/p/day – Per comms Stantec, based MOE design basis

Table 3.3: Estimated Population and Average Wastewater Volume (NZS4404:2010 and NZS 1547:2012)

Influent Location	**Bedroom Mix**		**Peak population**	**Expected Average Daily Flow (m^3/day)**	**Peak Wet Weather flow (m^3/day)**
General Activities					
Commercial Flows (Light) (Incl. Café, Retail and other)	2.16	0.4 L/s/ha for Commercial Space (12 hour period)		37.3	37.3
School (600 students + 60 teachers/staff)		660	53	34.7	34.7
Total People/day			**52.5**		
Options for Residential Development					**Average Flow (L/household equivalent/day)**
592 Apartments	10% 1 bedroom, 50% 2 bedroom, 40% 3 bedroom	1 - 2 bdrm ppl/unit of 2 and 3+ bdrm 3 ppl/unit	1,421	264	446
764 Terrace Houses	100% 2 bedroom	2 bdrm ppl/unit of 3	2,292	426	558
1,222 Standalone Houses	Mostly 3+	3 ppl	3,666	682	558
Total			**7,379**	**1,444**	**520 L/he/d**

3.3 Determinant Loading

The wastewater application rate to land will depend on soil's N loading, and soil's category (i.e. the ability of soil to percolate water which is known as soil's saturated and unsaturated hydraulic conductivity). The design average application depths across the proposed LTA areas ranges between 5 - 8 mm/day for the PCDI system adopted.

3.3.1 Land Treatment Area

The selection of the LTA locations and their total size allows for the following factors - the nutrient loading, total volume of wastewater generated, soil's saturated and unsaturated hydraulic conductivity. A total LTA area of 28.5 ha has been selected as seen in Figure 3.1. The land areas are detailed in Table 3.4.

Table 3.4: Areas of Discharge and Discharge Application

Overseer Block Groups	Land Treatment Area Label	Area (ha)	Average Discharge Application (mm/d)	Design Flow Rate (m^3/day)	Annual Flow Rate (m^3/year)
Area 1	B, C3, C4, C5, C6	4.5	5.4	250	89,089
Area 2	C1, C2, A, D, E, F, G	11.6	7.1	820	299,554
Area 3	H, I, J, K, L	7.2	7.1	515	187,716
Area 4	M	5.2	8.0	420	152,005
Total		**28.5**		**2,005**	**728,364**

The average discharge rate for the LTA sites are derived from the LEI's soil assessment report (Appendix A), and the proposed LTA's ability to remove nutrients.

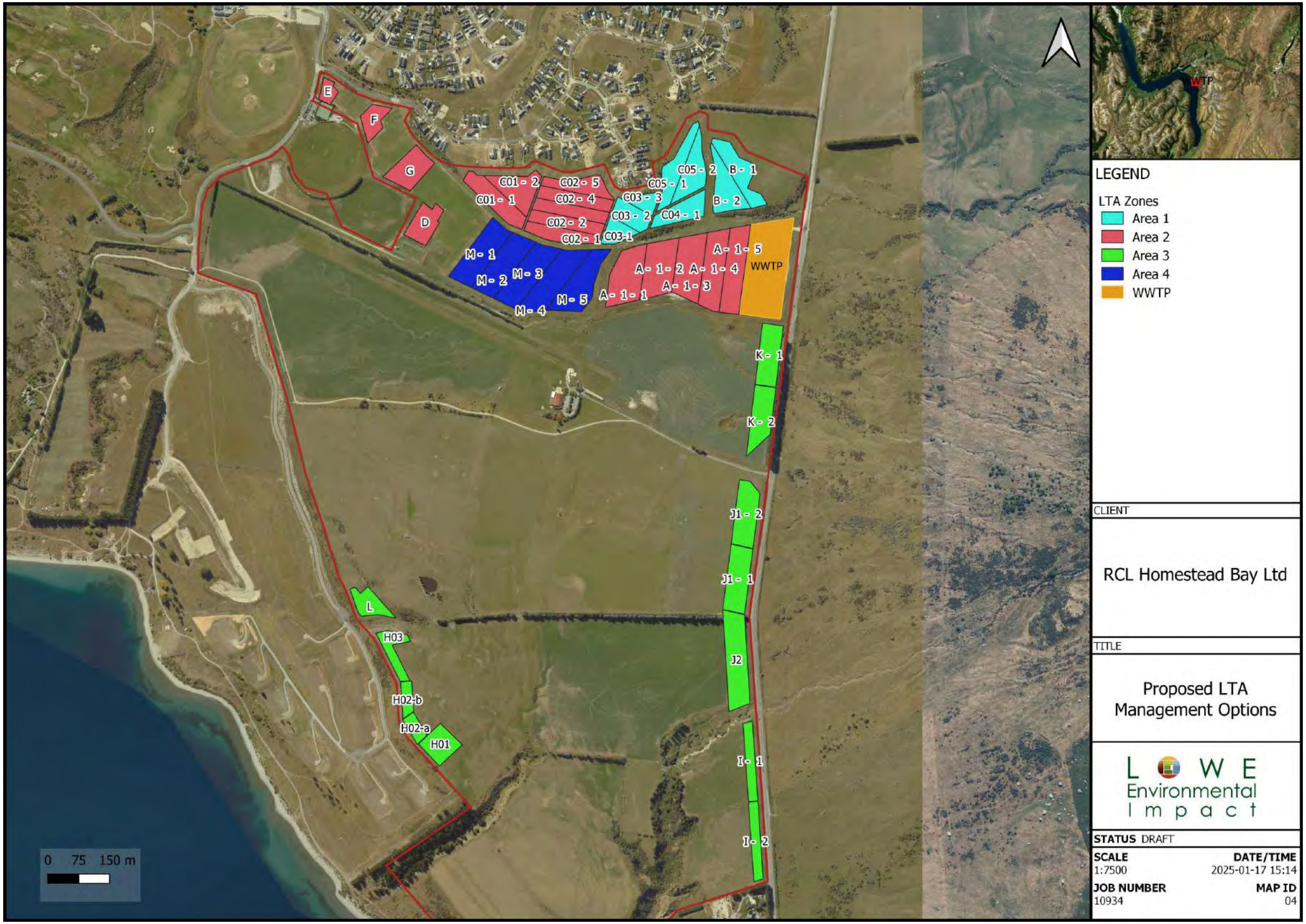

Figure 3.1: Proposed RCL Land Treatment Areas

It is emphasised that the above areas are, at this stage, indicative only. They have been nominated to create a plausible scenario using land owned by RCL that would not otherwise be developed. Over time some areas may not be needed (for example because the more conservative discharge rates are not observed) and there may be some reconfiguring of the size and locations of the LTAs through detailed design and through working with neighbouring landowners. It is therefore sought that any resource consent issued allow for flexibility as to the final locations of the LTAs, to allow pragmatic decisions to be made in the implementation of the scheme.

Using the wastewater effluent concentrations discussed in Section 3.2.2, the site loading for the development is assessed in Table 3.5.

Table 3.5: LTA Loading Scenario

Influent Source	**Average Daily Flow (m^3/day)**	**Total Nitrogen @ 7.5 mg/L** (kg/yr)	**Total Phosphorus @ 2.5 mg/L** (kg/yr)
General Activities			
Commercial Flows (Light) (Incl. Café, Retail and other)	37	102	34
School (600 students + 60 teachers/staff)	35	95	32
Sub Total	**72**	**197**	**66**
Domestic Activities			
592 Apartments	444	1,215	405
764 Terrace Houses	573	1,569	523
1,222 Standalone Houses	917	2,509	836
Sub Total	**1,934**	**5,293**	**1,764**
Total ADF	**2,005**	**5,490**	**1,830**
Land Treatment Area Selected			
LTA (ha)	**28.5 (Hectares)**		
Total Average Loading rate	**7.1 mm/d**	**193 kg/ha/yr**	**64 kg/ha/yr**

With the proposed PCDI system, further nutrient treatment is expected within the plant's root zone. A significant reduction in TSS and BOD_5, two key wastewater determinants, can also be expected, as well as removal of pathogens.

3.4 Wastewater Treatment Plant

There are numerous options for communal WWTPs suitable for RCL. Four activated sludge-type treatment systems have been considered, but others are available, including package plants or bespoke-designed plants.

The options considered include the following and are summarised in Table 3.6;

1. Submerged Aerated Filter (SAF);
2. Sequence Batch Reactor (SBR);
3. Membrane Bioreactor (MBR); and
4. Membrane Aerated Biofilm Reactor (MABR).

3.4.1 Submerged Aerated Filter (SAF)

The SAF system is a form of the activated sludge process (a wastewater treatment process characterised by a suspended growth of biomass), usually with a floating media to enhance biofilm development and with the settlement of solids taking place within a clarifier.

Wastewater enters a recirculating (primarily anaerobic) chamber where oxidising bacteria break down suspended solids; the influent is also mixed with returned activated aerated sludge from the clarifying chamber. This mixing stimulates bacteria and enhances the digestion of solids. Following primary treatment, wastewater enters an aeration chamber that contains submerged media on "bioblocks" (bioblocks allow for an increased surface area). Treated wastewater passes from the aeration chamber to a clarifying chamber, where the remaining particles of suspended solids settle out of suspension. The suspended solids that sink to the bottom of the chamber are drawn back to the first primary chamber for further processing or removed for disposal off-site.

The WWTP will be followed by further filtration (125 microns) and UV sterilisation to reduce pathogens.

3.4.2 Sequence Batch Reactor (SBR)

SBR is a form of activated sludge wastewater treatment. In a typical SBR process train, influent wastewater generally passes through screens and grit removal before the SBR. The wastewater then enters a partially filled reactor containing biomass, which is acclimated to the wastewater constituents during preceding cycles. Once the reactor is full, it behaves like a conventional activated sludge system but without a continuous influent or wastewater flow. The aeration and mixing are discontinued after the biological reactions are complete, the biomass settles, and the treated supernatant is removed. Excess biomass is wasted at any time during the cycle. Frequent biomass wasting holds the mass ratio of influent substrate to biomass nearly constant from cycle to cycle.

SBR technology generally requires a higher level of operator assistance to ensure the system is maintained and operating to a high standard; otherwise, it can be prone to failure and poor wastewater quality. SBRs are an aerated technology and, therefore, require a higher power input. They can reliably reduce nitrogen concentrations to low levels. As a result of the high level of aerobic microbial activity, a large volume of sludge is produced, requiring management and disposal.

SBRs have the ability to vary the treatment. The SBRs will be followed by further filtration (125 micron) and UV sterilisation to reduce pathogens.

3.4.3 Membrane Bioreactor (MBR)

A MBR system is a combination of the activated sludge process (a wastewater treatment process characterised by a suspended growth of biomass) with a micro or ultra-filtration system that rejects particles above 0.1 – 0.4micron in size (which is smaller than an individual bacteria). MBRs have two basic configurations: (1) an integrated configuration that uses membranes immersed in the bioreactor, and (2) a recirculating configuration where the mixed liquor circulates through a membrane module situated outside the bioreactor.

The key benefits of MBR technology for this application include:

- Reliably high level of treatment achieved
- Very compact process
- Good at handling seasonal loads
- Good at treating high strength wastewater
- Physical barrier prevents bacteria entering the treated water
- Physical barrier provides exceptionally clear, low turbidity permeate suitable for further disinfection via UV irradiation or chlorine disinfection
- Treated water is suitable for municipal reuse such as garden watering

3.4.4 Membrane Aerated Biofilm Reactor (MABR)

MABR is a modified activated sludge process, where the conversion of ammonia in raw wastewater to nitrate, known as nitrification is carried out in a compact and energy efficient manner. An MABR is characterized by submerged gas transfer membranes which provide air directly to a biofilm attached to the surface of the membrane. The gas transfer membrane allows for efficient oxygen transfer, applied directly to the biofilm carrying out the nitrification reaction.

In an MABR, the aeration membrane is not used to filter the water. Instead, it is used to provide oxygen-enriched air to the process biology, replacing the conventional fine bubble diffuser. In doing so the oxygen is introduced in the molecular, or 'bubbleless' form. This leads to highly efficient oxygen transfer, since the oxygen is no longer limited by diffusion from the inside of the air or gas bubble to the gas bubble surface and then across the surface to the surrounding water.

Because the membrane is being fed with molecular oxygen and is immersed in the tank being fed with the influent wastewater containing biodegradable organic matter, a biofilm forms on the membrane surface. An MABR is therefore an example of a 'fixed film' process - like a trickling filter or a moving bed bioreactor - as opposed to a purely suspended growth process (i.e. one based on activated sludge), as is the case for the MBR.

The MABR still has a mixed liquor of suspended particles, as with other fixed film processes such the moving bed bioreactor (MBBR), but at lower concentration than the MBR. Biological treatment is thus achieved both by the biofilm and by the suspended flocs.

As an MABR process is usually implemented as a part of a modified activated sludge process, it can often be used to improve the performance of other treatment processes that are based on the activated sludge process, such as SBR and MBR treatment plants. Improved performance, a smaller plant footprint, and improved OPEX costs can be gained through the addition of MABR treatment to these processes. This would allow the aeration membrane to be added over time allow staging enhancement of a SBR or MBR initial plant.

The major benefits of MABR treatment processes include:

- They are easily scalable and can be designed to be modular
- Extremely robust when faced with fluctuating flows and loads
- Excellent performance at low temperatures.
- They typically produce much less waste biological sludge due to the high efficiency of the biofilm requiring less biology to achieve the same rate of nitrification compared to other conventional treatment systems.
- Lower sludge production means lower operational, and disposal costs associated with sludge handling.
- By virtue of their energy efficient design, they offer better environmental performance when measured against other conventional treatment options

3.4.5 Summary of Communal System Options

The summary table below provides a qualitative assessment of the treatment system parameters, but weighting factors that are important to RCL need to be put against it.

The activated sludge is an appropriate technology for RCL that generally require a higher level of operator assistance to ensure the system is maintained and operating to a high standard. SBRs and MBRs are aerated technologies and, therefore, require a higher power input. As a result of the high level of aerobic microbial activity and the desire for Phosphorus removal, a large volume of sludge is produced, requiring management and disposal.

Table 3.6: Summary of Wastewater Treatment Options

Parameter	SAF	SBR	MBR	MABR
Capital expenditure	Moderate and high as capacity increases	Moderate	Moderate and high as capacity increases	Moderate and high as capacity increases
Running costs	Moderate to High	Moderate to High	High	Moderate
Additional carbon dosing	Possibly depending on required N conc	Possibly depending on required N conc	Unlikely	Unlikely
Power requirement	Moderate	Moderate	Moderate	Low
Modularity/staging	Moderate	Moderate	Good	Good
Maintenance requirement	Potentially High	Potentially High	Potentially High	Potentially High
Sludge production	Moderate to High	Moderate to High	Moderate	Moderate
Suitable for intermittent flow regimes	Moderate	Moderate	Low	Low
Remote servicing and trouble shooting	Yes	Unlikely	Unlikely	Unlikely
Operational complexity	Moderate	Moderate	High	High
Reliability	Moderate	Moderate to high	Moderate to high	Moderate to high
Wastewater treatment stability	Moderate	Good	High	High

The preferred WWTP type and supplier are likely to be determined following confirmation of the consented treatment standard, the LTA area, the development rate of wastewater flows (i.e. how modular the WWTP needs to be) and further evaluation attributes listed above.

Several suppliers and treatment processes are currently available to meet the likely final treatment standards (e.g. SBR, SAF MABr and Multistage Bardenpho). The systems generally have a low risk of odour; the treatment processes can be adjusted to meet possible future increases in treatment standards; the treatment plant can be readily staged and scaled to suit growth; activated sludge treatment systems are well-known techniques and used to service 70% of New Zealand reticulated sewer networks population.

It is not proposed that the resource consent specify the exact type of WWTP to be selected. It is, however, understood that as a basis for initial high-level design, at the time of writing, the favoured technology is a combined MABR/MBR activated sludge process.

The WWTP treatment plant and LTA are considered an integrated treatment train for the wastewater. The land treatment system provides further nutrient and bacterial removal from the wastewater.

3.4.6 Staged Development

Adopting a staged approach to the WWTP and LTA area based on flow is possible. Stage One (up to 500 m^3/day) accommodates the plant's much lighter loading and the difficulty of operating an extensive, activated sludge treatment system with less than 50% design capacity compared to its final expected load.

Potential treatment standards and scenarios for possible staging the WWTP capacity and land treatment area are outlined in Table 3.7. The staging is to illustrate that there is flexibility in the WWTP capacity and LTA commissioning.

Table 3.7 Demonstrates possible scenarios, with differences in the number of lots, wastewater loading rate, and LTA area. This illustrates the options RCL has with timing to invest in the wastewater treatment plant and installed land treatment area.

Table 3.7: Potential Development Scenarios

WWTP	Stage 1	Stage 2		Stage 3		Stage 4		Stage 5	Stage 6
Lots or dwelling equivalents	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,578
Design Flow Rate (QLDC CoP) (m3/day)	375	563	750	938	1,125	1,313	1,500	1,688	2,005
Expected flow 520 L/lot (m^3/day)	260	390	520	650	780	910	1,040	1,170	1,390
Nitrogen concentration at WWTP (mg/L)	20	15	10	12	10	7.5	7.5	7.5	7.5
Nitrogen mass (kg/yr)	2,738	3,080	2,738	4,106	4,106	3,593	4,106	4,620	5,488
Area required to meet 220 kg N/ha (ha)	12.4	14.0	12.4	18.7	18.7	16.3	18.7	21.0	24.9
Hydraulic loading at minimum area (mm/day)	3.0	4.0	6.0	5.0	6.0	8.0	8.0	8.0	8.0
Likely LTA area (ha)	14.2 Area 1 and Pt Area 2			19.7 Plus Pt Area 3				21.5 Plus Pt Area 3	28.5 Plus Area 4 and Pt Area 2
Possible scenario loading (mm/day)	2.6	4.0	5.3	4.8	5.7	6.7	7.6	7.8	7.0
Consent hydraulic limit (PWWF) (mm/day)	5	8	11	10	11	13	15	16	14
Possible scenario nitrogen loading rate (kg N/ha/yr)	193	217	193	208	208	182	208	215	193
Proposed Consent limits (kg N/ha)	220								

By proposing a 220 kg N/ha/yr nutrient limit to any zone and a maximum hydraulic loading rate, RCL is seeking development flexibility by treating the WWTP and LTA area as a treatment train which can be built in stages in response to the speed of housing development occupation. This allows RCL to either improve wastewater treatment quality or increase LTA size as development occurs. Having a fixed input standard to the LTA for total nitrogen loading of 220 kg N/ha/yr and maximum hydraulic loading rates provides certainty about the standard of effluent (both quality and quantity) from the WWTP part of the treatment train, to both ORC as the regulator and RCL as the owner and operator of the WWTP system. The LTA part of the treatment chain is addressed later in section 5 and summarised in Table 5.6.

The likely LTA area for development and the order that LTA zones are brought online will be influenced by the subdivision staging, speed of property sales, subdivision stage title requirements and reticulation infrastructure.

4 DISCHARGE ENVIRONMENT

4.1 Soils Investigation

LEI undertook a soil investigation, which was completed between 4th and 7th June 2024. The soil profile at a number of sites was photographed and logged. The soil profiles typically comprised 0.35 m of weathered topsoil (organic silt) with roots throughout, underlain by a silt subsoil down to alluvial or colluvial gravels at depth. These soil profiles can be seen in more detail in the soil investigation report attached in Appendix A.

A summary of this work concluded a design irrigation rate (DIR) for each of the site's dominant soils, which the LTA area can assimilate on a continuous basis. These rates are given in Table 4.1 and the soil map for the site can be seen in Figure 4.1.

Table 4.1: Design Irrigation Rate for each Soil Type

Soil Type	DIR (mm/day)
Barrhill Soils	11
Pigburn Soils	41
Wakatipu Soils	7
Manmade Soils*	16

These DIR rates represent a percentage of the soil's saturated and unsaturated hydraulic conductivity rate and inform the system design along with the nutrient loading rate.

*Manmade soil refers to the area of RCL land which has received surplus soil material from the development at Hanleys Farm.

Table 4.2: Averaged LEI Test Pit Logs by Soil Family

m bgl	Pigburn	m bgl	Wakatipu	m bgl	Barrhill
SMap class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0 - 0.3	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is weak and friable. Common fine roots. Boundary is abrupt and smooth.	0-0.35	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Common fine roots. Boundary is distinct and occluded.	0-0.40	Moist, 10YR 4/2 (dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.
0.3-0.9	Moist, 10YR 6/2 (light brownish grey) coloured soil. **No gravels**. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth. Some occlusions.	0.35-0.6	Moist, 10YR 5/8 (yellowish brown) coloured soil. **Slightly gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. Few fine roots. Boundary is sharp and smooth.	0.4-0.9	Moist, 10YR 5/4 (yellowish brown) coloured soil. **Very slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is firm, aggregate strength is weak and brittle. Few fine roots. Boundary is sharp and smooth. Oxide staining layers throughout the b horizon.
0.9-1.1	Moist, 10YR 6/3 (pale brown) coloured soil. **Very gravelly**, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth.	0.6-1.8+	Slightly moist, 10YR 7/3 (very pale brown) coloured soil. **Extremely gravelly**, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain. Soil strength is firm, aggregate strength is slightly firm and brittle. No roots. Concreted texture but water soaks away.	0.9-1	Slightly moist, 10YR 5/4 (yellowish brown) coloured soil. **Extremely gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. No roots. Boundary is sharp and smooth.
1.1-1.45	Moist, 10YR 6/1 (grey) coloured soil. **Slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-			1-1.4	Moist, 10YR 6/3 (pale brown) coloured soil. **No gravels**. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt

m bgl	Pigburn	m bgl	Wakatipu	m bgl	Barrhill
SMap class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
	plastic, fine sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. Few fine roots. Boundary is sharp and smooth.				loam. Apedal massive. Soil strength is slightly firm, aggregate strength is weak and brittle. Organic staining from roots. Boundary is sharp and smooth.
1.45-1.8+	Moist, 10YR 6/1 (grey) coloured soil. **Very gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. Few fine roots. Mixture of size class gravels.			1.4-1.7+	Moist, 10YR 6/3 (pale brown). **Extremely gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. No roots. Mixed size of gravels and sand.

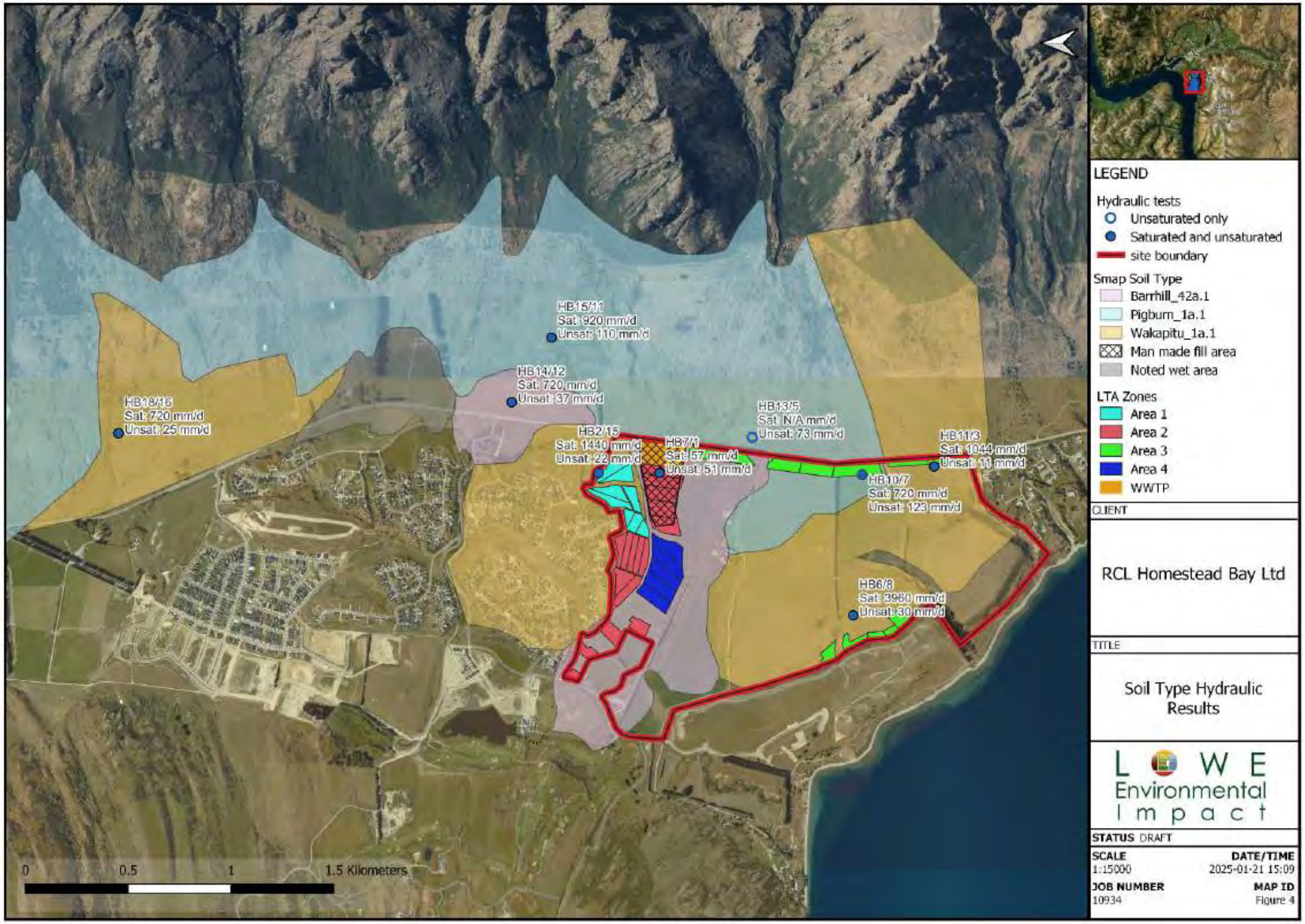

Figure 4.1: Soil Hydraulic Testing

4.2 Groundwater

4.2.1 Geology

Geological maps indicate that the site comprises Holocene alluvial fan and lake deposits overlaying a metamorphic basement of schist. The deposits have formed as part of an ancient outlet of Lake Wakatipu to the Kawarau River.

Bore logs indicate the alluvium likely extends to 40+m across the site, shallowing toward Jacks Point.

4.2.2 Hydrogeology

In the alluvial fan deposits and fluvial sediments, the groundwater is likely to act in an unconfined manner, with water levels controlled broadly by the lake level but varying with local recharge areas and topography. The Remarkables schist basement may provide a source of groundwater in basement rock fractures, but there is no information available for the site.

There is likely a groundwater divide within the surrounding surface catchment, with some shallow groundwater moving north toward the Kawarau River and some moving south to Lake Wakatipu.

There is some local confinement due to lake sediments (silts) toward the lake side of the property. Silts are recorded in Bore Logs' F42/0150 and F42/0150A near the surface (3 - 4 m), with water levels being in the order of 1 m below ground. These silts are not present in all the logs in the area and so may be of only local extent.

The direction of groundwater flow for the RCL's site is likely South-southwest, and Lake Wakatipu is the likely receiving environment of surface and shallow groundwater.

One aquifer test (F42/0150) has been undertaken in the area, indicating the sediments are relatively transmissive. Testing estimated an aquifer transmissivity (T) of 1,127 m^2/day.

Geosolve's geotechnical investigation drilled three bores for deep investigation, and 46 shallow test pits cross the Lot 8 land holding. The map of the testing locations is shown in Appendix C.

4.2.3 Water Levels

Based on water level data held by Otago Regional Council (ORC), groundwater levels are unlikely to be within 2 m of the ground surface across the site.

No groundwater was observed in the test pits to a depth of 1.8 m, with mottling only observed in one location.

Geosolve bore holes and test pits intercepted groundwater at depths in only some locations, as presented in Table 4.3.

Table 4.3: Geosolve Groundwater Data (Appendix C)

Bore Test pit	Water Depth bgl
BH1	5.2 m
BH2	7.3 m
BH3	4.9 m
TP07	4.2 m
TP09	3.1 m
TP14	4.1 m
TP41	2.6 m
TP42	1.9 m
TP47	0.9 m

The shallow water in TP42 and TP47 reflects the existing ephemeral stream surface water channels. No shallow groundwater was found in the other test pits undertaken by either LEI or Geosolve Ltd.

4.2.4 Well Distribution

Well depths range from very shallow (< 5 m deep), to the deepest at 55 m below ground level, located at Lakeside Estates, Southeast of the site.

4.2.5 Bore Logs

Appendix C contains drilling logs for the deeper wells in the area and the investigation wells drilled by Geosolve.

4.3 Surface Water

4.3.1 Water Conservation (Kawarau) Order 1997

Lake Wakatipu is listed in Schedule 2 of the Water Conservation (Kawarau) Order 1997, which sets out the characteristics of the waters to be protected because they are considered outstanding. Restrictions and prohibitions include fish passage to be maintained and water quality to be managed to Class AE (for aquatic ecosystem purposes), CR (for contact recreation purposes), F (for fishery purposes), and FS (for fish spawning purposes) standards. A detailed analysis of receiving water standards for different streams and lakes is presented in the LWP report (LWP 2025).

4.3.2 Lake Wakatipu Surface Water Catchment

Lake Wakatipu has an area of 291 km^2 with an average depth of 230 m. The total volume of the lake is 66,930 million cubic metres. All forms of recreational boating are undertaken on the lake. The shores of the lake are popular for picnicking, swimming, fishing and passive recreation.

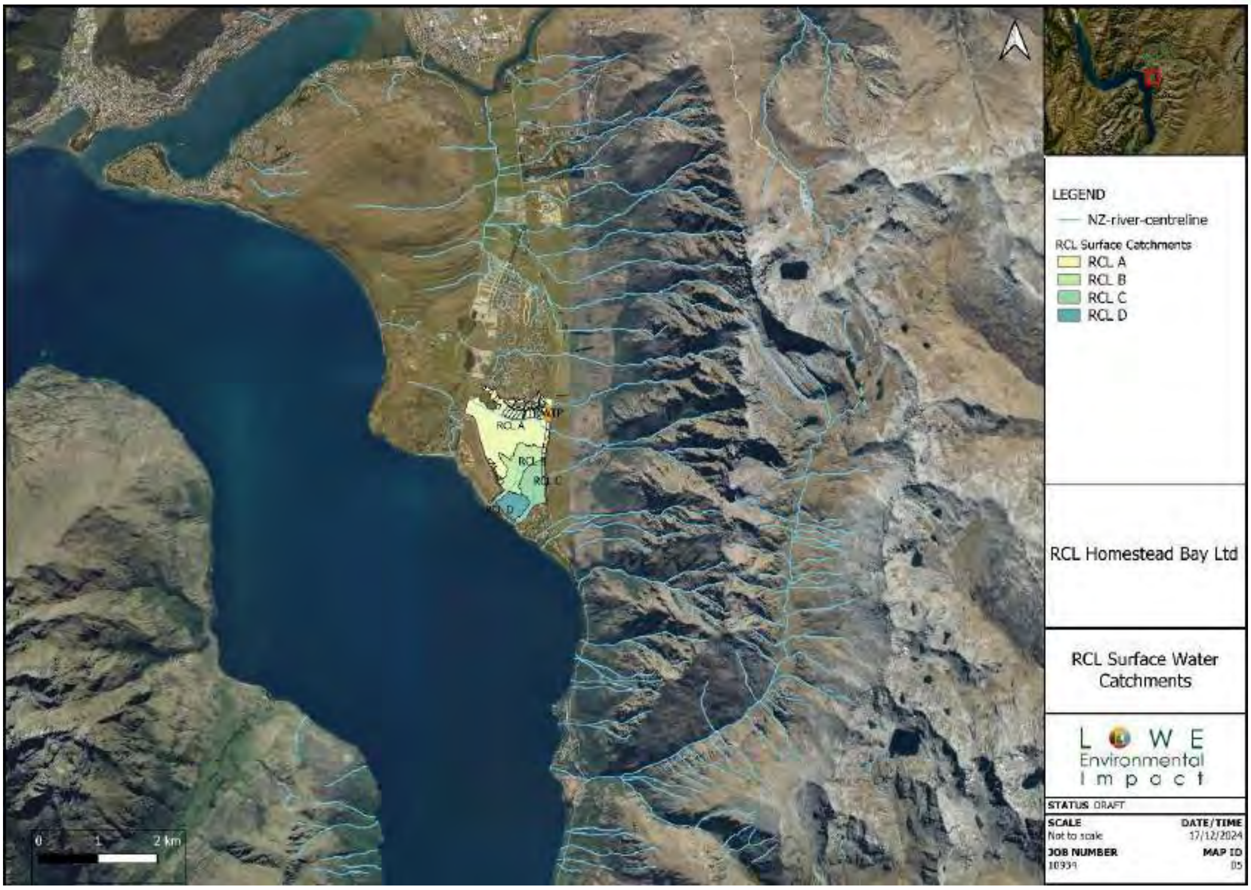

Figure 4.2: RCL Surface Water Catchments

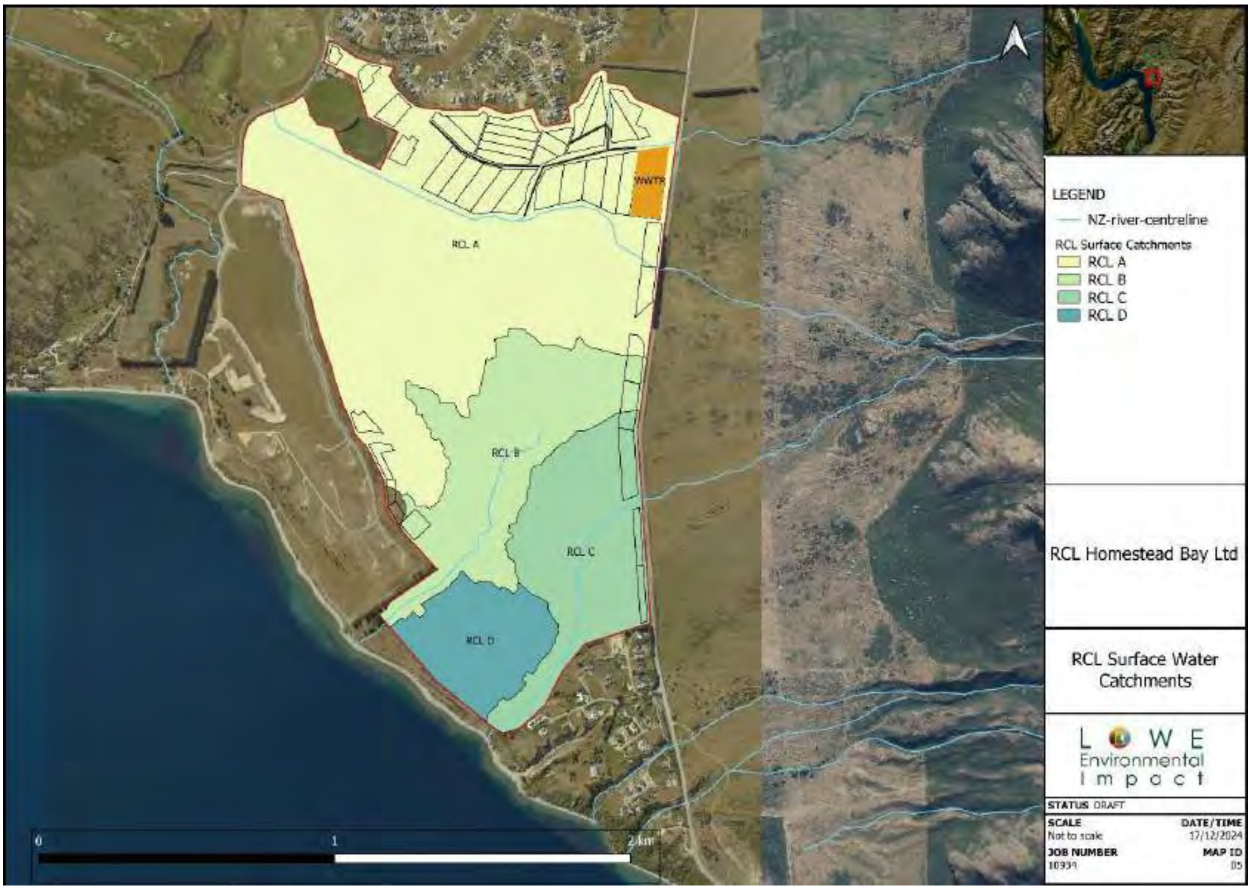

Figure 4.3: RCL Catchments and Potential LTA Locations

Table 4.4 Presents the area of each surface water catchment (derived from contour analysis) relative to the RCL site. Nutrient leaching for water applied to RCL A would contribute to groundwater, Lake Wakatipu and potentially surface water, if groundwater enters the lower reach of Jacks Point Stream.

Wastewater is also proposed to be applied in Catchments RCL B and RCL C. The associated drainage is expected to enter groundwater, and, ultimately Lake Wakatipu as presented in Figure 4.2 and Figure 4.3. Additionally, while thought to be an unlikely scenario, it is possible that some treated wastewater could indirectly enter into the unnamed watercourses 1 and 2 via groundwater. No wastewater is proposed to be applied in catchment RCL D which is only rainfall fed.

Table 4.4: RCL Surface Water Catchment Areas

Catchment	Lake Wakatipu Catchment (Ha)
RCL A	122
RCL B	36
RCL C	30
RCL D	16

4.3.3 ORC Water Quality Monitoring

Otago Regional Council carries out long-term water quality monitoring as part of its State of the Environment programme, and short-term monitoring programmes are carried out in some catchments to provide more detailed information. These programmes assist with regional planning and provide an understanding of the need to protect water quality.

Lake Wakatipu's average water quality readings between 2015 and 2022 are shown in Table 4.5 below. Lake Wakatipu is classified as Group 5 for receiving water, as categorised by the Regional Plan: Water for Otago (RWP) which sets limits as shown in Table 4. Sampling undertaken by ORC in the lake and at the outlet to the Kawarau River shows all the determinants are much lower than these limits. A mid-lake monitoring site has also been developed, the data from which will be included in the detailed assessment to support the consent application.

Table 4.5: Lake Wakatipu Median Water Quality at the Lake Wakatipu Open Water 10 m (2015 and 2022)

		Water Quality (Lake Wakatipu Open Water 10 m)	ORC-RWP
	Unit		Limits for Lake Wakatipu in RWP Schedule 15 (Table 15.2.5)
TP	g/m³	0.002	0.005
TN	g/m³	0.065	0.1
E. Coli	No./100 ml	<1.0	10
NH_4-N	g/m³	0.003	0.01
Turbidity	g/m³	0.6	3

Trophic level index (TLI) is a common method for describing the health of lakes. It is an indicator of how much growth or productivity occurs in the lake, with productivity directly related to nutrient availability. A microtrophic lake has a trophic level of less than 2. This indicates that the lake has low productivity, and the water quality is very good, with very low levels of nutrients and algae and high oxygen levels. Oligotrophic lakes have relatively low levels of nutrients, sparse growth of algae and high oxygen levels. Lake Wakatipu has good water quality, with a trophic level of 2 – 3. Lake Wakatipu’s TLI is shown in Figure 4.4 below.

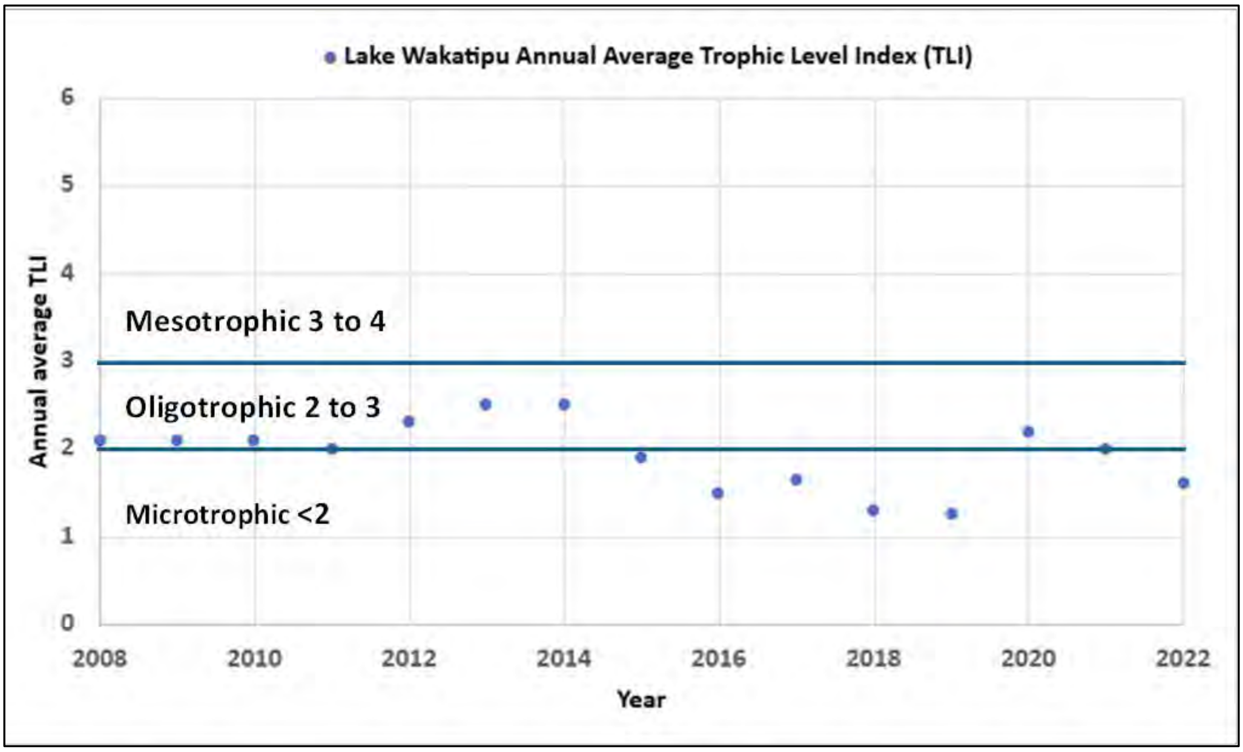

Figure 4.4: Lake Wakatipu Trophic Level Index (2008 to 2022, LAWA Data)

The Trophic Level Index (TLI) of Lake Wakatipu is low and reflects the current landuse and nutrient losses.

5 DISCHARGE SYSTEM

5.1 Discharge Within the LTA

5.1.1 Network

Within each LTA area, water will be discharged at the required pressure into a number of the submains from the treated wastewater mainline. From the mainline, an automated valve will actuate before the water flows through the submain to each zone.

Each of the zones considered will allow for low-rate discharge at a design dry weather loading rate of between 5.4 and 8 mm/d based on the DIR of each zone and proposed landuse, as seen in Figure 3.1.

5.1.2 Application Rate

The DIR of the proposed LTA areas are given in Table 5.1.

Table 5.1: Proposed Design Irrigation Rate for each LTA

LTA	Area (ha)	Soil Type	Modelled DIR (mm/day)	LTA Dry Weather Flow (CoP) (m^3/d)
A	5.5	Manmade	7.1	393
B	1.5	Wakatipu Soils	5.4	80
C01, 02	4.2	Wakatipu Soils	7.1	301
C03, 04, 05	3.0	Wakatipu Soils	5.4	149
D	0.6	Barrhill Soils	7.1	40
E	0.2	Barrhill Soils	7.1	14
F	0.4	Barrhill Soils	7.1	29
G	0.7	Barrhill Soils	7.1	48
H	1.4	Wakatipu Soils	7.1	114
I	0.9	Wakatipu Soils	7.1	64
J	3	Pigburn Soils	7.1	214
K	1.5	Barrhill Soils	7.1	107
L	0.4	Wakatipu Soils	7.1	31
M	5.2	Barrhill Soils	8	421
Total	**28.5**			**2,005**

The soil types and proposed DIR confirm that the estimated ADF for the RCL development option of 2,005 m^3/d can be discharged within the proposed 28.5 ha LTAs at sufficiently low DIRs.

5.1.3 Zone Dosing

The dose volume will be developed using the design daily volume of 2005 m^3/day. The submain will be laid below the ground level and have sealed toby boxes at each control valve.

The LTA areas listed in Table 5.1 will be further divided into zones suitable for the LTA layout and total size, to match the land form, with an average size of zone being approximately 0.7 ha (7,000 m^2) and a range of 0.2 to 1.4 ha. These zones will be grouped to allow dosing and rest periods to cycle around the LTA area, ensuring that the treated wastewater loading meets the soil infiltration and to allow nutrient assimilation.

By way of example, the average irrigation zone will have approximately 7,000 m of dripper line at 200 to 300 mm depth (below any freezing layer), with 0.6 m spacing between drippers and the lines laid 1 m apart. Each dripper has a flow rate of 1.6 L/hr resulting in the discharge specifications seen in Table 5.2.

Table 5.2: Application System Specification

Description	Units	Data
System Type	-	Land Treatment Application
Application Area (Net)	ha	28.5
Application System	-	Subsurface drip
Lateral & Emitter Type	-	Anti syphon Pressure compensating Subsurface Drip
Minimum Emitter Pressure	m	11.0 (to achieve good flushing)
Emitter Discharge	L/hr	1.6
Emitter Spacing	m	0.6
Lateral Spacing	m	1.0
Lateral depth	m	0.2 to 0.3
System Application Rate	mm/hr	~2.67
Daily application	mm/day	Up to 8.0
Average Duration of One Operation	hours	2.6 (Range 2.2 to 2.99)

5.1.4 Pumping Duty

It is proposed that WWTP include treated water storage to allow for batch discharge of wastewater to the LTA. The daily volume will be partially stored and based on the level of the treated water storage; irrigation will occur. The discharge rate will be automated based on the zones next available for irrigation. At times of higher inflow, additional zones and pumps would be used to discharge the daily volume at a rate of up to 53 L/s. The proposed system's duty under normal operation and wet weather flows is presented in Table 5.3. The actual pump/s duty will vary based on the zones irrigating at any one time.

Table 5.3: Irrigation System Duty

DUTY TABLE (@Point of Connection)			
		Average Dry Weather Flow	**Peak Wet Weather Flow**
Dispersal Area	ha	28.5	28.5
Target Daily Discharge	m^3/day	2,005	3,973
Dispersal Equivalent Application Depth	mm/day	7.0	13.9
Dispersal Application Rate	mm/hr	2.67	2.67
Duration of one Operation (depending on the Zone DIR)	hrs	2.02 to 2.99	4.04 to 6.0
Max. Daily Operation Duration	hrs	21.05	20.86
Estimated Discharge Required	m^3/h	95.2 (5 zone combinations)	190.5 (10 zone combinations)
Estimated Discharge Required	L/s	26.5	52.9

5.1.5 Flushing

Flushing submains will attach with a tap to the end of each lateral. The flushing submains may be connected back into a mainline that can be automated to discharge into the influent sewer and be returned to the WWTP or discharged to land at the end of the laterals, which is more common.

5.2 Nutrient Loading Rate

Plant and microbial removal and the soil cation exchange capacity are the primary mechanisms for the assimilation of nutrients and water by land application systems. The plant system's total assimilative capacity depends on the land area utilised, with the loading rate refined based on the crop type and its management. Table 5.4 provides example nutrient uptake rates for different crop types.

Table 5.4: Crop Nutrient Uptake

Crop / Land use	N uptake (kg/ha/year)	P uptake (kg/ha/year)	Reference
Pasture – irrigated, cut and carry	**500 - 600**	**130 – 160**	Morton *et al.* (2000)
Pastoral – irrigated grazed system	200 - 240	52 – 64	FLRC (2009), Williams and Haynes (1990)
Standard Rotation Forestry – Pine	100 (kg/ha/year)	30 (kg/ha/year)	Nicholas (2003)
Standard Rotation Forestry – Eucalypt	50 (kg/ha/year)	10 (kg/ha/year)	Myers *et al.* (1999)
Native planting	100 - 200	35	Ongoing research by ESR and Canterbury University, initial findings that it is similar uptake to grazed pasture

Land use of the communal LTA is generally one of the following three methods stated in the order of preference for nitrogen renovation:

1. Cut and Carry (including complementary farming activities (crop));
2. Sheep grazing; and
3. Landscaped areas or cut and leave (including community green spaces and indigenous vegetation planting (biodiversity restoration)).

5.2.1 Cut and Carry

"Cut" refers to mowing grass or grass-type crops, tree felling (replanting with juvenile plants) or pruning vegetation back to stimulate regrowth; "carry" refers to removing all dry matter from the site for sale or grazing elsewhere. The removal of the cut material from the site will result in lower nitrogen leaching into groundwater.

5.2.2 Sheep Grazing

Sheep grazing removes dry matter (and thus nutrients) but recycles some nutrients back to the soil store; however the net input of nutrients from sheep urine and faeces back to the soil will be less than that eaten by the sheep and turned into meat, wool and energy. Sheep are generally rotated around the site to optimise grazing and vegetation removal.

5.2.3 Landscaped or Cut and Leave

This option is suitable if the lawn and landscaped areas are managed for aesthetic reasons for which vegetation growth and removal are undesirable. The net result is limited nutrient removal off-site if the clippings are not collected; the plant life cycle of regeneration and decay will inevitably result in most nutrients taken up by the plants re-entering the soil matrix during the decay phase. However, plant uptake will slow the rate of nutrient leaching, and nitrogen losses occur due to denitrification. In addition, evapotranspiration will reduce hydraulic pressure on the soil. Some landscaping plants, such as Manuka, appear to have other benefits in wastewater LTAs. If Manuka or similar plants are added to the site, these are going to not only accumulate N and P but also have been shown to emit nitrification inhibiting and bactericide chemicals, reducing N_2O emission and killing harmful pathogens while enhancing native ecosystems.

5.2.4 LTA Management Summary

The LTA management can be a combination of all land use types with the wastewater application rate and timing matched to the above-ground land use. "Cut and Carry" lucerne or pasture where the site is not too steep for harvesting machinery provides a suitable supplementary feed source, while grazing or irrigation of regenerative vegetation is also feasible.

5.3 LTA Nitrogen Loading Rate

The management for Area 1 (Table 3.4) is planted native vegetation or light grazing, while other areas will be mown landscaped areas with grass cut and carried off site. Considering the information in the Table 5.4, it is assumed at full development that the proposed average loading rate of 193 kg N/ha/yr is a sustainable loading rate in the aforementioned LTA's.

During the initial stages, as housing connections come online and flows are less than 30% of the WWTP stage's capacity, the ability to remove nitrogen may be limited within the WWTP. This is proposed to be managed by applying higher nitrogen concentration wastewater to the LTA over a larger area, meeting an agreed capped nitrogen load (suggested to be 220 kg N/ha/yr). As the number of connections increases, there will be improved treatment quality, so that once flows exceed 30% of the WWTP capacity the system will be operating at progressively higher treatment standards and ultimately a treatment quality of a 12-month average total nitrogen quality of 7.5 mg/L.

5.4 Phosphorus Loading Rate

The P loading rate to the LTA surface is proposed to be up to 64 kg P/ha/yr. Phosphorus losses across the site will depend not only on plant uptake but also on soil adsorption capacity. The plant uptake and export within the supplement or turf clippings is estimated using Overseer to be 30 kg P/ha/yr. Allowing for plant uptake and export off the LTA area, the full design capacity net P loading to the soil matrix is 34 kg P/ha/yr.

5.5 Current Land Use and Permitted Baseline Loss

Wastewater systems

The Otago Regional Council (ORC) manages small-scale discharges from small-scale septic tanks, wastewater systems (discharge of less than 2000 litres per day) and long drops using Permitted Activity Rules 12.A.1.1 to 12.A.1.4 in the Regional Plan: Water for Otago (RPW) Plan. These permitted activity rules allow discharge of effluent, provided certain conditions are met. Within the permitted activity rule, the lot size is not a condition of the rule.

Application of Nitrogen

A landholding's diffuse N loss is managed under RPW. Under Rule 12.C.1.3 (a) (i) and Map H6 of the RWP, from 1 April 2026 it will be a permitted activity to apply nitrogen or use land in a way (across the total area of land managed by a landholder) that leaches up to 15 kg N/ha/yr. The nitrogen application rate is not limited under the rule, provided the residual leaching rate is less than 15 kg N/ha/yr modelled using Overseer® version 6 or later.

By way of comparison, this permitted N loss of 15 kg N/ha/yr across the proposed housing development area and Land Treatment Areas (LTA) could plausibly occur under a more intensive cropping and dry stock operation on this land. It is, therefore, a useful comparison of the proposal against what will be permitted by the RPW.

The permitted activity rule sets the landholding's permitted nitrogen mass that can be lost without consent. This means that the currently permitted leaching equates to a mass of 3,015 kg N/yr, being (201 ha x 15 kg/ha/yr) from the new subdivision and LTA area.

In relation to this proposal, this mass can be allocated between the loss associated with the new subdivision area and the loss from areas used for LTA.

The subdivision area is expected to leach 0 - 3 kg N/ha/yr from stormwater and gardens; for this development, the area is 172 ha equalling up to 517 kg N/yr, the remaining nitrogen mass of 2,498 kg N (3,015-517) can be applied to the LTA area of 28.5 ha LTA, allowing a permitted leaching rate from the LTA's of 87.9 kg N/ha/yr.

Table 5.5 shows the proposed loadings and N losses using OverseerFM modelling.

5.6 Overseer Outcomes

In addition to looking at the existing and permitted nutrient loss for the area, nutrient modelling using OverseerFM was undertaken. The current landuse nutrient budget and proposed system LTA nutrient budget were produced to indicate the potential leaching from the proposed application of treated wastewater on the LTAs. The input Nitrogen loading was applied at a rate of 149 to 222 kg N/ha/yr evenly across the year.

Nitrogen loading was applied as a soluble fertiliser, such as nitrate, to 28.5 ha of blocks. Using nitrate is conservative, as some of the WWTP effluent nitrogen will be in an ammoniacal form that is more tightly adsorbed onto soil cation exchange sites than soluble nitrate.

In the proposed LTA system, OverseerFM modelling applied the wastewater as irrigation in the form of drip irrigation. The total application depth modelled varied evenly across the year from 2,064 mm to 3,060 mm. There is no seasonal variability in the modelled irrigation depth.

A cut and carry system involves removing cut pasture and removing it off the site, which is applied to 24 ha of the land treatment area, with the remaining 4.4 ha modelled as lightly grazed by stock. The sheep grazing is to replicate irrigation of native plantings, and this cannot be modelled in OverseerFM.

The cut and carry is modelled as baleage or similar. For the OverseerFM model, 10 t DM/ha/yr of pasture silage was cut and exported off the 24 ha irrigated block. This model shows the effects of a typical cut-and-carry system, which could be conventional baleage or collected pastoral or turf grass cuttings.

The OverseerFM nutrient budget shows a total leaching value for the 4 different LTA areas to range from 60 to 91 kg N/ha/yr . This leaching is dominated by winter losses, as is to be expected, as irrigation is applied all year round (the nitrogen loss profile is similar to summer vs winter loss with the current farming operation). The total leaching value for phosphorus is 1.4 to 2.1 kg P/ha/yr. Table 5.5 presents a summary of the RCL OverseerFM modelling. Additional Overseer modelling is presented in Appendix B.

Table 5.5: Nitrogen and Phosphorus Leaching - RCL LTA Scenario Summary

Scenario	**Description**	**N added or removed**	**(Kg/ha/yr)**	**P added or removed**	**(Kg P/ha/yr)**
LTA	RCL Land Treatment Area (28.5 ha)	N Added:	193	P Added:	64
		N removed as supplements:	185	P removed as supplements:	30
		N lost to water:	62	P lost to Water (overland flow)	1.8
Balance of the land holding	Lot 8 and 12 housing area (172 ha)	N lost to water:	2.2	P lost to Water (overland flow)	<0.1
Total Land Area Summary	201.5 ha	Total Development Area Average	10.2	Area Average	0.3

With the development of the WWTP and LTA's, there will be a potential increase of 212 kg nitrogen from what is currently occurring with the land and a reduction of 964 kg N able to enter the environment every year compared with the RPW allowable N loss. This equates to an 11 % increase over current landuse, and a decrease of 31% compared to the RWP "baseline" leaching[3].

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[3] ORC Regional Water Plan permits leaching of 15 kg N/ha/yr for land in nitrate sensitive catchments

The calculation of Nitrogen loading pre and post proposed development are presented in Table 5.6. During the initial development period, as stages of the new subdivision are developed, the net reduction is expected to be greater.

Table 5.6: Nitrogen Budget Pre and Post-Development Nitrogen Leaching Estimate
Land Use Area (ha) N Leached (kg/ha/yr) (kg/yr)

Pre-Development Nitrogen Leaching Estimate			
Land Use	**Area (ha)**	**N Leached (kg/ha/y)**	**(kg/y)**
Farmed area of subdivision and LTA permitted	201	15	3,015
Current landuse uses	201	9.1	1,839
Post-Development Nitrogen Leaching Estimate			
Land Use	**Area (ha)**	**Overseer estimated N Leached (kg/ha/yr)**	**(kg/yr)**
LTA (now including town and new housing development)	28.5	72	1,656
New housing development and recreational areas	172.6	2	**395**
Total Post-development	**201**		**2,051**

OverseerFM also presented the drainage nitrogen concentration associated with leaching. In the current farming system the drainage volume represents the balance between rainfall and evaporation. The concentration of N is reported to decrease with the LTA development due to increased drainage from the irrigation, adding to the water balance.

5.7 Alternative Literature Assessment Method

An alternative analysis to OverseerFM to estimate the leaching from the land treatment area is to consider research undertaken by Beggs et. al. (2011). Beggs found that wastewater applied to land undergoes further biological processes, with research trials indicating that the concentration of nitrogen applied to the soil by wastewater treatment systems via subsurface drip irrigation is not 100% lost via leaching.

In the soil, many other processes utilise the nitrogen that is applied. Secondary treated wastewater systems can be used with sub-subsurface drip irrigation. Subsurface drip irrigation is more effective at removing nitrogen as it is located around 200 mm below ground and applies around 7 mm of treated wastewater per day to the active subsoil layer. Biological processes can further break down the nitrogen in the sub-surface layer, taken up by plant roots for growth, and exported by cut and carry harvesting systems.

The soils of the land treatment area are considered to be equivalent to a silt loam soil (Loam). Based on the findings of Beggs et. al., (2011) (see Figure 5.1), the fate of wastewater nitrogen applied to land via subsurface drip irrigation in a Loam soil is:

- 0 – 32% lost via root uptake from plants;
- 40 – 62% lost via Denitrification; and
- 30% lost via leaching

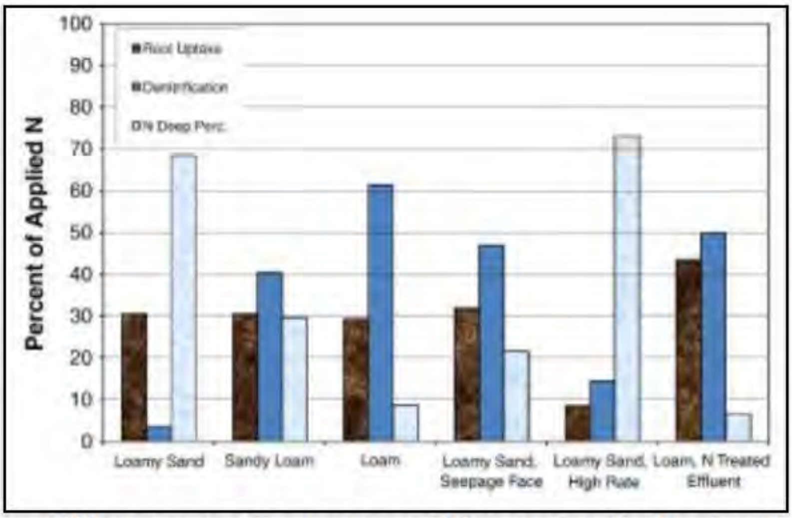

Figure 5.1: Fate of Nitrogen in Wastewater Effluent Applied to Land (Beggs, et. al., 2011)

For the proposed LTA system, if 193 kg N/Ha/yr is applied to 28.5 ha LTA, using Beggs et al., (2011), 8% to 30% estimation being leached below the root zone equates to 15 to 57 kg N/ha/yr. This is comparable to the OVERSEER® estimate in the section above for cut and carry of 72 kg N/ha.

Table 5.7 shows the total nutrient loss for the baseline current farming system on the RCL land, which, with QEII, is operated as one farming unit, and future scenarios of removing the RCL land from agricultural production and adding the different LTA areas.

The nitrogen is removed in the cut and carry process, and a proportion of nitrogen is lost to the water (leached). The difference between the nitrogen gained and lost is due to other losses that occur, for example, the transfer of nitrogen into the atmosphere.

Table 5.7: Total Nutrient Losses for Baseline and the RCL Scenarios

	Total losses				
Analyses	**N (kg/y)**	**N (kg/ha/y)**	**P(kg/y)**	**P (kg/ha)**	**GHG (t)**
Year 23-24 farm use and a combined QEII and RCL operation	8,039	9.0	128	0.1	3,121.7
23-24 RCL- Only Blocks*	1,839	9.1	7	0.1	
RCL LTA	2,052	10.2	61	0.3	91.9

* Refers to the total N losses/y from those located at RCL (Lot 8, lucerne, barley and Lot 12)

5.8 Phosphorus

As previously discussed in Section 3, the proposed application rate will be approximately 64 kg P/ha/yr. This rate is less than the suggested phosphorus plant uptake capacity of 130 kg P/ha/yr – 160 kg P/ha/yr (Morton et al., 2000) for a cut and carry regime and but greater than estimated for the current farming operation by OVERSEER® of 34 kg P/ha/yr.

The soil's P retention properties were investigated to assess the fate of the surplus P (30 kg P/ha if using the 34 kg/ha uptake from OVERSEER®). Phosphorus is a cation (unlike nitrate, an anion) and is not very mobile within the soil profile. The soil test analysis shows that the proposed LTA soil profile can retain large amounts of added P before the P migrates further down the soil/subsoil profile. In Table 5.8, the P retention has been calculated for the first 1.5 m of the soil/subsoil profile based on the Landcare Research laboratory analysis. Using 1.5 m is considered conservative, and depending on the depth of groundwater, there is a potentially greater subsoil depth for P storage.

The P retention analysis suggests that P supplied over 135 years at full loading rates can be stored within the first 1.5 m of the soil profile before significant P migration to lower subsoils. This storage potential is much greater than the proposed consent duration of 35 years. Providing the land application of treated effluent is discontinued before the soil's capacity to absorb phosphorus is reached, the phosphorus would be expected to remain embedded in the soil, posing no environmental risk.

Table 5.8: Phosphorus Storage Capacity

Parameter	Manmade Soil	Pigburn (Sites: HB 8/2, HB 9/6, HB 10/7)	Wakatipu (Sites: HB 6/8, HB 5/9, HB 1/14, HB 2/15)
Bulk Density (kg/m^3)	1,300	1,300	1,300
Average P Sorption (mg/kg)	321	235	508
Treatment Soil Depth (m)	1	1	1
P Storage Capacity (kg P/ha)	4,175	3,052	6,607
Design P Storage Capacity (kg P/ha)	4,611		
P Loading Rate less DM export (kg P/ha/yr)	34		
Site Life (years)	135		

Therefore, the leaching/runoff of total phosphorus and DRP off the LTA is expected to be low given:

- The conservative average hydraulic rate application rate (average 7 mm/d);
- The large P retention capacity of the soil;
- The added wastewater P is the primary source of phosphorus for the plant uptake; and
- There is a considerable vertical distance to any ground or surface water.

There is a low potential for phosphorus leaching to groundwater due to the large depth of soil matrix before any potential groundwater, and most, if not all, phosphorus will be retained within the soil profile and not be leached to groundwater and ultimately, Lake Wakatipu.

5.9 Service Structure

The WWTP will likely be constructed in the ground and designed to mitigate the aesthetic effects. It will also be fenced and planted to limit access to maintenance and monitoring staff.

The use of subsurface drip irrigation allows the treated wastewater to be discharged into the topsoil layer within the root zone, allowing flow through natural soil (silts, sands, and gravels), adsorption, and dispersion of the contaminants of concern within the ground and groundwater before flowing into the surface water receiving environment.

The effluent discharged into LTAs will be safe for recreational contact, meaning co-use with passive recreation activity can be a practical outcome.

The Remote Telemetry Control (TCOM) will allow various functions, including remote monitoring capability, electronic logging of effluent flows, pump run times and alarm logs with audible and visual alarm features.

6 OPERATION REGIME

6.1 Daily Operation

The maximum daily discharge at the site will be the wet weather flow volume, as discussed in Section 5. The proposed staged flows for the LTA will be determined based on the staging of the development, as seen in Figure 3.1. Each zone will be designed for the discharge at a rate of 2.6 mm/hr, i.e. to apply 7 mm/day. The irrigation system will operate in that zone for 2.7 hrs. The duration of irrigation each day or return period determines the daily average discharge during dry weather flow based on the irrigation depths specified in Section. 5.1.2 and 12 to 16 mm/d for short periods of wet weather.

The dose volume can be managed to each zone, allowing the resting of the LTA and zone rotation. This operation is proposed to be automated to meet each zone's infiltration capabilities and will allow the control of the volume discharged per day.

Further information on the daily operation will be included in an Operation and Management Plan (OMP). The OMP is typically proposed as a condition of consent and incorporates information needed to demonstrate compliance with consent conditions.

6.2 Seasonal Operation

The daily operations will remain very similar throughout the year. However, the flows for the WWTP are likely to fluctuate with the higher stormwater I/I. This profile will result in the frequency of the dosing to each zone increasing up to the daily discharge depth or shorter return cycle.

During times of high flows, the water will be treated, and some buffering storage will occur within the WWTP.

6.3 Monitoring

Surface water quality in the streams and groundwater monitoring may be a requirement of the consent. Further information on the monitoring will be included in the OMP required as part of the consent compliance.

6.4 Surface Flow

The proposed PCDI discharge is to the subsurface soils at rates which are well below the soils hydraulic capacity, so there will be no ponding of treated wastewater. The DIR will also ensure that the breakout of the treated wastewater does not occur.

The recommended LTAs include some sloping sites. As an extra assurance, on the more highly sloped land associated with Area 1 irrigation zones and along the hill slope toe for Area 2, the proposal is to include subsurface French drains (Figure 6.1) to intercept any lateral flow and allow for this to infiltrate into the deep subsoil or to be collected for discharge into a wetland system. The conceptual location of the drains is shown in Figure 6.2.

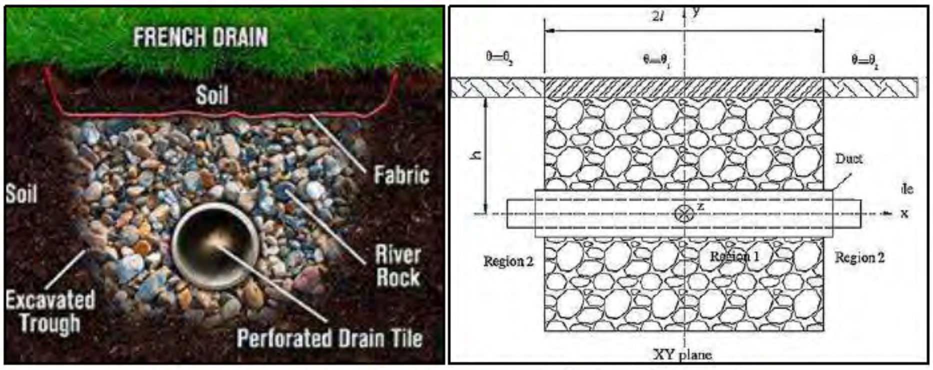

Figure 6.1: Indicative French Drain Design

Figure 6.2: Indicative French Drain Location

7 CONCLUSIONS AND RECOMMENDATIONS

This concept design report demonstrates there is a feasible treatment chain involving a WWTP and LTA discharge options that can be configured, flexibly implemented and managed to treat the development's WW to achieve a very small increase in current total losses of nutrients from the site if the QLDC COP flows occur, while being considerably (about 30%) lower than the total site loading calculated as being permitted under the RWP. Designing the wastewater treatment and discharge system the system to align with the expected nutrient losses from this landform enable social, economic, and cultural well-being of the Queenstown Lakes District Council (QLDC) community to be met while minimising adverse environmental effects.

Key conclusions include:

1. Sustainability: The system facilitates the beneficial reuse of water and nutrients. The staged development approach ensures flexibility as wastewater flows increase.
2. Nitrogen Management: The system manages total nitrogen (TN) leaching potential through a combination of optimised treatment at the WWTP and efficient land application.
3. Environmental Protection: Subsurface drip irrigation and conservative hydraulic loading rates minimise the risk of groundwater contamination and surface water impacts.
4. Future Steps: The next phase involves preparing the discharge consent application, detailed nutrient loss assessment, and environmental effects studies. .

Overall, the proposed design is intended to meet regulatory requirements while providing a robust and scalable wastewater treatment solution for the Homestead Bay development.

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9 APPENDICES

Appendix A	Soil Assessment
Appendix B	Overseer Modelling
Appendix C	Geosolve Logs

APPENDIX A

Soil Assessment

MEMORANDUM Job 10934

To: Dan Wells, RCL

From: Millie Taylor and Shamim Al Mamun, Lowe Environmental Impact

Date: 23 September 2024

Subject: Homestead Bay Development Soils Site Investigation

Dear Dan,

The following information outlines the results of the site investigation into the potential of wastewater dispersal at the Homestead Bay and QEII sites, based on LEI staff's visit on June 4th to 7th, 2024.

OVERVIEW

RCL Homestead Bay Limited (RCL) is investigating the Homestead Bay and QEII properties south of Jacks Point on Kingston Road SH6 to discharge community-treated wastewater to multiple land treatment areas (LTA). The sites have been earmarked due to their proximity to the proposed subdivision and available suitable land.

The sites are currently owned separately by RCL and QE11. The RCL site is located on Lot 8 DP 443832 (163.46 ha), while the QEII farming block is located on titles Part Lot 1 DP 26261 (656.94 ha) and Lot 2 DP 26261 (205.98 ha). Part of the RCL lot has been used previously for clean fill, but the rest of the site is low-sloping to rolling pasture with some cattle grazing. The QEII site is generally steeper at the foot of the Remarkables and is pasture with a small area of cropping and deer/cattle grazing. The QEII land is dominated by gravels due to the relative proximity to the mountains, whereas the RCL land has a deeper loess profile. Both sites are consistent with the S-map descriptions and what is expected from the current classification.

DESKTOP SOIL CHARACTERISTICS

Landcare Research Soils Map

An assessment of the area's Landcare Research soil map (S-Map) suggests the soil is classified as Typic Immature Pallic Loam with well-drained rapid permeability, as attached in Appendix B. The S-Map also suggests a very low water logging vulnerability and medium nitrogen leaching vulnerability.

The soil type specific to the site was confirmed in the LEI site investigation (this report).

Jacks Point Soils Investigation

The Homestead Bay residential zoned area occupies sloping topography from the east down to the flats of the central plain area south of the Jacks Point development. In the assessment of the soils from Jacks Point, the land consists of four main soil types.

Table 1: Soil Information

Soil Family	Characteristics (S-Map)	Irrigation Suitability
Wakatipu	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic Soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be dry in summer and wet in winter. It is formed in a blanket deposit of silt sized windblown materials overlying poorly stratified poorly sorted gravel sand and mud deposited from glacial ice or meltwater, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth is 20 - 45 (cm), due to densely packed gravels that mechanically impedes root growth. Generally, the soil is well drained with moderate vulnerability of water logging in non-irrigated conditions and has moderate to low soil water holding capacity. Inherently these soils have a high structural vulnerability and a moderate N leaching potential, which should be accounted for when making land management decisions.	Subsoil infiltration limitation; Year-round irrigation possible
Pigburn	This soil belongs to the Recent soil order of the New Zealand soil classification. Recent Soils are weakly developed, showing limited signs of soil-forming processes although a distinct topsoil is present, a B horizon is either absent or only weakly expressed. It is formed in alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is slightly stony. The subsoil has dominantly loam textures, with very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally, the soil is well drained with very low vulnerability of water logging in non-irrigated conditions and has moderate to high soil water holding capacity. Inherently these soils have a high structural vulnerability and a moderate N leaching potential, which should be accounted for when making land management decisions.	Limited to nil Subsoil infiltration limitation; Year-round irrigation possible
Barrhill	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic Soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be dry in summer and wet in winter. It is formed in a blanket deposit of silt sized windblown materials overlying	Some subsoil infiltration limitation; Year-round irrigation possible

Soil Family	Characteristics (S-Map)	Irrigation Suitability
	alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with gravel content of less than 3%. The plant rooting depth extends beyond 1m. Generally, the soil is moderately well drained with very low vulnerability of water logging in non-irrigated conditions and has high soil water holding capacity. Inherently these soils have a high structural vulnerability and a low N leaching potential, which should be accounted for when making land management decisions.	
Tucker	This soil belongs to the Recent soil order of the New Zealand soil classification. Recent Soils are weakly developed, showing limited signs of soil-forming processes although a distinct topsoil is present, a B horizon is either absent or only weakly expressed. It is formed in weathered soil and rock material mantling slopes, from schist parent material. The topsoil typically has sand texture and is moderately stony. The subsoil has dominantly sand textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally, the soil is well drained with very low vulnerability of water logging in non-irrigated conditions and has moderate to low soil water holding capacity. Inherently these soils have a very high structural vulnerability and a high N leaching potential, which should be accounted for when making land management decisions	Potential for year-round irrigation at low application rates

At Jacks Point, the dominant soils have been classified as AS/NZS1547 Category 3.

These soils generally aligned with those seen at Homestead Bay across both the RCL and QEII sites, and contain the following soil types:

- Wakatipu soils – cover the greatest area and are typically flat to gently sloping soils, which are formed in glacial deposits;
- Barrhill soils – are soils located in the central valley and also east of Jacks Point on the QEII property; and
- Pigburn soils – occupy a large area of the QEII property and are typically characterised as being a recent soil which is weakly developed.

The Tucker soils were not found at the Homestead Bay area.

Homestead Bay Soil Investigations

A comprehensive soil investigation was undertaken by LEI at these two sites on behalf of RCL between 4 to 7 June 2024. It comprised of the machine excavation of 17 test pits, nine of which also included hydraulic testing, as shown in Figure 1. These test pits were excavated down to a depth of approximately 2 m, with hydraulic testing completed at a depth of 0.2 m.

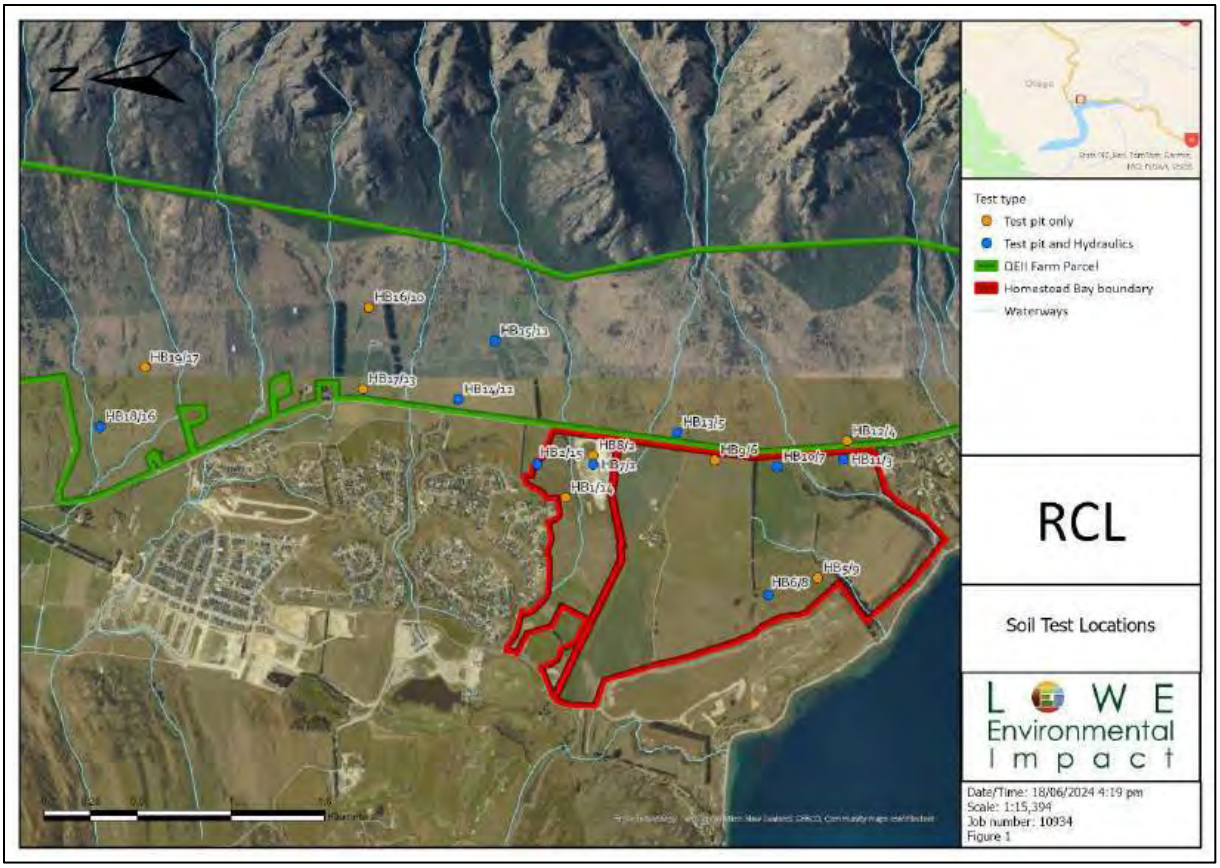

Figure 1: Location of Soil Test Sites

The RCL and QEII sites both contain a mixture of all three soil types, Barrhill, Pigburn, and Wakatipu, as noted in Error! Reference source not found.. The area of sites HB7/1 and HB8/2 is the clean fill site of the nearby Jacks Point subdivision, so it is classed differently due to this human interfered soil profile. The area of HB17/13 is also classed differently due to the note from the farmer of the presence of groundwater springs during wet periods, as well as the appearance of mottling in the profile, despite the Barrhill classification.

The soil profile at each site was photographed and logged with these individual profiles included as an attachment to this report. The summary of average soil profiles for each soil type is supplied in Table 2. The soil profiles typically comprised of 0.35 m of weathered topsoil (organic silt) with roots throughout, underlain by a silt subsoil down to alluvial or colluvial gravels at depth.

These soil logs show a consistent silt loam down to 0.9 m, with ranging stratification of gravels below this. Soil Categories 2 and 3 within AS/NZS 1547:2012 are representative of sands and loams.

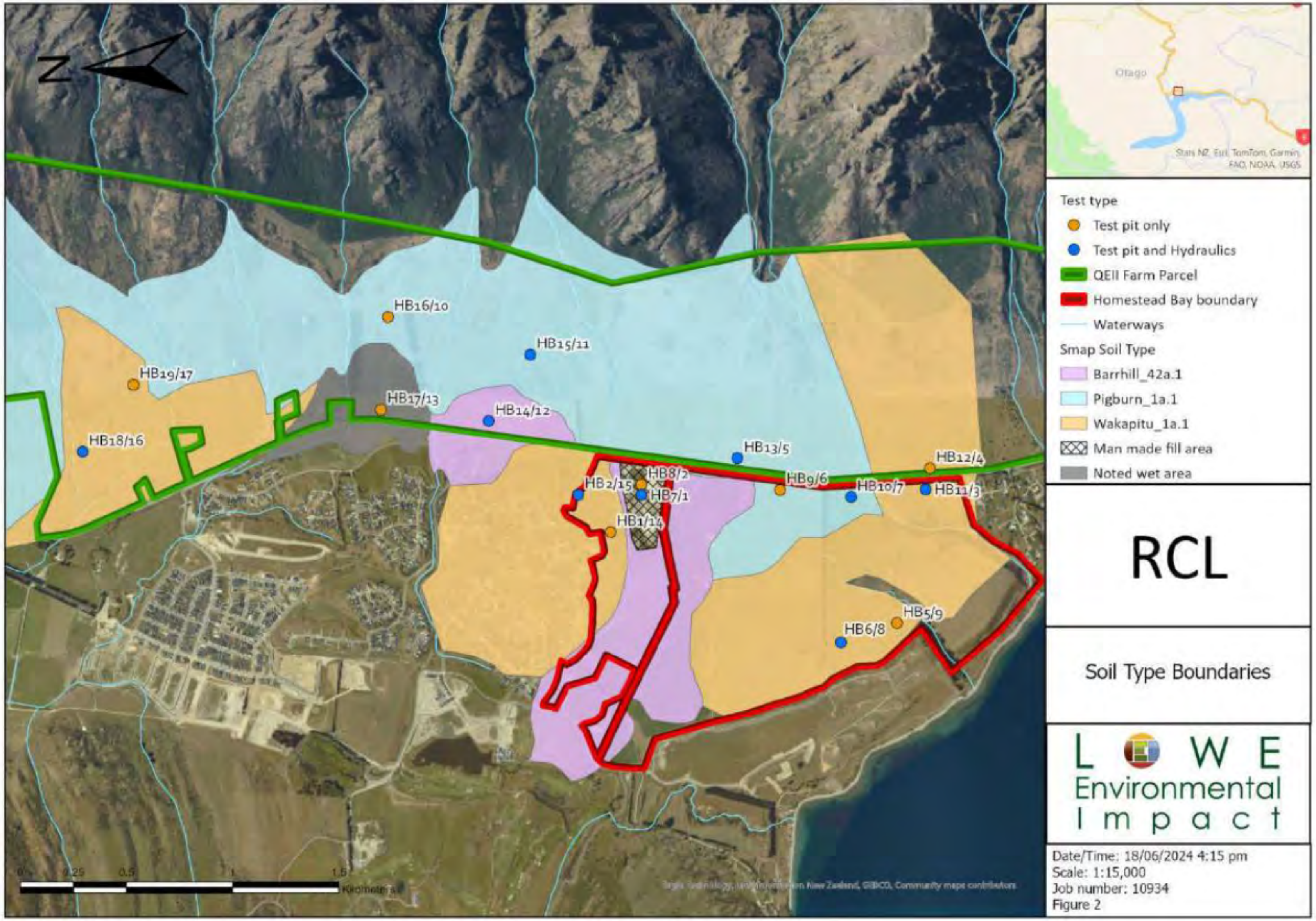

Figure 2: Soil Type Boundaries

Table 2: Averaged LEI Test Pit Logs by Soil Family

Below ground level (m)	**Pigburn**	**Below ground level (m)**	**Wakatipu**	**Below ground level (m)**	**Barrhill**
S-Map class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0 - 0.3	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is weak and friable. Common fine roots. Boundary is abrupt and smooth.	0-0.35	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Common fine roots. Boundary is distinct and occluded.	0-0.40	Moist, 10YR 4/2 (dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.
0.3-0.9	Moist, 10YR 6/2 (light brownish grey) coloured soil. **No gravels**. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth. Some occlusions.	0.35-0.6	Moist, 10YR 5/8 (yellowish brown) coloured soil. **Slightly gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. Few fine roots. Boundary is sharp and smooth.	0.4-0.9	Moist, 10YR 5/4 (yellowish brown) coloured soil. **Very slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is firm, aggregate strength is weak and brittle. Few fine roots. Boundary is sharp and smooth. Oxide staining layers throughout the b horizon.
		0.6-1.8+			

Below ground level (m)	**Pigburn**	**Below ground level (m)**	**Wakatipu**	**Below ground level (m)**	**Barrhill**
S-Map class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0.9-1.1	Moist, 10YR 6/3 (pale brown) coloured soil. **Very gravelly**, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth.		Slightly moist, 10YR 7/3 (very pale brown) coloured soil. **Extremely gravelly**, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain. Soil strength is firm, aggregate strength is slightly firm and brittle. No roots. Concreted texture but water soaks away.	0.9-1	Slightly moist, 10YR 5/4 (yellowish brown) coloured soil. **Extremely gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. No roots. Boundary is sharp and smooth.
1.1-1.45	Moist, 10YR 6/1 (grey) coloured soil. **Slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. Few fine roots. Boundary is sharp and smooth.			1-1.4	Moist, 10YR 6/3 (pale brown) coloured soil. **No gravels**. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is weak and brittle. Organic staining from roots. Boundary is sharp and smooth.
1.45-1.8+	Moist, 10YR 6/1 (grey) coloured soil. **Very gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. Few fine roots. Mixture of size class gravels.			1.4-1.7+	Moist, 10YR 6/3 (pale brown). **Extremely gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. No roots. Mixed size of gravels and sand.

LEI SOILS TESTING RESULTS

Hydraulic Conductivity Tests

Saturated and unsaturated hydraulic conductivity tests were undertaken at nine sites (Figure 1) at a depth of 0.2 m using a combination of double-ring infiltrometers and unsaturated plate permeameters. This depth was assessed as the drippers would be laid due to this depth. Table 3 presents the saturated hydraulic conductivity (total flow through the soil, including macropores, such as root and wormholes) for the sites.

Saturated hydraulic conductivity describes the ease with which water moves through soil when all its pores are completely filled with water. In this fully saturated state, water movement is driven primarily by gravity and the pressure gradient, as there are no air-filled pores to impede the flow. The larger pores, or macropores, such as those created by root channels, cracks, and spaces between soil aggregates, dominate water flow under saturated conditions. Water flows through these macropores quickly due to the low resistance and the direct path they provide. Soil texture, structure, and the presence of organic matter significantly influence the rate of water movement, with sandy soils generally exhibiting higher saturated conductivity than clayey soils due to their larger pore spaces. The conductivity is also influenced by the degree of soil compaction and the connectivity of the pore network. In undisturbed, well-structured soils and in soils where a lot of sands and gravels are present, the rate of water percolation is higher, while in compacted or poorly structured soils, it is lower due to the reduction in macropore space.

The saturated tests are likely to provide a more representative result of the gravity drainage through the larger macropores. The faster draining soils in the saturated tests are the Wakatipu soils, which all displayed an extremely gravelly, concreted type soil beyond around 0.6 m depth. This natural concreted type layer, quickly percolate water when applied, supporting this high infiltration rate.

The testing at site HB 13/5 was unsuccessful because the soil was too gravelly to install the double rings properly, preventing LEI from obtaining an additional reading. The manmade clean fill site had the lowest saturated conductivity, likely due to the anthropic nature of the site experiencing artificial compaction with heavy machinery. Pigburn and Barrhill gave similar saturated hydraulic conductivity readings.

Table 3: Soil Saturated Hydraulic Conductivity (K_{sat})

Serial no.	Site	Soil Type	Topsoil Average K_{sat} (mm/day)
1	Site HB2/15	Wakatipu	1,440
2	Site HB6/8	Wakatipu	3,960
3	Site HB7/1	Manmade	150
4	Site HB10/7	Pigburn	720
5	Site HB11/3	Wakatipu	1,044
6	Site HB13/5	Pigburn	*Too gravelly to conduct testing
7	Site HB14/12	Barrhill	720
8	Site HB15/11	Pigburn	920
9	Site HB18/16	Wakatipu	720

Table 4 presents the unsaturated hydraulic conductivity (represents the flow through meso and micropores, i.e. full matrix flow through the soil) for the nine sites. Field tests using the plate permeameters ($K_{-40\ mm}$) found that the rate moving through the soil indicated a strongly unified soil texture which showed only small increments of change across the different pressures. The unsaturated tests are well grouped between the soil types, with the faster draining soils being the Pigburn, compared with the slower draining Wakatipu and Barrhill.

Unsaturated hydraulic conductivity, which describes how water moves through soil when the soil is not fully saturated, primarily occurs through the soil's micro and mesopores. Micropores are the small pores in the soil, often found within soil aggregates or between tightly packed soil particles. They play a significant role in retaining water against gravity due to capillary forces, and they control water movement when the soil is at lower moisture levels.

Mesopores are slightly larger pores than micropores, and they facilitate water movement when the soil is at moderate moisture levels. In unsaturated conditions, mesopores allow water to flow through the soil more readily than micropores, but they still retain water that plants can access.
Together, the micro and mesopores regulate the unsaturated conductivity in soils, with the rate of water movement depending on the pore size distribution and soil moisture content. At lower soil moisture levels, water primarily moves through micropores, while at higher unsaturated conditions, mesopores become more active in conducting water.

Table 4: Soil Unsaturated Hydraulic Conductivity ($K_{-40\ mm}$)

Serial no.	Site sample number	Soil Type	Field investigation of topsoil average unsaturated hydraulic conductivity, K_{-40} (mm/day)	Landcare Research laboratory result unsaturated hydraulic conductivity, K_{-40} (mm/day)
1	Site HB2-15	Wakatipu	22	360
2	Site HB6-8	Wakatipu	30	768
3	Site HB11-3	Wakatipu	11	336
4	Site HB18-16	Wakatipu	25	624
5	Site HB7-1	Manmade	53.5	96
6	Site HB10-7	Pigburn	123	312
7	Site HB13-5	Pigburn	73	336
8	Site HB15-11	Pigburn	110	480
9	Site HB14-12	Barrhill	37	72

The value of unsaturated hydraulic conductivity in the topsoil of the sites ranged from 11 to123 mm/day. The unsaturated hydraulic conductivity of the sample cores of the sites those were sent to Landcare Research ranged from 72 to 768 mm/day. The variation between field observation and laboratory tests are expected as the plate permeameter (field observation) method usually are conducted by using one to four replications which considers variability of unsaturated hydraulic conductivity in 2-4 spots and the average results are considered whereas in laboratory studies only one sample has been considered. The variability in the properties of soils in field conditions is also common.

The hydraulic results based on soil distribution are shown below in Error! Reference source not found.. The distribution of these rates supports the proposal to irrigate based on soil type.

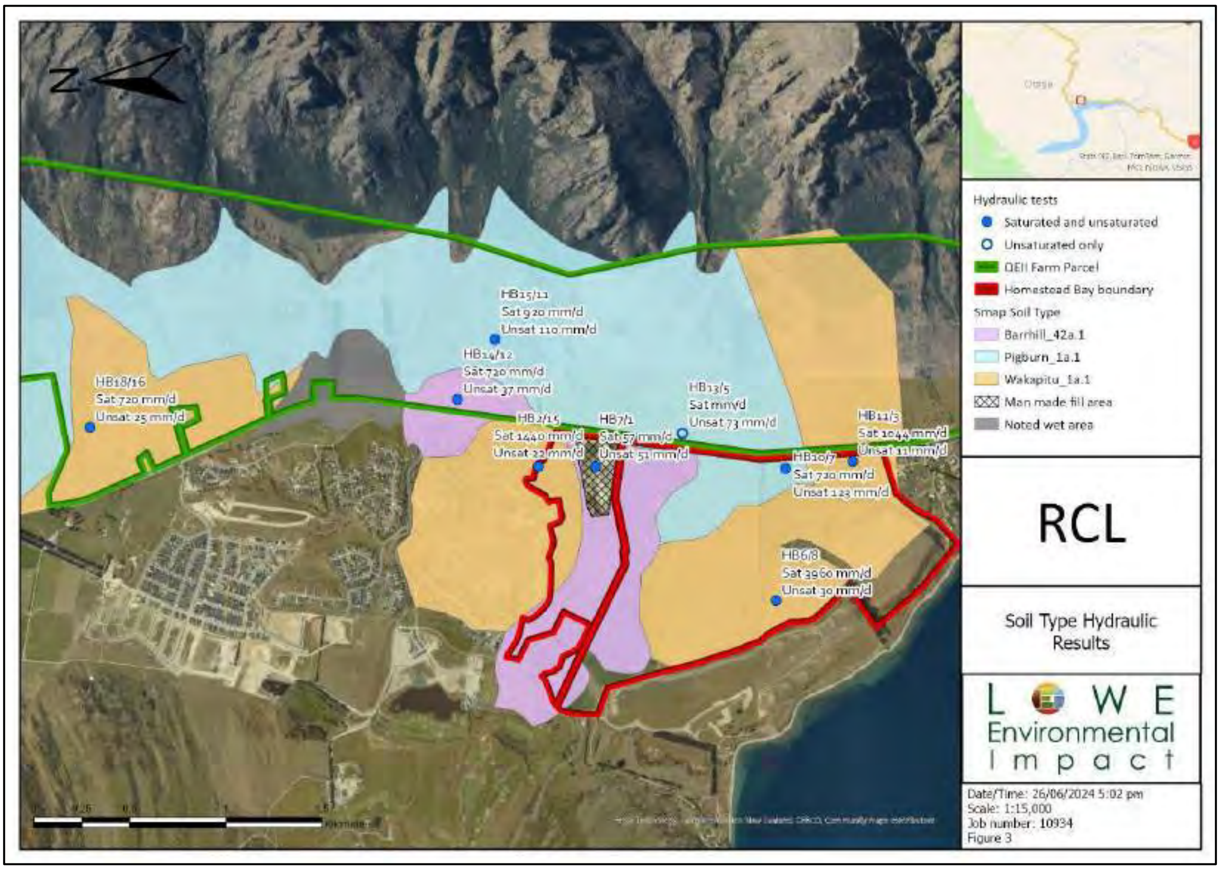

Figure 3: Soil Hydraulic Distribution

Field measurements typically only observe clean water effects, but the impact of wastewater constituents must also be considered. Organic material, solids and nutrients in the wastewater can allow the development of microbial growth, commonly referred to as biofilm, which in turn can result in a 'clogging' effect of the soil pores, particularly near the irrigation line outlets. This can reduce the soil's infiltration capacity. In addition, the salt concentration will influence the soil wetting by altering the water tension.

Crites and Tchobanoglous (1998) recommend a value of 10 - 30% of the K_{sat} to provide a Design Irrigation Rate (DIR). LEI has conservatively adopted a value of 10% of the K_{sat} and 30% of the K_{unsat} to provide a DIR.

Due to the previously mentioned consistent grouping by soil type, the design application rates have been prepared separately for Barrhill, Pigburn, and Wakatipu soil types. These are shown below in Table 5, Table 6, and Table 7.

DIR DEPENDING ON SOIL TYPES

Barrhill Soils

The Barrhill soil DIR is calculated from on-site measurements and from past investigations on the neighbouring Jacks Point development.

Table 5: Barrhill Design Irrigation Rate

Items	**Saturated hydraulic conductivity (K_{sat})**	**Unsaturated hydraulic conductivity (K_{-40})**
Field Measurement low permeability subsoil (mm/day)	720 ± 0	37
Adjustment (%)	10	30
DIR (mm/day)	72 ± 0	11.0

DIR recommended by the investigation is up to 11 mm/day.

Pigburn Soils

The Pigburn soils dominate the higher elevations of the QEII site and part of the RCL site. These soils show a high saturated infiltration rate and unsaturated hydraulic conductivity.

Table 6: Pigburn Design Irrigation Rate

	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	820 ± 173	137 ± 61
Adjustment (%)	10	30
DIR (mm/day)	82 ± 17	41 ± 18

The DIR recommended from the investigation is up to 41 mm/day.

Wakatipu Soils

The Wakatipu soils experience higher saturated infiltration rates due to the rapid infiltration at around 0.6 m depth. The lower unsaturated infiltration rate is similar to that of the Barrhill soils, which are also pallic soils.

Table 7: Wakatipu Design Irrigation Rate

	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	1,791 ± 1,300	24.2 ± 10.7
Adjustment (%)	10	30
DIR (mm/day)	179 ± 130	7.3 ± 3.2

The DIR recommended from the investigation is up to 7 mm/day.

Manmade Soils

The manmade soils are imported as clean fill of unsuitable construction foundation material from the nearby developments. This area has been identified for the location of the WWTP but could also be used for an LTA.

Table 8: Manmade Design Irrigation Rate

	Saturated (K_{sat})	Mean Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	150 ± 52	53.5 ± 15.5
Adjustment (%)	10	30
Maximum DIR (mm/day)	15 ± 5.2	16.1 ± 4.7

The DIR recommended from the investigation is up to 15 mm/day (Table 9). However, due to the nature of the parent material and the mechanical/landfilling compaction that has been undertaken, a lower infiltration rate of 5 mm/day is recommended as a conservative approach.

Proposed Design Irrigation Rate

The soil investigation has indicated that all of the site's soils have a high hydraulic capacity to assimilate the wastewater. Based on this information, LEI concludes that DIR should be further informed based on land treatment area, nitrogen leaching and catchment nitrogen effects. Proposed DIRs for this community system need to consider the land area available, land use and catchment sensitivities. Table 9 presents recommended rates for the basis of the scheme design and nutrient modelling.

Table 9: Proposed Design Application Rate

	Proposed DIR (mm/day)
Barrhill Soils	7
Pigburn Soils	7
Wakatipu Soils	7
Manmade Soils	5

Depending on the LTA area, final selected DIR will be recommended in the Conceptual Design report.

Soil's Physical properties in relation to hydraulic conductivity

The Table 10 provides a detailed overview of the soil physical properties across various sites, including particle density, dry bulk density, total porosity, macro-porosity, and micro-porosity. These parameters are essential in understanding the soil's ability to retain water, support plant growth, and allow for air and water movement through the soil profile (Brady et al., 2008; McLaren and Cameroon, 1996).

Table 10: Soil physical properties

Site no.	Particle Density (g/cm³)	Dry Bulk (g/cm³)	Total porosity (%)	Macro-porosity (%)	Micro-porosity (%)
HB 7/1	2.72	1.60	41	13	28
HB 8/2	2.72	1.28	53	16	37
HB 11/3	2.79	1.49	47	13	34
HB 12/4	2.75	1.43	48	11	37
HB 13/5	2.80	1.34	52	10	43
HB 9/6	2.82	1.33	53	8	45
HB 10/7	2.78	1.44	48	10	38
HB 6/8	2.67	1.43	47	15	31
HB 5/9	2.68	1.32	51	15	36
HB 16/10	2.76	1.33	52	15	37
HB 15/11	2.80	1.36	52	13	39
HB 14/12	2.82	1.45	49	9	40
HB 17/13	2.77	1.27	54	12	43
HB 1/14	2.65	1.30	51	11	40
HB 2/15	2.69	1.34	50	14	36
HB 18/16	2.77	1.33	52	14	38
HB 19/17	2.79	1.41	50	13	37

Particle Density and Dry Bulk Density:

Particle density is a measure of the mass of soil particles per unit volume, typically excluding pore spaces. In this dataset, the particle density ranges from 2.65 g/cm³ to 2.82 g/cm³, indicating slight variations in the mineral composition of the soils across the sites. Soils with higher particle density, such as Site HB 9/6 and HB 14/12 (2.82 g/cm³), may contain heavier minerals, possibly contributing to different soil behaviour compared to those with lower particle density, such as Site HB 1/14 (2.65 g/cm³).

Bulk density is a measure of soil compaction, expressed as the mass of soil per unit volume. Dry bulk density, on the other hand, measures the mass of soil, including pore spaces, and it is a key indicator of soil compaction. Lower bulk density values generally indicate better soil structure with more pore spaces, which are crucial for root penetration and water infiltration. Dry bulk density ranges from 1.27 g/cm³ at Site HB 17/13 to 1.60 g/cm³ at Site HB 7/1. Soils with higher bulk density, such as Site HB 7/1, may be more compacted, reducing porosity and potentially limiting water movement and root growth. For pasture soils, the target bulk density typically falls within the range of 0.7 to 1.4 g/cm³ (Sparling et al., 2008). At these levels, soil is considered to have an adequate balance between compactness and porosity, allowing for sufficient root growth and water infiltration.

A bulk density below 0.7 g/cm³ indicates that the soil is too loose, which can lead to issues such as erosion or insufficient support for plants. On the other hand, a bulk density above 1.4 g/cm³ suggests that the soil is becoming too compacted, potentially restricting root penetration, reducing water infiltration, and impairing overall soil health. Managing bulk density within this target range helps maintain soil structure conducive to healthy pasture growth. In the investigated site the in soils ranged from 1.27 to 1.60 g/cm³. Th bulk density in site HB 17/13 was the lowest (1.27 g/cm³) whereas the bulk density in site HB 7/1 was the highest (1.60 g/cm³). Site HB 19/17, HB 12/4, HB 6/8, HB 10/7, HB 14/12, HB 11/3 and HB 7/1 had higher bulk density than the prescribed level (Sparling et al., 2008). This high bulk density needs to be decreased for better plant growth and environmental wellbeing.

Total Porosity

Total porosity, which represents the proportion of soil volume occupied by pores, is inversely related to bulk density. Higher porosity values suggest a greater ability of the soil to store water and air, which is essential for healthy plant growth and water infiltration. The sites show a range of total porosity from 41% at Site HB 7/1 to 54% at Site HB 17/13. Higher porosity, as seen in Site HB 17/13, indicates that the soil has more spaces available for air and water, which could enhance plant growth and water percolation.

Macro-porosity and Micro-porosity

Macro-porosity refers to the larger pores in the soil that allow for rapid drainage and air exchange, whereas micro-porosity includes smaller pores that retain water for plant use. In this dataset, macro-porosity ranges from 8% at Site HB 9/6 to 16% at Site HB 8/2, while micro-porosity varies between 28% and 45%. Sites with higher macro-porosity, such as HB 8/2, are likely to have better drainage but may also be more prone to drying out, especially in periods of low rainfall. Conversely, higher micro-porosity, as seen in Site HB 9/6 (45%), suggests a greater capacity to hold water, which can be crucial during dry periods but may also slow down drainage, potentially leading to waterlogging under higher rates of water application.

Macroporosity are essential for water drainage, air exchange, and root growth. For pasture soils, the target range for macroporosity is 6 to 30% (Sparling et al., 2008), with 30% considered high and ideal for most agricultural purposes. Adequate macroporosity (within the 6-30% range) ensures that the soil has enough large pores to allow for efficient water movement and root development, critical for sustaining pasture productivity. A macroporosity below 6% is considered low, indicating that the soil may be too compacted, leading to poor drainage and limited oxygen availability to plant roots, which can stifle growth and reduce pasture yield.

In the tested sites, all the sites macroporosity was more than 6% which implies that sites macroporosity is in reasonable condition. The lowest macro porosity was observed in site HB 9/6 (8%) and highest was observed in site HB 8/2 (16%).

Implications for Soil Management

Understanding these physical properties is critical for effective soil management. Soils with lower bulk density and higher porosity, like those at Site HB 17/13, are generally more favourable for root growth and water infiltration, making them suitable for a wide range of crops. However, these soils might require more frequent irrigation due to their higher drainage capacity. On the other hand, soils with higher bulk density and lower porosity, such as those at Site HB 7/1, may need management practices that improve structure, such as adding organic matter or reducing compaction through appropriate tillage practices.

Water holding capacity

Field Capacity (FC)

FC is crucial when applying treated wastewater to soils because it represents the maximum amount of water the soil can hold after excess water has drained away. Applying wastewater up to the FC level ensures that the soil is sufficiently moist without causing waterlogging, which could lead to runoff, leaching of nutrients, and potential contamination of groundwater.

Available Water Capacity (AWC)

AWC indicates the range of water available for plant use between field capacity and the wilting point. In treated wastewater applications, knowing the AWC helps in determining the appropriate amount and frequency of wastewater irrigation, ensuring that plants receive enough moisture without over-irrigation, which could cause nutrient imbalances or pollution.

Gravimetric Water Content

This measure provides insights into the actual water content in the soil as a percentage of its dry weight. It is useful in assessing how much treated wastewater has been retained by the soil after application. Monitoring gravimetric water content helps in optimizing water use efficiency and preventing excessive buildup of moisture that could lead to anaerobic conditions or soil degradation.

Volumetric Water Content

Volumetric water content, expressed as a percentage of the soil's total volume, is key to understanding how much water is present in the soil at various moisture levels. It is particularly important in the context of treated wastewater application, as it helps in tracking how the soil's moisture profile changes with irrigation, ensuring that the soil maintains adequate moisture for plant growth without reaching saturation levels that could result in surface runoff or nutrient leaching.

Table 11 presents, Field Capacity (%), which provides insight into the water-holding capacity of the soil after excess water has drained away and the soil has reached a point where it holds water against gravity. The values range from 27% to 41%, indicating significant variability among the samples field capacity. The highest field capacity was observed in sample HB 9/6 (41%) whereas the lowest field capacity was observed in sample HB 7/1 with 27%.

Available Water Capacity (AWC % v/v), represents the volume of water available for plant uptake, calculated as the difference between the water content at Field Capacity and the Permanent Wilting Point. AWC values in these samples range from 15% to 37%, reflecting the soil's ability to supply water to plants. Higher AWC values, such as 37% in sample HB 9/6, indicate that a significant portion of the retained water is accessible to plants, making this soil highly suitable for agricultural purposes. Conversely, lower AWC values, like the 15% observed in sample HB 7/1, suggest that even though the soil may hold water, less of it is available for plants to absorb, potentially leading to stress during dry spells.

The gravimetric water content (GWC) of the soils across the different sites shows considerable variability, reflecting their differing capacities to retain water under various conditions. At saturation, the GWC at saturation ranges from a low of 26% at Site HB 7/1 to a high of 43% at Site HB 17/13, indicating that some soils, like HB 17/13, can hold significantly more water when fully saturated compared to others.

Table 11: Gravimetric Water Content

Plot	Field Capacity (%)	AWC (% v/v) (-10 to -1500 kPa)	Gravimetric Water Content (%w/w)				
			At field condition (%w/w)	At saturation (%w/w)	@ -5 kPa (%w/w)	@ -10 kPa (%w/w)	@ -1500kPa (%w/w)
HB 7/1	27	15	12	26	18	17	7
HB 8/2	33	26	18	41	29	26	5
HB 11/3	30	21	11	31	23	20	6
HB 12/4	34	29	16	34	26	24	4
HB 13/5	37	27	12	39	32	27	7
HB 9/6	41	37	12	40	34	30	2
HB 10/7	35	31	13	33	26	24	3
HB 6/8	29	24	17	33	22	20	4
HB 5/9	33	24	16	39	27	25	7
HB 16/10	34	26	19	39	28	25	6
HB 15/11	36	31	17	38	28	26	4
HB 14/12	38	26	20	33	28	26	8
HB 17/13	40	29	28	43	34	32	9
HB 1/14	35	24	19	39	31	27	8
HB 2/15	31	23	17	38	27	23	7
HB 18/16	35	23	20	39	28	26	8
HB 19/17	34	24	18	35	26	24	8

As the soil begins to drain and reaches -5 kPa, the GWC decreases, with values ranging from 18% at Site HB 7/1 to 34% at Site HB 17/13, again highlighting the superior water retention ability of Site HB 17/13.

At -10 kPa, which is closer to the soil's field capacity, the GWC further decreases, with the lowest value at 17% for Site HB 7/1 and the highest at 32% for Site HB 17/13.

Finally, at -1500 kPa, which represents the wilting point where water is no longer available to plants, the GWC ranges from 2% at Site HB 9/6 to 9% at Site HB 17/13.

This data indicates that soils like those at HB 17/13 consistently exhibit higher water retention across all moisture levels, making them more resilient during dry periods. In contrast, soils at HB 7/1, with consistently lower GWC values, are likely to dry out faster and may require more frequent irrigation to sustain plant growth, highlighting the need for tailored water management practices based on the specific characteristics of each site.

It is also important to note here that the gravimetric water content in site HB 7/1 was only 52 to 60% of the gravimetric water content in site 17/13 at saturation to field capacity (saturation to -10kPa)

A similar result was observed when the volumetric water content was considered. That is site HB 17/13 had the highest water retention capability which implies that volumetric water content and gravimetric water content are actually showing the similar result.

Table 12: Volumetric Water Content

Sites	Volumetric Water Content (% v/v)				
	At field moisture	At saturation	@ -5 kPa	@ -10 kPa	@ -1500kPa
HB 7/1	20	41	28	27	12
HB 8/2	24	53	37	33	7
HB 11/3	17	47	34	30	9
HB 12/4	23	48	37	34	5
HB 13/5	16	52	43	37	10
HB 9/6	16	53	45	41	3
HB 10/7	19	48	38	35	4
HB 6/8	24	47	31	29	6
HB 5/9	22	51	36	33	9
HB 16/10	26	52	37	34	8
HB 15/11	23	52	39	36	5
HB 14/12	29	49	40	38	12
HB 17/13	36	54	43	40	11
HB 1/14	24	51	40	35	10
HB 2/15	22	50	36	31	9
HB 18/16	26	52	38	35	11
HB 19/17	26	50	37	34	11

The Table 12 provides a detailed overview of the Volumetric Water Content (% v/v) across various sites, measured at different soil moisture conditions: field moisture, saturation, and specific matric potentials (-5 kPa, -10 kPa, and -1500 kPa). The data shows significant variation in water content across the sites, with field moisture values ranging from 16% to 36%, indicating differences in the soil's ability to retain water under natural conditions. The saturation values, which range from 41% to 54%, highlight the maximum water content the soils can hold, reflecting the soil's porosity.

At the matric potentials of -5 kPa and -10 kPa, the water content decreases as the soil dries, with notable declines in water retention. The water content at -1500 kPa, representing the permanent wilting point ranges between 3% and 12%.

This variation across the sites suggests differences in soil texture, structure, and organic matter content, influencing the soil's water retention and availability to plants. The site HB 7/1 has the lowest available water content but the highest water percentage at wilting point implying that to manage water application in this site will need special care so that no ponding or waster logging happens that might affect the management of wastewater and plant growth negatively.

PHOSPHORUS

Maximum Phosphorus (P) sorption capacity of soils calculated from Landcare Research tests data

At different concentration of Phosphorus (P) in solution, there is a corresponding P sorption by the soil. The P sorption capability in soils is a key indicator of how effectively a soil can absorb and hold phosphorus, a critical nutrient for plant growth. This percentage represents the proportion of added phosphorus that is adsorbed by the soil, preventing it from being lost through leaching or runoff. High phosphorus adsorption is particularly important in preventing environmental issues such as eutrophication. Several factors influence phosphorus retention in soils, including soil texture, pH, organic matter content, and mineral composition. Soils with a high clay content generally have higher phosphorus sorption due to the greater surface area and charge of clay particles, which provide more binding sites for phosphorus. The pH of the soil also plays a significant role, with high and low pH impacting availability and leaching; in acidic soils (low pH <5.8), phosphorus tends to bind with iron and aluminium oxides, increasing sorption, whereas, at high pH >7, P tends to react with Ca and becomes unavailable.

Organic matter usually increases phosphorus sorption depending on the specific organic compounds present and their interactions with soil minerals. Soils rich in iron and aluminium oxides typically exhibit high phosphorus retention. Understanding phosphorus retention percentages is crucial for effective nutrient management in agriculture. In soils with high retention, more phosphorus may need to be applied to meet crop needs, while in soils with low retention, careful management is required to prevent phosphorus loss. By optimizing phosphorus retention through the soil and wastewater management practices, it is possible to improve crop yields while protecting the environment.

Phosphorus (P) sorption in soils (Error! Reference source not found.) is a critical factor in determining the availability of this essential nutrient for plant uptake and its potential impact on the environment. Phosphorus plays a crucial role in plant growth, contributing to processes like energy transfer, photosynthesis, and the synthesis of nucleic acids. However, phosphorus is often a limiting nutrient in soils due to its strong tendency to bind to soil particles, making it less available to plants. Understanding phosphorus sorption dynamics is vital for effective soil management, optimizing fertilization practices, and preventing environmental issues like eutrophication.

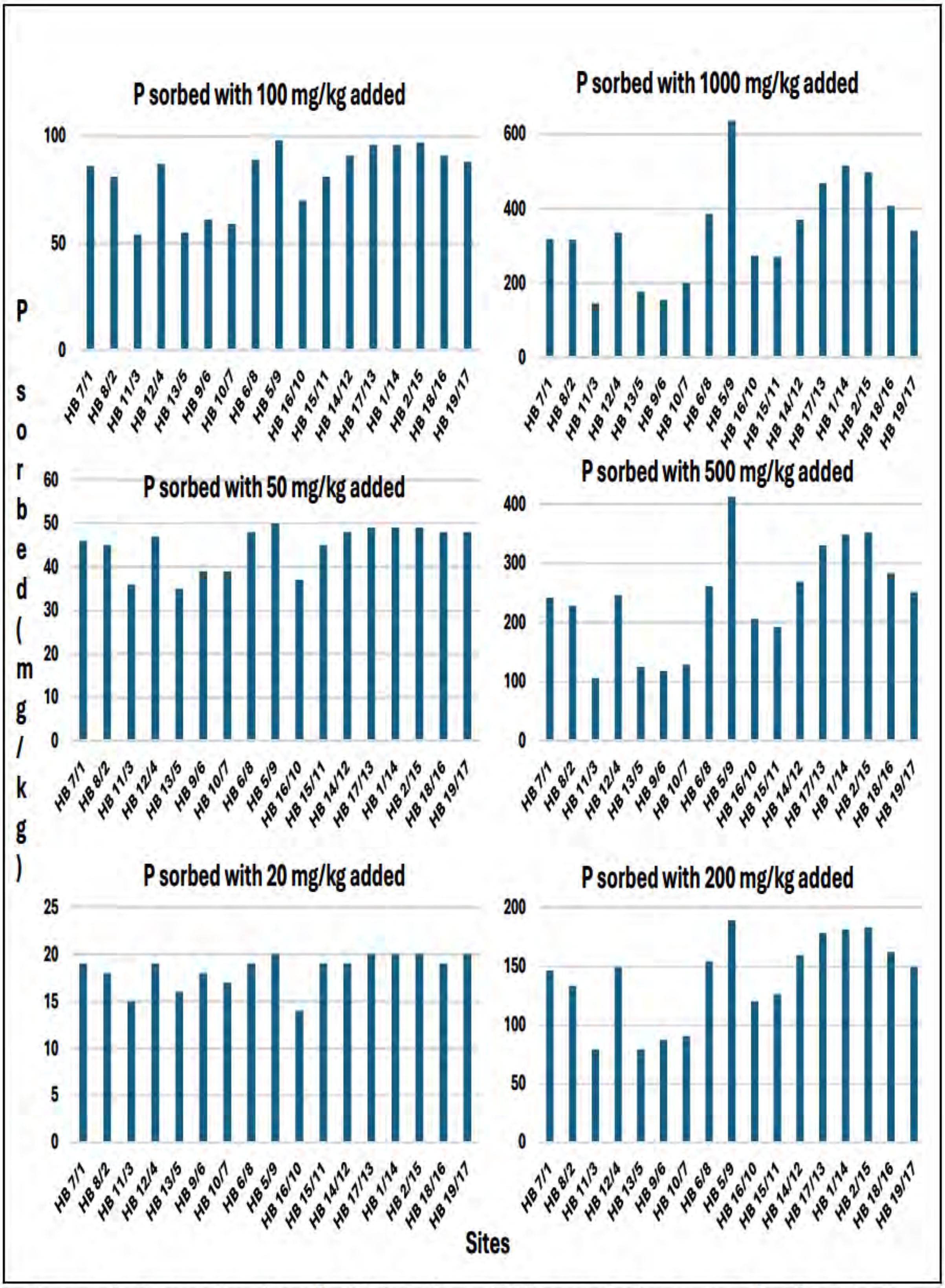

Figure 4: P sorption (mg/kg) by Soils at Different P Concentration in Solution (mg/kg)

The low sorption values of some sites suggest that the soils at these sites are less effective at retaining phosphorus, making it more susceptible to phosphorus leaching. This can lead to nutrient loss and increased environmental risks, particularly in areas where phosphorus runoff might contribute to water pollution. Soils with low phosphorus could be amendeded with biochar as biochar has been reported to increase phosphorus retention in soils and supply of P to plants when plants need it (Glaser & Lehr, 2019).

The Maximum Phosphorus Sorption Capacity (MPSC) (mg/kg) in soil samples ranged from 1,887-8,507 mg/kg soil (Table 13) which has been calculated by using the data from Landcare Research.

The highest MPSC was observed at Site HB 5/9, with a value of 8,507 mg/kg, suggesting a superior ability to adsorb phosphorus, which could be attributed to factors such as high clay content, organic matter, or the presence of minerals like iron and aluminum oxides known for high phosphorus sorption. In contrast, the lowest capacity was recorded at Site HB 11/3, with an MPSC of 1,887 mg/kg, indicating a lower potential to retain phosphorus, possibly due to lower reactive surface area or different mineralogical composition.

Several other sites exhibited relatively high phosphorus sorption capacities, such as HB 1/14 (6,575 mg/kg) and HB 17/13 (5,881 mg/kg), which are likely influenced by similar soil properties that enhance phosphorus retention. On the other hand, sites like HB 9/6 (1,958 mg/kg) and HB 13/5 (2,534 mg/kg) had lower capacities, highlighting variability in soil characteristics across the locations.

The significant variability in MPSC among the sites emphasizes the need for site-specific soil management practices to optimize phosphorus use efficiency. Understanding these variations can help in designing appropriate soil amendments and management strategies that enhance phosphorus sorption, reduce leaching, and mitigate environmental impacts associated with phosphorus runoff.

The significant difference between these sites highlights the variability in phosphorus sorption across different soil types. Managing these differences is crucial for optimizing fertilization practices and minimizing environmental impact.

Table 13: Maximum Phosphorus Sorption Capacity (mg/kg) of Soils in different Sites

Site number	Maximum Phosphorus Sorption Capacity (mg/kg)
HB 7/1	4,175
HB 8/2	4,429
HB 11/3	1,887
HB 12/4	4,380
HB 13/5	2,534
HB 9/6	1,958
HB 10/7	2,769
HB 6/8	5,097
HB 5/9	8,507
HB 16/10	4,035
HB 15/11	3,499
HB 14/12	4,764
HB 17/13	5,881
HB 1/14	6,575
HB 2/15	6,248
HB 18/16	5,324
HB 19/17	4,464

Implications for Soil Management

The significant variation in phosphorus sorption between different sites underscores the importance of understanding and managing soil-specific phosphorus dynamics. Soils with high sorption capacities, like those at HB 5/9, are effective at retaining applied phosphorus, which is beneficial for long-term nutrient availability and environmental protection. However, these soils may require higher phosphorus inputs to meet crop needs, as a substantial portion of the applied phosphorus is immobilized within the soil matrix and is not immediately available to plants.

On the other hand, soils with low phosphorus sorption capacities, such as those at HB 11/3, pose a different set of challenges. These soils are more susceptible to phosphorus loss through leaching, which can lead to reduced phosphorus availability for crops and increased risk of environmental pollution. Effective management strategies for these soils might include the use of phosphorus sorption enhancing amendments eg. Biochar (Glaser & Lehr, 2019; Jindo, et al. 2020), more frequent but smaller phosphorus applications, or the implementation of buffer zones to prevent runoff.

Summary:

The summary given below that has been derived from the discussion of the report.

- The DIR (Design Irrigation Rates) has been recommended as 7 mm/day for all sites except HB 7/1 (manmade site) where the DIR has been recommended as 5 mm/day.
- For increasing the sites water holding capacity, P retention and P sorption capability, the soils are recommended to use a biochar (if necessary) to increase the discharge rates especially where the infiltration rate was seen slow eg. HB 11/3, HB 9/6 and HB 7/1.

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Appendices

Appendix A	Field Investigation Soil Profile Descriptions
Appendix B	Landcare Research Soil Reports

APPENDIX A

Field Investigation Soil Profile Descriptions

LEI Soil Profile Description		
June 6, 2024 3:46 PM	*HB1/14*	
Millie	*Elevated rolling hills*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 903

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.08185743, 168.75313995

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Pasture	
A	0 - 30 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels.* No *mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is distinct and occluded.*	
B1	30 - 50 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is diffuse and convolute. B horizon merging into bw.*	

B2	50 - 80 cm	*Moist, 10YR 8/4 (very pale brown)* coloured soil. *Very gravelly, angular, fine gravel.* No mottles, *non-sticky, non-plastic, loamy sand. Apedal massive*. Soil strength is firm, aggregate strength is weak and friable. *Few fine roots. Boundary is abrupt and wavy*. *Mixed zone of b and bw horizon. Compacted sand with mixed-in gravels.*	
C	80 - 180 cm	*Moist, 10YR 8/2 (very pale brown)* coloured soil. *Extremely gravelly, angular, coarse gravel.* No mottles, *non-sticky, non-plastic, loamy sand. apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots. Cemented type texture but water drains away fine*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description

June 6, 2024 4:28 PM	*HB2/15*	
Millie	*Elevated rolling hills closest to highway*	
overcast, calm	*Much the same as HB1/14 but bigger boulders in b horizon*	
Soil Core # (if collected)	Top soil:	Sub soil: 832

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.08058172, 168.75546644

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Pasture/browntop	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and occluded.*	
B1	25 - 50 cm	*Moist, 10YR 3/6 (dark yellowish brown)* coloured soil. *Moderately gravelly, sub-rounded, boulders. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is weak, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and convolute. Some boulders amongst smaller gravels in this layer.*	

B2	50 - 90 cm	*Slightly moist, 10YR 7/3 (very pale brown)* coloured soil. *Extremely gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is distinct and wavy*. *Patches of above layer interspersed into this intermediate layer. The layer is concreted in hardness and texture, but water still soaks away when profile is wetted.*	
C	90 - 180 cm	*Slightly moist, 10YR 7/3 (very pale brown)* coloured soil. *Extremely gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots. Concreted texture but water soaks away.*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description

June 5, 2024 4:49 PM	*HB5/9*	
Millie	*Flat mound*	
overcast, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 691

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.09377604, 168.74686383

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Pasture	
A	0 - 25 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. No *gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and occluded.*	
B	25 - 55 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. No mottles, non-sticky, slightly plastic, sandy clay loam. Apedal massive.* Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth.*	

C	55 - 150 cm	*Dry, 10YR 6/1 (grey)* coloured soil. *Very gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal massive*. Soil strength is hard, aggregate strength is hard and brittle. *No roots. Cemented type later same as site 6.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 3:49 PM	*HB6/8*	
Millie	*Rolling hills closest to lake*	
overcast, calm	*Wanaka soil*	
Soil Core # (if collected)	Top soil:	Sub soil: 693

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.09138058, 168.74586377

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	20 cm	Groundcover: Pasture	
A	0 - 20 cm	*Moist, 10YR 3/3 (dark brown)* coloured soil. *No gravels*. *No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Many fine roots. Boundary is sharp and irregular.*	
B	20 - 60 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Moderately gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, slightly plastic, sandy clay loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Abundant roots. Boundary is sharp and smooth.*	

C	60 - 170 cm	*Dry, 10YR 6/1 (grey)* coloured soil. *Extremely gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is hard, aggregate strength is very firm and brittle. *Common fine roots. Concreted texture but water soaks away on it. Consolidated sand and gravels. Roots down to around 70cm.*	


HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 12:22 PM	*HB7/1*	
Millie	*Flat fill site*	
fine, calm	*Anthropic soil, clay starting at 50cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 738

Soil	Anthropic Soil on top of Pigburn 1a.1
NZSC	Anthropic Soil / Weathered Fluvial Recent Soils (RFW)
Drainage	Clay starting at 50 cm, Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08324649, 168.75527559

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	50 cm	Groundcover: Poor pasture and bare soil	
A	0 - 50 cm	*Moderately moist, 10YR 4/3 (brown)* coloured soil. *Moderately gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, silty clay. Apedal cloddy.* Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B	50 - 85 cm	*Moderately moist, 10YR 5/2 (greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. Few fine 10YR 5/8 mottles, slightly sticky, slightly plastic, clay. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth*. *Soil colour 5/10Y greenish gray gley chart 1*	
C	85 - 180 cm	*Slightly moist, 10YR 5/2 (greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravels. Common medium 10YR 5/8 mottles*, *slightly sticky, slightly plastic, loamy clay. Apedal cloddy*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots.*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 2:26 PM	*HB8/2*	
Millie	*Flat backfill closest to alps*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 829

Soil	Anthropic Soil on top of Pigburn 1a.1
NZSC	Anthropic Soil / Weathered Fluvial Recent Soils (RFW)
Drainage	Clay starting at 50 cm, Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08327028, 168.75587617

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	40 cm	Groundcover: Poor pasture	
A	0 - 40 cm	*Moist, 10YR 4/3 (brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and smooth.*	
B	40 - 90 cm	*Moist, 2.5y6/3 light yellowish brown coloured soil. Moderately gravelly, angular, coarse gravel. Few fine 10YR 5/8 mottles, slightly sticky, slightly plastic, clay. Apedal massive*. Soil strength is firm, aggregate strength is firm and semi-deformable. *Few fine roots. Boundary is sharp and smooth.*	

C	90 - 180 cm	*Moist, 2.5y6/3 light yellowish brown coloured soil*. Moderately *gravelly, angular, coarse gravel. Few coarse 10YR 5/8 mottles, slightly sticky, slightly plastic, loamy clay. Apedal massive*. Soil strength is firm, aggregate strength firm and semi-deformable. *No roots.*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 11:15 AM	*HB9/6*	
Millie	*Pasture beside airfield*	
overcast, calm	*Generally homogeneous profile*	
Soil Core # (if collected)	Top soil:	Sub soil: 697

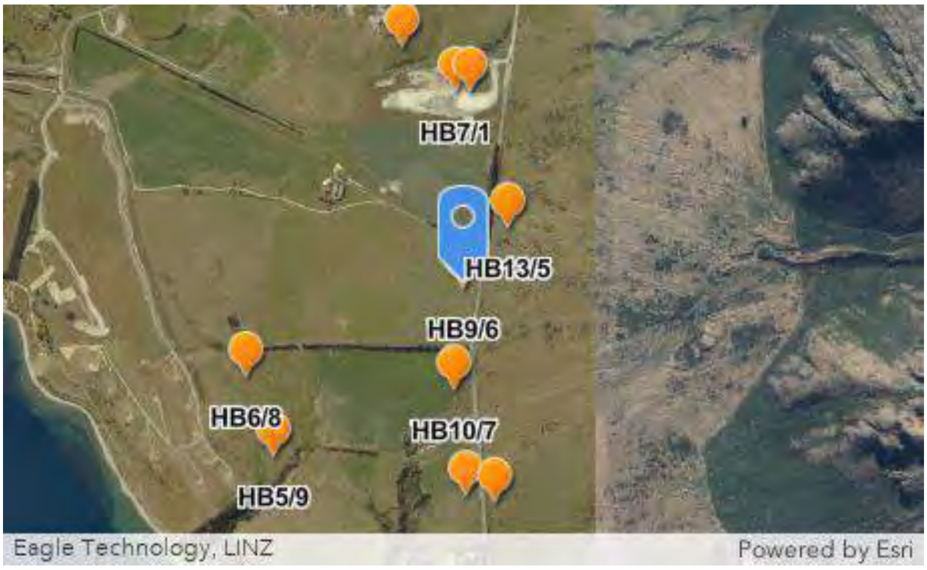
Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08911557, 168.75516592

Horizon	Depth (cm)	Description	Image
Topsoil	30 cm	Groundcover: Pasture	
A	0 - 30 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and smooth.*	
B1	30 - 80 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels.* No *mottles, non-sticky, slightly plastic, silty clay. Apedal massive.* Soil strength is weak, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B2	80 - 90 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *gravels, moderately gravelly, angular, fine gravel no mottles, non-sticky, non-plastic, clay loam. apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B3	90 - 130 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels*. No *mottles, non-sticky, slightly plastic, silty clay. Apedal massive*. Soil strength is weak, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*.	
B4	130 - 140 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *Very gravelly, angular, fine gravel.* No *mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth. Coloured stones.*	

B5	140 - 150 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B6	150 - 160 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *Moderately gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *No roots. Boundary is sharp and smooth*.	
B7	160 - 180 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth*.	

C	180 cm +	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Mixture of size class gravels.*	


HB7/1
HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 1:42 PM	*HB10/7*	
Millie	*Flats closest to stream*	
overcast, calm	*Possible rabbit burrow at 70cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 714

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09209636, 168.75452343

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	20 cm	Groundcover: Mixed pasture	
A	0 - 20 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and smooth.*	
B1	20 - 45 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, sandy clay loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B2	45 - 90 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. No mottles, non-sticky, slightly plastic, silty clay. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*.	
B3	90 - 105 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Very gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
B4	105 - 145 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels*. N*o mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Much the same as 3rd horizon.*	

C	145 cm +	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Very gravelly, angular, coarse gravel.*	


HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 4:00 PM	*HB11/3*	
Millie	*Farmland*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 688

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09526211, 168.75478687

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	35 cm	Groundcover: Pasture	
A	0 - 35 cm	*Slightly moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and occluded.*	
B	35 - 85 cm	*Slightly moist, 10YR 5/6 (yellowish brown)* coloured soil. *Moderately gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive.* Soil strength is firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

C	85 - 180 cm	*Moderately moist, 10YR 7/2 (light grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is hard, aggregate strength is slightly firm and brittle. *No roots. Quite concreted from 85cm and large rocks.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description

June 4, 2024 4:46 PM	*HB12/4*	
Millie	*Base of alluvial fan*	
fine, calm	*Likely landslide material from 70cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 680

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09549271, 168.75602208

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Browntop and ryegrass	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is sharp and occluded. Earthworms observed*	

B	25 - 50 cm	*Moist, 10YR 5/6 (yellowish brown)* coloured soil. *Very gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Many fine roots. Boundary is sharp and smooth*.	
C	50 - 90 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Moderately gravelly, angular, boulders. No mottles, non-sticky, non-plastic, loamy clay. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Very large boulders 30cm wide. Hard to dig down with digger.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 5, 2024 10:08 AM	*HB13/5*	
Millie	*Lower fan*	
overcast, calm	*At hydraulic sites, the was a ranging amount of gravels. Several holes were dug to find non gravelly soils to do unsats. Unable to conduct saturated tests*	
Soil Core # (if collected)	Top soil:	Sub soil: 850

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.0873764, 168.75717342

Horizon	Depth (cm)	Description	Image
Topsoil	25 cm	Groundcover: Pasture	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is sharp and smooth.*	

B1	25 - 45 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is weak, aggregate strength is weak and very friable. *Few fine roots. Boundary is sharp and smooth. Some occlusions.*	
B2	45 - 60 cm	*Moist, 10YR 5/2 (greyish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth.*	
B3	60 - 75 cm	*Moist, 10YR 7/1 (light grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth.*	

B4	75 - 90 cm	*Moist, 10YR 4/1 (dark grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and smooth*.	
B5	90 - 105 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
B6	105 - 145 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable.*Few fine roots. Boundary is sharp and smooth. A layer of fine gravels through the middle, uncompacted.*	

C	145 - 180 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Mixture of size class gravels.*	


HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
HB6/8
HB10/7
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 6, 2024 12:23 PM	*HB14/12*	
Millie	*Lower flats beside Jacks Point entrance driveway*	
overcast, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 730

Soil	Barrhill 42a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Moderately Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.07694565, 168.7601236

Horizon	Depth (cm)	Description	Image
Topsoil	25 cm	Groundcover: Pasture/browntop	
A	0 - 25 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and occluded.*	

B1	25 - 90 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles*, *non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*. *Oxide staining layers throughout the b horizon.*	
C	90 - 100 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth*.	
B2	100 - 180 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles*, *non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *No roots. Iron oxide staining layers at 110-125cm.*	


HB17/13
HB16/10
HB14/12
HB15/11
HB2/15
HB1/14
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 6, 2024 10:36 AM	*HB15/11*	
Millie	*Flat alluvial fan*	
fine, calm	*Gravels beyond 180cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 689

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.07883283, 168.76397055

Horizon	Depth (cm)	Description	Image
Topsoil	25 cm	Groundcover: Poor pasture	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and smooth.*	
B1	25 - 50 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Some occlusions*	

B2	50 - 70 cm	*Dry, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Many fine roots. Boundary is sharp and smooth*.	
B3	70 - 110 cm	*Dry, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
C1	110 - 145 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	

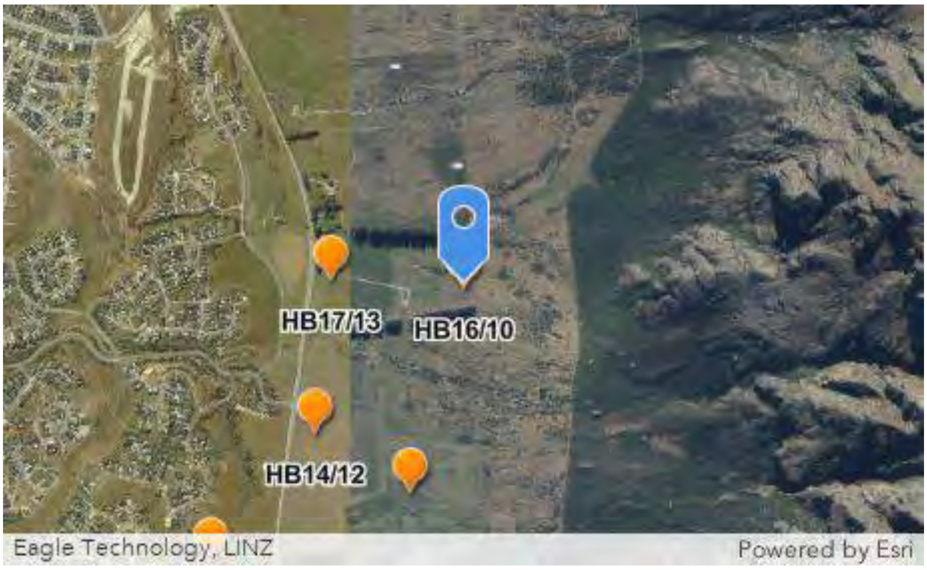
C2	145 - 160 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth*. *Mixed size gravels and sand.*	
C3	160 - 180 cm	*Moderately moist, 10YR 5/4 (yellowish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots.*	


HB17/13
HB16/10
HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 6, 2024 8:53 AM	*HB16/10*	
Millie	*Alluvial fan in deer paddock*	
overcast, calm	*Topsoil core at 80mm due to gravels*	
Soil Core # (if collected)	Top soil: 672	Sub soil: 687

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.07288304, 168.76664941

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	20 cm	Groundcover: Poor pasture	
A	0 - 20 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is indistinct and smooth.*	
B	20 - 170 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, sub-angular, boulders. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Common fine roots. Roots down to 70cm. Very mixed grades of gravels not well stratified. Site is at base of mountains on possible fan.*	


HB17/13
HB16/10
HB14/12
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 6, 2024 2:21 PM	*HB17/13*	
Millie	*Turnip paddock*	
overcast, calm	*Farmer mentioned that this paddock experiences overflow drainage and springs can pop up in winter. this is confirmed with the presence of mottles*	
Soil Core # (if collected)	Top soil:	Sub soil: 739

Soil	Barrhill 42a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Moderately Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.07240964, 168.76113465

Horizon	Depth (cm)	Description	Image
Topsoil	40 cm	Groundcover: Turnips	
A	0 - 40 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.*	

B1	40 - 90 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Thin layer of small gravels at 55-60cm. Mottling throughout b horizon.*	
B2	90 - 100 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Extremely gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B3	100 - 140 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Organic staining from roots. Boundary is sharp and smooth*.	

C	140 - 170 cm	*Moist, 10YR 6/3 (pale brown). Extremely gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *No roots. Mixed size of gravels and sand.*	


HB17/13
HB16/10
HB14/12
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 7, 2024 9:57 AM	*HB18/16*	
Millie	*Flats closest to farm house*	
overcast		
Soil Core # (if collected)	Top soil:	Sub soil: 707

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.05969167, 168.7594749

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Browntop	
A	0 - 30 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and occluded.*	
B1	30 - 65 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is indistinct and occluded.*	

B2	65 - 95 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. No *gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth. Some occlusions from above.*	
C	95 - 185 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. *Extremely gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is firm, aggregate strength is weak and friable. *No roots. Ranging sizes of gravels up to boulders. Seam of iron coating at 120-130cm but same material. Water drains away easily.*	


HB18/16
HB19/17
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 7, 2024 11:16 AM	*HB19/17*	
Millie	*Elevated flats*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 898

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.06198426, 168.76333246

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Browntop	
A	0 - 30 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is distinct and occluded.*	
B1	30 - 75 cm	*Moist, 10YR 6/6 (brownish yellow)* coloured soil. *Slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Patches of gravels at around 45-55cm. Topsoil occlusions down to 70cm.*	

B2	75 - 93 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. *Extremely gravelly, sub-angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth. Potential slip material.*	
C	93 - 190 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Seams of iron coatings throughout the horizon as well as a darker orange seam at 128cm but not a hard pan. No gravels struck at 190cm.*	

HB18/16
HB19/17
Eagle Technology, LINZ
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APPENDIX B

Landcare Research Soil Reports

Environmental Chemistry Laboratory
Analytical Report – Soils

Manaaki Whenua
Landcare Research

Manaaki Whenua – Landcare Research
Riddet Rd, Massey University Campus, Private Bag 11052, Palmerston North 4442
Phone: +64 6 353 4800

Job number: LJ24009

Date received: 15 July 2024

Customer: Henry van der Vossen, Lowe Environmental Impact
PO Box 4667, Palmerston North 4442

Date reported: 14 August 2024

Notes: Samples were dried and ground by the MW-LR Physics Laboratory in Palmerston North.

Analysis was carried out between the 17th and 26th of July 2024.

Client ID	Sample No.	Air dry soil water content (calculation)* (%)	Phosphate retention (method 132) (%)
738 HB 7/1	M24/0598	1.1	22
829 HB 8/2	M24/0599	1.4	17
688 HB 11/3	M24/0600	0.8	12
680 HB 12/4	M24/0601	1.4	8
850 HB 13/5	M24/0602	0.7	6
697 HB 9/6	M24/0603	0.8	12
714 HB 10/7	M24/0604	0.9	0
693 HB 6/8	M24/0605	1.3	16
691 HB 5/9	M24/0606	1.8	33
687 HB 16/10-2	M24/0607	1.2	21
689 HB 15/11	M24/0608	0.8	17
730 HB 14/12	M24/0609	1.4	22
739 HB 17/13	M24/0610	1.4	25
903 HB 1/14	M24/0611	1.7	29
832 HB 2/15	M24/0612	1.3	29
707 HB 18/16	M24/0613	1.5	25
898 HB 19/17	M24/0614	1.2	18

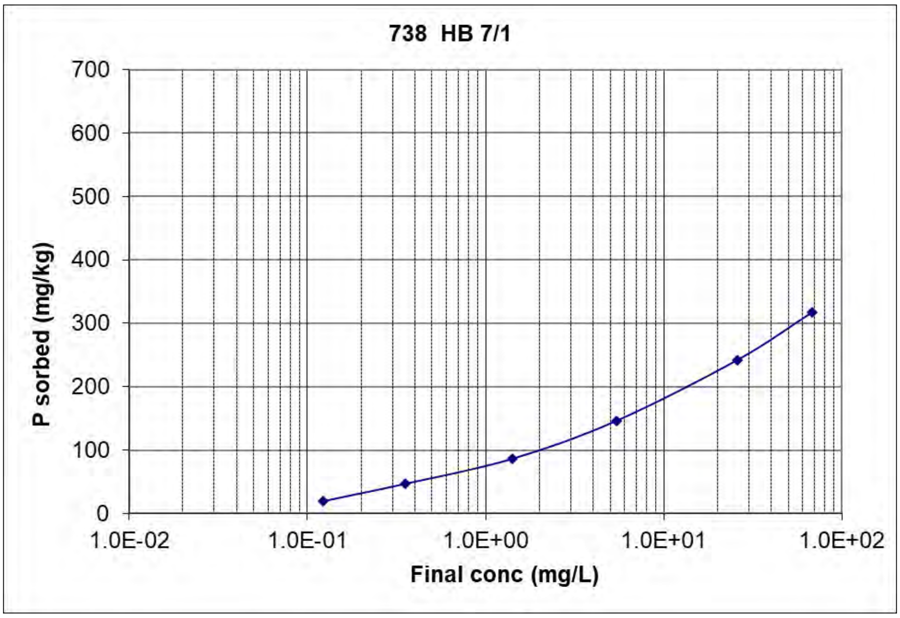
[redacted]

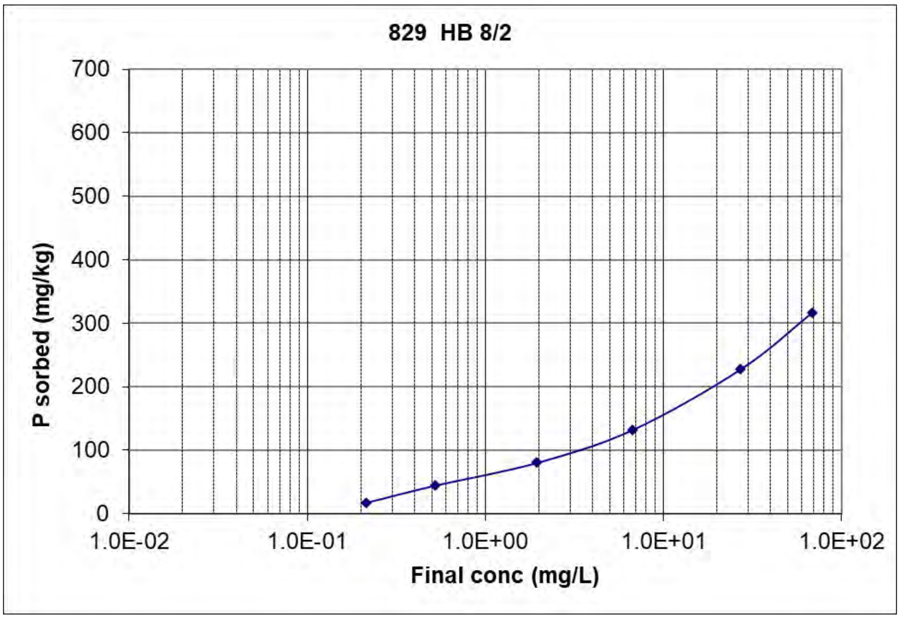
Ngaire Foster, Lab Manager

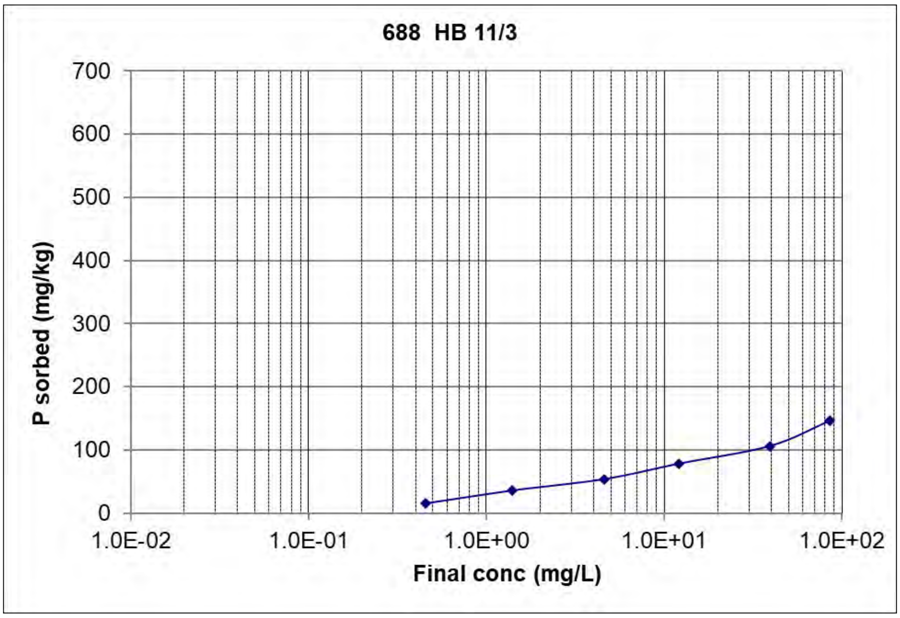
Results apply to the samples as received and are expressed on an oven-dry (105°C) basis. Details of method codes are available online at https://www.landcareresearch.co.nz/partner-with-us/laboratories-and-diagnostics/environmental-chemistry-laboratory/soil-testing. This report may not be reproduced, except in full, without the consent of the signatory.

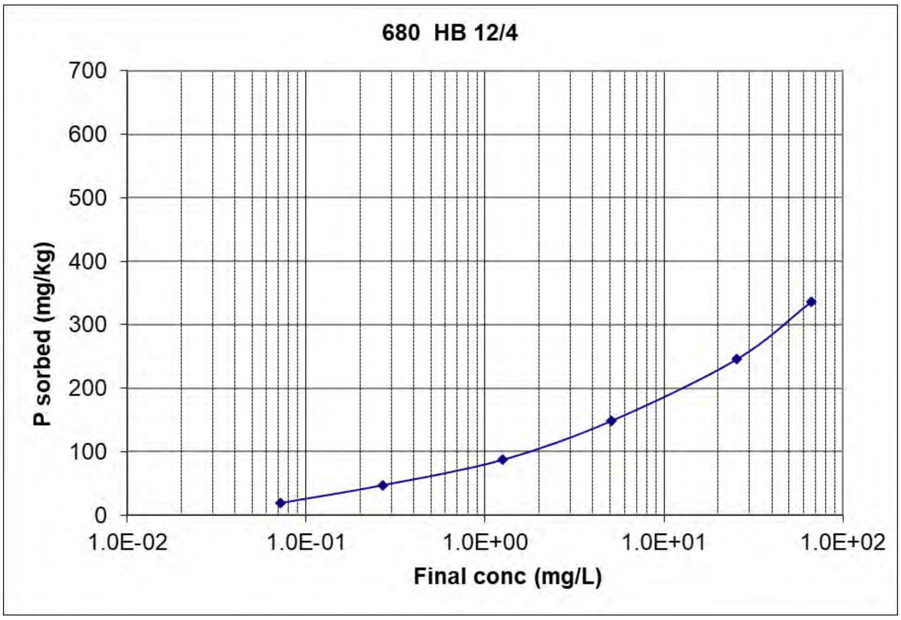
Client ID	Sample No.	Final conc with 2 mg/L added (method 134) mg/L	Final conc with 5 mg/L added (method 134) mg/L	Final conc with 10 mg/L added (method 134) mg/L	Final conc with 20 mg/L added (method 134) mg/L	Final conc with 50 mg/L added (method 134) mg/L	Final conc with 100 mg/L added (method 134) mg/L
738 HB 7/1	M24/0598	0.12	0.36	1.41	5.42	25.8	68.2
829 HB 8/2	M24/0599	0.22	0.52	1.94	6.74	27.2	68.3
688 HB 11/3	M24/0600	0.45	1.40	4.60	12.1	39.4	85.4
680 HB 12/4	M24/0601	0.07	0.27	1.26	5.10	25.4	66.4
850 HB 13/5	M24/0602	0.42	1.53	4.51	12.1	37.5	82.3
697 HB 9/6	M24/0603	0.23	1.13	3.90	11.3	38.2	84.5
714 HB 10/7	M24/0604	0.28	1.13	4.10	11.0	37.1	80.0
693 HB 6/8	M24/0605	0.08	0.23	1.06	4.57	23.9	61.4
691 HB 5/9	M24/0606	0.02	0.05	0.23	1.07	8.78	36.4
687 HB 16/10-2	M24/0607	0.61	1.28	2.99	8.04	29.4	72.6
689 HB 15/11	M24/0608	0.11	0.47	1.94	7.41	30.8	72.9
730 HB 14/12	M24/0609	0.05	0.23	0.93	4.14	23.1	63.0
739 HB 17/13	M24/0610	0.01	0.10	0.42	2.15	17.0	53.2
903 HB 1/14	M24/0611	0.01	0.12	0.38	1.90	15.2	48.4
832 HB 2/15	M24/0612	0.03	0.10	0.34	1.72	14.8	50.2
707 HB 18/16	M24/0613	0.06	0.23	0.90	3.79	21.7	59.3
898 HB 19/17	M24/0614	0.02	0.24	1.16	5.07	24.9	65.9

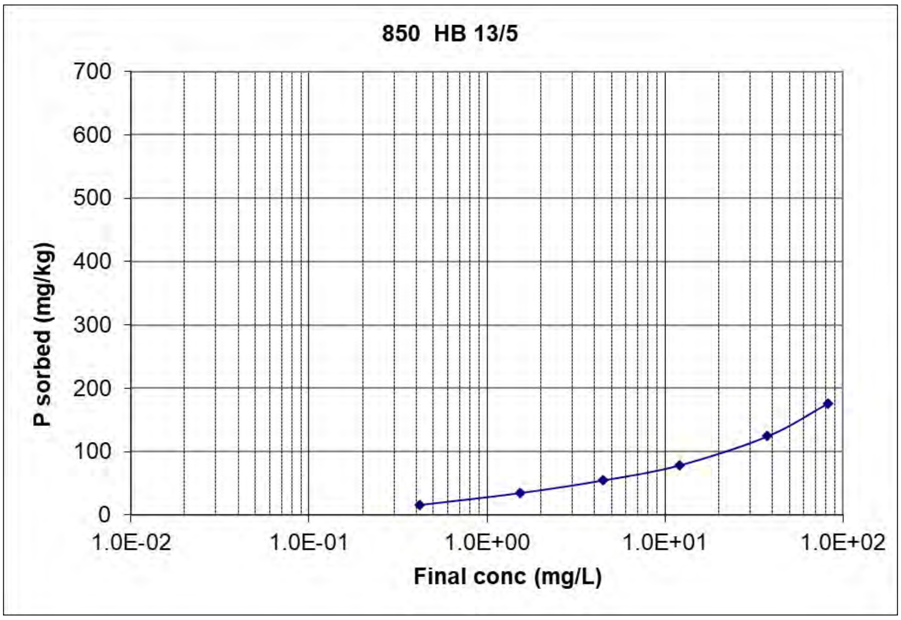
Client ID	Sample No.	P sorbed with 20 mg/kg added (method 134) (mg/kg)	P sorbed with 50 mg/kg added (method 134) (mg/kg)	P sorbed with 100 mg/kg added (method 134) (mg/kg)	P sorbed with 200 mg/kg added (method 134) (mg/kg)	P sorbed with 500 mg/kg added (method 134) (mg/kg)	P sorbed with 1000 mg/kg added (method 134) (mg/kg)
738 HB 7/1	M24/0598	19	46	86	146	242	318
829 HB 8/2	M24/0599	18	45	81	133	228	317
688 HB 11/3	M24/0600	15	36	54	79	106	146
680 HB 12/4	M24/0601	19	47	87	149	246	336
850 HB 13/5	M24/0602	16	35	55	79	125	177
697 HB 9/6	M24/0603	18	39	61	87	118	155
714 HB 10/7	M24/0604	17	39	59	90	129	200
693 HB 6/8	M24/0605	19	48	89	154	261	386
691 HB 5/9	M24/0606	20	50	98	189	412	636
687 HB 16/10-2	M24/0607	14	37	70	120	206	274
689 HB 15/11	M24/0608	19	45	81	126	192	271
730 HB 14/12	M24/0609	19	48	91	159	269	370
739 HB 17/13	M24/0610	20	49	96	178	330	468
903 HB 1/14	M24/0611	20	49	96	181	348	516
832 HB 2/15	M24/0612	20	49	97	183	352	498
707 HB 18/16	M24/0613	19	48	91	162	283	407
898 HB 19/17	M24/0614	20	48	88	149	251	341

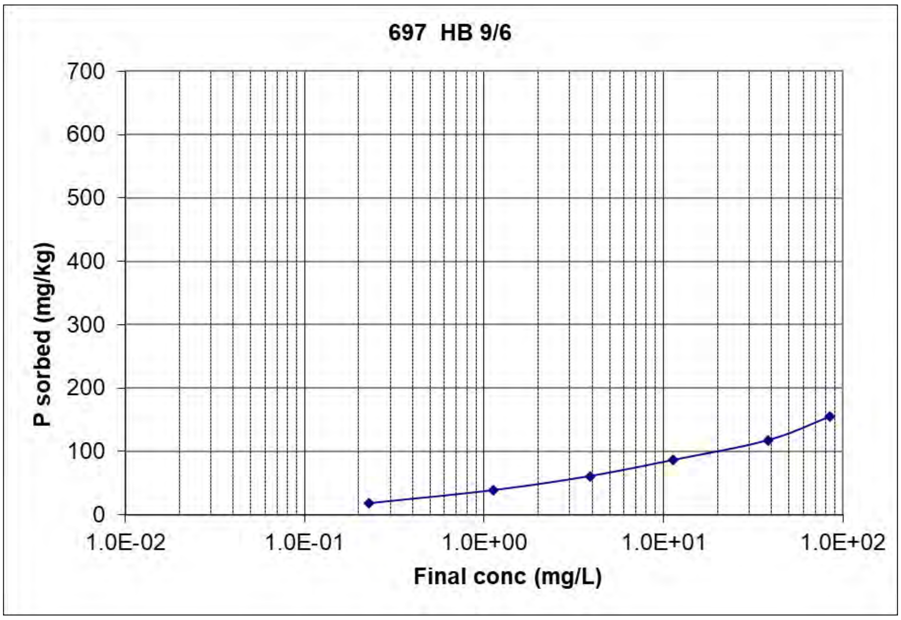

738 HB 7/1
P sorbed (mg/kg)
700
600
500
400
300
200
100
0
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


829 HB 8/2
P sorbed (mg/kg)
700
600
500
400
300
200
100
0
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


688 HB 11/3
P sorbed (mg/kg)
700
600
500
400
300
200
100
0
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


680 HB 12/4
700
600
500
400
300
200
100
0
P sorbed (mg/kg)
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


850 HB 13/5
700
600
500
400
300
200
100
0
P sorbed (mg/kg)
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)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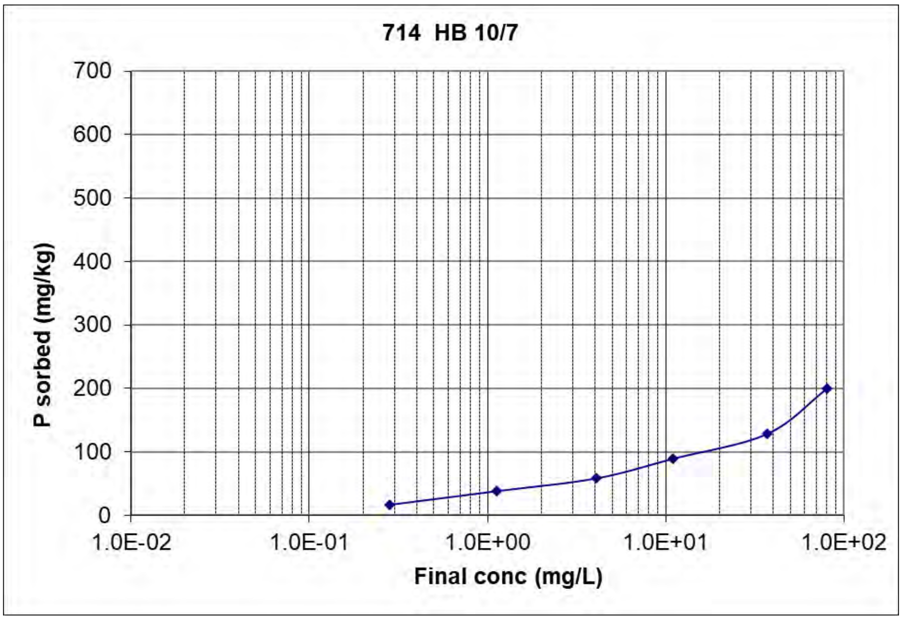
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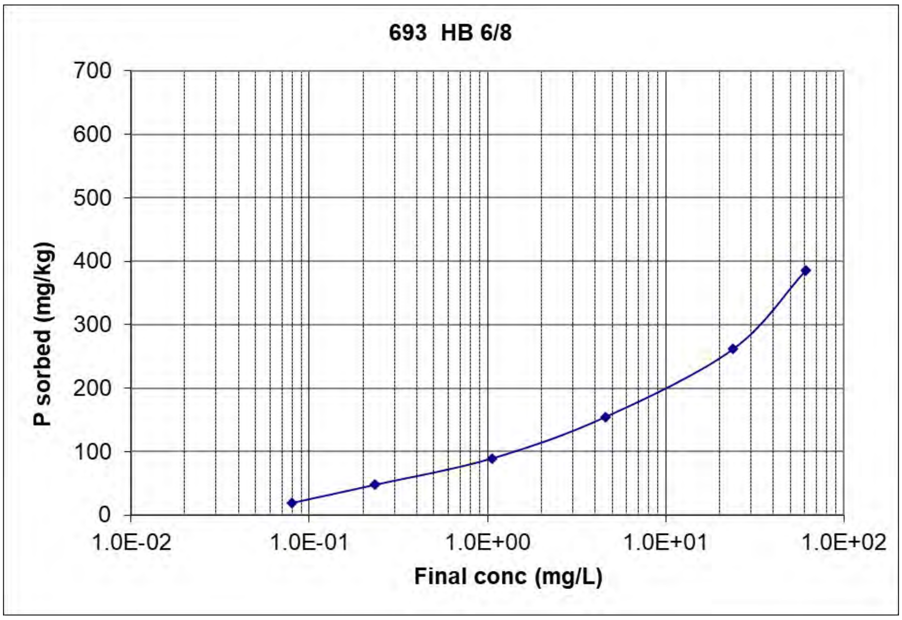
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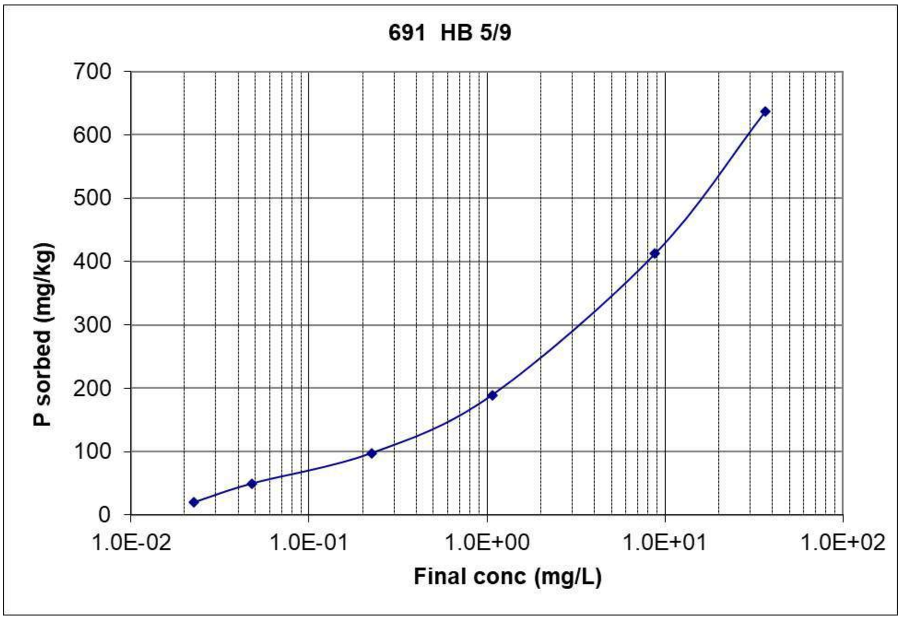
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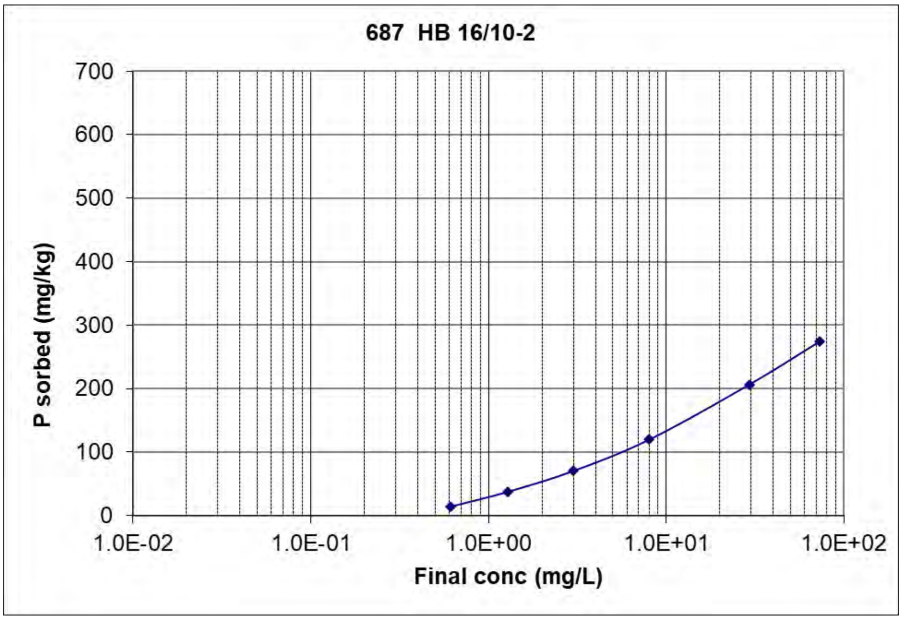
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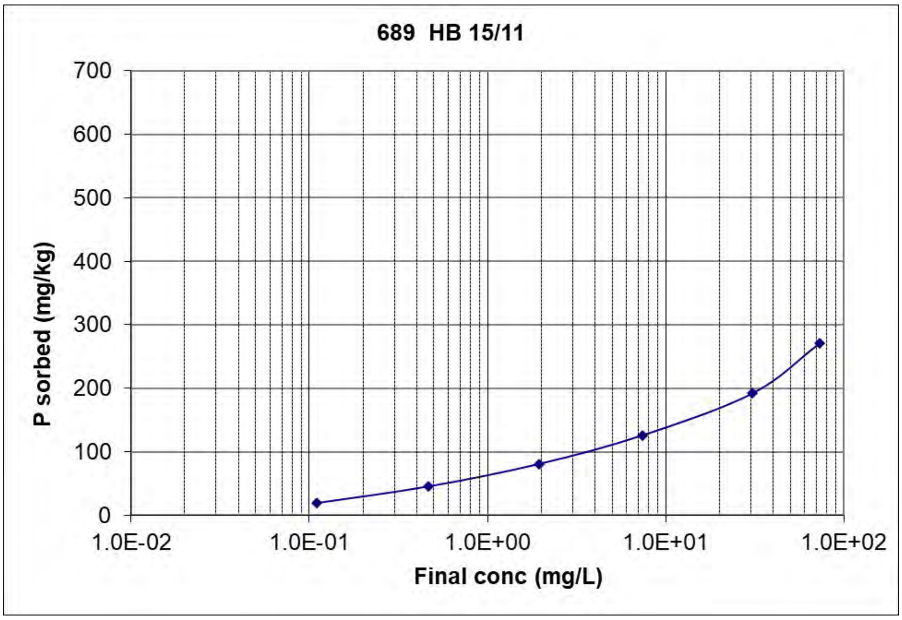
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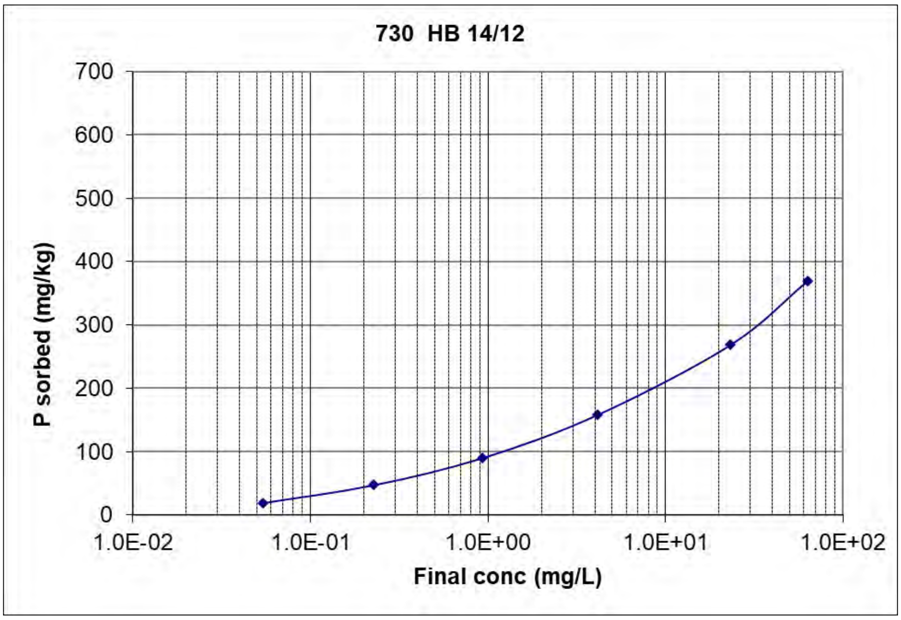
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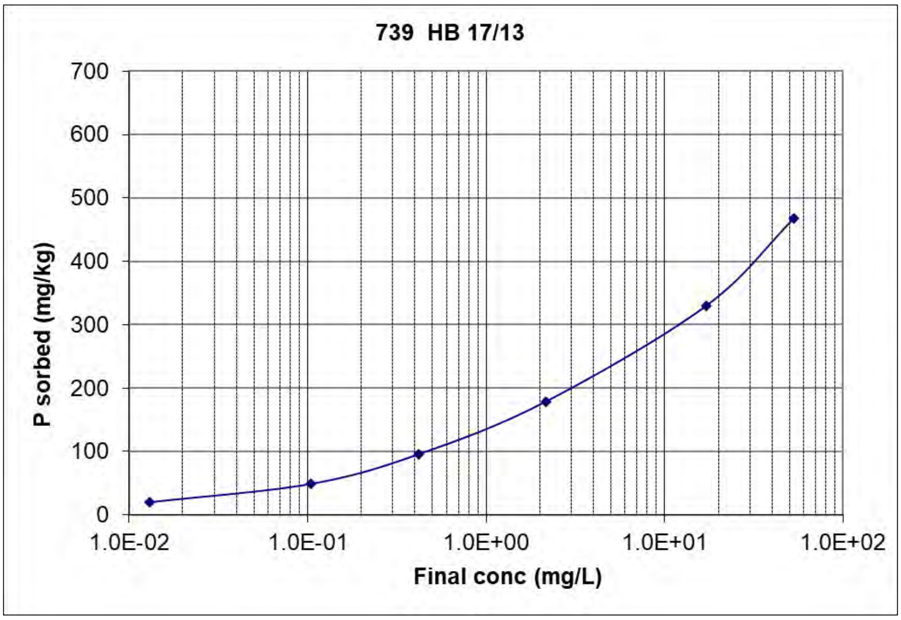
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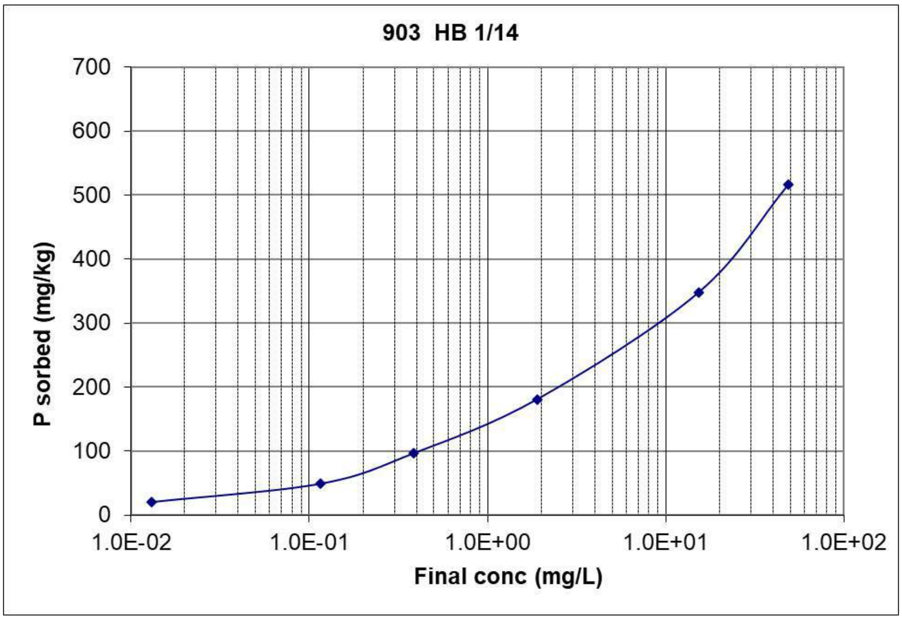
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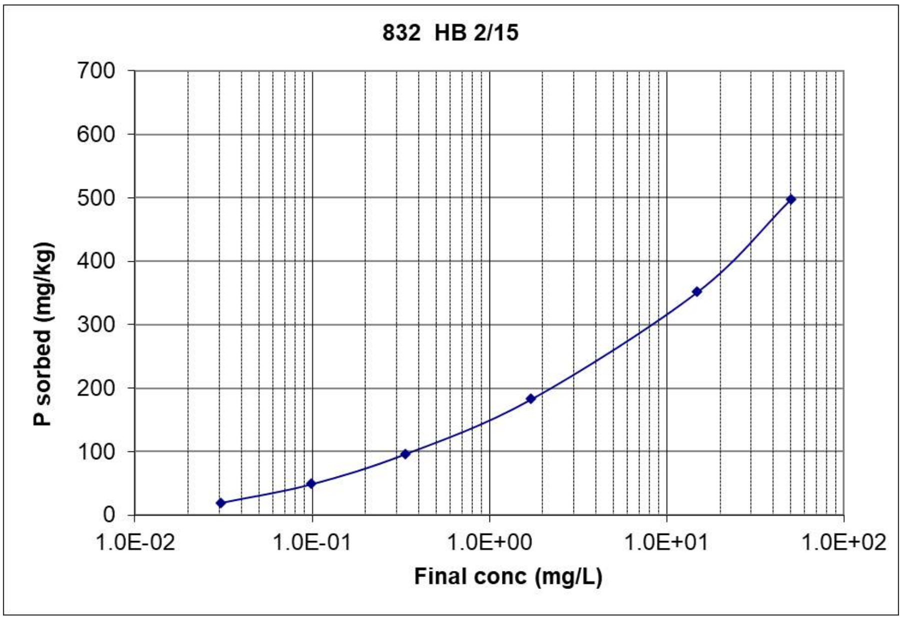
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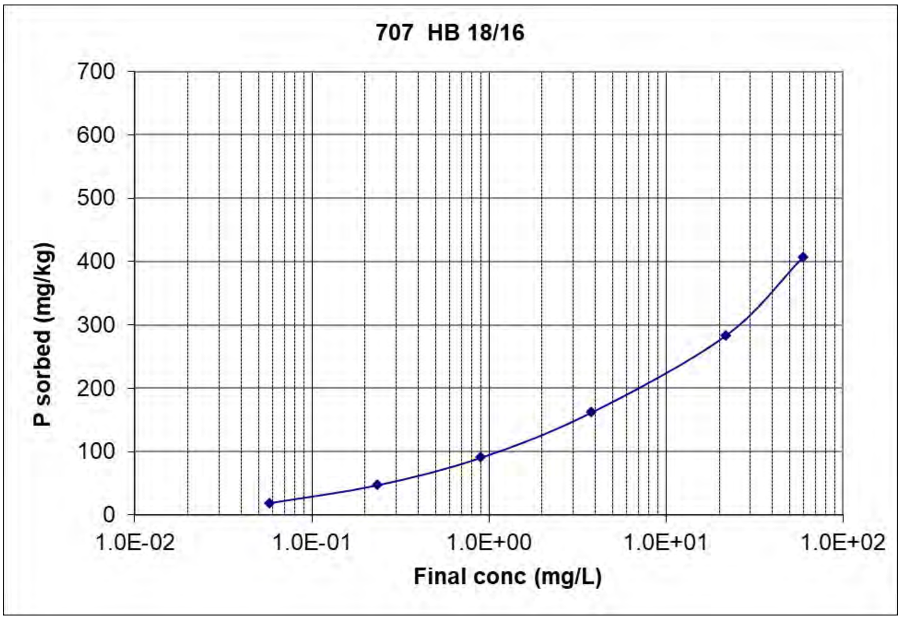
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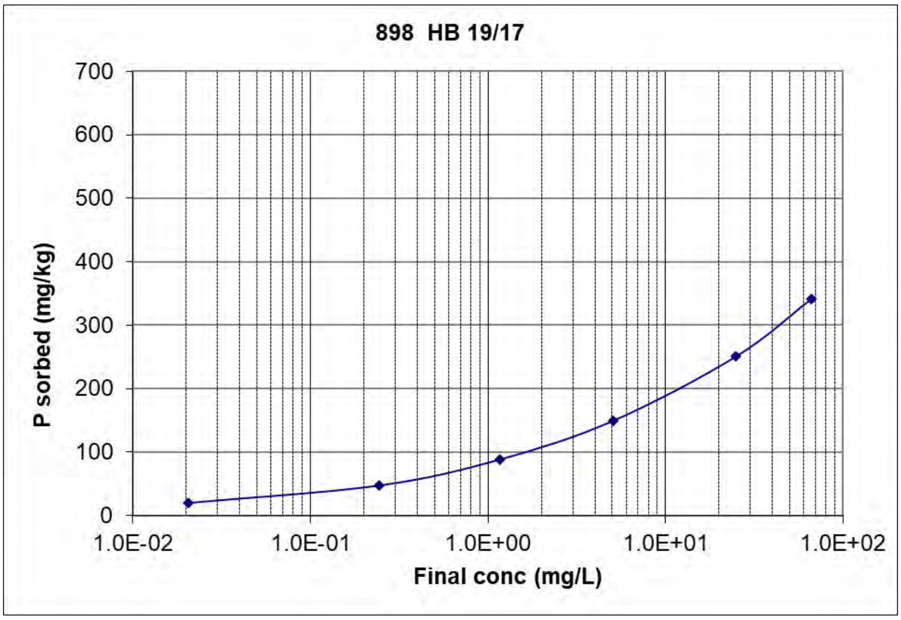
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1.0E+02
Final conc (mg/L)

Soil Physics Laboratory
Analytical Report

Manaaki Whenua – Landcare Research
Riddet Rd, Massey University Campus,
Private Bag 11052, Palmerston North 4442
Phone: +64 6 353 4800

Job number: PJ23052

Customer: Lowe Environmental Impact
Millie Taylor

Date received: 10 June 2024

Date Analysed: 8 July 2024 to 29 July 2024

Date reported: 13 August 2024

Homestead Bay

Sample name	Core number	ID number	Remarks	Particle density (g/cm^3)	Dry bulk density (g/cm^3)	Porosity (%)	Macro-Porosity (-5 kPa) (%)	Air Capacity (-10 kPa) (%)	Field capacity (%)	AWC (%)	K-40 (mm/hr)
HB 7/1	738	PP23-1730	1	2.72	1.60	41	13	15	27	15	4
HB 8/2	829	PP23-1731		2.72	1.28	53	16	20	33	26	-
HB 11/3	688	PP23-1732		2.79	1.49	47	13	16	30	21	14
HB 12/4	680	PP23-1733		2.75	1.43	48	11	14	34	29	-
HB 13/5	850	PP23-1734		2.80	1.34	52	10	16	37	27	14
HB 9/6	697	PP23-1735		2.82	1.33	53	8	12	41	37	-
HB 10/7	714	PP23-1736		2.78	1.44	48	10	13	35	31	13
HB 6/8	693	PP23-1737		2.67	1.43	47	15	17	29	24	32
HB 5/9	691	PP23-1738		2.68	1.32	51	15	18	33	24	-
HB 16/10-2	687	PP23-1740		2.76	1.33	52	15	18	34	26	-
HB 15/11	689	PP23-1741		2.80	1.36	52	13	16	36	31	20
HB 14/12	730	PP23-1742		2.82	1.45	49	9	10	38	26	3
HB 17/13	739	PP23-1743		2.77	1.27	54	12	14	40	29	-
HB 1/14	903	PP23-1744		2.65	1.30	51	11	16	35	24	-
HB 2/15	832	PP23-1745		2.69	1.34	50	14	19	31	23	15
HB 18/16	707	PP23-1746		2.77	1.33	52	14	17	35	23	26
HB 19/17	898	PP23-1747		2.79	1.41	50	13	15	34	24	-

Remarks: 1) Large stones removed from lower surface and backfilled

Sample name	**Gravimetric water content (%w/w)**					**Volumetric water content (%w/w)**				
	As received moisture	Saturation (calc.)	5 kPa	10 kPa	1500 kPa	As received moisture	Saturation (calc.)	5 kPa	10 kPa	1500 kPa
HB 7/1	12	26	18	17	7	20	41	28	27	12
HB 8/2	18	41	29	26	5	24	53	37	33	7
HB 11/3	11	31	23	20	6	17	47	34	30	9
HB 12/4	16	34	26	24	4	23	48	37	34	5
HB 13/5	12	39	32	27	7	16	52	43	37	10
HB 9/6	12	40	34	30	2	16	53	45	41	3
HB 10/7	13	33	26	24	3	19	48	38	35	4
HB 6/8	17	33	22	20	4	24	47	31	29	6
HB 5/9	16	39	27	25	7	22	51	36	33	9
HB 16/10-2	19	39	28	25	6	26	52	37	34	8
HB 15/11	17	38	28	26	4	23	52	39	36	5
HB 14/12	20	33	28	26	8	29	49	40	38	12
HB 17/13	28	43	34	32	9	36	54	43	40	11
HB 1/14	19	39	31	27	8	24	51	40	35	10
HB 2/15	17	38	27	23	7	22	50	36	31	9
HB 18/16	20	39	28	26	8	26	52	38	35	11
HB 19/17	18	35	26	24	8	26	50	37	34	11

Macro-porosity cited here is determined between total porosity and tension of -5 kPa, for consistency with the National Soils Database of New Zealand (NSD).
Air Capacity cited here is determined between total porosity and tension of -10 kPa. This may be referred to as Macro-porosity for specifications requiring this characteristic to be measured at -10 kPa. It is important to be aware what tension has been used, particularly with historical or NSD

References:
Gradwell, M.W. 1972: Methods for physical analysis of soils. *Scientific Report 10C.* Lower Hutt, N.Z. Soil Bureau.
Cook FJ, Lilley GP, Nunns RA 1993. Unsaturated hydraulic conductivity and sorptivity: Laboratory measurement. In: Carter MR ed. Soil sampling and methods of analysis. Boca Raton, FL, Lewis Publishers. Pp. 615–624.

[redacted]

Shane Cox
Laboratory Manager – Soil Physics

APPENDIX B

Overseer Modelling

LOWE
Environmental
Impact

MEMORANDUM **Job 10934**

To: Brian Ellwood

From: Jimena Rodriguez

Date: 17 December 2024

Subject: **OVERSEER Nutrient Modelling for Homestead Bay**

This memo summarises the OverseerFM nutrient modelling outcomes for the baseline (current farm system) and two scenarios that modelled the discharge of wastewater from a 'residential and commercial development' at RCL's Homestead Bay.

The baseline data was provided by Matt Little, who is the farm manager for both properties. Attachment A is the farm map provided by Matt indicating the boundary of the farm. The properties are operated together and have been modelled as a single operating unit.

BASELINE NUTRIENT LOSS RATES

The baseline Overseer input Data used in the nutrient modelling is provided in the following tables.

Table 1: Overseer Blocks and Area

Block	Property	Area (ha)
Dryland flats	QEII	135
Hill	QEII	400
Irrigation	QEII	80
Lot 8	RCL	134
Lot 12	RCL	36
Lucerne	RCL	13.4
Young grass	QEII	18
Barley	RCL	16.7
Bush	QEII	25.5
Trees	QEII	43.4

Table 2: Baseline Fertiliser Inputs

Blocks	Area (ha)	Fertiliser and Application Rate
Young grass	18	- Cropzeal: 250 kg/ha in Spring - Lime: 1-3 tonnes in Spring - DAP sulphur super: 125 kg/ha in spring - Urea- rate assumed 55 kg N/ha in April
Swedes	10	- Cropzeal: 250 kg/ha in Spring - DAP sulphur super: 125 kg/ha in spring
Dryland flats	125	- DAP sulphur super: 125 kg/ha in spring Urea- rate assumed 55 kg N/ha in October and March
Hill	400	- Super 10: 125 kg/ha in late winter - Lime: 1-3 tonnes in Spring
Irrigation	80	- DAP sulphur super: 125 kg/ha in spring
Airstrip -Barely	16.7	- Cropzeal and some urea Rate assumed to 80 kg N/ha in September and November

Table 3: Baseline Stock

	Sheep			Beef					Deer
Month	Ewes	Hoggets	Lambs	Cows	Steer	Heifers	Rep Heifers	Bulls	Hinds
July	1,800	520		110	65	65	25	4	840
Aug	1,800	520		110	65	65	25	4	840
Sep	1,780	520	2,520	110	65	65	25	4	840
Oct	1,770	520	2,520	110	65	65	25	4	840
Nov	1,670	520	2200	110	65	65	25	4	840
Dec	1,650	520	1,800	110	65	65	25	4	840
Jan	1,500	520	1,500	110	65	65	25	4	840
Feb	1,375	450	1,100	110	65	65	25	4	840
Mar	1,350	-	400	110	65	65	25	4	840
Apr	1,800	520	150	110	65	65	25	4	840
May	1,800	520		110	65	65	25	4	840
Jun	1,800	520		110	65	65	25	4	840

Table 4: Baseline Supplements and Crops

Crop Type	Harvest Block		Destination	Amount Made (T)	Animals Fed
Barley	Airstrip		Most Blocks	120	Deer
Baleage	Irrigation		Most Blocks	650 bales	Most
Swedes	Cattle yards			110	Weaners

- Irrigation block:
    - 80 ha
    - Application depth 52 mm
    - Irrigation from November to March

SCENARIOS

1. RCL:
    - In this scenario, the Wastewater from the residential development is discharged to A1, A2, A3 and A4 at RCL property (see map in Appendix B for the identification and location of each area).
    - The number of animals is reduced proportional to the reduction in the total area available for grazing, keeping the stock unit per ha similar to the baseline. In this Scenario, Lot 8 (165 ha) is a house block (residential development); the rest of Lot 8 and 12 (8 ha) will be landscaped lawns mowed at least twice a year, with the grass will be collected.
    - The area (ha) and average annual discharge depth (mm/day) where the WW is discharged is summarised in Table 5 below:

Table 5: Areas of Discharge and Discharge Depth

Overseer Block Groups	Land Treatment Area's	Area (ha)	Average Discharge Depth (mm/d)	Design Flow Rate (m3/day)	Annual Flow Rate (m3/year)
Area 1	C3, C4, C5 and JP buffer-grazed	4.5	5.4	250	89,089
Area 2	C1, C2, A, D, E, F, G	11.6	7.1	820	299,554
Area 3	H,I,J,K,L	7.2	7.1	515	187,716
Area 4	JP Village	5.2	8.0	420	152,005
Total		**28.5**	**7.0**	**2,005**	**728,364**

- Table 6 summarises the N and P loading (kg/ha) per month that is discharged in Areas groups 1 to 4. The nutrient loading and discharge depth are the same for the four areas. Therefore, it is summarised as A1 to A4. The nitrogen is provided in the model as organic fertiliser.

Table 6: Total N and P Applied (kg/ha) in Irrigation Wastewater

Area 1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	167	151	167	162	167	162	167	167	162	167	162	167	1,971
Nitrogen Loading kg	57	51	57	55	57	55	57	57	55	57	55	57	668
N Loading kg/ ha	12.6	11.3	12.6	12.2	12.6	12.2	12.6	12.6	12.2	12.6	12.2	12.6	148
P Loading kg	19	17	19	18	19	18	19	19	18	19	18	19	223
P Loading kg/ ha	4	4	4	4	4	4	4	4	4	4	4	4	49

Area 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	220	199	220	213	220	213	220	220	213	220	213	220	2,592
Nitrogen Loading kg	191	172	191	185	191	185	191	191	185	191	185	191	2,247
N Loading kg/ ha	16.5	14.9	16.5	16.0	16.5	16.0	16.5	16.5	16.0	16.5	16.0	16.5	194
P Loading kg	64	57	64	62	64	62	64	64	62	64	62	64	749
P Loading kg/ ha	6	5	6	5	6	5	6	6	5	6	5	6	65

Area 3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	220	199	220	213	220	213	220	220	213	220	213	220	2,592
Nitrogen Loading kg	120	108	120	116	120	116	120	120	116	120	116	120	1,408
N Loading kg/ ha	16.5	14.9	16.5	16.0	16.5	16.0	16.5	16.5	16.0	16.5	16.0	16.5	194
P Loading kg	40	36	40	39	40	39	40	40	39	40	39	40	469
P Loading kg/ ha	6	5	6	5	6	5	6	6	5	6	5	6	65

Area 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	248	224	248	240	248	240	248	248	240	248	240	248	2,920
Nitrogen Loading kg	97	87	97	94	97	94	97	97	94	97	94	97	1,140
N Loading kg/ ha	18.6	16.8	18.6	18.0	18.6	18.0	18.6	18.6	18.0	18.6	18.0	18.6	219
P Loading kg	32	29	32	31	32	31	32	32	31	32	31	32	380
P Loading kg/ ha	6	6	6	6	6	6	6	6	6	6	6	6	73

- Supplements:

  The management for the Area 1 group is grazed by sheep or planted in native forestry, while Area 2, 3 and 4 are operated as cut & carried; baleage will be harvested four times per year, removing approximately 10 t DM/ha/yr.

OVERSEER OUTCOMES

The nutrient loss for the baseline farmed area total, the RCL blocks of the current system and the proposed RCL total subdivision and Land treatment areas are presented in Table 7.

Table 7: Total Losses for Baseline and the Scenario

	Total losses				
Analyses	**N (kg/y)**	**N (kg/ha/y)**	**P(kg/y)**	**P (kg/ha)**	**GHG (t)**
Year 2023-2024 (Baseline)	8,039	9.0	128	0.1	3,121.7
RCL- baseline*	1,839	9.1			
RCL LTA	2,052	10.2	62	0.3	91.9

* refers to the total N losses/y from those located at RCL (Lot 8, lucerne, barley and Lot 12)

Table 8 illustrates the nutrient loss rates for the individual blocks, which comprise the RCL area during the current farming period as a baseline and the proposed housing development.

Table 8: Nitrogen Losses Per Block for the Baseline and RCL-LTA

	Blocks	**Blocks area (ha)**	**Total N loss (kg/y)**	**N leaching (kg/ha/y)**	**Total P Loss (kg/y)**	**P Loss (kg/ha/yr)**
Year 2023-2024 Baseline	Lot 8	134	1,188	9	4	0.1
	Lucerne	13.4	148	10.8	0	0.1
	Barley	16.7	284	16.9	1	0.1
	Lot 12	36	219	6.5	2	0.1
	N losses from lucerne, barley lot 8 and lot 12		*1,839*	9.1	7	0.1
RCL LTA	Area 1- C3, C4, C5, JP Buffer - grazed	4.5	411	91.6	16	3.4
	Area 2- C1, C2, A, D, E, F, G	11.6	582	50.1	14	1.2
	Area 3 - i, H, J, K, L	7.2	352	48.5	9	1.2
	Area 4 - JP Village	5.2	311	60	6	1.3
	Lot 8 and 12 other areas	8	24	3	0	
	Lot 8 housing	165	371	2	16	0.1
	N losses		2,052	10.2	61	0.3

COMMENTS

Year 2023-2024- Baseline (original farm system)

- In the baseline, there are 10 blocks: Dryland flat, Hill, Irrigation, Lot 8, Lot 12, Lucerne, Young grass, Barley, Swedes, Bush and Scrub.
- The N losses per ha for the baseline equals to 9.0 kg N/ha.
- The total N losses from the baseline is **8,039 kg N/y**.
- Total N losses from RCL-specific Blocks, Lot 8, Lot 12, Lucerne, and Barley blocks equal **1,839 kg N /y**. These blocks are the only blocks kept in the Scenario below (RCL- LTA) with WW applied.

RCL- LTA

- WW volume discharged per year equals to 728,364 m^3/yr or averaging 1,996 m^3/day.
- In the RCL development scenario, WW is discharged to four areas (A1 to A4) which are located in Lot 8 and 12.
- The N loss per ha for the full development area equals 10.2 kg N/ha.
- The total N losses for this scenario equals to **2,052 kg N/y** (212 kg N/yr higher than the RCL baseline model), where WW will be discharged.
- A RCL housing development block was added to the model, which is the block where the houses will be built. N losses from this block are equal to 371 kg N/yr.

With WW applied to Areas 1, 2, 3 and 4, the total N losses increased by 212 kg N/yr (1,839 kg N/yr compared to 2,052 kg N/yr).

Table 9 compares the N losses permitted by the ORC Water Plan (RWP)[1] and the N losses obtained from OverseerFM. The N losses predicted by Overseer is 2,052 kg N/y, which is 986 kg N/y lower than the amount permitted without consent by the RWP (3,038 kg N/y).

Table 9: Permitted N Losses by the RWP and N losses Modelled by OverseerFM

Block	Property	Area (ha)	Permitted N Loss (15 kg N/ha/y)	Modelled loss (kg N/y)
Lot 8 and Lot 12	RCL	8	120	24
Lot 8 housing	RCL	165	2,475	371
A1 to A4	RCL	28.5	428	1,656
Total		200.1	**3,038**	**2,052**

*This is the total amount lost from A1, A2, A3, A4 and area from lot 12 modelled by Overseer

---

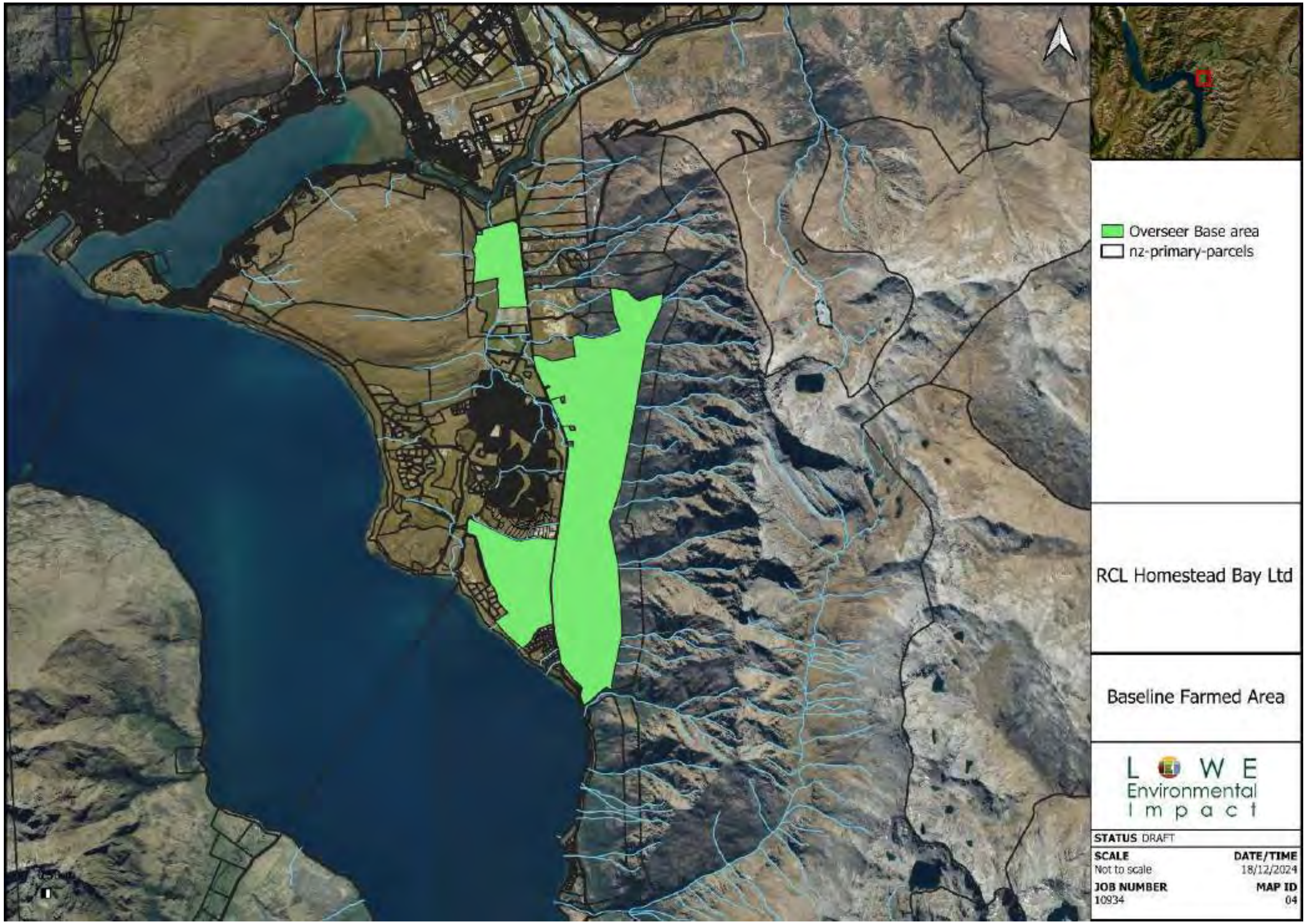
[1] ORC Regional Plan: Water for Otago (RPW) Plan

APPENDICES

Appendix A	Farm Map
Appendix B	Identification and Location of the LTA at RCL Property

APPENDIX A

Farmed Area Maps

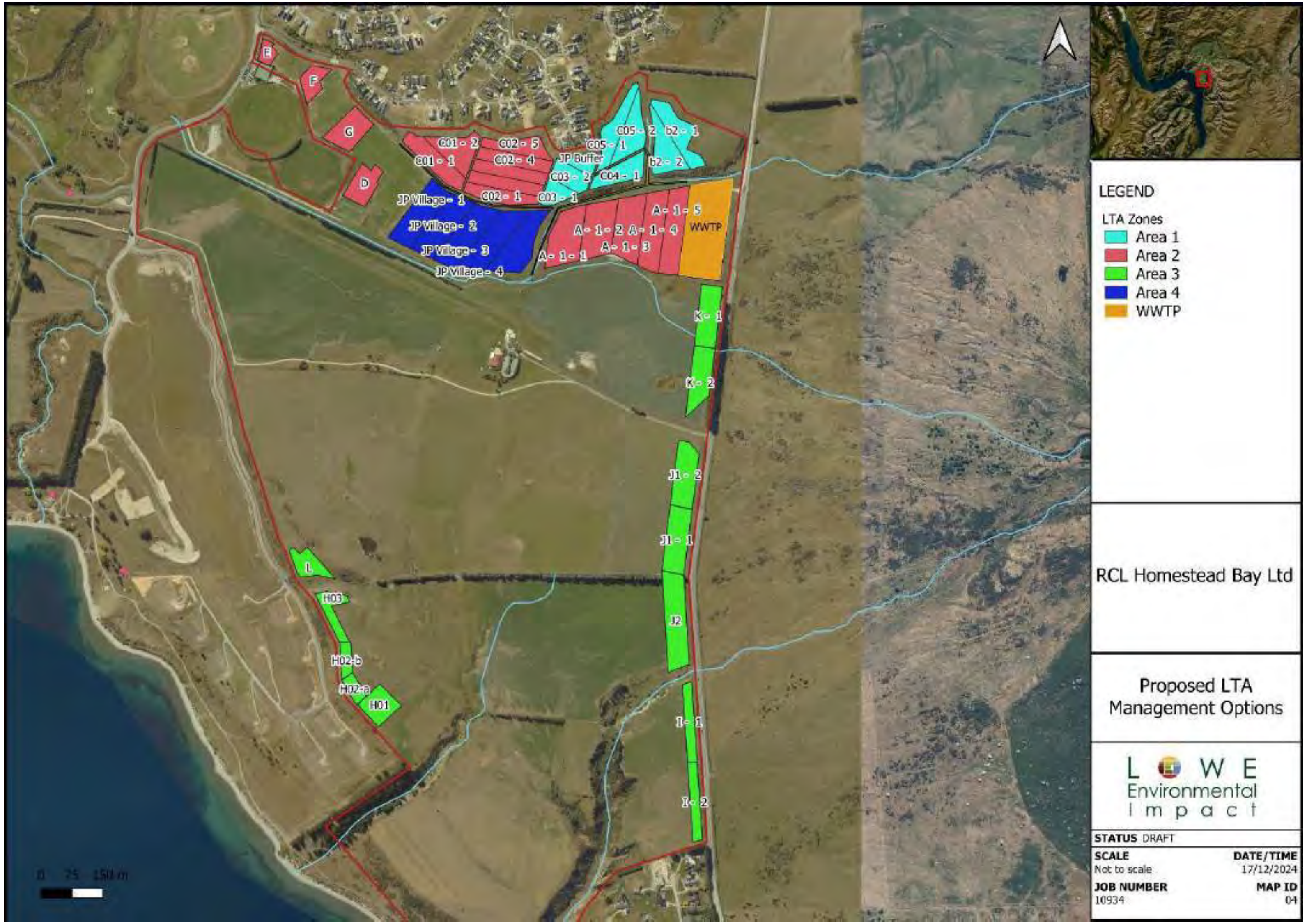


Appendix A: Baseline Farmed Area

Appendix A: Paddock Map

APPENDIX B

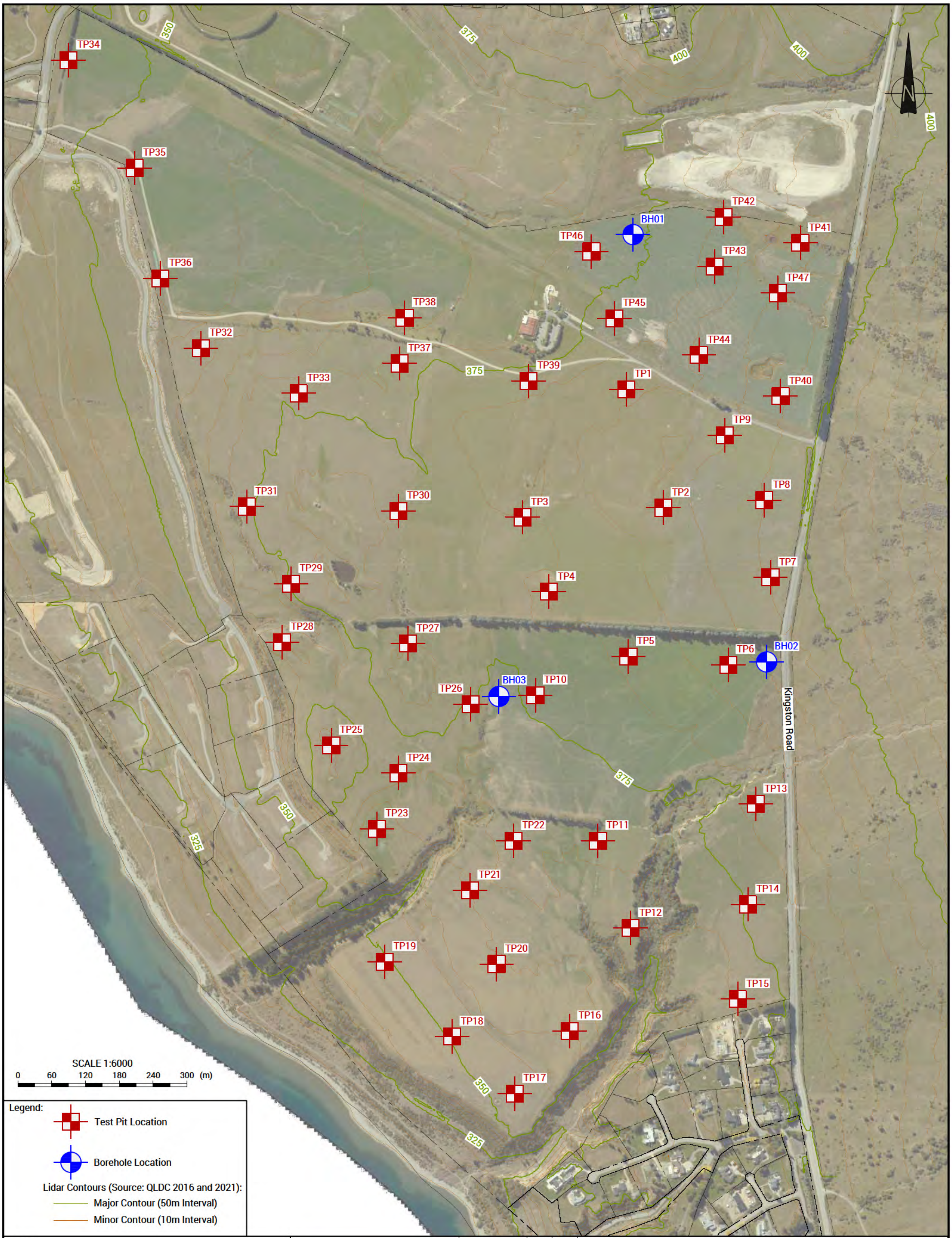
Identification and Location of the LTA at RCL



Appendix B: Proposed Land Treatment Areas

APPENDIX C

Geosolve Logs



Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

DRAWN	WCG	Nov.24
DRAFTING CHECKED		
APPROVED		
CADFILE: 220556.01-I.dwg		
SCALES (AT A3 SIZE): 1:6000		
PROJECT No: 220556.01		

RCL Henley Downs Ltd
Homestead Bay
Geotechnical Assessment (GI)
Investigation Site Plan

FIG No: Appendix A, Figure 1

Rev: 0

TEST PIT LOG

HOLE NO.: TP01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical

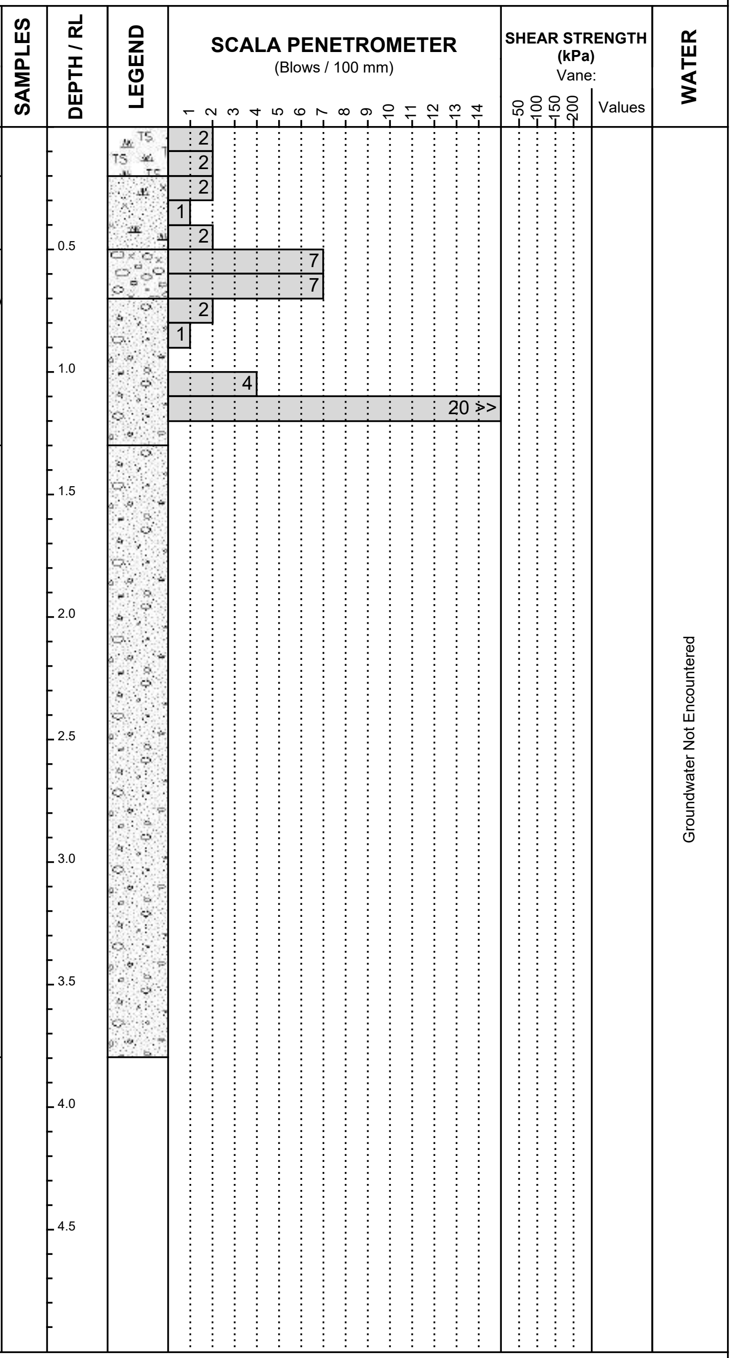
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265689.0 mE, 4998600.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 04/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Organic silty SAND, trace rootlets, brown. 0.20 m
LOESS	Silty fine SAND, with rootlets and organic inclusions, brownish orange, massive. Loose, moist. 0.50 m
WEATHERED GLACIAL TILL	Sandy fine to coarse GRAVEL, with minor to some silt and trace cobbles, orange, massive. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse. 0.70 m Fine SAND, with trace to minor gravel and trace silt. 500 mm diameter boulder at 1.20 m, orange and grey, massive. Loose to medium dense, moist to wet. 1.30 m
GLACIAL TILL	Fine to medium SAND, with minor gravel and trace cobbles and boulders up to 500 mm in diameter. Orange sand banding throughout, light grey, massive. Dry to moist, gravels are fine to coarse, subrounded to rounded. 3.80 m
	End Of Hole: 3.80 m



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

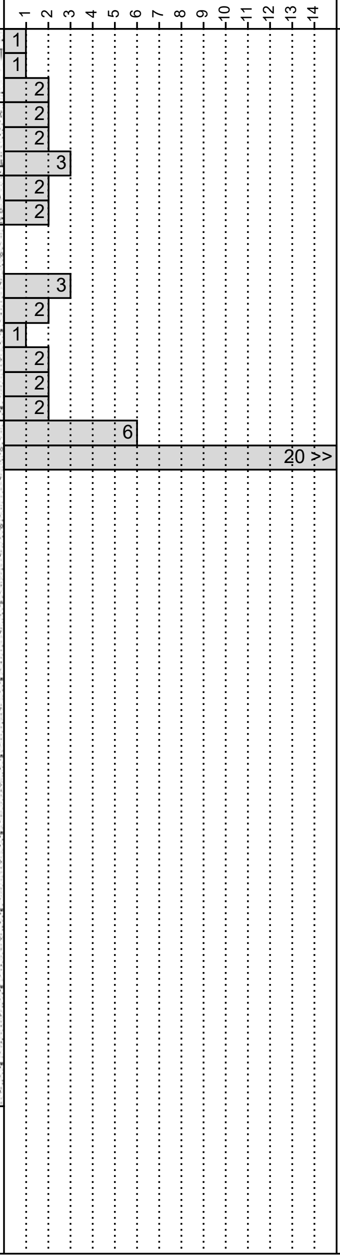
HOLE NO.: TP02

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 22/10/2024
COORDINATES: 1265764.0 mE, 4998393.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 04/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty SAND, trace rootlets, brown. 0.30 m			Groundwater Not Encountered
LOESS	Silty fine SAND, with rootlets and organic inclusions, brownish orange, massive. Loose, moist. 0.60 m		0.5	
WEATHERED GLACIAL TILL	Sandy fine to coarse GRAVEL, with minor silt and trace cobbles, orange and grey, massive. Loose to medium dense, moist , gravels are subrounded to rounded. Sand is fine to coarse. 0.80 m			
	Fine SAND, with trace to minor gravel and trace silt and boulders up to 400 m in diameter, orange and grey, massive. Loose, moist, gravels are fine to medium, subrounded to rounded. 1.60 m		1.0 1.5	
GLACIAL TILL	Fine to coarse SAND, with minor gravel, trace cobbles and boulders up to 300 mm in diameter, light grey, massive. Dense, dry to moist, gravels are fine to coarse, subrounded to rounded. 4.40 m		2.0 2.5 3.0 3.5 4.0	
	End Of Hole: 4.40 m		4.5	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane:

50	100	150	200	Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.: TP03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265515.0 mE, 4998365.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 04/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Organic silty SAND, trace rootlets, brown.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, with trace organic inclusions, grey. Firm, moist.	0.70 m
	Sandy, silty fine to coarse GRAVEL, brown and grey, chaotic. Medium dense, moist to wet, gradual top and bottom contacts, gravels are subrounded to rounded. Sand is coarse.	1.00 m
	Sandy fine to coarse GRAVEL, orange, chaotic. Medium dense, moist, immediate contact at base, gravels are subrounded to rounded. Sand is coarse.	1.30 m
GLACIAL TILL	Fine to coarse SAND, with minor gravel and trace cobbles and boulders, grey, massive, with orange banding decreasing with depth. Dense, moist, gravels are fine to coarse, subrounded to rounded.	3.80 m
	End Of Hole: 3.80 m	

SCALA PENETROMETER (Blows / 100 mm)

DEPTH / RL	
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	1
0.4–0.5	1
0.5–0.6	2
0.6–0.7	1
0.7–0.8	6
0.8–0.9	6
0.9–1.0	
1.0–1.1	4
1.1–1.2	7
1.2–1.3	18 >>
1.3–1.4	20 >>

SHEAR STRENGTH (kPa) Vane: Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP04

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

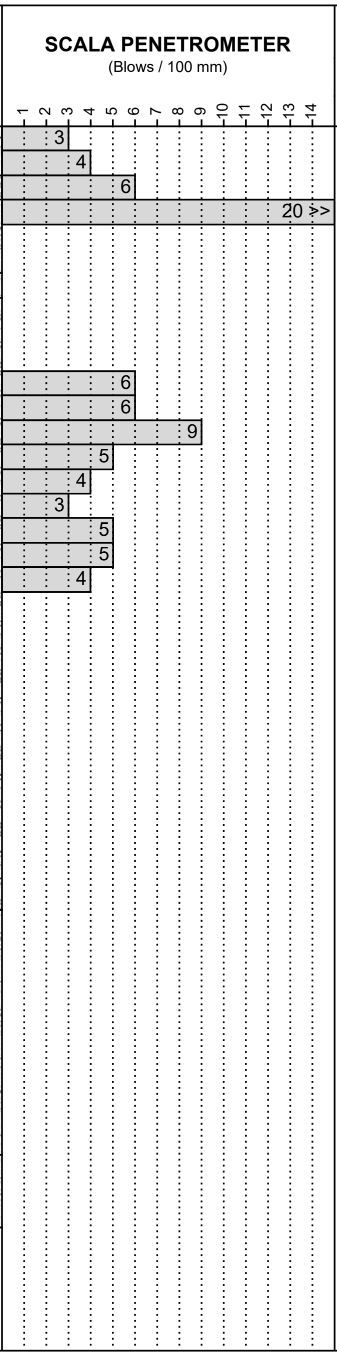
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 22/10/2024
COORDINATES: 1265567.0 mE, 4998235.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 04/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic silty SAND, trace rootlets, brown.	0.20 m
UNCONTROLLED FILL	Silty, sandy fine to coarse GRAVEL, with Fragments of steel pipe, dark orange. Dry to moist, gravels are rounded, Sand is fine to medium .	0.30 m
OUTWASH DEPOSITS	Fine to coarse SAND, with minor gravel and trace silt, grey and orange, loosely bedded. Medium dense, moist, gravels are fine to coarse, rounded.	0.60 m
	Coarse SAND, grey , bedded. Medium dense, moist.	0.70 m
	Sandy fine to coarse GRAVEL, trace cobbles, with some beds of gravel with trace sand, grey and orange, bedded. Medium dense, moist, dipping between 5-10° towards 222°, gravels are subrounded to rounded. Sand is fine to coarse.	3.20 m
	Gravelly fine to coarse SAND, with beds of coarse sand, grey, bedded. Medium dense, moist, dipping between 5-10° towards 222°, gravels are fine to coarse, subrounded to rounded.	4.20 m
GLACIAL TILL	Sily SAND, with trace gravel, grey, minor laminations. Medium dense, moist to wet, horizontal contact, gravels are fine to medium, subrounded to rounded.	4.50 m
	End Of Hole: 4.50 m	

SAMPLES

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER Groundwater Not Encountered

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit collapsing in coarser gravels

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP05

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 22/10/2024

COORDINATES: 1265714.0 mE, 4998126.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.		0.20 m	TS	
ALLUVIAL FAN DEPOSITS	SILT, with trace to minor fine sand, dark grey, with brown staining, trace laminations. Firm, moist, low plasticity.		1.50 m		Groundwater Not Encountered
	Sandy SILT, dark grey, trace laminations. Firm to stiff, moist, low plasticity, sand is fine.		4.50 m		
	End Of Hole: 4.50 m				

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	2
0.4–0.5	2
0.5–0.6	2
0.6–0.7	2
0.7–0.8	2
0.8–0.9	2
0.9–1.0	
1.0–1.1	1
1.1–1.2	1
1.2–1.3	2
1.3–1.4	2
1.4–1.5	3
1.5–1.6	4
1.6–1.7	4
1.7–1.8	4
1.8–1.9	4

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP06

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

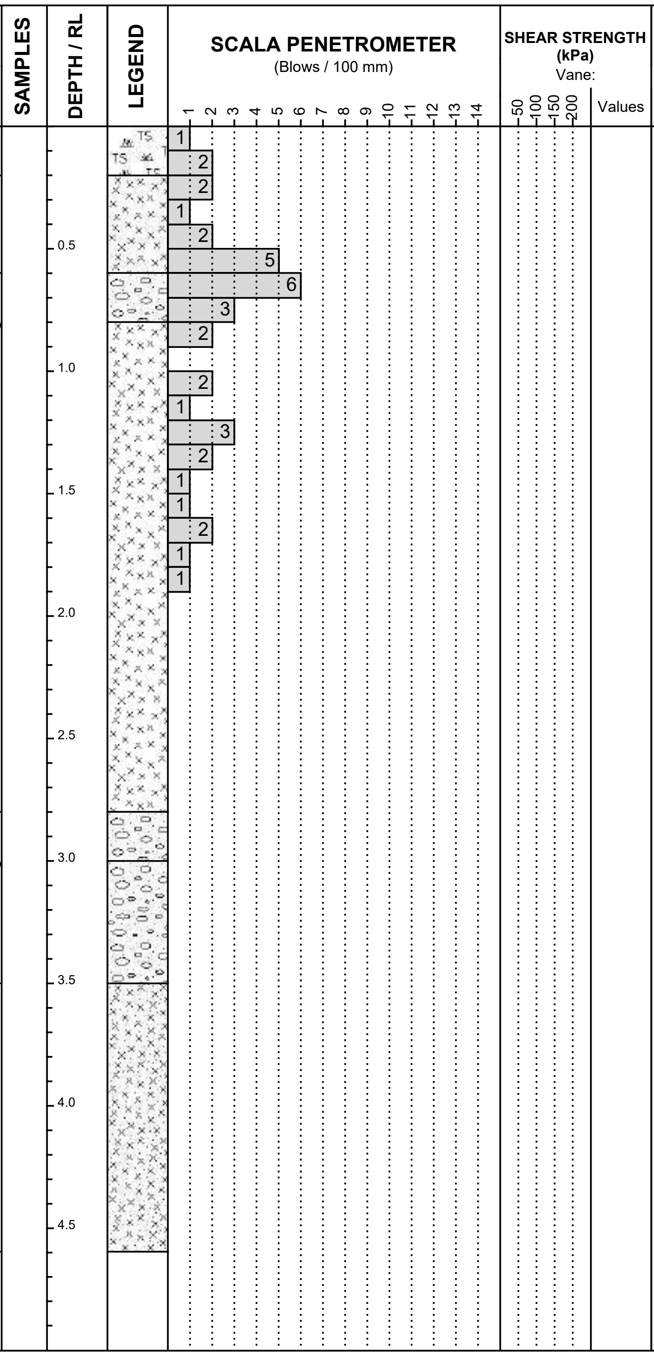
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 22/10/2024

COORDINATES: 1265891.0 mE, 4998119.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with trace gravel and fine sand, dark grey, laminated. Firm , moist, low plasticity.	0.60 m
	Sandy fine to coarse GRAVEL, dark grey, discontinuous . Medium dense, moist, gravels are rounded. Sand is medium to coarse.	0.80 m
	SILT, with trace gravel and fine sand, dark grey, with brown mottling, trace laminations. Loose to medium dense, moist.	2.80 m
	Sandy fine to coarse GRAVEL, with trace cobbles and boulders up to 200 mm in diameter, dark grey. Moist, gravels are rounded. Sand is medium to coarse.	3.00 m
	Sandy fine to coarse GRAVEL, dark grey, discontinuous . Medium dense, moist, gravels are rounded. Sand is medium to coarse.	3.50 m
	Sandy SILT, grey, trace laminations. Firm to stiff, moist to wet, low plasticity, sand is fine.	4.60 m
	End Of Hole: 4.60 m	



WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP07

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 22/10/2024

COORDINATES: 1265959.0 mE, 4998281.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

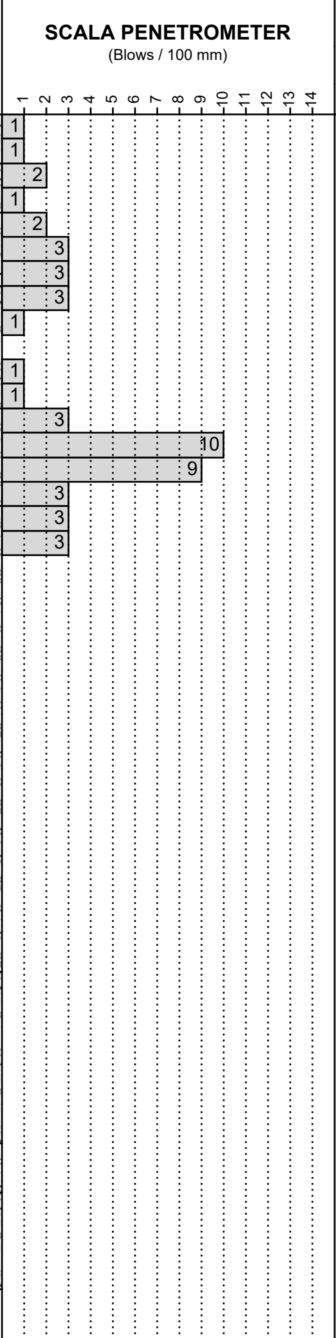
LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown. 0.20 m		
ALLUVIAL FAN DEPOSITS	SILT, with trace to minor fine sand, dark grey. Firm to stiff, moist, low plasticity. 0.40 m		
	Silty fine to coarse GRAVEL, trace sand, dark grey. Medium dense, moist, gravels are subrounded to rounded. 0.65 m		
	Sandy fine to coarse GRAVEL, with trace silt, dark grey. Medium dense, moist, gravels are subrounded to rounded. 0.70 m		
	SILT, with minor fine sand, dark grey. Firm to stiff, moist, low plasticity. 1.20 m		
	Sandy fine to coarse GRAVEL, trace silt, dark grey. Medium dense, moist, dipping at 5° towards 225°, gravels are subrounded to rounded. 1.60 m		
	Sandy fine to coarse GRAVEL, with trace silt, dark grey. Medium dense, moist, gravels are subrounded to rounded. 3.50 m		
	Sandy SILT, grey. Firm to stiff, moist to wet, low plasticity, sand is fine. 4.20 m		
	Sandy fine to coarse GRAVEL, trace silt, dark grey. Medium dense, saturated, dipping at 5° towards 225°, gravels are subrounded to rounded. 4.40 m		◁ 22/10/2024
	Sandy SILT, grey. Firm to stiff, saturated, low plasticity, sand is fine. 4.80 m		
	End Of Hole: 4.80 m		



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

DEPTH / RL: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

PHOTO(S)

REMARKS

Target depth achieved. Pit walls collapsing below 4.2 m

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:07:27 am

TEST PIT LOG

HOLE NO.: TP08

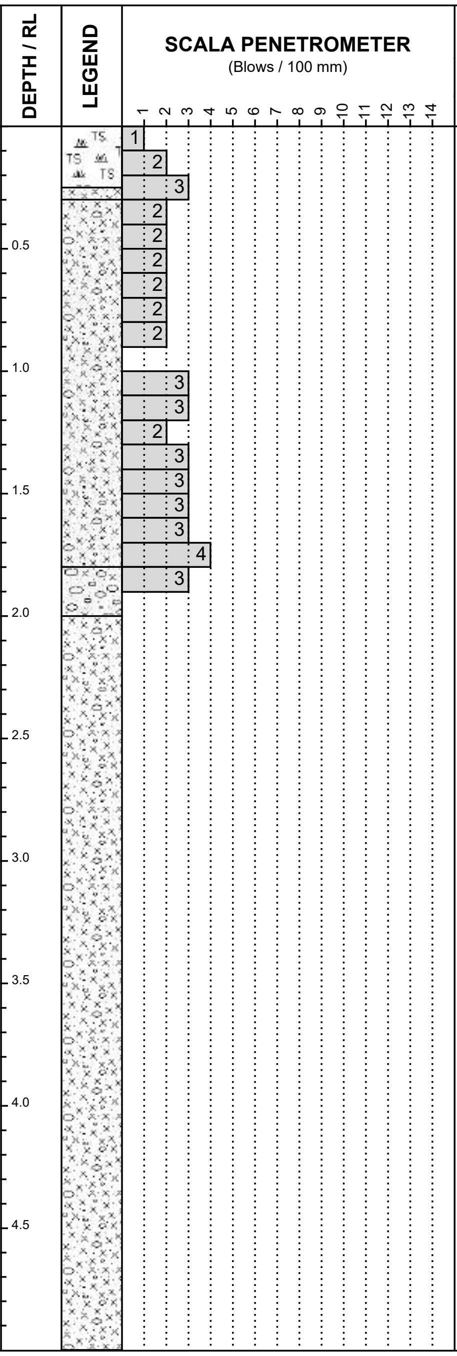
CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265942.0 mE, 4998418.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.25 m	Groundwater Not Encountered
ALLUVIAL FAN DEPOSITS	Sandy SILT, with trace gravel, light grey. Stiff, moist.	0.30 m	
	SILT, with trace to minor sand, dark grey, discontinuous 100 mm sandy gravel layer at 1.50 m. Firm to stiff, moist, sand is fine.	1.80 m	
	Sandy fine to coarse GRAVEL, with minor silt, dark grey. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	2.00 m	
	SILT, with some fine sand, grey with brown mottling, occasional discontinuous sandy gravel layers. Stiff, moist.	5.00 m	
	End Of Hole: 5.00 m		

SAMPLES | **DEPTH / RL** | **LEGEND** | **SHEAR STRENGTH (kPa)** Vane: 50 100 150 200 Values

SCALA PENETROMETER (Blows / 100 mm)



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- Standing Water Level
- Out flow
- In flow

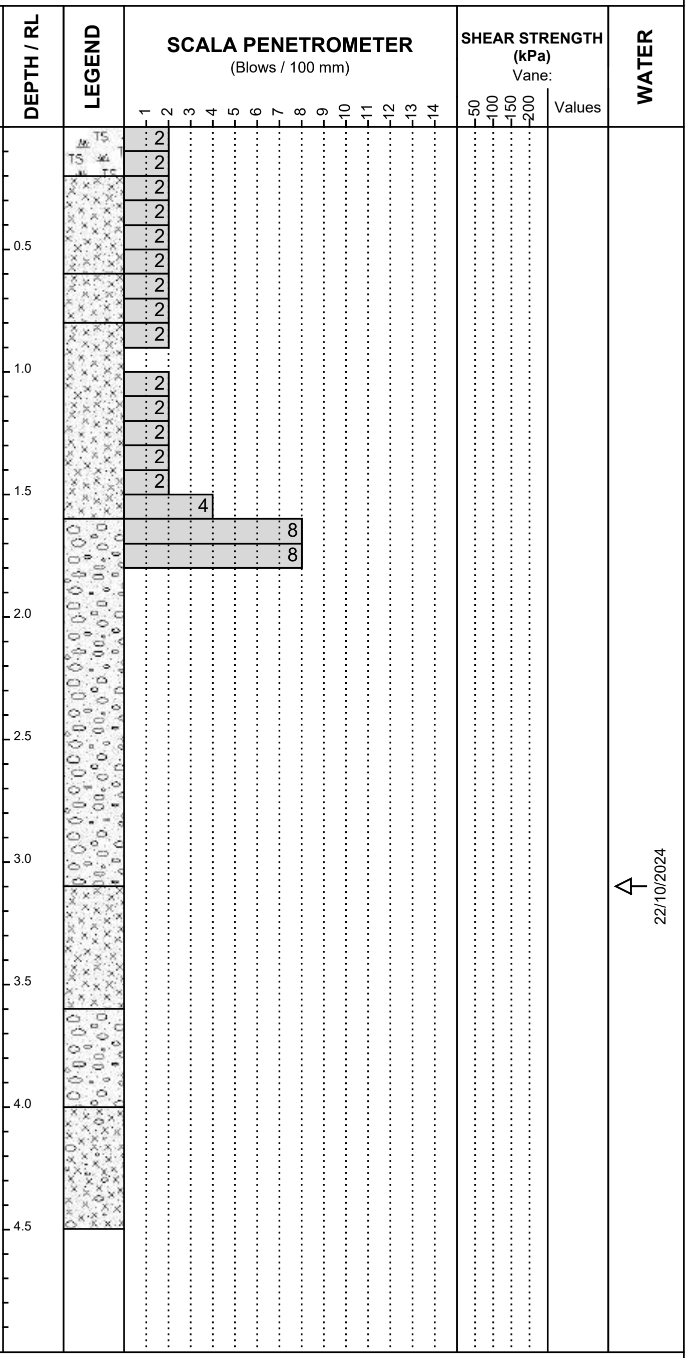
TEST PIT LOG

HOLE NO.: TP09

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265867.0 mE, 4998529.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.		0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with minor fine sand, dark grey. Firm, moist, low plasticity.		0.60 m
	Sandy SILT, with trace gravel, light grey. Firm, moist, gravels are fine to medium, subrounded to rounded. Sand is fine.		0.80 m
	SILT, with minor sand, dark grey, mottled orange. Firm, moist, low plasticity, sand is fine.		1.60 m
	Sandy fine to coarse GRAVEL, with trace silt, cobbles and boulders, dark grey, mottled orange. Medium dense, saturated, gravels are subrounded to rounded. Sand is fine to coarse.		3.10 m
WEATHERED GLACIAL TILL	SILT, with minor sand, grey. Firm, saturated, low plasticity, sand is fine.		3.60 m
	Sandy fine to coarse GRAVEL, with trace silt, cobbles and boulders, dark grey, mottled orange. Medium dense, saturated, gravels are subrounded to rounded. Sand is fine to coarse.		4.00 m
GLACIAL TILL	SILT, with trace to minor sand and gravel, light grey. Very stiff, moist, sand is fine to medium. Gravels are fine and subrounded.		4.50 m
	End Of Hole: 4.50 m		



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

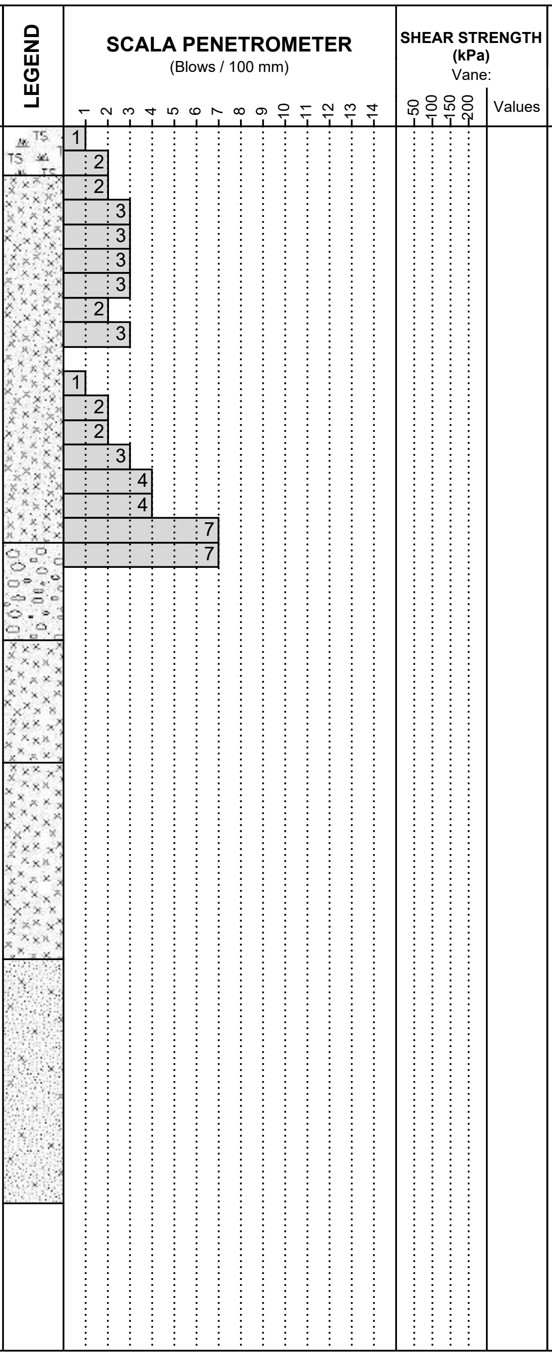
TEST PIT LOG

HOLE NO.: TP10

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265552.0 mE, 4998050.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.		0.20 m	
ALLUVIAL FAN DEPOSITS	SILT, with minor sand, dark grey. Firm, dry to moist, low plasticity, sand is fine.		1.70 m	
	Sandy fine to coarse GRAVEL, with trace silt, dark brownish grey. Moist, gravels are subrounded. Sand is fine.		2.10 m	
GLACIAL POND SEDIMENT	SILT, with trace fine sand, grey. Stiff, dry, low plasticity, friable.		2.60 m	Groundwater Not Encountered
	SILT, trace rootlets, grey, massive. Very stiff, dry, low plasticity, powdery.		3.40 m	
	Fine SAND, with minor silt and trace gravel, white and grey, massive. Hard, moist, gravels are medium to coarse, rounded.		4.40 m	
	End Of Hole: 4.40 m			



0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	3
0.4–0.5	3
0.5–0.6	3
0.6–0.7	3
0.7–0.8	2
0.8–0.9	3
1.0–1.1	1
1.1–1.2	2
1.2–1.3	2
1.3–1.4	3
1.4–1.5	4
1.5–1.6	4
1.6–1.7	7
1.7–1.8	7

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:07:41 am

TEST PIT LOG

HOLE NO.: TP11

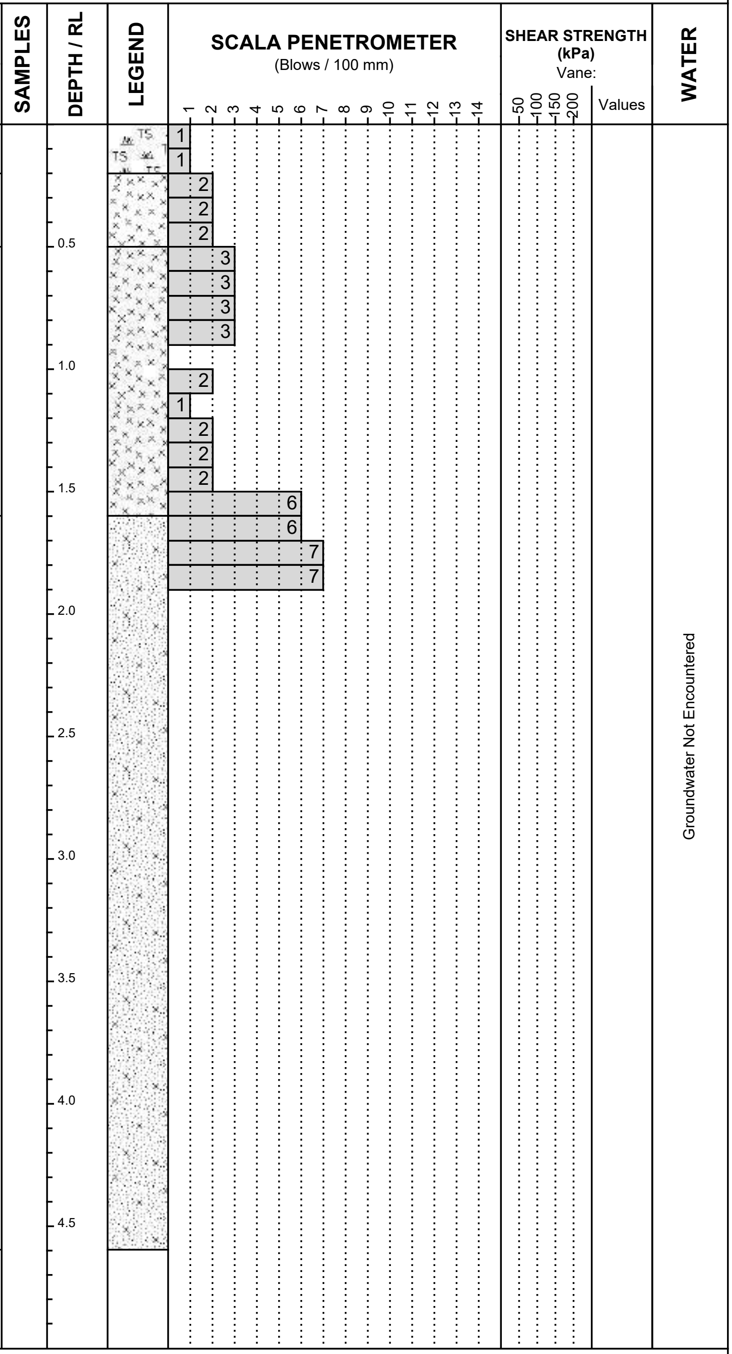
CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Kingston Road, Drift Bay 9371	**CONTRACTOR:**	Base Contracting	**START DATE:**	23/10/2024
COORDINATES:	1265674.0 mE, 4997797.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	23/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown. 0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with trace fine sand, brownish grey. Firm, dry to moist, low plasticity. 0.50 m
	SILT, with trace fine sand, greyish brown. Firm, dry to moist, low plasticity. 1.60 m
GLACIAL POND SEDIMENT	Fine SAND, with trace silt, light grey and orange banding, minor laminations, interbedded with 10-50 mm of silt bands. Medium dense, moist. 4.60 m
	End Of Hole: 4.60 m



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

TEST PIT LOG

HOLE NO.: TP12

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265739.0 mE, 4997644.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 23/10/2024
END DATE: 23/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Organic sandy SILT, trace rootlets, dark brown.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, with trace fine sand, brownish grey. Firm, dry to moist, low plasticity.	0.60 m
	SILT, with trace fine sand, grey. Firm, dry to moist, low plasticity.	0.70 m
	SILT, with trace fine sand, with organic staining, brown. Firm, dry to moist, low plasticity.	0.75 m
	SILT, with trace fine sand, grey. Firm, dry to moist, low plasticity.	1.40 m
GLACIAL POND SEDIMENT	Sandy fine to medium GRAVEL, grey, bedded. Loose to medium dense , dry to moist, gravels are subrounded to rounded. Sand is medium to coarse.	1.60 m
	Fine SAND, with trace silt, light grey, minor laminations within silt. Loose to medium dense , dry to moist, pockets of sandy gravel at base contact.	3.10 m
	Sandy, fine to coarse GRAVEL, grey, bedded. Medium dense, dry to moist, gravels are subrounded to rounded. Sand is fine to coarse.	3.50 m
	Silty, fine SAND, grey, bedded. Medium dense, dry to moist.	4.40 m
	End Of Hole: 4.40 m	

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	2
0.1–0.2	3
0.2–0.3	3
0.3–0.4	3
0.4–0.5	3
0.5–0.6	2
0.6–0.7	3
0.7–0.8	3
0.8–0.9	3
1.0–1.1	2
1.1–1.2	3
1.2–1.3	3
1.3–1.4	3
1.4–1.5	3
1.5–1.6	3
1.6–1.7	3
1.7–1.8	3
1.8–1.9	3

SHEAR STRENGTH (kPa) Vane: Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:07:51 am

TEST PIT LOG

HOLE NO.: TP13

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265951.0 mE, 4997874.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

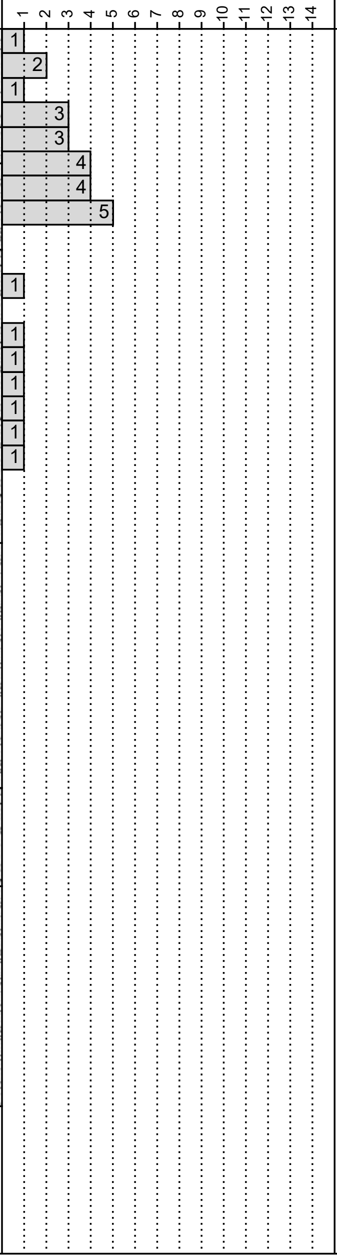
SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Sandy organic SILT, trace rootlets, blackish brown.	0.40 m
ALLUVIAL FAN DEPOSITS	Fine to medium SAND, with trace silt and organic inclusions, greyish brown. Loose, moist.	0.55 m
	Sandy GRAVEL, trace silt and rootlets, greyish brown. Loose, moist.	0.90 m
	SILT, with trace to minor sand, greyish brown. Firm, moist to wet, low plasticity, sand is fine .	2.10 m
	Sandy fine to coarse GRAVEL, trace silt and cobbles, greyish brown. Medium dense, moist, dipping gently to 261°, gravels are subrounded. Sand is fine to coarse.	3.10 m
	SILT, with trace to minor sand, greyish brown. Firm, moist to wet, low plasticity, sand is fine .	3.50 m
	Sandy fine to coarse GRAVEL, trace silt and cobbles, greyish brown. Medium dense, moist, dipping gently to 261°, gravels are subrounded. Sand is fine to coarse.	4.40 m
	End Of Hole: 4.40 m	

SAMPLES

DEPTH / RL: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:07:55 am

PHOTO(S)

REMARKS

Target depth achieved. Pit walls collapsing in coarser soils

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP14

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265945.0 mE, 4997695.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Sandy organic SILT, minor rootlets, blackish brown.	0.30 m
ALLUVIAL FAN DEPOSITS	Slightly organic SILT, blackish brown. Firm, moist, low plasticity.	0.60 m
	SILT, with trace sand and gravel, brown orange. Firm, moist, low plasticity, sand is fine. Gravels are fine to medium, subrounded.	0.70 m 0.85 m
	Sandy, silty fine to coarse GRAVEL, with trace cobbles and boulders up to 400 mm in diameter, brown orange. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to coarse.	1.30 m
	Sandy, fine to coarse GRAVEL, with trace silt, brown orange. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to coarse.	
GLACIAL TILL	Fine to coarse SAND, with minor gravel, trace cobbles and boulders up to 400 mm in diameter, light whitish grey, massive. Dense, dry to moist, gravels are subrounded to rounded.	3.40 m
	Sandy, fine to coarse GRAVEL, trace cobbles and boulders up to 500 mm in diameter, orange grey, massive. Medium dense to dense, dry to moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.10 m
	End Of Hole: 4.10 m	

SCALA PENETROMETER (Blows / 100 mm)

DEPTH (m)	Blows
0.0–0.1	1
0.1–0.2	2
0.2–0.3	1
0.3–0.4	2
0.4–0.5	2
0.5–0.6	2
0.6–0.7	2
0.7–0.8	5
0.8–0.9	7
1.0–1.1	6
1.1–1.2	7
1.2–1.3	20 >>

SHEAR STRENGTH (kPa) Vane: Values

WATER: In flow at 4.0 m, 23/10/2024

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP15

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265934.0 mE, 4997527.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 23/10/2024
END DATE: 23/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Sandy organic SILT, minor rootlets, blackish brown.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, trace sand and organic inclusions, greyish brown. Firm, moist, low plasticity, sand is fine.	0.50 m
	Sandy, silty, fine GRAVEL, brownish grey. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to medium.	0.60 m 0.70 m
	Silty, fine SAND, grey. Medium dense, moist.	0.80 m
	Sandy, silty, fine GRAVEL, brownish grey. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to medium.	
	Fine SAND, with minor silt, grey. Loose, wet, sand is fine.	1.30 m
	Silty, fine SAND, grey. Medium dense, wet.	1.70 m
	Fine to medium SAND, grey, bedded. Loose, wet.	2.00 m
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL, with trace cobbles and boulders up to 400 mm in diameter, brown, bedded. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.40 m
GLACIAL TILL	Fine to medium SAND, with minor gravel, whitish grey, massive. Dense, dry to moist, gravels are fine to coarse, rounded.	4.80 m
	End Of Hole: 4.80 m	

SAMPLES | **DEPTH / RL** | **LEGEND**

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	1
0.1–0.2	1
0.2–0.3	2
0.3–0.4	2
0.4–0.5	2
0.5–0.6	4
0.6–0.7	2
0.7–0.8	4
0.8–0.9	2
0.9–1.0	
1.0–1.1	1
1.1–1.2	3
1.2–1.3	2
1.3–1.4	3
1.4–1.5	3
1.5–1.6	3
1.6–1.7	3
1.7–1.8	3
1.8–1.9	3

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 | Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP16

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024

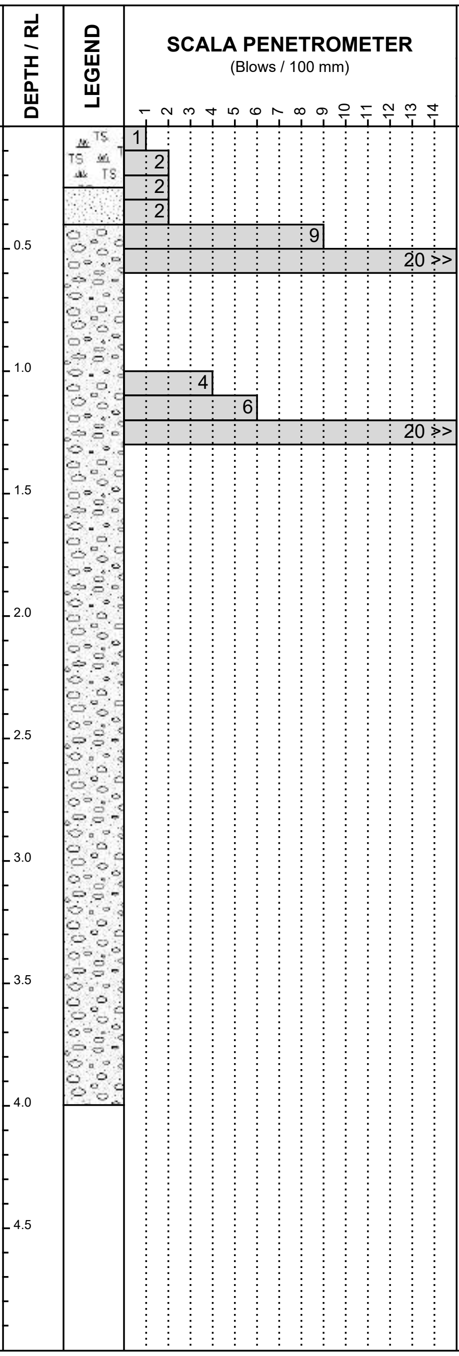
COORDINATES: 1265639.0 mE, 4997457.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Sandy organic SILT, minor rootlets, brown.	0.25 m
LOESS	Fine SAND, with trace silt, rootlets and organic inclusions, orange. Firm, moist.	0.40 m
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 500 mm in diameter, orange, interbedded with sandy layers. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.00 m
	End Of Hole: 4.00 m	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP17

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

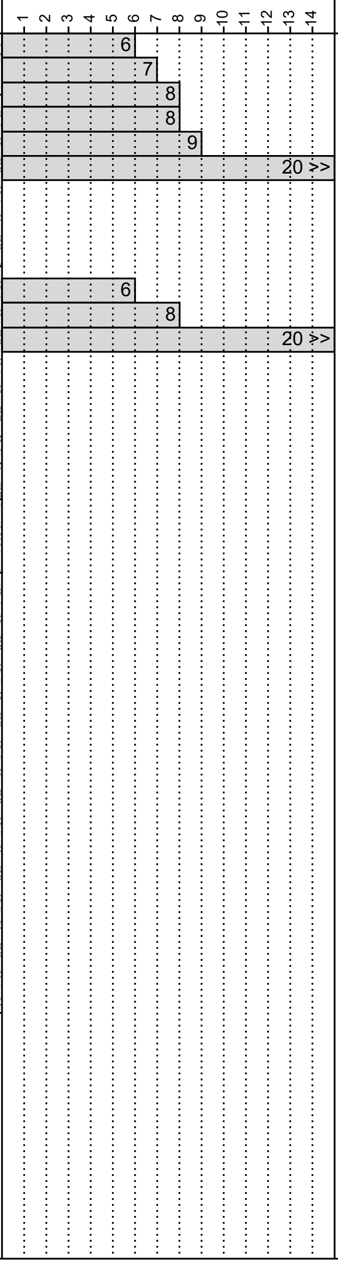
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265503.0 mE, 4997339.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Gravelly organic SILT, with trace sand and rootlets, brown. Dry to moist, gravels are fine to medium.	0.25 m
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, trace rootlets, orange, bedded. Medium dense, dry to moist, gravels are subrounded. Sand is fine to coarse.	0.95 m
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.	1.90 m
	Fine to medium SAND, grey, bedded. Medium dense, moist.	2.20 m
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 150 mm in diameter, grey, bedded. Moist, gravels are subrounded. Sand is fine to coarse.	4.00 m
	End Of Hole: 4.00 m	

SAMPLES

LEGEND

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

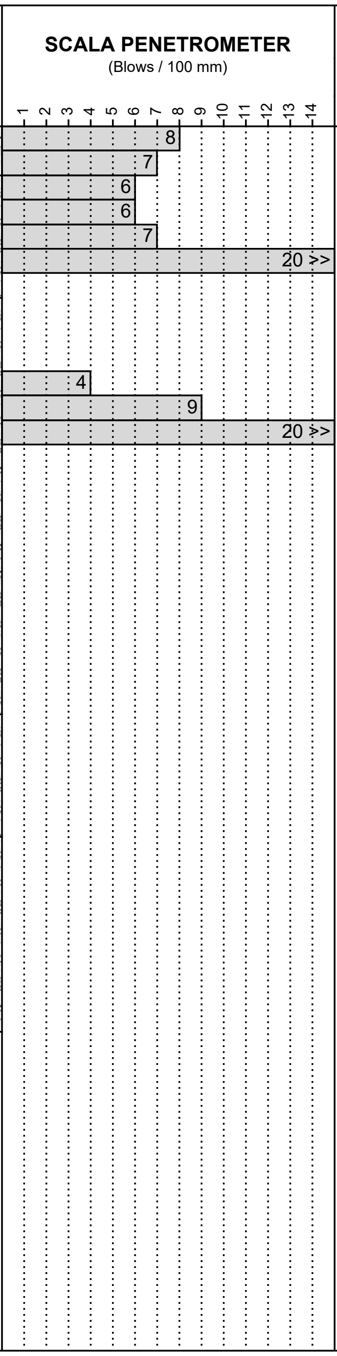
TEST PIT LOG

HOLE NO.: TP18

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265426.0 mE, 4997339.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Gravelly organic SILT, with trace sand and rootlets, brown. Dry to moist, gravels are fine to medium.		0.20 m	Groundwater Not Encountered
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, trace rootlets, orange, bedded. Medium dense, dry to moist, gravels are subrounded. Sand is fine to coarse.		0.70 m	
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.		2.40 m	
	Sandy, fine to coarse GRAVEL, grey, bedded. Dense, dry to moist, sand is fine to coarse.		2.90 m	
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.		3.70 m	
	End Of Hole: 3.70 m			



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.: TP19

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 24/10/2024

COORDINATES: 1265305.0 mE, 4997565.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 24/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

ELEVATION: Existing ground level

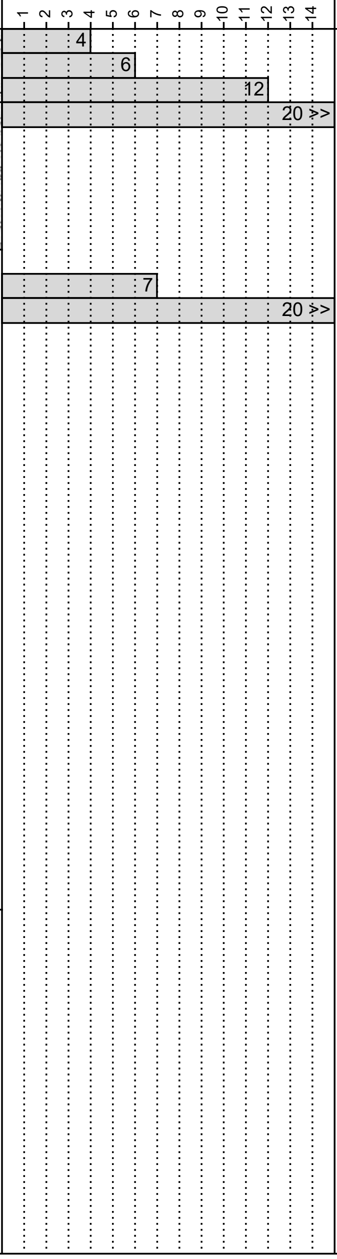
OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist.		0.30 m	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL, trace rootlets within the top 200 mm, with trace cobbles and boulders up to 300 mm in diameter, orange, bedded. Medium dense, dry to moist, gravels are subangular to subrounded. Sand is fine to coarse.		0.90 m	Groundwater Not Encountered
	Sandy fine to coarse GRAVEL, interbedded with sand, with trace cobbles and boulders up to 200 mm in diameter, grey and orange, bedded. Medium dense, dry to moist, gravels are subangular to subrounded. Sand is fine to coarse.		3.60 m	
	End Of Hole: 3.60 m			

SCALA PENETROMETER

(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaning vertical

WATER

- Standing Water Level
- Out flow
- In flow

TEST PIT LOG

HOLE NO.: TP20

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 24/10/2024

COORDINATES: 1265503.0 mE, 4997570.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 24/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist. 0.30 m			Groundwater Not Encountered
LOESS	Sandy SILT with a trace of gravel and organics, brownish/orange. Low plasticity, moist, sand, fine; gravel, fine to medium, subrounded. 0.60 m		0.5	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with a trace of silt, brownish/orange. Medium dense, moist, Silt content decreasing with depth, gravel, surrounded; sand, fine to coarse. 0.80 m			
	Gravelly fine to coarse SAND with a trace of silt and cobbles, grey. Dense, moist, sand, mostly fine to medium; gravel, fine to coarse, rounded to subrounded. 1.20 m		1.0	
	Sandy fine to coarse GRAVEL with trace cobbles and boulders, grey, interbedded sandy layers. Medium dense, moist, bedded, gravel, subrounded; sand, fine to coarse. 4.20 m		1.5 2.0 2.5 3.0 3.5 4.0	
	End Of Hole: 4.20 m		4.5	

SCALA PENETROMETER
(Blows / 100 mm)

0.0–0.1	1
0.1–0.2	2
0.2–0.3	5
0.3–0.4	5
0.4–0.5	12
0.5–0.6	20 >>
1.0–1.1	20 >>

SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:08:31 am

TEST PIT LOG

HOLE NO.: TP21

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 24/10/2024

COORDINATES: 1265451.0 mE, 4997699.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 24/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

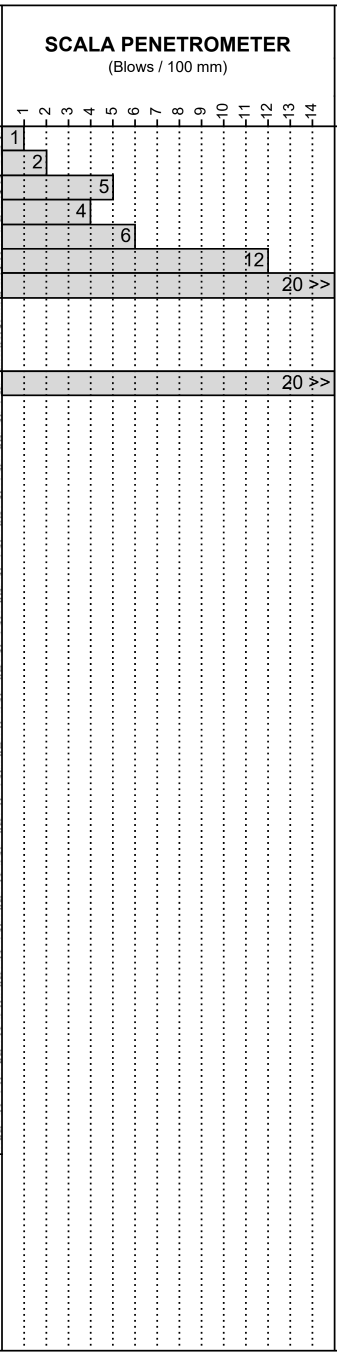
ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist.	0.20 m
LOESS	Sandy SILT with a trace of gravel and organics, brownish/orange. Low plasticity, moist, sand, fine; gravel, fine to medium, subrounded.	0.70 m
OUTWASH DEPOSITS	Gravelly fine to coarse SAND with a trace of silt and cobbles, grey. Dense, moist, sand, mostly fine to medium; gravel, fine to coarse, rounded to surrounded. Boulders up to 200 mm.	1.00 m
	Sandy fine to coarse GRAVEL with trace cobbles and boulders, grey, interbedded sandy layers. Medium dense, moist, bedded, gravel, subrounded; sand, fine to coarse.	4.20 m
	End Of Hole: 4.20 m	

SCALA PENETROMETER (Blows / 100 mm)



DEPTH (m)	Blows / 100 mm
0.0–0.1	1
0.1–0.2	2
0.2–0.3	5
0.3–0.4	4
0.4–0.5	6
0.5–0.6	12
0.6–0.7	20 >>
1.0–1.1	20 >>

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

GEOSOLVE
ENGINEERING CONSULTANTS

TEST PIT LOG

HOLE NO.: TP22

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 24/10/2024
COORDINATES: 1265527.0 mE, 4994805.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

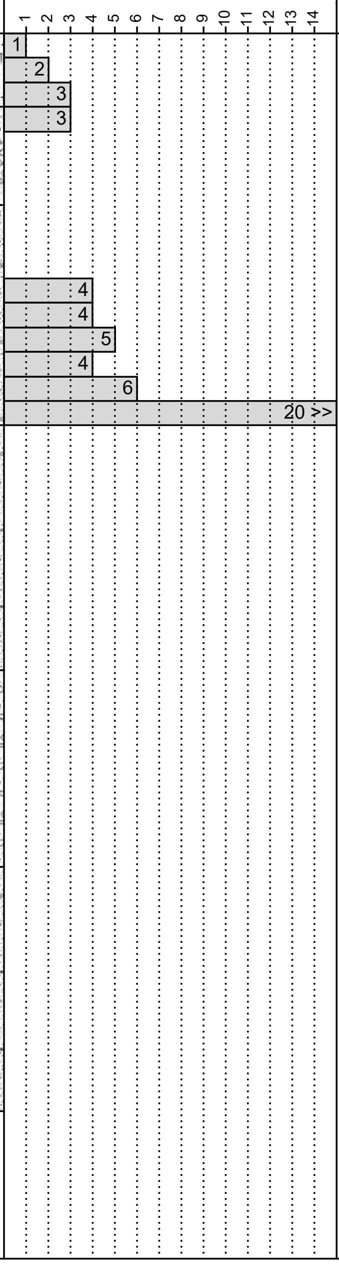
SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Sandy organic SILT with a trace rootlets, dark brown. Moist.	0.30 m
COLLUVIUM	Sandy fine to coarse GRAVEL with minor silt and a trace of rootlets and organics, orange. Medium dense, moist, chaotic, gravel, subrounded; sand, fine to medium.	0.70 m
OUTWASH DEPOSITS	Fine SAND, light orange, interbedded 200 mm with silty sand beds. Medium dense, moist to wet.	1.60 m
	Fine to medium SAND with some gravel and a trace of silt, grey. Dense, moist, bedded, gravel, fine to medium, subrounded to rounded.	2.60 m
	Sandy fine to coarse GRAVEL with a trace of cobbles, dark grey. Medium dense, moist, bedded, gravel, rounded to subrounded; sand, medium to coarse.	3.40 m
	Gravelly coarse SAND, grey. Medium dense, wet, bedded, gravel, fine to coarse, rounded to subrounded.	4.40 m
	End Of Hole: 4.40 m	

SAMPLES

DEPTH / RL: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

LEGEND

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

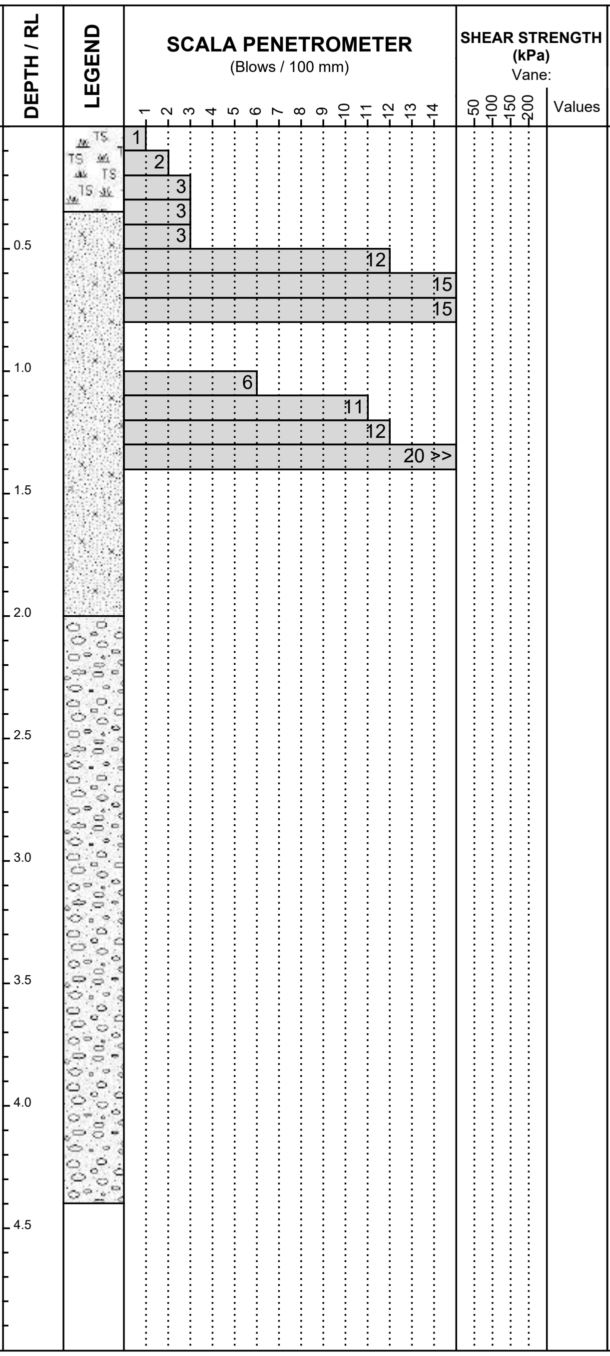
TEST PIT LOG

HOLE NO.: TP23

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265281.0 mE, 4997801.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 24/10/2024
END DATE: 24/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Sandy organic SILT with a trace rootlets, dark brown. Moist, strong organic smell. 0.35 m		
OUTWASH DEPOSITS	Silty fine SAND with a trace of gravel, grey. Medium dense to dense, wet. Moist from 0.6 m, minor laminations, gravel, fine to medium, subrounded. 2.00 m		Groundwater Not Encountered
	Sandy fine to coarse GRAVEL with a trace of silt, cobbles and boulders, orange/grey. Medium dense, moist, bedded, gravel, subrounded to rounded. Sand, fine to coarse; boulders up to 250 mm. 4.40 m		
	End Of Hole: 4.40 m		



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP24

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 25/10/2024

COORDINATES: 1265315.0 mE, 4997901.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 25/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

ELEVATION: Existing ground level

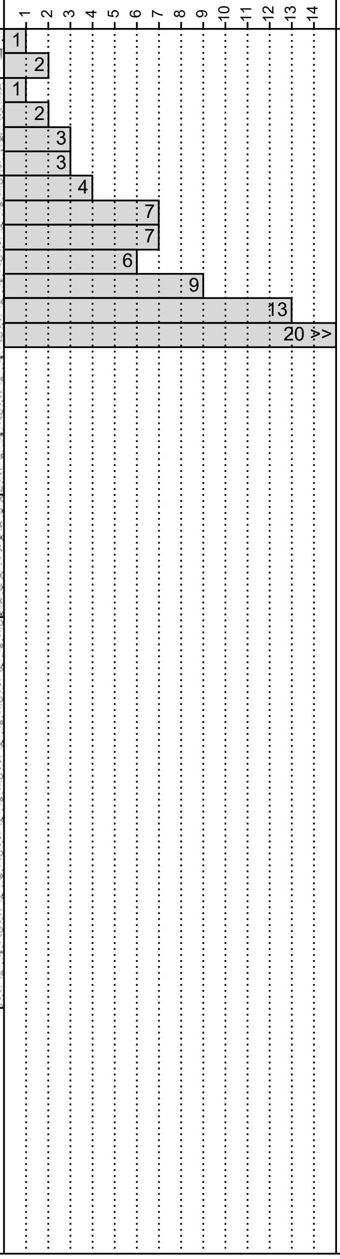
OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL	WATER
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine.	0.20 m	Groundwater Not Encountered
LOESS	Silty fine SAND with a trace of roots and organics, orange. Wet.	0.60 m	
GLACIAL TILL	Fine to medium SAND with minor silt and gravel with a trace of cobbles, grey/orange banding, interbedded siltier layers. Medium dense, moist, gravel, fine to coarse, subrounded.	1.90 m	
	Sandy SILT, light grey. Dense, dry, excavator struggling, sand, fine.	2.40 m	
	Fine to coarse SAND with minor silt and gravel with a trace of cobbles and boulders, grey, interbedded siltier layers. Medium dense, moist, gravel, fine to coarse, subrounded. Boulders up to 750 mm diameter.	4.00 m	
	End Of Hole: 4.00 m		

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

SCALA PENETROMETER
(Blows / 100 mm)



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP25

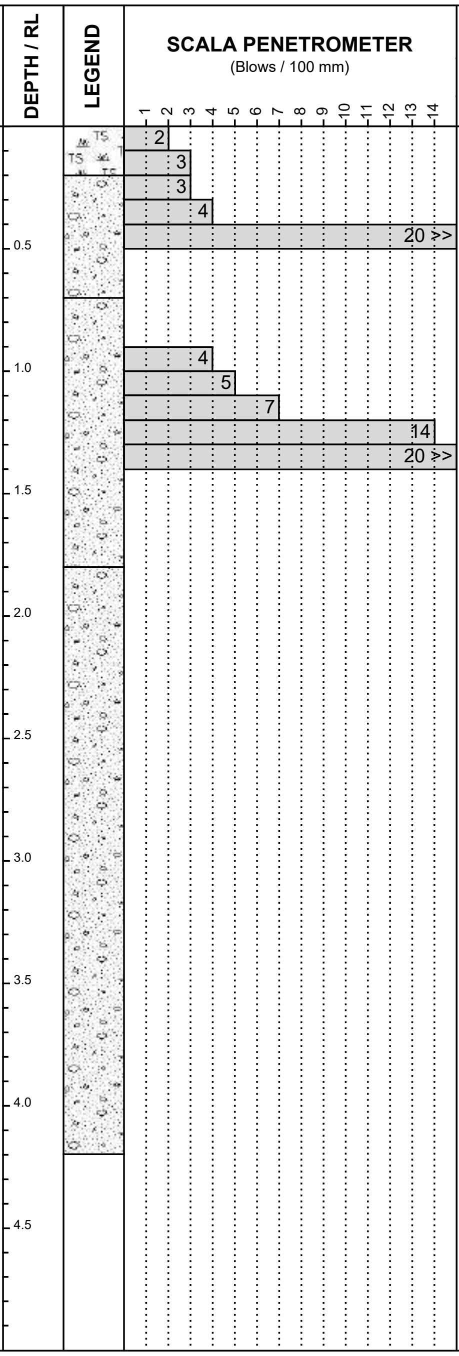
CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265193.0 mE, 4997945.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 25/10/2024
END DATE: 25/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	WATER
TOPSOIL	Sandy organic SILT with minor gravel and trace rootlets, brown. Wet, sand, fine; gravel, fine to coarse, subrounded to subangular. 0.20 m	Groundwater Not Encountered
COLLUVIUM	Fine to coarse SAND with minor gravel and a trace of silt and organics, grey/orange. Medium dense, moist, chaotic, gravel, fine to coarse, surounded. 0.6 m: two 20 mm thick brown beds near basal contact 0.70 m	
GLACIAL TILL	Fine to coarse SAND with minor gravel and a trace of cobbles and silt, grey with orange streaks. Medium dense, dry to moist, sand, mostly fine to medium; gravel, fine to coarse, subrounded to rounded. 1.80 m	
	Gravelly fine to coarse SAND with a trace of silt, cobbles, grey/brown, interbedded siltier layers. Dense, dry to moist, gravel, fine to coarse, subrounded to rounded. Boulders up to 200 mm diameter. 4.20 m	
	End Of Hole: 4.20 m	



SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP26

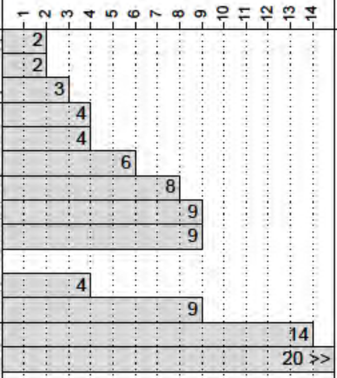
CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 25/10/2024
COORDINATES: 1265437.0 mE, 4998029.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 25/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Sandy organic SILT with trace rootlets, brown. Moist, sand, fine.	0.30 m
COLLUVIUM	Silty fine SAND with a trace of gravel and organics, orange . Loose to medium dense, moist, chaotic.	0.60 m
GLACIAL TILL	Fine to coarse SAND with a trace of silt, gravel, cobbles and boulders, grey with orange banding. Medium dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	1.20 m
	Fine to coarse SAND with a trace of silt, gravel, cobbles and boulders, light grey, interbedded siltier layers. Medium dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	2.40 m
	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, grey. Dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	3.90 m
	End Of Hole: 3.90 m	

SAMPLES | **DEPTH / RL**: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 | **LEGEND**

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 | Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP27

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Kingston Road, Drift Bay 9371

COORDINATES: 1265322.0 mE, 4998132.0 mN (NZTM2000)

LOCATION METHOD: Handheld GPS

ELEVATION: Existing ground level

CONTRACTOR: Base Contracting

EQUIPMENT: 13T

ACCURACY: ± 3 m

OPERATOR: Jeremy

START DATE: 25/10/2024

END DATE: 25/10/2024

LOGGED BY: JMJ

CHECKED DATE: 05/11/2024

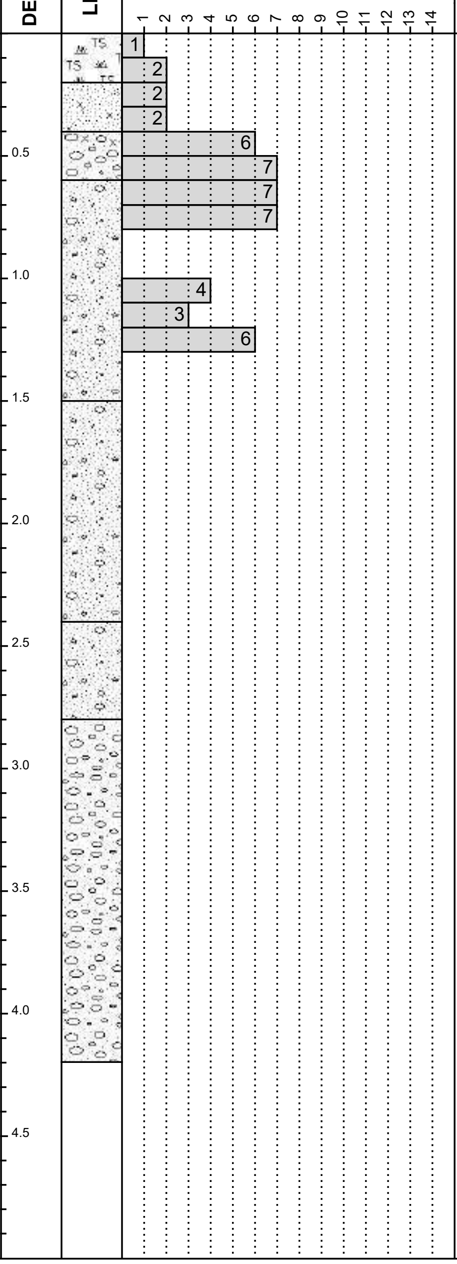
SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine.	0.20 m
LOESS	Silty fine SAND with a trace of rootlets and organics, orange. Loose to medium dense, moist to wet.	0.40 m
COLLUVIUM	Sandy fine to coarse GRAVEL with minor silt and trace organics, orange/grey. Medium dense, moist to wet, chaotic, gravel, fine to coarse, subrounded; sand, fine to coarse.	0.60 m
OUTWASH DEPOSITS	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, grey/orange, interbedded siltier layers. Medium dense to dense, moist to wet, gravel, fine to coarse, subrounded; boulders up to 250 mm diameter.	1.50 m
	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, orange/grey, interbedded siltier layers. Dense, moist, gravel, fine to coarse, subrounded; boulders up to 400 mm diameter.	2.40 m
	Gravelly SAND with a trace of silt, cobbles of boulders, grey. Dense, moist to wet, gravel, fine to coarse, subrounded; boulders up to 400 mm diameter.	2.80 m
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey/brown. Medium dense, moist, bedded, gravel, fine to coarse, subrounded. Boulders up to 300 mm.	4.20 m
	End Of Hole: 4.20 m	

SAMPLES

DEPTH / RL

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



Depth (m)	Blows / 100 mm
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	2
0.4–0.5	6
0.5–0.6	7
0.6–0.7	7
0.7–0.8	7
1.0–1.1	4
1.1–1.2	3
1.2–1.3	6

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls collapsing from 2.8 m. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP28

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 25/10/2024

COORDINATES: 1265098.0 mE, 4998124.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 25/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

LOGGED BY: JMJ

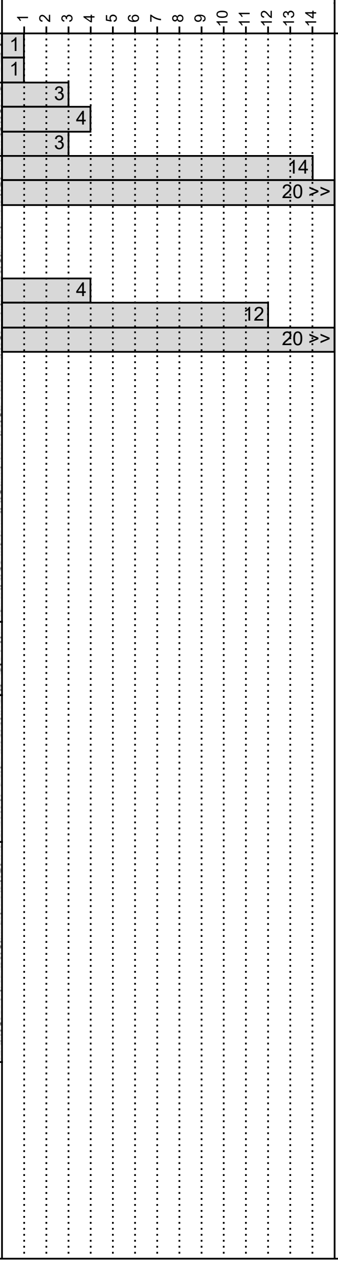
ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine.	0.20 m
COLLUVIUM	Fine to coarse SAND with minor gravel and silt with a trace of organics, orange. Medium dense, moist to wet, chaotic, gravel, fine to coarse, subrounded.	0.50 m
OUTWASH DEPOSITS	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, orange/grey. Dense, moist, gravel, fine to coarse, subrounded. Boulders up to 400 mm.	2.40 m
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, moist, bedded, sand, fine to coarse; gravel, subrounded. Boulders up to 250 mm.	2.70 m
GLACIAL TILL	Fine SAND, grey. Medium dense, dry to moist.	3.30 m
	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, orange/grey. Dense, moist, gravel, fine to coarse, subrounded. Boulders up to 400 mm.	4.20 m
	End Of Hole: 4.20 m	

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP29

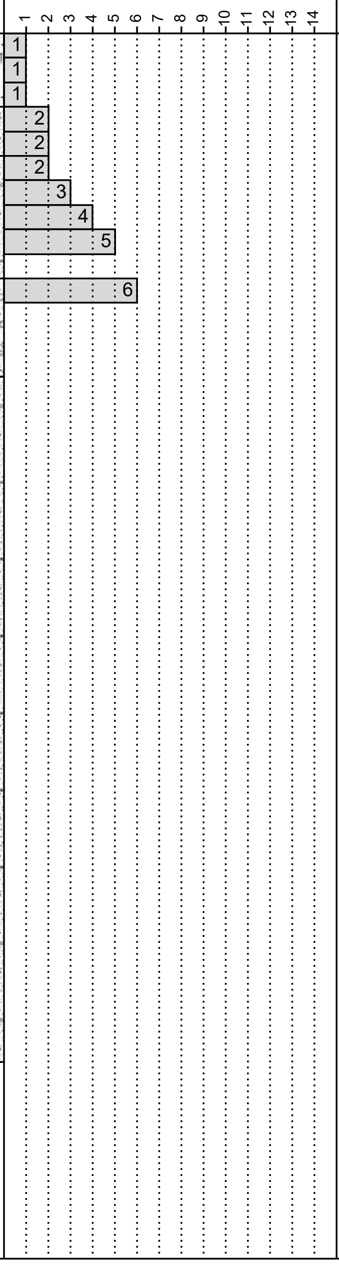
CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES:	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Moist. 0.30 m			Groundwater Not Encountered
LOESS	Silty fine SAND with a trace of organics, orange. Loose to medium dense, moist to wet. 0.50 m		0.5	
COLLUVIUM	Gravelly fine to medium SAND with minor to trace silt and a trace of cobbles, orange. Loose to medium dense, moist, chaotic, gravel, fine to coarse, subrounded to rounded. 1.00 m		1.0	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles, orange and grey, interbedded sandy gravels and fine sands. Medium dense, moist, bedded, gravel, subrounded to rounded; sand, fine to coarse.. 1.40 m		1.5	
	Gravelly fine to coarse SAND with trace cobbles, dark grey. Dense, moist, bedded, gravel, rounded to subrounded; sand, medium to coarse. 4.20 m		2.0 2.5 3.0 3.5 4.0	
	End Of Hole: 4.20 m		4.5	

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

SCALA PENETROMETER (Blows / 100 mm)



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.: TP30

CLIENT: RCL Henley Downs Ltd

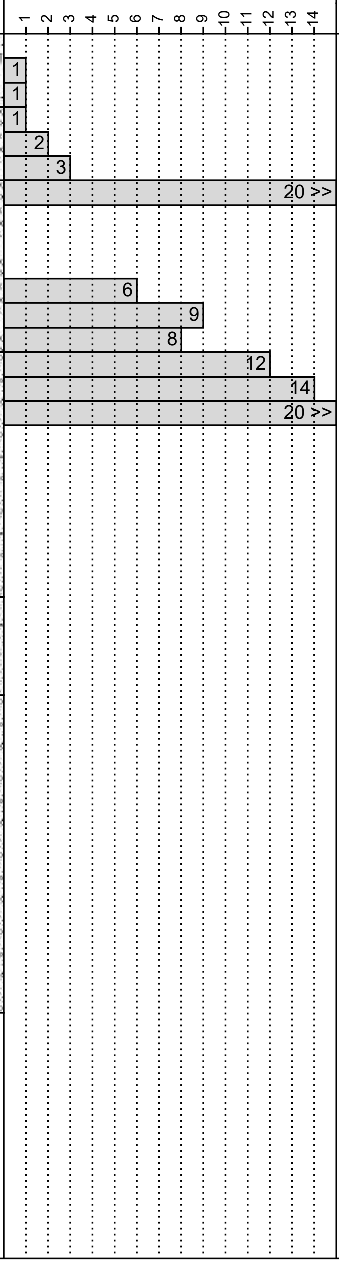
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES: 1265294.0 mE, 4998366.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with a trace of rootlets, brown. Moist to wet, low plasticity.		0.30 m	Groundwater Not Encountered
WEATHERED GLACIAL TILL	SILT with minor to trace of sand, trace organics and rootlets, light orange/brown. Firm, wet, low plasticity, sand, fine.		0.60 m	
GLACIAL TILL	SILT, grey with orange streaks. Stiff to very stiff, wet, low plasticity.		1.30 m	
	Gravelly fine to coarse SAND with minor to no silt and trace cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded.		2.30 m	
	Fine to coarse SAND with some gravel, dark grey . Dry to moist, gravel, fine to coarse, subrounded. Sand and gravel mostly fine to medium, trace coarse.		2.70 m	
	Gravelly fine to coarse SAND with minor to no silt and trace cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded.		4.00 m	
	End Of Hole: 4.00 m			

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- Standing Water Level
- Out flow
- In flow

TEST PIT LOG

HOLE NO.: TP31

JOB NO.: 220556.01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265025.0 mE, 4998362.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 25/10/2024
END DATE: 25/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

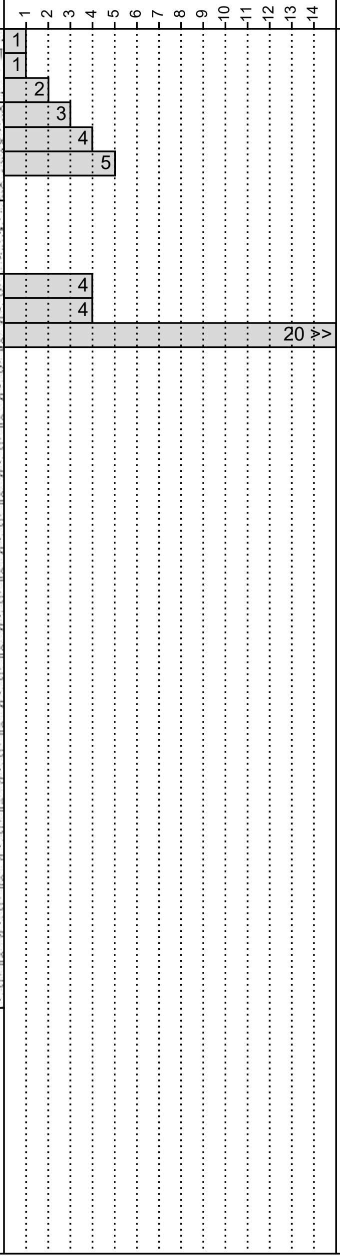
SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Organic SILT with trace rootlets, brown. Moist, low plasticity.	0.30 m
COLLUVIUM	Sandy SILT with minor gravel and trace organics, orange. Firm, moist, low plasticity, sand, fine to coarse (mostly fine), gravel, fine to coarse, subrounded.	0.70 m
OUTWASH DEPOSITS	Fine to coarse SAND with some gravel and a trace of silt and cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded. Sand is mostly fine.	1.00 m
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, dark grey. Dense, moist, bedded, gravel, subrounded to rounded; sand, fine to coarse, mostly medium to coarse. Boulders up to 250 mm in diameter.	4.00 m
	End Of Hole: 4.00 m	

SAMPLES

DEPTH / RL: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP32

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 25/10/2024

COORDINATES: 1264932.0 mE, 4998640.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 25/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

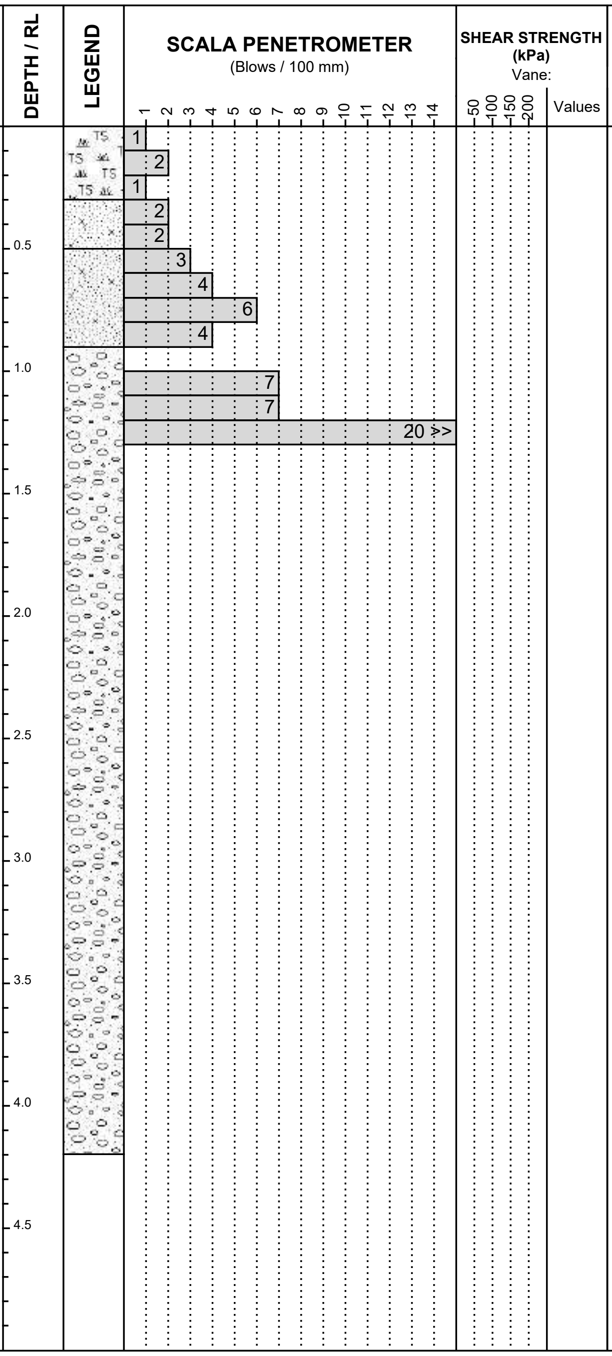
LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic SILT with trace rootlets, dark brown. Wet. 0.30 m		Groundwater Not Encountered
LOESS	Silty fine SAND with trace organics, orange. Loose, wet. 0.50 m		
COLLUVIUM	Gravely fine SAND with minor silt and trace cobbles, orange/brown orange. Medium dense, wet, chaotic, gravel fine to coarse, subrounded to rounded. 0.90 m		
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles and boulders, orange/grey becoming grey. Dense, moist, bedded, gravel, subrounded to rounded; sand, fine to coarse - mostly medium to coarse; boulders up to 250 mm diameter. 4.20 m		
	End Of Hole: 4.20 m		



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP33

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

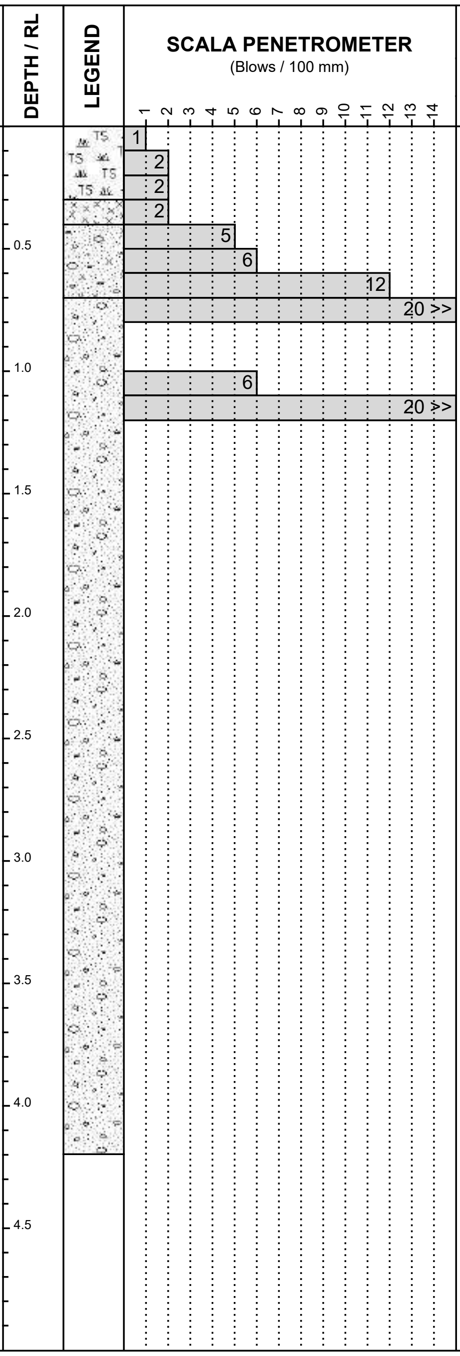
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 25/10/2024
COORDINATES: 1265108.0 mE, 4998567.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 25/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with trace rootlets, dark brown. Moist.	0.30 m
LOESS	Sandy SILT with a trace of gravel and organics, orange. Firm, moist, low plasticity, sand, fine; gravel, fine to coarse, subrounded.	0.40 m
COLLUVIUM	Gravelly fine to carse SAND with minor silt, orange. Medium dense, moist, gravel, fine to coarse, subrounded to rounded.	0.70 m
GLACIAL TILL	Gravelly fine to coarse SAND with trace silt and cobbles, orange/grey, beds of medium to coarse sand. Dense, moist, sand, rarely coarse; gravel, fine to coarse, subrounded to rounded.	4.20 m
	End Of Hole: 4.20 m	

SAMPLES

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

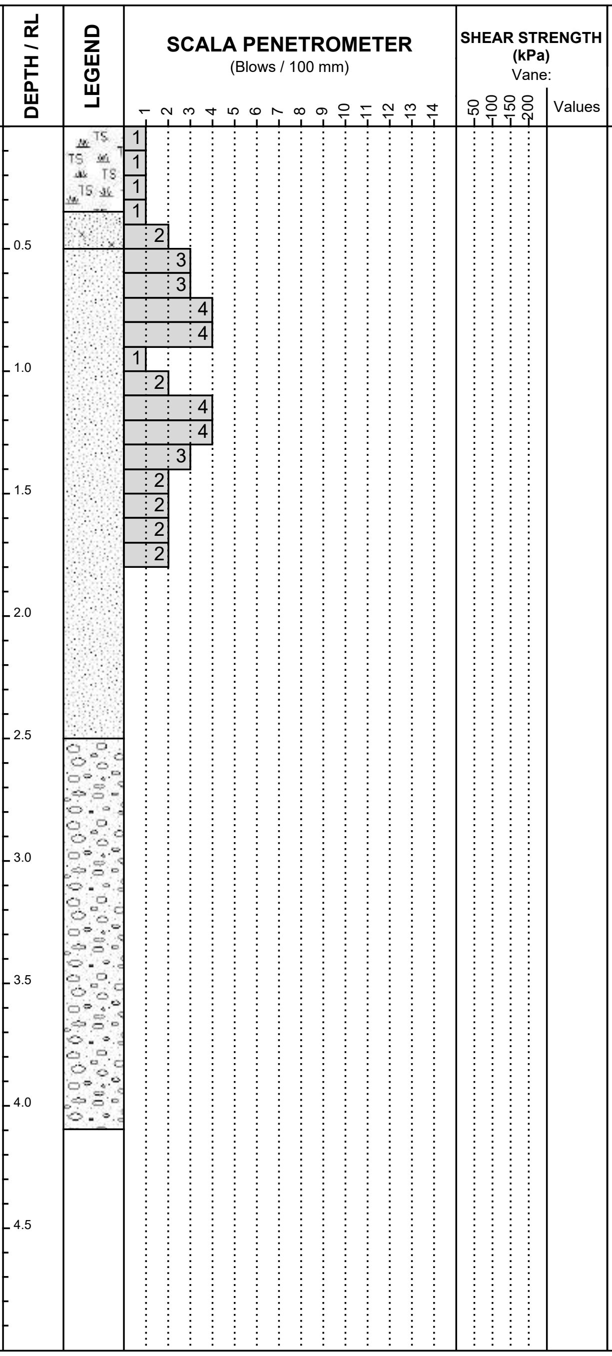
TEST PIT LOG

HOLE NO.: TP34

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1264674.0 mE, 4999141.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with minor sand and gravel with a trace of rootlets, dark brown. Wet, sand, fine to medium; gravel, fine to coarse, subrounded to rounded.		0.35 m	Groundwater Not Encountered
LOESS	Fine SAND with minor silt and a trace of gravel and organic inclusions, orange, unit dipping towards 094. Loose to medium dense, moist.		0.50 m	
ALLUVIAL FAN DEPOSITS	Fine SAND with trace rootlets, grey/orange becoming grey. Loose, moist.		2.50 m	
GLACIAL OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles, grey/orange . Medium dense, moist, bedded, gravel, subrounded; sand, fine to coarse.		4.10 m	
	End Of Hole: 4.10 m			



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP35

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1264800.0 mE, 4998955.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

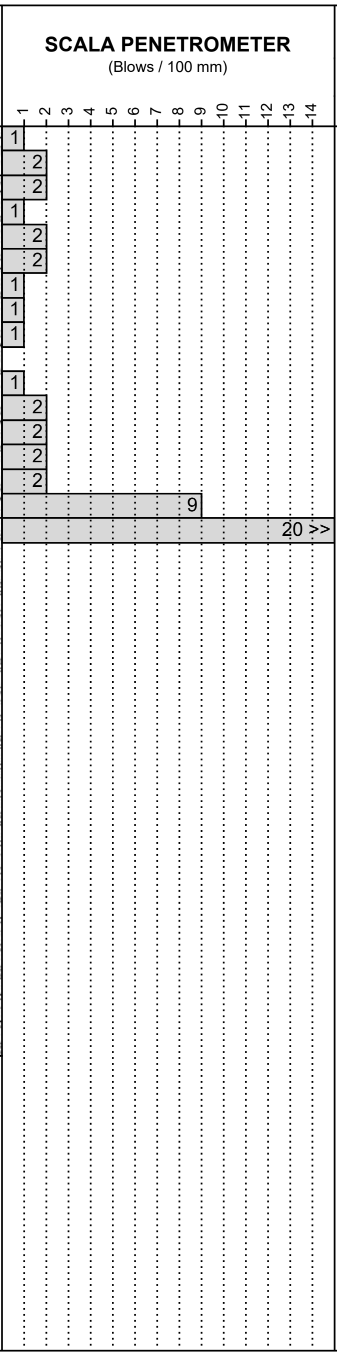
SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with minor roots and rootlets, dark brown. Wet.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT with a trace rootlets in upper 400 mm, brownish grey. Firm, moist, low plasticity.	1.60 m
GLACIAL OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL, brownish grey, slightly bedded. Medium dense, wet, pit walls collapsing, gravel, subrounded; sand, fine to coarse, mostly medium to coarse.	3.80 m
	End Of Hole: 3.80 m	

SAMPLES

DEPTH / RL

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



Depth (m)	Blows / 100 mm
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	1
0.4–0.5	2
0.5–0.6	2
0.6–0.7	1
0.7–0.8	1
0.8–0.9	1
0.9–1.0	
1.0–1.1	1
1.1–1.2	2
1.2–1.3	2
1.3–1.4	2
1.4–1.5	2
1.5–1.6	9
1.6–1.7	20 >>

SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

End of test, test pit walls collapsing. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP36

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024

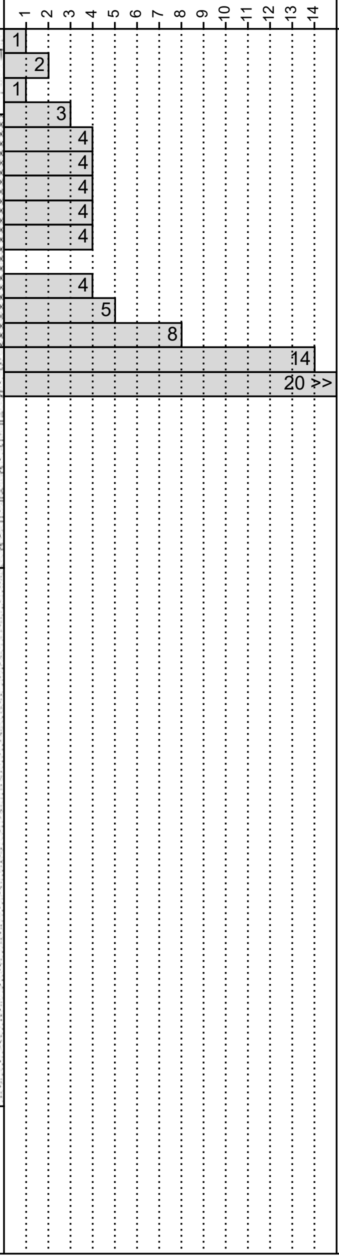
COORDINATES: 1264854.0 mE, 4998761.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024

LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with minor rootlets, black. Wet.		0.35 m		Groundwater Not Encountered
UNCONTROLLED FILL	Sandy fine to medium GRAVEL with a trace of silt, brown/grey, rootlets in upper 300 mm. Medium dense, wet, uniform, gravel, subangular; sand, fine to coarse, mostly medium to coarse.		1.30 m		
GLACIAL POND SEDIMENT	Sandy fine to coarse GRAVEL, grey/orange, interbedded sandier layers increasing near basal contact. Dense, wet, bedded, gravel, subrounded; sand, fine to coarse.		2.20 m		
OUTWASH DEPOSITS	Fine SAND with a trace of siltand rootlets, grey. Medium dense, moist.		4.40 m		
	End Of Hole: 4.40 m				

SCALA PENETROMETER
(Blows / 100 mm)



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP37

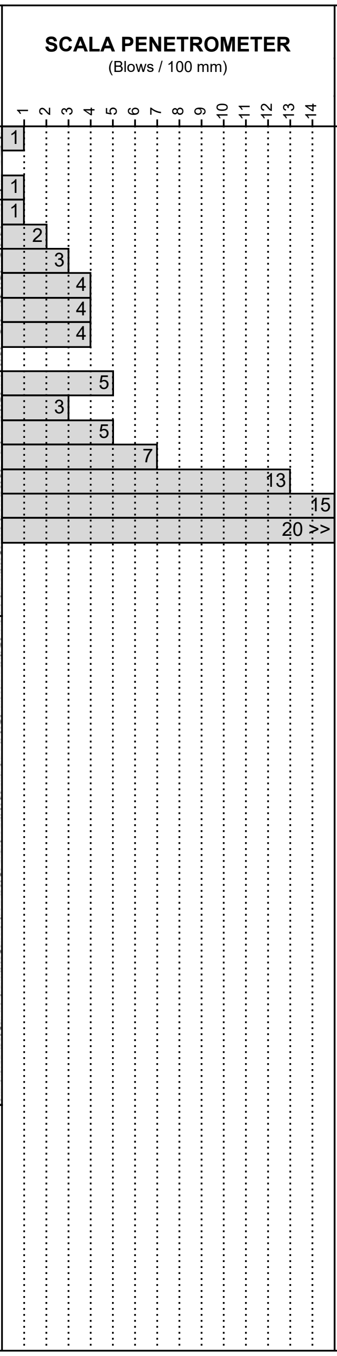
CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265285.0 mE, 4998628.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 29/10/2024
END DATE: 29/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Wet.	0.30 m
LOESS	Fine SAND with minor silt and a trace of organics, orange/brown. Loose, wet.	0.50 m
COLLUVIUM	Gravelly fine SAND with minor silt, orange/brown. Medium dense, wet, gravel, fine to medium, subrounded to subangular.	1.00 m
GLACIAL TILL	Fine to medium SAND with some gravel and a trace of silt, orange/grey. Medium dense, moist, gravel, fine to coarse (mostly fine to medium), subrounded.	2.00 m
	Fine to medium SAND with some gravel and a trace of silt and cobbles/boulders, orange/grey. Dense, moist, gravel, fine to coarse (mostly fine to medium), subrounded. Cobbles and boulders up to 300 mm diameter, subrounded.	4.00 m
	End Of Hole: 4.00 m	

SAMPLES | **DEPTH / RL** | **LEGEND**

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 | Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

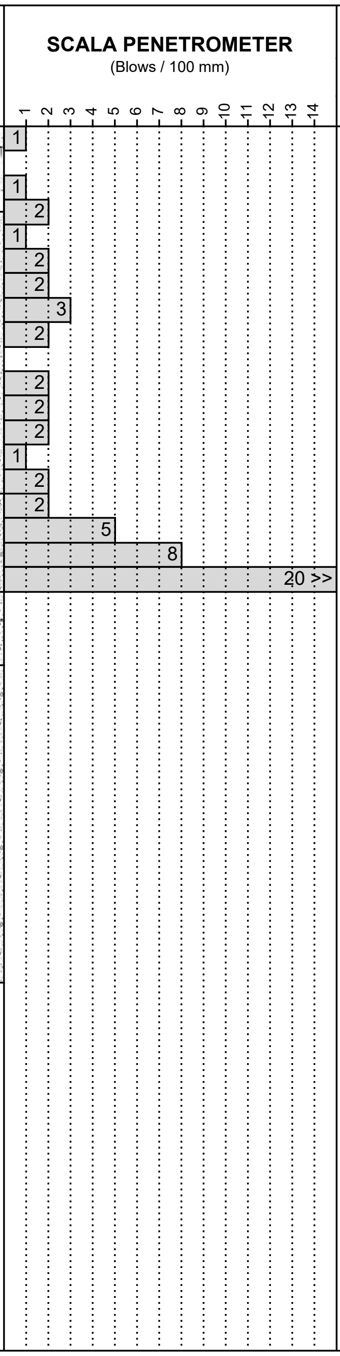
HOLE NO.: TP38

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1265290.0 mE, 4998710.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	WATER
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Wet. 0.35 m			TS	
LOESS	Fine to medium SAND with a trace of silt and organics, light yellow/grey. Loose, wet, sand, mostly fine. Organic content decreases with depth. 1.50 m		0.5 1.0 1.5		
GLACIAL TILL	Fine to medium SAND with minor silt and a trace of gravel, light yellow/grey. Medium dense, wet, gravel, fine to coarse, subrounded. 1.90 m Gravelly fine to coarse SAND with trace cobbles and boulders, brownish grey. Medium dense to dense, wet, gravel, fine to coarse, subrounded; boulders up to 200 mm diameter. 2.20 m Fine to coarse SAND with some gravel and trace cobbles and boulders, grey, zones of medium to coarse sand. Dense, moist, sand, mostly fine to medium; gravel, fine to coarse, mostly fine to medium. Boulders up to 250 mm. 3.50 m		2.0 2.5 3.0 3.5		Groundwater Not Encountered
	End Of Hole: 3.50 m		4.0 4.5		

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

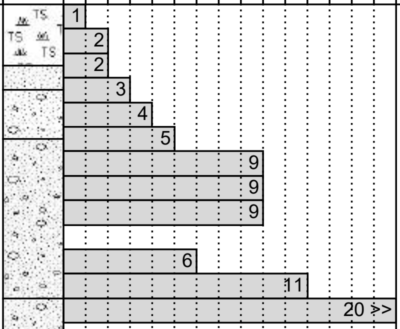
HOLE NO.: TP39

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1265515.0 mE, 4998607.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty SAND with trace rootlets, brown. Moist.		0.25 m	Groundwater Not Encountered
LOESS	Fine SAND with a trace of silt and organics, orange. Loose to medium dense, moist to wet.		0.35 m	
COLLUVIUM	Gravelly fine to medium SAND with a trace of silt, orange. Medium dense, moist to wet, gravel, fine to coarse, subrounded.		0.55 m	
GLACIAL TILL	Fine to medium SAND with some gravel and a trace of silt, grey/brown. Medium dense to dense, moist to wet, gravel, fine to coarse, subrounded.		1.20 m	
	Fine to medium SAND with some gravel and trace cobbles and boulders, grey. Dense, moist, gravel fine to coarse, subrounded.		3.60 m	
	End Of Hole: 2.60 m			

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP40

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 12659656.0 mE, 4998600.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 29/10/2024
END DATE: 29/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic SILT with trace rootlets, black. Wet. 0.15 m		
ALLUVIAL FAN DEPOSITS	SILT with minor to trace sand, blackish/brown. Firm, wet, sand, fine. Moderately sensitive . 0.55 m		Groundwater Not Encountered
	Silty fine SAND and silty SAND, dark brown/grey. Firm, wet. Saturated from 0.9 m, well interbedded with discontinuous gravelly beds, sand, fine. Moderately sensitive . 1.40 m		
	Silty fine to coarse GRAVEL with minor sand, dark brown/grey. Saturated , sand, fine to medium. 1.60 m		
	Silty fine SAND and silty SAND, dark brown/grey. Firm, saturated , well interbedded with discontinuous gravelly beds, sand, fine. Moderately sensitive. 2.70 m		
	End Of Hole: 2.70 m		

DEPTH / RL: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

SCALA PENETROMETER
(Blows / 100 mm)

1 2 3 4 5 6 7 8 9 10 11 12 13 14

1, 1, 1, 2, 2, 1, 1, 2, 1, 1, 2, 3, 2, 3, 1, 1, 1

SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

PHOTO(S)

REMARKS

End of test, test pit walls collapsing. Seepages through out the pit walls, some with high outflow. Water level remaining at 1.3 m bgl, 15 minutes after completion of test pit excavation

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP41

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1265986.0 mE, 4998873.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	WATER
TOPSOIL	Organic SILT with trace rootlets, black. Saturated . 0.10 m			TS	
UNCONTROLLED FILL	Medium to coarse GRAVEL with a trace of sand and silt, blackish grey. Medium dense, saturated, gravel, subrounded; sand, fine to medium. 0.40 m				
ALLUVIAL FAN DEPOSITS	SILT with minor sand, grey. Firm, wet , sand, fine. Moderately sensitive. 1.40 m		0.5 1.0		
	Gravelly fine to medium SAND with a trace of silt, grey. Medium dense, wet, gravel, fine to coarse, subrounded. 1.70 m		1.5		
	Boulders in gravelly SAND matrix, grey. Medium dense, wet, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 2.20 m		2.0		
	SILT with minor sand, grey. Firm, wet, sand, fine. Moderately sensitive. 2.60 m		2.5		
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, saturated, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 2.80 m				◁ 29/10/2024
	SILT with minor sand, grey. Firm, saturated, sand, fine. Moderately sensitive. 4.00 m		3.0 3.5		
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, saturated, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 4.20 m		4.0		
	End Of Hole: 4.20 m		4.5		

SCALA PENETROMETER
(Blows / 100 mm)

4	
9	
1	
1	
2	
2	

SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:10:05 am

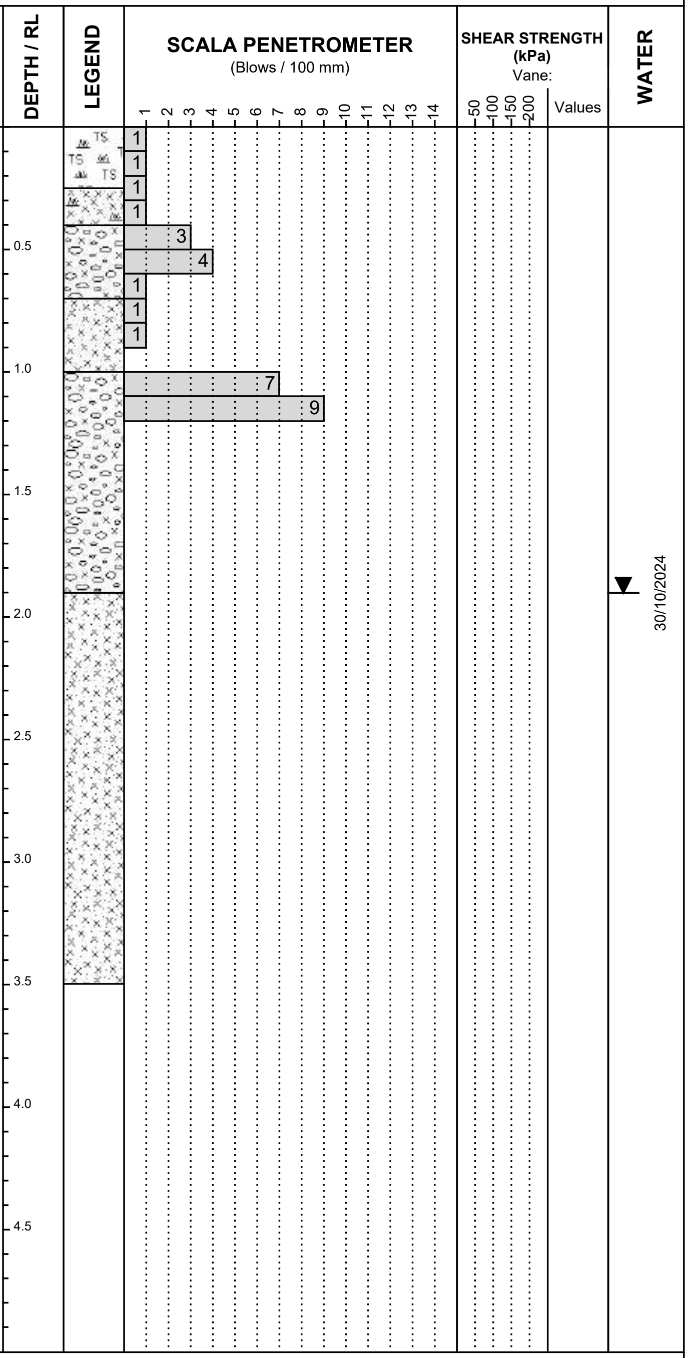
TEST PIT LOG

HOLE NO.: TP42

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 30/10/2024
COORDINATES: 1265848.0 mE, 4998934.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 30/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with trace rootlets, black. Wet.		0.25 m
ALLUVIAL FAN DEPOSITS	Slightly organic SILT with minor sand, dark black and grey. Firm, moist to wet, low plasticity, sand, fine. Non sensitive.		0.40 m
	Silty fine to coarse GRAVEL with trace sand and cobbles, dark grey. Firm, wet, gravel, subrounded to rounded; sand, fine to medium.		0.70 m
	Sandy SILT, grey. Medium dense, wet, sand, fine. Slightly sensitive.		1.00 m
	Silty fine to coarse GRAVEL with trace sand and cobbles, dark grey. Firm, saturated, gravel, subrounded to rounded; sand, fine to medium.		1.90 m
	Sandy SILT, grey. Medium dense, saturated, sand, fine. Slightly sensitive.		3.50 m
	End Of Hole: 3.50 m		



PHOTO(S)

REMARKS

Pit collapsing below water table, test terminated. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

GEOSOLVE
ENGINEERING CONSULTANTS

TEST PIT LOG

HOLE NO.: TP43

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371	**CONTRACTOR:** Base Contracting	**START DATE:** 30/10/2024
COORDINATES: 1265836.0 mE, 4998825.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 30/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic SILT with trace rootlets, black. Wet.	0.20 m
ALLUVIAL FAN DEPOSITS	Slightly organic SILT with minor sand, dark black/grey. Firm, moist, low plasticity , sand, fine. Non-sensitive.	0.50 m
	Silty fine to coarse GRAVEL with a trace of sand, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium.	1.00 m
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with minor cobbles and trace boulders, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium. Boulders up to 100 mm diameter.	2.20 m
	Fine SAND with a trace of gravel, grey. Medium dense, moist, gravel, fine to coarse, surrounded.	2.60 m
	Silty fine to coarse GRAVEL with a trace of sand, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium.	3.20 m
GLACIAL TILL	Silty fine to medium SAND with a trace of gravel, light orange/grey. Medium dense, moist, gravel, fine to coarse (mostly fine to medium), rounded.	4.20 m
	End Of Hole: 4.20 m	

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	1
0.1–0.2	1
0.2–0.3	2
0.3–0.4	2
0.4–0.5	1
0.5–0.6	9
0.6–0.7	20 >>
1.0–1.1	9
1.1–1.2	13
1.2–1.3	20 >>

SHEAR STRENGTH (kPa) Vane: Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP44

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

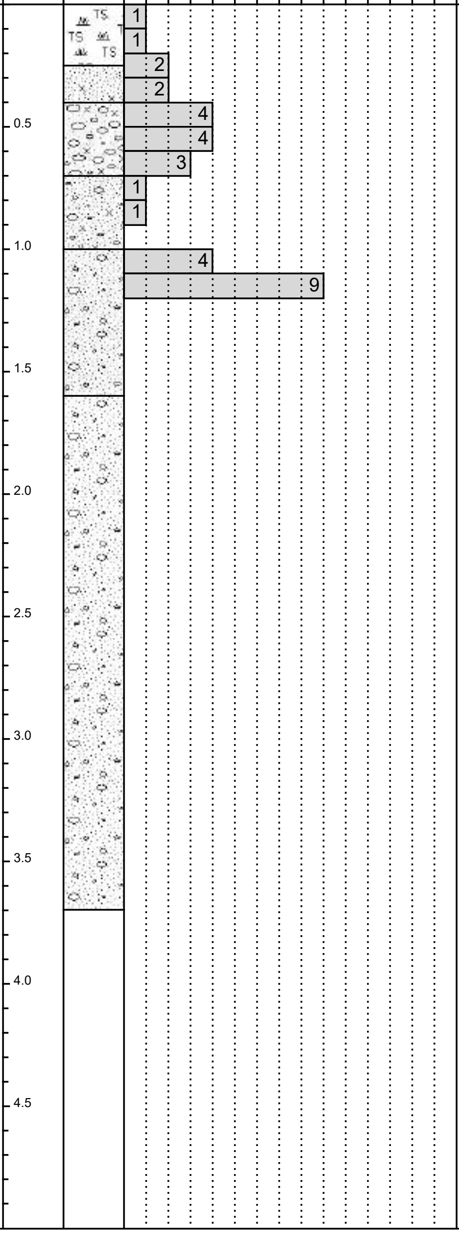
SITE LOCATION: Kingston Road, Drift Bay 9371
COORDINATES: 1265815.0 mE, 4998666.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 30/10/2024
END DATE: 30/10/2024
LOGGED BY: JMJ
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic silty fine SAND with trace of rootlets, dark brown. Moist.	0.25 m
LOESS	Silty fine SAND with a trace of organics, orange. Loose to medium dense, moist, gravel, fine to coarse, rounded.	0.40 m
WEATHERED GLACIAL TILL	Sandy silty fine to coarse GRAVEL, orange. Medium dense, wet to saturated, gravel, subrounded to subangular; sand, fine to medium.	0.70 m
GLACIAL TILL	Fine to coarse SAND with minor gravel and silt, light grey. Loose, wet, gravel, fine to coarse, subrounded; sand, mostly fine.	1.00 m
	Gravelly fine to coarse SAND with a trace of silt and cobbles/boulders, light grey, excavator struggling. Dense, dry to moist, excavator struggling, gravel, fine to coarse (mostly fine to medium), subrounded. Boulders up to 300 mm diameter.	1.60 m
	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, light grey, excavator struggling. Dense, dry to moist, excavator struggling, gravel, fine to coarse (mostly fine to medium), subrounded. Boulders up to 300 mm diameter.	3.70 m
	End Of Hole: 3.70 m	

SAMPLES | DEPTH / RL | LEGEND



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 | Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP45

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

CONTRACTOR: Base Contracting

START DATE: 30/10/2024

COORDINATES: 1265662.0 mE, 4998725.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 30/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

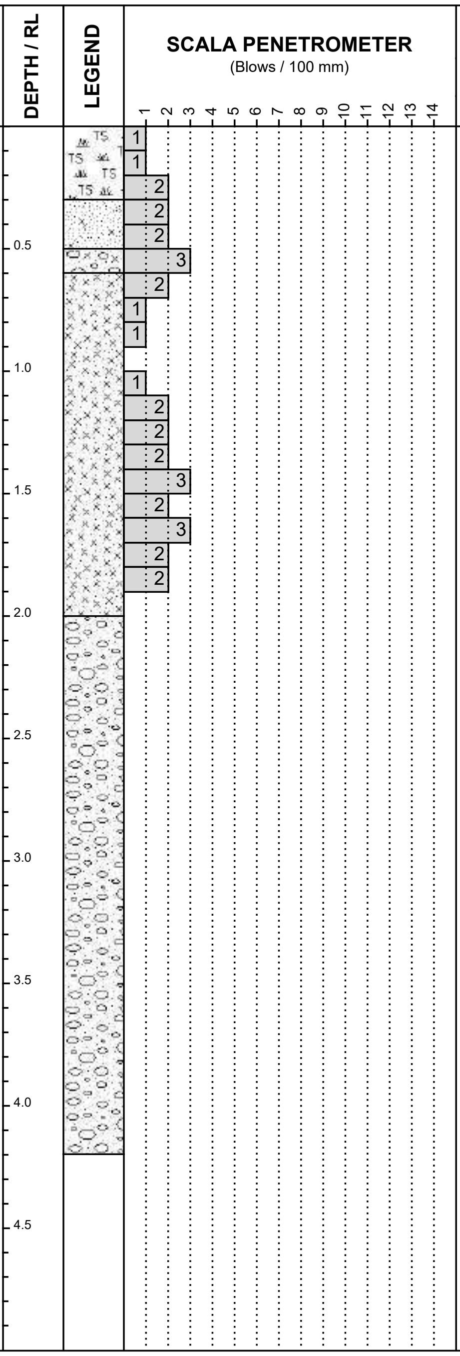
LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic silty fine SAND with trace rootlets, blackish/brown. Moist. 0.30 m		Groundwater Not Encountered
ALLUVIAL FAN DEPOSITS	Silty fine SAND with trace organics, dark grey. Loose, moist. 0.50 m		
	Silty sandy GRAVEL with trace rootlets, dark grey, lenses out to 213 degrees. Medium dense, moist, sand, fine to medium. Gravel, fine to medium, subrounded. 0.60 m		
	SILT with minor sand, grey. Firm, moist, low plasticity, sand, fine. 2.00 m		
GLACIAL OUTWASH DEPOSITS	Sand fine to coarse GRAVEL with minor cobbles and trace boulders, grey, interbedded bands of fine sand. Medium dense, moist, bedded, gravel, rounded to subrounded; sand, fine to coarse. Boulders up to 300 mm diameter. 4.20 m		
	End Of Hole: 4.20 m		



SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP46

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

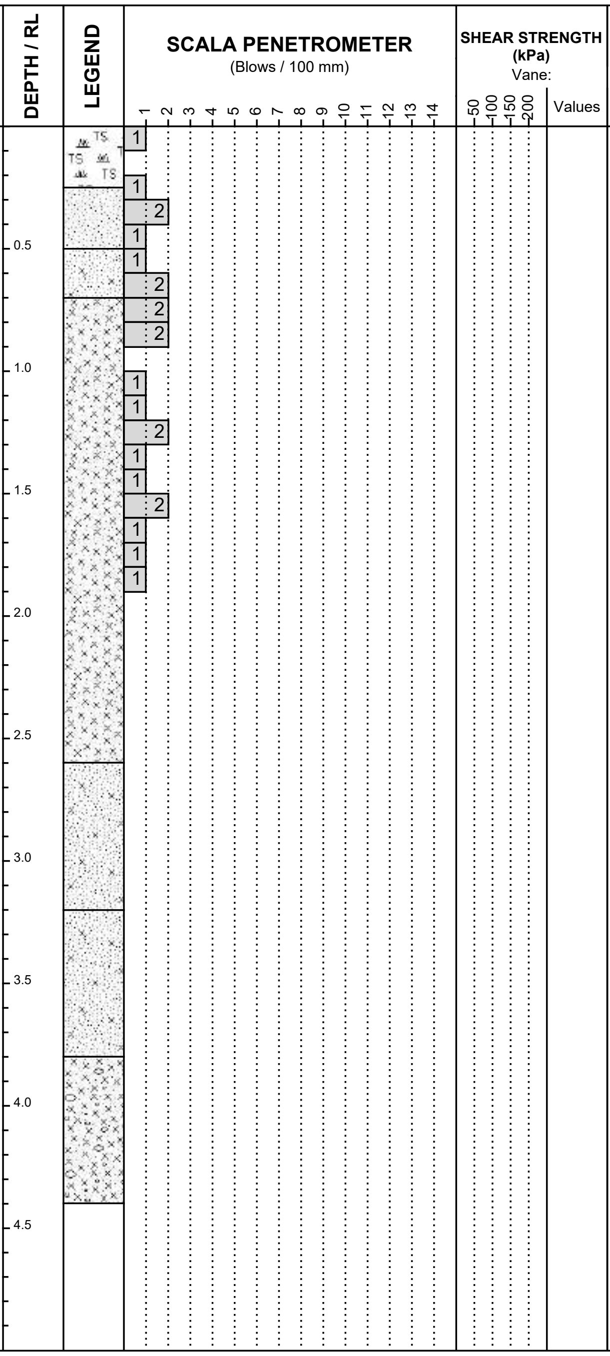
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 30/10/2024

COORDINATES: 1265622.0 mE, 49978884.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 30/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty fine SAND with trace rootlets, blackish/brown. Moist.		0.25 m	
LOESS	Fine SAND with a trace of rootlets, light grey. Loose, dry to moist.		0.50 m	
ALLUVIAL FAN DEPOSITS	Silty fine SAND with trace organics, dark grey. Loose, moist.		0.70 m	Groundwater Not Encountered
	SILT with minor sand, brownish/grey. Firm, moist, low plasticity , sand, fine.		2.60 m	
	Fine SAND with minor silt, grey. Loose, moist.		3.20 m	
	Silty fine SAND with trace organics, dark grey. Loose, moist.		3.80 m	
GLACIAL TILL	Sandy SILT with minor gravel, grey/orange. Stiff, moist, sand, fine; gravel, fine, surrounded.		4.40 m	
	End Of Hole: 4.40 m			



PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 6/11/2024 8:10:25 am

TEST PIT LOG

HOLE NO.:	TP47
JOB NO.:	220556.01

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

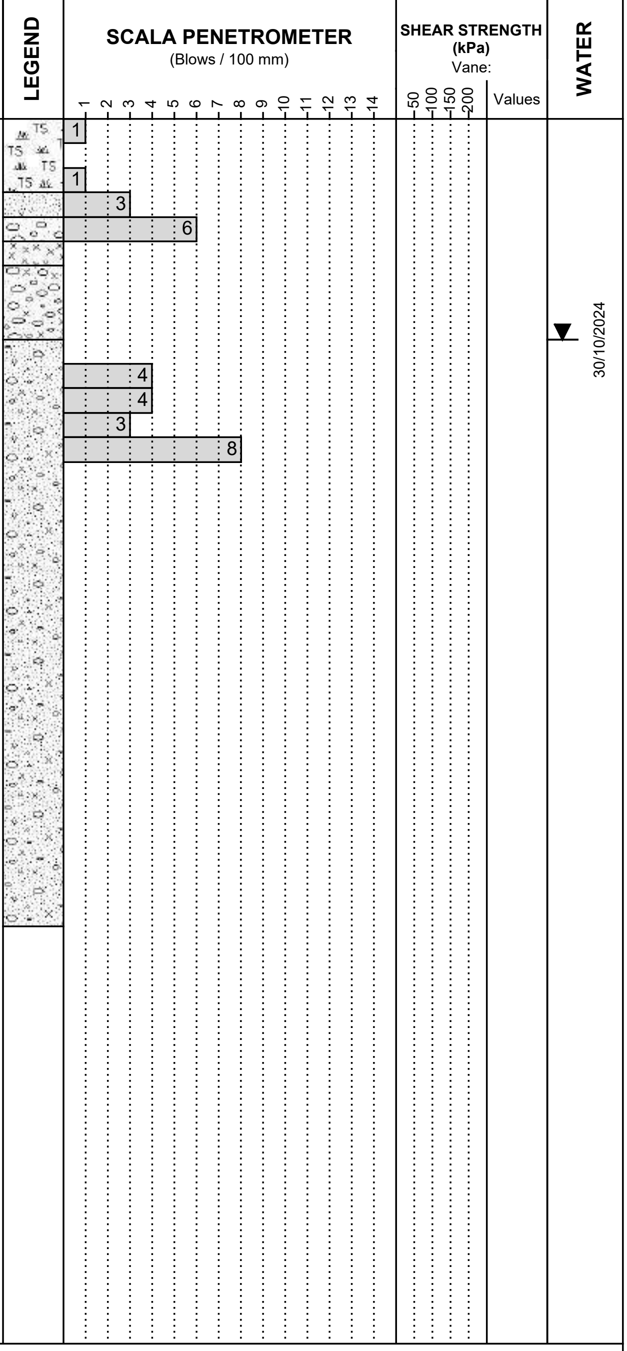
SITE LOCATION: Kingston Road, Drift Bay 9371
CONTRACTOR: Base Contracting
START DATE: 30/10/2024

COORDINATES: 1265950.0 mE, 4998783.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 30/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 05/11/2024

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with minor rootlets, dark brown. Soft, saturated.	0.30 m
ALLUVIAL FAN DEPOSITS	Silty fine to medium SAND, dark grey. Loose, wet.	0.40 m
	Sandy fine to medium GRAVEL with trace rootlets, dark grey. Loose, wet, gravel, subrounded; sand, coarse.	0.50 m
	SILT with a trace of sand, grey. Soft, wet, low plasticity, sand, fine.	0.60 m
	Sandy fine to coarse GRAVEL with minor silt and trace of cobbles and boulders, grey. Loose, saturated, gravel, subrounded; sand, fine to coarse; boulders up to 300 mm.	0.90 m
GLACIAL TILL	Fine to medium SAND with minor silt and gravel, with trace of cobbles and boulders, light orange/grey, dipping 224/10 . Dense, wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	3.30 m
	End Of Hole: 3.30 m	



PHOTO(S)

REMARKS

End of test, maximum excavator reach, hole collapsing. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

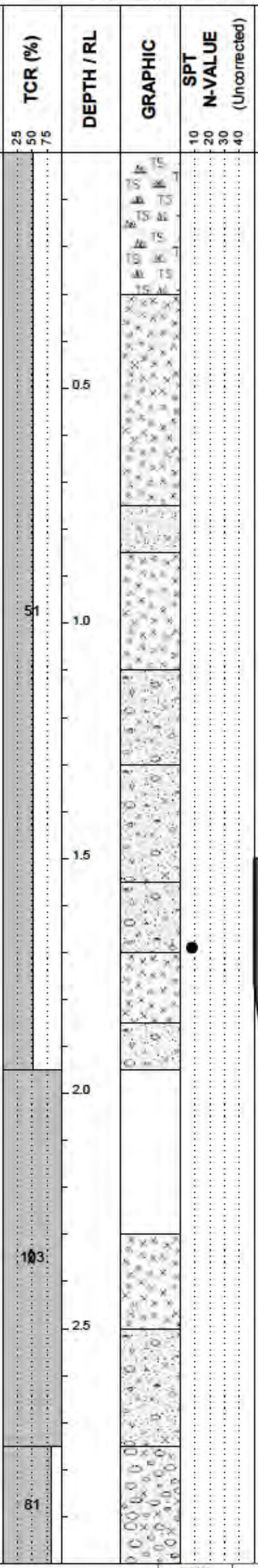
SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT, with trace gravel and rootlets, dark brown . Gravels are fine to medium, angular to subrounded.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, with trace gravel, with lenses of sand and organic inclusions, brownish grey. Soft, moist, low plasticity, gravels are fine, subangular to subrounded. Sand is fine to medium.	0.75 m
	Silty, fine SAND, with trace gravel and organic inclusions , brownish grey. Loose, moist, non-plastic, gravels are fine to medium, subangular to rounded.	0.85 m
	SILT, with trace gravel, with lenses of sand and organic inclusions, brownish grey. Soft, moist, low plasticity, gravels are fine to medium, subangular to subrounded. Sand is fine to medium.	1.10 m
	Silty fine SAND, with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded.	1.30 m
	Gravelly fine to medium SAND, with minor silt, light grey. Loose, moist, gravels are fine subangular to rounded.	1.55 m
	Silty fine SAND, with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded.	1.70 m
	SILT, with trace sand and gravel. With trace organic inclusions and rootlets, brownish grey, mottled orange and brown. Firm, moist , low plasticity, sand is fine. Gravels are fine and subrounded to rounded.	1.85 m
	Silty fine SAND, with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded.	1.95 m
	NO CORE RECOVERY.	2.30 m
	SILT, with trace sand, light grey. Firm, dry, low plasticity, sand is fine.	2.50 m
	Silty fine SAND, with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded.	2.75 m
	Sandy fine to coarse GRAVEL, with minor silt, brownish grey. Loose, moist, gravels are subangular to subrounded. Sand is fine to medium.	3.00 m



SPT DATA (Uncorrected)

SPT (S) 1.50m
1, 1 / 2, 2, 2, 2
375mm
N=8

SAMPLES

WATER

INSTALLATION

Cement
0.3m
Bentonite

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

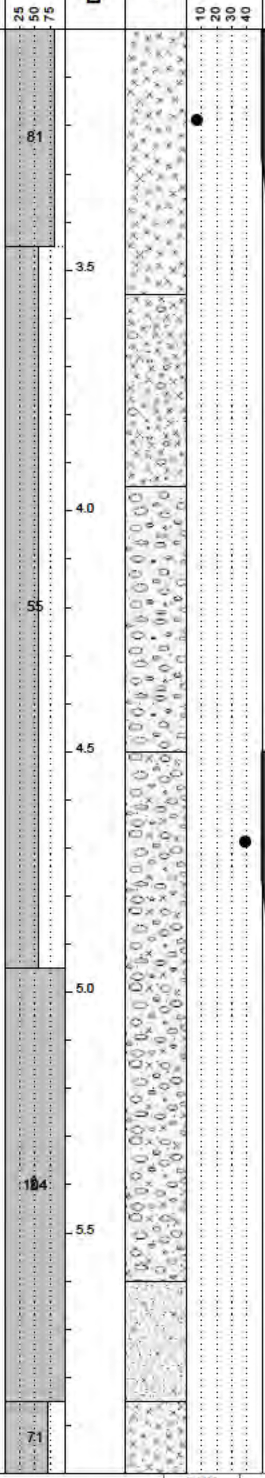
GEOSOLVE

SOIL LOG

HOLE NO.: **BH01**

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024



UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	SILT, grey. Soft, moist, low plasticity. 3.55 m		81	3.5		●	SPT (S) 3.00m 2, 2 / 2, 2, 2, 1 375mm N=7			Bentonite
	SILT, with some sand and minor gravel, brownish grey. Firm, moist , low plasticity, sand is fine. Gravels are fine, subrounded to rounded . 3.95 m									
	Sandy fine to coarse GRAVEL, with trace silt , brownish grey. Medium dense, moist , Gravels are angular to rounded. Sand is fine to coarse. 4.50 m		55	4.0 4.5						
	Sandy, fine to coarse GRAVEL, with some silt, grey. Dense, moist, Gravels are angular to rounded. Sand is fine to coarse. 5.60 m		104	5.0 5.5		●	SPT (S) 4.50m 8, 10 / 8, 8, 10, 13 375mm N=39		▼ 22/10/2024	
	Silty fine SAND, with trace fine gravel, brownish grey, mottled orange. Medium dense, moist, gravels are subrounded to rounded. 5.85 m									
	SILT, with some sand and trace gravel, brownish grey, mottled orange. Firm, moist, low plasticity, sand is fine. Gravels are fine, subrounded to 6.65 m		71							

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
	rounded . 6.65 m		71	6.5		●	SPT (S) 6.10m 3, 2 / 4, 4, 4, 4 375mm N=16			Bentonite
	Silty fine SAND, brownish grey. Medium dense, wet, low plasticity. 6.75 m									
	Sandy fine to medium GRAVEL, with some silt, grey. Medium dense, wet, gravels are subangular to rounded. Sand is fine to coarse. 7.10 m			7.0						
	SILT, with some sand and trace gravel, brownish grey, mottled orange. Firm, moist, low plasticity, sand is fine. Gravels are fine, subrounded to rounded . 7.25 m									
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL, with trace silt , grey. Medium dense, moist, gravels are subangular to subrounded. 7.60 m		58	7.5						
	Silty fine to coarse SAND, with trace fine gravel, brownish grey, with slight orange mottling. Medium dense, wet, sand is predominantly fine to medium. Gravels are subrounded. 8.80 m		121	8.0 8.5		●	SPT (S) 7.60m 3, 5 / 4, 3, 4, 4 375mm N=15			
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL, with trace silt , grey. Medium dense, moist, gravels are subangular to subrounded. 8.95 m									
	9.10 m		83							

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	SILT, with minor sand, brownish grey, mottled orange. Firm , moist, low plasticity, sand is fine. 9.10 m									Bentonite
	Silty, gravelly fine to coarse SAND, brownish grey. Medium dense, moist, gravels are fine to medium subangular to subrounded. 9.55 m		83	9.5			SPT (S) 9.10m 4, 3 / 4, 5, 5, 4 375mm N=18			
	Sand is predominantly fine to medium. Gravels are subrounded, silty fine to coarse SAND, with trace fine gravel. Medium dense, moist, non-plastic. 9.80 m									
	Silty, sandy fine to coarse GRAVEL, grey. Medium dense, moist, sand is fine to medium. 10.20 m			10.0						
GLACIAL TILL	Fine to medium SAND, with some silt and gravel, light brownish grey. Dense, moist, gravels are fine to coarse, subangular to subrounded. 10.70 m		63	10.5			SPT (S) 10.60m 14, 11 / 15, 17, 18 375mm N=50			
	Sandy fine to medium GRAVEL, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse. 11.65 m		90	11.0 11.5						
	Gravelly fine to medium SAND, with minor silt, light greyish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded. 12.60 m									

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: **BH01**

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Gravelly fine to medium SAND, with minor silt, light greyish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded. 12.60 m		83	12.5			SPT (S) 12.20m 17, 16 / 11, 9, 14, 16 375mm N=50			Bentonite
	Sandy fine to medium GRAVEL, with trace silt, grey. Very dense, moist, gravels are subangular to subrounded. Sand is fine to coarse. With a fine to medium sand bed between 13.00 and 13.10 m . 13.30 m		66	13.0						
	Gravelly fine to medium SAND, with trace silt, light grey. Very dense, moist, gravels are fine to medium subangular to rounded. 14.00 m			13.5			SPT (S) 13.70m 11, 17 / 24, 26 375mm N=50			
	Sandy SILT, with some gravel, brownish grey, with slight orange mottling. Very stiff, moist, low plasticity, sand is fine. Gravels are fine to coarse subangular to rounded. 15.00 m		95	14.0 14.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

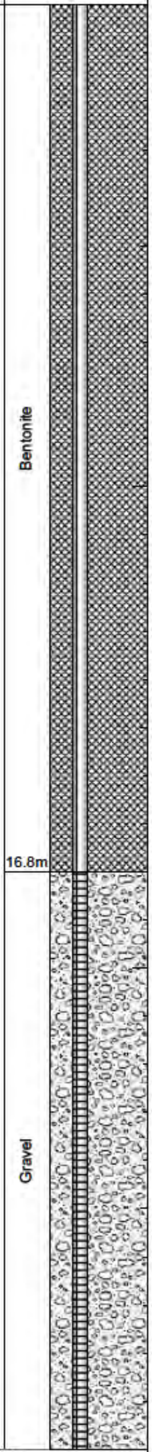
GEOSOLVE

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024



UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	Sandy fine to coarse GRAVEL, with trace minor silt, grey and brown. Very dense, dry, gravels are subangular to rounded. Sand is fine to coarse. 15.65 m			15.5			SPT (S) 15.20m 17, 13 / 12, 12, 21, 5 375mm N=50			Bentonite
	Sandy fine to coarse GRAVEL, with some silt, grey brown. Very dense, moist, gravels are subangular to rounded. Sand is fine to medium. 16.30 m			16.0						
	Sandy fine to coarse GRAVEL, with minor silt, whitish grey. Very dense, dry, gravels are angular to rounded. Sand is fine to coarse. 18.90 m			16.5 17.0 17.5			SPT (S) 16.70m 20, 17 / 20, 22, 8 375mm N=50			16.8m Gravel

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

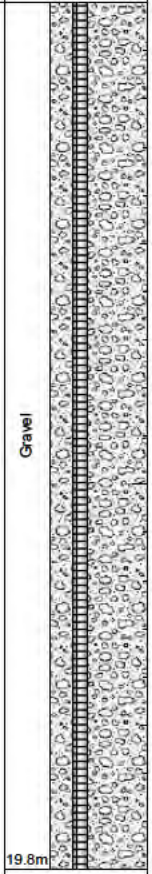
SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL, with minor silt, whitish grey. Very dense, dry, gravels are angular to rounded. Sand is fine to coarse. 19.90 m			18.5 19.0 19.5			SPT (S) 18.30m 29, 21 375mm N=50 SPT (S) 19.80m 26, 24 375mm N=50			Gravel 19.8m
	End Of Hole: 20.20m			20.0 20.5						



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

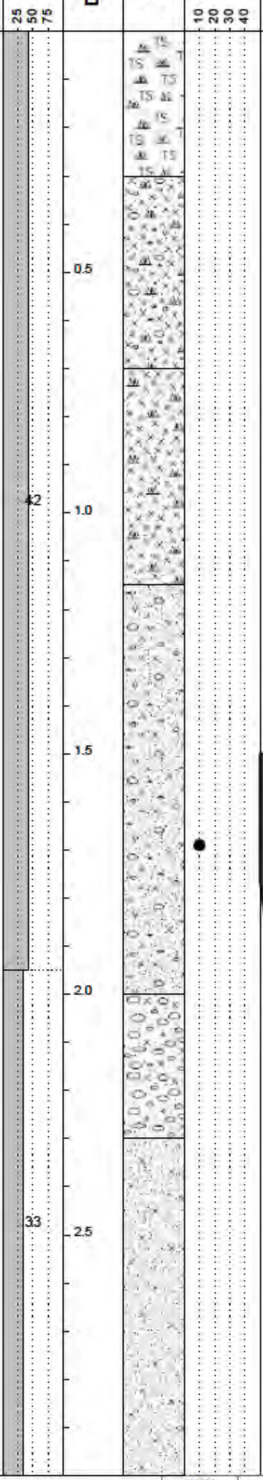
SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
TOPSOIL	Organic SILT, with trace gravel and rootlets, dark brown . Gravels are fine to medium, angular to subrounded. 0.30 m							Cement 0.3m
ALLUVIAL FAN DEPOSITS	Slightly organic gravelly, sandy SILT, dark brownish grey. Soft, wet, low plasticity, gravels are fine to coarse, angular to rounded. Sand is fine. 0.70 m			0.5				Bentonite
	Slightly organic sandy SILT, with trace gravel, brownish grey. Soft, wet, low plasticity, sand is fine. Gravels are fine to medium, subangular to rounded. 1.15 m		42	1.0				
	Silty fine SAND, with some gravel, grey. Loose, wet, non-plastic, gravels are fine to medium subangular to rounded. 2.00 m			1.5	SPT (S) 1.50m 3, 2 / 2, 3, 3, 2 375mm N=10			
	Sandy fine to coarse GRAVEL, with some silt, grey. Loose, moist to wet, gravels are angular to subrounded. Sand is fine to coarse. 2.30 m			2.0				
	Fine to medium SAND, with some silt and trace gravel, grey brown. Loose, moist, gravels are fine to medium, subangular. 3.80 m		33	2.5				



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 22/10/2024

CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)

ELEVATION: Ground

END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

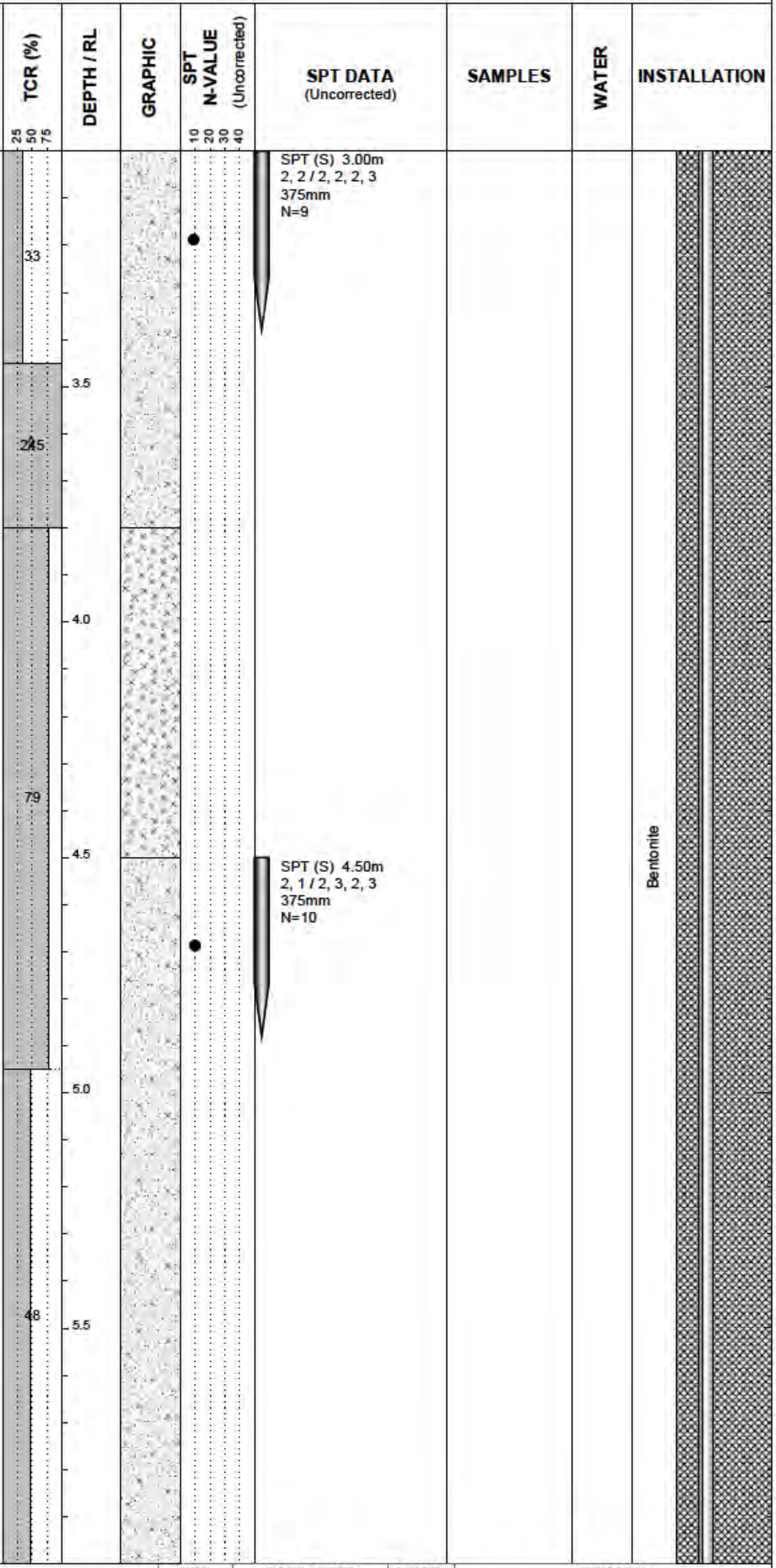
CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matty

CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SPT DATA (Uncorrected)
ALLUVIAL FAN DEPOSITS	[CONT] Fine to medium SAND, with some silt and trace gravel, grey brown. Loose, moist, gravels are fine to medium, subangular. 3.80 m	SPT (S) 3.00m 2, 2 / 2, 2, 2, 3 375mm N=9
	SILT, with some sand and trace gravel, brownish grey, with slight orange mottling. Soft, moist, low plasticity, sand is fine to medium. Becoming sandy between 4.25 and 4.50 m. Gravels are fine to medium subangular to subrounded. 4.50 m	
	Silty fine SAND, with trace coarse sand and fine gravel, brownish grey. Loose, moist, non-plastic. 6.00 m	SPT (S) 4.50m 2, 1 / 2, 3, 2, 3 375mm N=10



REMARKS

Target depth achieved

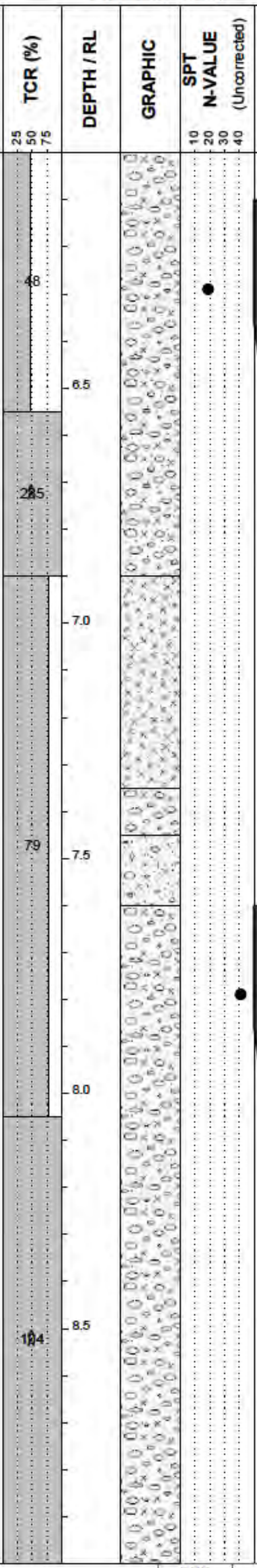
REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024



UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL, with some silt, grey. Medium dense, moist, gravels are subangular to rounded. Sand is fine to coarse. 6.90 m		SPT (S) 6.10m 3, 3 / 4, 4, 6, 5 375mm N=19			
	Sandy SILT, grey, brown. Firm, moist, low plasticity, sand is fine. 7.35 m				▼ 23/10/2024	
GLACIAL OUTWASH	Silty, sandy fine to coarse GRAVEL, grey. Medium dense, moist, gravels are subangular to subrounded. 7.45 m					Bentonite
	Silty, gravelly fine to medium SAND, grey. Medium dense, wet, non-plastic, gravels are fine to medium, subangular to subrounded. 7.60 m					
	Sandy fine to coarse GRAVEL, with trace to some silt, grey. Medium dense to dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 9.10 m		SPT (S) 7.60m 3, 8 / 10, 8, 8, 15 375mm N=41			

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: **BH02**

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: **220556.01**

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL OUTWASH	[CONT] Sandy fine to coarse GRAVEL, with trace to some silt, grey. Medium dense to dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 9.10 m		104				SPT (S) 9.10m 39, 11 375mm N=50			Bentonite
	NO SPT RECOVERY. 9.55 m		0	9.5						
	NO CORE RECOVERY. 10.60 m		0	10.0 10.5						
	Sandy fine to coarse GRAVEL, with trace to some silt, grey. Very dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 12.00 m		250 36	11.0 11.5			SPT (S) 10.60m 9, 11 / 12, 24, 12, 2 375mm N=50			

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 4/11/2024 9:57:36 am

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 22/10/2024
END DATE: 23/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	Sandy fine to coarse GRAVEL, grey. Very dense, moist to wet, gravels are subangular to rounded. Sand is medium to coarse. 13.00 m		36	12.5		SPT (S) 12.20m 13, 18 / 16, 14, 13, 7 375mm N=50			Bentonite
	Sandy SILT, with trace gravel, light grey. Very stiff, wet, low plasticity, sand is fine. Gravels are fine to medium angular to subrounded. 13.30 m		62	13.0					
	Sandy fine to coarse GRAVEL, grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 14.20 m		100	13.5 14.0		SPT (S) 13.70m 18, 18 / 19, 18, 13 375mm N=50			
	Sandy fine to coarse GRAVEL, with minor to some silt, with trace cobbles and boulders, light brownish grey. Very dense , moist to wet, ravels are angular to rounded. Sand is fine to coarse. 16.85 m		50	14.5					

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 22/10/2024

CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)

ELEVATION: Ground

END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matty

CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL, with minor to some silt, with trace cobbles and boulders, light brownish grey. Very dense , moist to wet, ravels are angular to rounded. Sand is fine to coarse. 16.85 m		50 80	15.5 16.0 16.5	SPT (S) 15.20m 10, 14 / 15, 19, 16 375mm N=50 SPT (S) 16.70m 10, 40 375mm N=50			Bentonite 16m Gravel
	Silty, fine to coarse GRAVEL, with trace some sand and trace cobbles, bluish grey and brown. Very dense, wet, gravels are fine to coarse angular to subangular. Sand is medium to coarse . 17.50 m		157	17.0				
SUB-GLACIAL SEDIMENT	Gravelly SILT, with some sand and clay content, greyish brown. Stiff, wet, low plasticity, gravels are fine to coarse, subangular to rounded. 17.70 m			17.5				
	Sandy SILT, with minor gravel, greenish, greyish brown. Very stiff, moist , non-plastic, sand is fine. Gravels are fine to medium, subrounded. 18.00 m							

TCR (%) scale: 25 50 75

SPT N-VALUE (Uncorrected) scale: 10 20 30 40

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 4/11/2024 9:57:36 am

GEOSOLVE

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 22/10/2024

CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)

ELEVATION: Ground

END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matty

CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
SUB-GLACIAL SEDIMENT	SILT, with some sand and gravel. With iron oxidation staining and calcrete nodules, greenish brown, bluish grey, slightly laminated and fissured. Hard, dry, non-plastic, sand is fine. Gravels are fine to coarse subangular to rounded. 18.30 m									Gravel
	Gravelly SILT, with minor sand, with iron oxidation staining and calcrete nodules, greenish brown, bluish grey, slightly laminated. Very stiff, moist to wet, low plasticity, gravels are fine to coarse. Sand is fine. 19.20 m		125	18.5 19.0			SPT (S) 18.30m 50 375mm N=50			19m
	End Of Hole: 19.20m			19.5 20.0 20.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

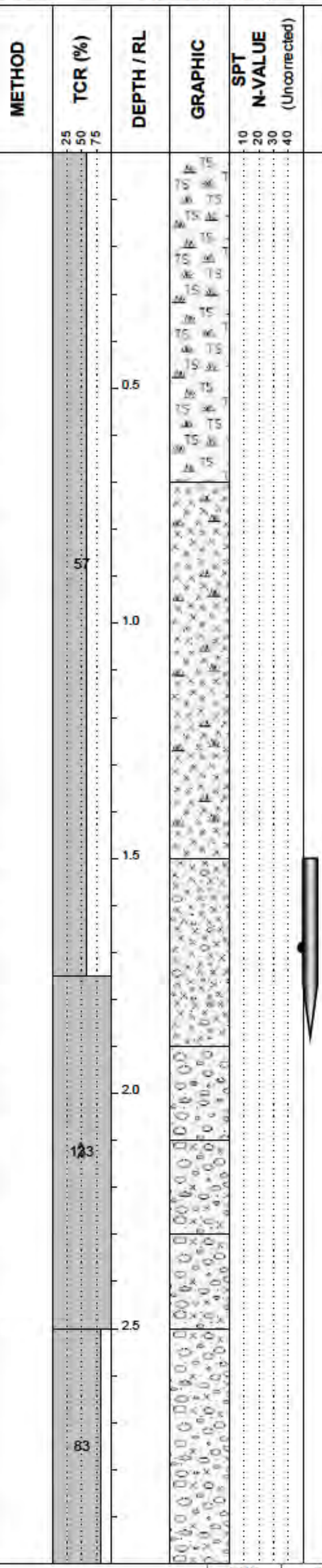
SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Organic SILT, with trace gravel and rootlets, dark brown . Gravels are fine to medium, angular to subrounded. 0.70 m
GLACIAL OUTWASH SILT	SILT, with trace fine sand and gravel, and some organic inclusions, light greyish brown, with orange brown speckling. Soft, moist to wet, low plasticity. 1.50 m
	Gravelly SILT, with minor sand and trace rootlets, light greyish brown, with orange brown speckling . Stiff, wet, low plasticity, gravels are fine to medium, angular to subrounded. Sand is fine to medium. 1.90 m
	Sandy, fine to coarse GRAVEL, with trace cobbles, grey. Dense, moist, gravels are subangular to rounded. Sand is fine to medium. 2.10 m
	Silty, sandy fine to coarse GRAVEL, greyish brown. Dense, moist , gravels are subangular to rounded. Sand is medium. 2.30 m
	Sandy fine to coarse GRAVEL, with minor silt, light greyish brown. Dense, moist , gravels are subangular to rounded. Sand is medium. 2.50 m
	Silty, sandy fine to coarse GRAVEL, light grey and brown. Very dense, wet, Gravels are angular to rounded. Sand is fine to coarse. 3.70 m



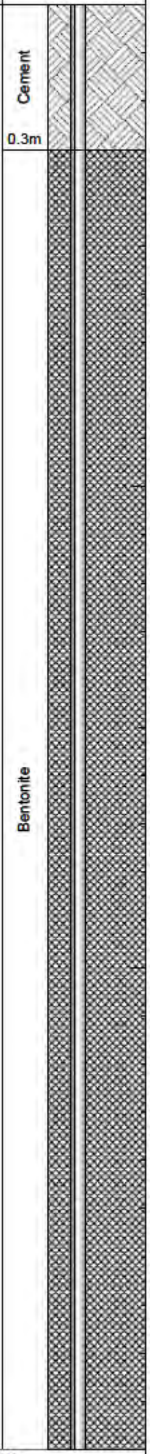
SPT DATA (Uncorrected)

SPT (S) 1.50m
2, 3 / 27, 23
375mm
N=50

SAMPLES

WATER

INSTALLATION



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL OUTWASH SILT	[CONT] Silty, sandy fine to coarse GRAVEL, light grey and brown. Very dense, wet, Gravels are angular to rounded. Sand is fine to coarse. 3.70 m		83	3.5			SPT (S) 3.00m 7, 12 / 16, 13, 12, 9 450mm N=50			Bentonite
	Sandy fine to coarse GRAVEL, with some silt, grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 3.95 m									
	Sandy fine to coarse GRAVEL, grey. Very dense, moist, gravels are subangular to rounded . 4.20 m		63	4.0						
	Sandy fine to coarse GRAVEL, with some silt, grey, slightly brown. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 4.60 m			4.5			SPT (S) 4.50m 11, 17 / 26, 217, 17, 0 375mm N=50			
	Sandy fine to medium GRAVEL, with minor silt, grey and brown. Very dense, moist, gravels are angular to subrounded. 5.30 m		222	5.0					▼ 24/10/2024	
	Sandy, fine to coarse GRAVEL, with trace to some silt, and trace cobbles, grey, brown and orange. Dense to very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 6.60 m		51	5.5						

TCR (%) scale: 25 50 75
SPT N-VALUE scale: 10 20 30 40

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 23/10/2024

CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)

ELEVATION: Ground

END DATE: 24/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

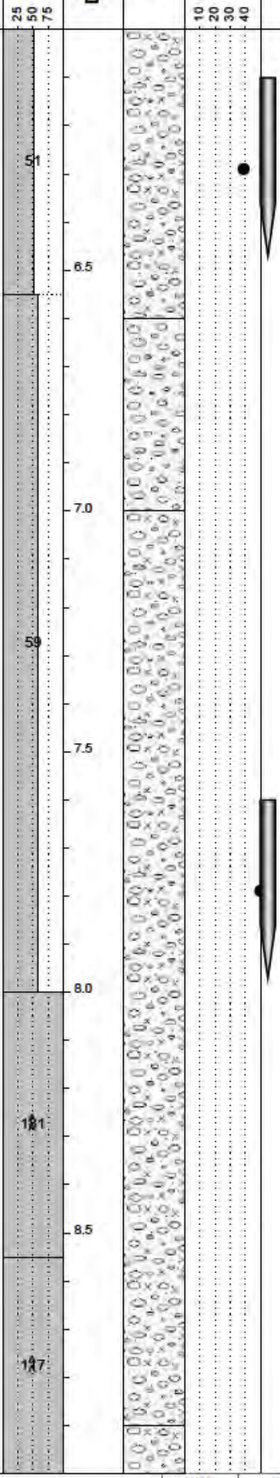
CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matty

CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL OUTWASH SILT	[CONT] Sandy, fine to coarse GRAVEL, with trace to some silt, and trace cobbles, grey, brown and orange. Dense to very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 6.60 m		51	6.5	SPT (S) 6.10m 8, 9 / 10, 10, 10, 9 375mm N=39			Bentonite
	Sandy, fine to coarse GRAVEL, with trace silt, grey brown. Very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 7.00 m			7.0				
GLACIAL TILL	Sandy, fine to coarse GRAVEL, with minor to some silt, and trace cobbles, grey, brown and orange. Very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 8.90 m		59 101 107	7.5 8.0 8.5	SPT (S) 7.60m 11, 15 / 16, 14, 16, 4 375mm N=50			
	Sandy, fine to coarse GRAVEL, with some silt , grey, brown, bluish grey and orange . Very dense, 8.95 m							



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	moist, gravels are subangular to rounded. Sand is fine to coarse. 9.85 m		127	9.5			SPT (S) 9.10m 19, 23 / 22, 28 375mm N=50			Bentonite
	Sandy, fine to coarse GRAVEL, with trace silt and cobbles, grey brown. Very dense, moist, gravels are angular to subrounded . 10.15 m			10.0						
	Gravelly fine to medium SAND, with trace silt, brown. Very dense, moist, gravels are fine to coarse, predominantly fine to medium, and subangular to subrounded. 10.50 m		68							
	Silt, gravelly fine to medium SAND, grey, brown and orange. Very dense, moist , gravels are fine to coarse subangular to subrounded . 10.60 m			10.5						
	Sandy, fine to coarse GRAVEL, with minor silt, grey brown. Very dense, moist, gravels are angular to subrounded . 11.45 m		124	11.0			SPT (S) 10.60m 23, 29 / 17, 18, 15 375mm N=50			
	Sandy fine to coarse GRAVEL, with minor to some silt, grey, brown, bluish grey and orange. Very dense, moist, gravels are fine to coarse angular to rounded. Sand is fine to coarse. 12.10 m		121	11.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 4/11/2024 9:57:40 am

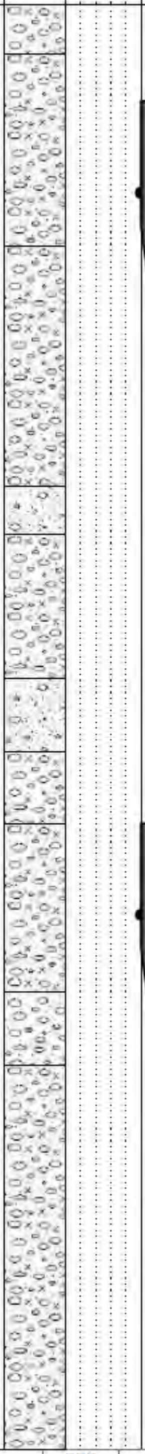
SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: Ground
ACCURACY: ± 1m
DRILLER: Matty
START DATE: 23/10/2024
END DATE: 24/10/2024
LOGGED BY: WF
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL, with minor to some silt, grey, brown, bluish grey and orange. Very dense, moist, gravels are fine to coarse angular to rounded. Sand is fine to coarse. 12.10 m		101					Bentonite
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown. Very dense, moist, gravels are angular to subrounded. Sand is medium to coarse. 12.50 m				SPT (S) 12.20m 38, 12 375mm N=50			
	Silty, sandy fine to coarse GRAVEL, light greenish grey. Very dense, moist to wet, gravels are angular to rounded. Sand is medium to coarse. 13.00 m			12.5				
	Medium to coarse SAND, with some gravel, grey, brown. Very dense, moist to wet, gravels are fine to medium, subrounded. 13.10 m		71	13.0				
	Sandy fine to coarse GRAVEL, with some silt, grey, brown and orange. Very dense, moist to wet, gravels are subangular to rounded. Sand is fine to coarse. 13.40 m							
	Medium to coarse SAND, with some gravel, grey, brown. Very dense, moist to wet, gravels are fine to medium, subrounded. Sand is predominantly coarse. 13.55 m			13.5				
	Sandy fine to coarse GRAVEL, with some silt, grey, brown and orange. Very dense, moist to wet, gravels are subangular to rounded. Sand is fine to coarse. 13.70 m							
	Silty, sandy fine to medium GRAVEL, light greenish grey and brown. Very dense, moist to wet, gravels are subangular to subrounded. Sand is fine to coarse . 14.05 m			14.0	SPT (S) 13.70m 22, 24 / 43, 7 375mm N=50			
	Sandy fine to medium GRAVEL, with trace silt, light greenish grey and brown. Very dense, moist to wet, gravels are subangular to subrounded. Sand is medium to coarse. 14.20 m							
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist, gravels are angular to rounded. Sand is medium to coarse. 15.50 m		55	14.5				



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: **BH03**

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: **220556.01**

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist, gravels are angular to rounded. Sand is medium to coarse.		55				SPT (S) 15.20m 19, 31 375mm N=50			Bentonite
	Silty, sandy, fine to medium GRAVEL, light greyish brown, with dark brown speckling . Very dense, wet, gravels are subangular to subrounded. 15.50 m			15.5						
	15.60 m Silty, sandy fine to coarse GRAVEL, brownish grey. Very dense, wet, gravels are angular to subrounded. Sand is fine to medium.									
	15.75 m Sandy fine to coarse GRAVEL, with some silt, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse. 15.85 m		100							
GLACIAL TILL	15.95 m Gravelly medium to coarse SAND, with trace silt, grey and brown. Very dense, moist, gravels are fine to medium, subangular to subrounded. 16.05 m			16.0						
	Sandy fine to coarse GRAVEL, with some silt, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse.									
	Gravelly fine to coarse SAND, with trace silt, orangish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded.									
	16.45 m Sandy fine to coarse GRAVEL, with minor to some silt. With trace decayed organic matter, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse.			16.5						
			105				SPT (S) 16.70m 24, 22 / 31, 19 375mm N=50			16.8m
				17.0						Gravel
			67	17.5						
	18.05 m									

TCR (%) scale: 25 50 75
SPT N-VALUE scale: 10 20 30 40

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Henley Downs Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: Ground
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matty
CHECKED DATE: 05/11/2024

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL, with minor to some silt. With trace decayed organic matter, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse. 18.05 m 18.20 m		67							
	Gravelly medium to coarse SAND, with trace silt, greenish grey and brown. Very dense, wet, gravels are fine to medium, subangular to subrounded.						SPT (S) 18.30m 25, 25 375mm N=50			
	Sandy fine to coarse GRAVEL, with minor to some silt, with trace cobbles, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse. 18.90 m		85	18.5						
	Sandy, fine to medium GRAVEL, greenish grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 19.05 m			19.0						Gravel
	Gravelly medium to coarse SAND, with trace silt, greenish grey and brown. Very dense, wet, gravels are fine to medium, subangular to subrounded. 19.30 m									
	Gravelly, medium to coarse SAND, grey and brown. Very dense, moist , gravels are fine to medium, subangular to subrounded. 19.40 m									
GLACIAL TILL	Sandy fine to coarse GRAVEL, with some silt, grey and brown. Very dense, moist, gravels are subangular to rounded. 19.50 m		200	19.5						
	Medium to coarse SAND, with some silt, grey and brown. Very dense, moist. 19.65 m									
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist to wet, gravels are angular to rounded. Sand is medium to coarse. 19.90 m						SPT (S) 19.80m 50 375mm N=50			19.8m
	End Of Hole: 20.20m			20.0						
				20.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

APPENDIX B

Geotechnical Report 2025

GEOSOLVE

ace
association of consulting and engineering

Telarc. Registered
Quality
ISO 9001

Geotechnical Assessment for Resource Consent

Homestead Bay, Queenstown

Report prepared for:
RCL Homestead Bay Limited

Report prepared by:
GeoSolve Limited

Distribution:
RCL Homestead Bay Ltd
GeoSolve Limited (File)
January 2025
GeoSolve Ref: 220556.01

Version	Issue Date	Purpose	Author	Reviewed
1	24/01/25	Issue for consent application	JMJ	PGF/TP

GEOTECHNICAL
WATER RESOURCES
PAVEMENTS

Table of Contents

1 Executive Summary

- The site is considered appropriate for the proposed mixed use development from a geotechnical perspective provided the recommendations of this report are followed. Further geotechnical consideration will be required for the detailed design, and completion reporting stages of the project.
- The site stratigraphy typically comprises alluvial fan deposits, beach deposits, lake sediments, uncontrolled fill, loess, colluvium, glacial pond sediment, glacial till and outwash deposits.
- The regional groundwater was observed in the piezometers installed in the boreholes at depth below the site. Perched groundwater was encountered at shallow depths along the elevated eastern site boundary.
- The liquefaction assessment has identified a risk in elevated eastern areas where shallow groundwater is present. . Engineering solutions will be available to allow development in this area. Further assessment can be completed and may remove, or reduce, the assessed liquefaction risk, which is considered conservative.
- A slope stability analysis has been for the slopes around the southern and southwestern creeks. The results show the slopes do not meet the required factors of safety and building setbacks are required.
- The soil materials present at shallow depths will vary with respect to foundation bearing. Good ground will not be present in some areas and specific engineering design will be required where this is the case.
- Geotechnical assessment of the proposed earthworks plans should be undertaken at the detailed design stage of the project.
- Recommendations for temporary and permanent batter slopes are provided in Table 5.1. Slopes that require to be steeper than those described should be subject to specific engineering design.
- Any engineered fill that is utilised as bearing for foundations or to form batter slopes should be placed and compacted in accordance with NZS 4431:2022 and certification provided to that effect by a chartered professional engineer. A suitably qualified person should inspect all excavations, batter slopes, lot areas prior to the placement of engineered fill.
- For detailed design purposes it is recommended that the site is classified “Class D – deep soil site” in accordance with NZS 1170.5:2004 seismic provisions.

2 Introduction

2.1 General

This report presents the results of a geotechnical investigation and assessment completed by GeoSolve Limited for a proposed mixed use development at Homestead Bay, Queenstown.

Photograph 2.1: Looking west over central and northern areas of the proposed development area .

The investigation and assessment has been undertaken for RCL Homestead Bay Limited in accordance with GeoSolve proposal reference 220556.01, dated 9 October 2024, which outlines the scope of work and the conditions of engagement.

2.2 Development

The Paterson Pitts Group (PPG) preliminary subdivision plans depict the formation of a mixed use development comprising approximately 1839 low to medium density residential lots, 24 medium density residential superlots, 47 high density superlots and 2 commercial lots. A school development zone is proposed in the north west corner of the development area. A new reservoir infrastructure zone is proposed in the north east corner of the development area, in Lot 12.

No earthworks plans are available at this stage, however, GeoSolve understand that earthworks will be required to facilitate development.

3 Site Description

The site is located at Homestead Bay, approximately 6 km south of Frankton, Queenstown, between Homestead Bay Road, Chief Reko Road and Kingston Highway (SH6). The site forms part of an existing farm, as shown in Figure 3.1 below. The site is legally described as Lot 8 DP 443832 and Lot 12 DP 364700 and is approximately 205 hectares in size.

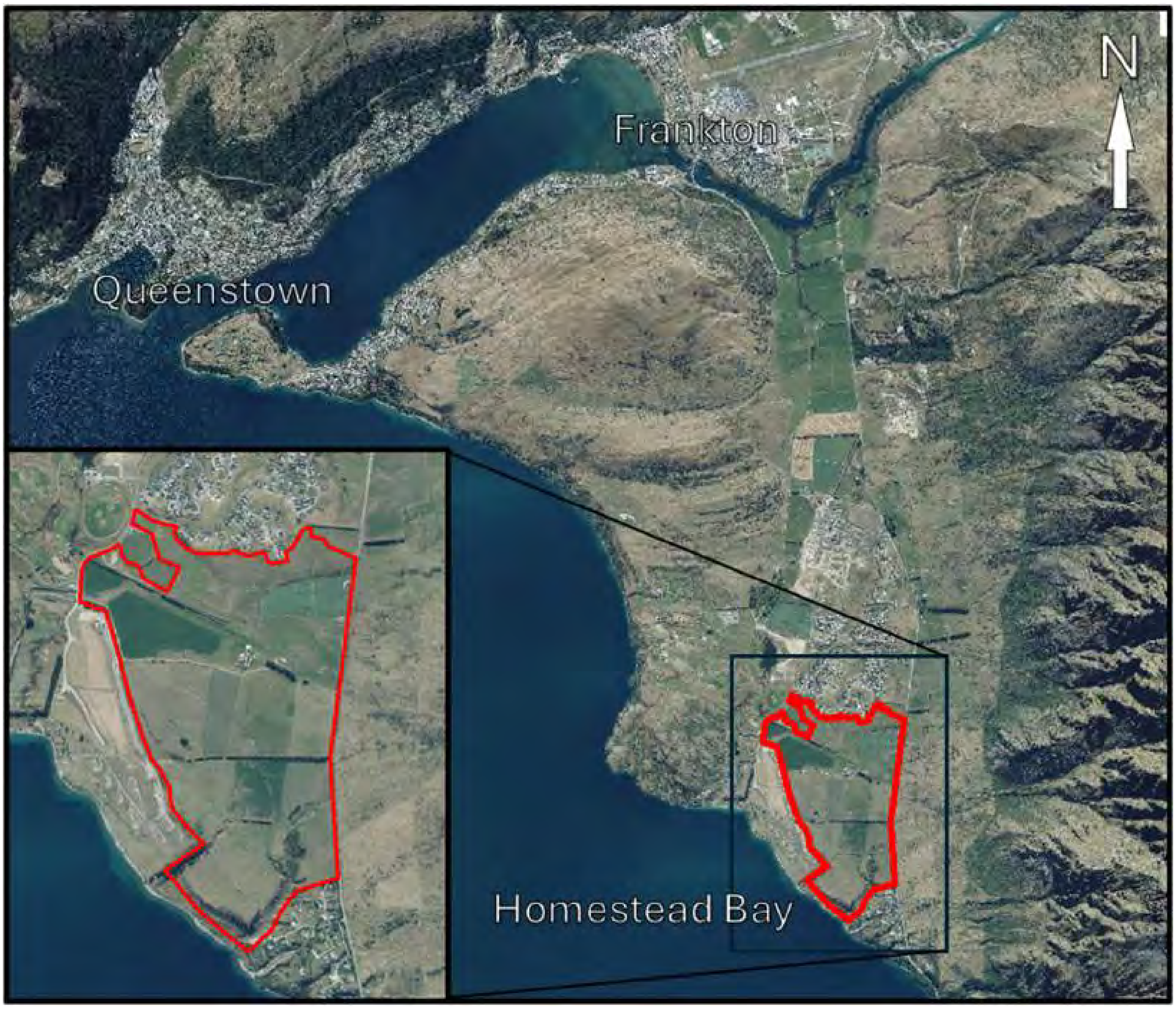


Figure 3.1: Site location plan showing the proposed development area is outlined in red. Aerial Image retrieved from QLDC GIS. Image not to scale.

The development proposal is mostly contained within Lot 8 which comprises pastural farmland, farm tracks and associated farming infrastructure. The NZone skydiving company occupy an area in the northern portion of the site where a grassed airstrip and associated buildings are present.

Lot 12 remains largely unmodified under the proposal, however a reservoir structure is proposed in the north eastern area. Associated pipework will head south to service the proposed development in Lot. 8.

Vegetation cover comprises grass, feed crop paddocks, tree shelter belts and scattered bushes. Dense matagouri scrub is found in the deeply incised creek channels towards the southern area of the site.

3.1 Geomorphological Mapping and Surface Drainage

The subject site is located within the Homestead Bay area at the western foot of the Remarkables Range. Whakatipu Waimāori (Lake Wakatipu) is approximately 45 m west of the south-western corner, and 800 m to the south of the north-western corner of the site.

The site generally slopes from approximately 410 m RL in the northeast corner to approximately 320 m RL in the lower southwestern corner. A topographic contour plan for the site has been produced using LiDAR contour data at 10 m intervals (Wakatipu, 2021) sourced from QLDC GIS database as shown in Figure 1a, Appendix A. Geomorphological observations made across the site are also presented on Figures 1b-c, Appendix A.

No evidence of large scale historical earthworks were observed in Lot 8, however, it is expected that minor earthworks have been completed to construct the runway in the northwest of the site. Other minor earthworks undertaken as part of the operation of the farm are also expected. A clean fill site is present in the eastern area of Lot 12.

Three significant surface drainage channels are present across the site, named Northern, Middle, and Southern Creeks respectively. A smaller and ephemeral creek drains southwest from the centre of the site. Numerous other ephemeral or abandoned shallow stream channels are present. The Southern Creek flows across the site towards the south-west and Lake Wakatipu. The Middle and Northern creeks flow to the west into modified stream channels. The three channels are shown on Appendix A, Figure 1b.

The site topography can be generally separated into three distinct geomorphological environments. For the purposes of this report, we have separated the site into the following topographic zones.

- Zone A – Elevated eastern areas, alluvial fan geomorphology.
- Zone B – Lower lying north western area, alluvial fan and historic lake environment.
- Zone C – Elevated western area with Glacial materials and geomorphology.

The topographic zones are shown in Figure 3.2 with a generalised description provided in Sections 3.1.1 to 3.1.3 below. The zones have been defined by review of historic aerial photography, site inspection, and intrusive ground investigations. The intrusive ground investigations and the site stratigraphy are described in Sections 4 and 5 below.

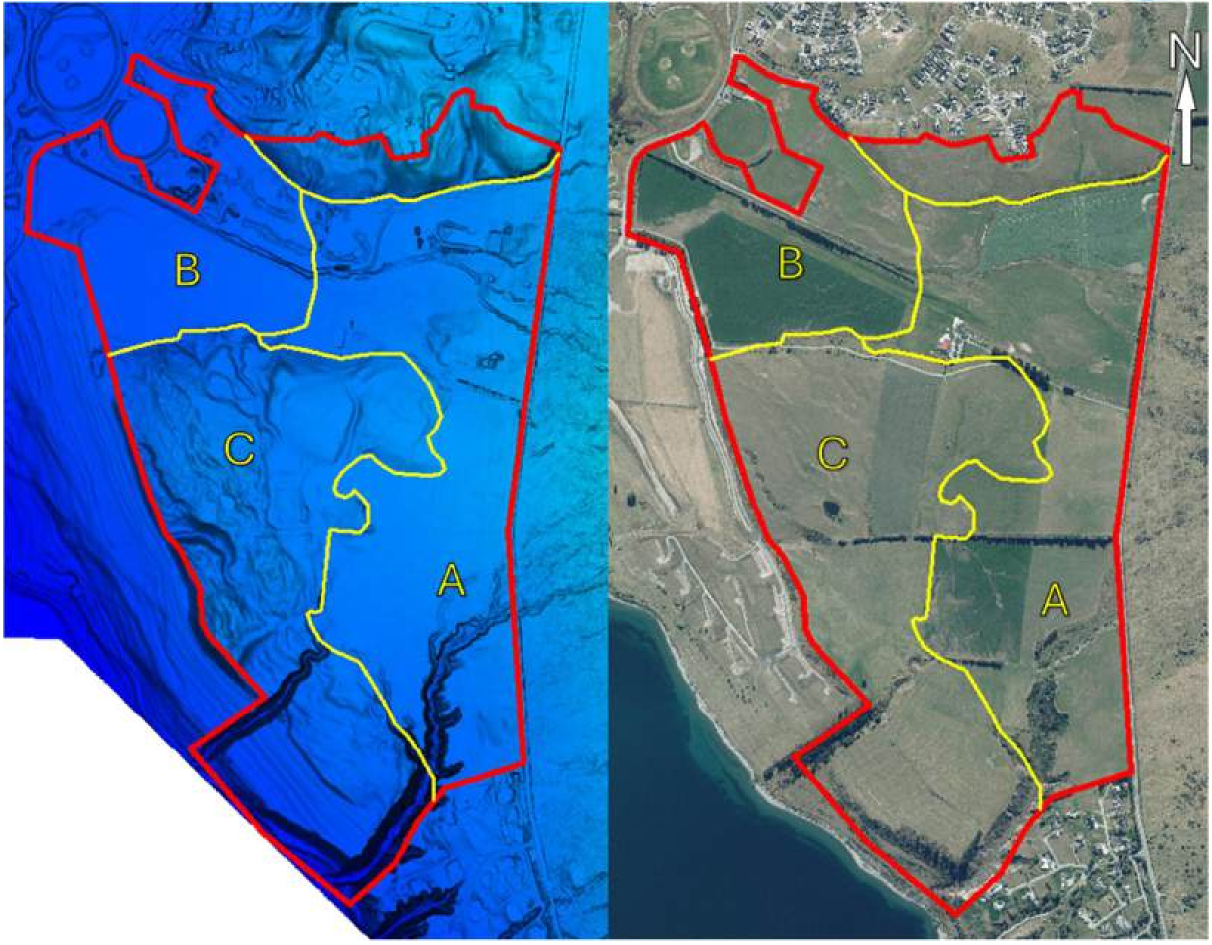


Figure 3.2: Generalised topographic/geomorphic zones (yellow) and site boundary (red). Basemap DEM produced from 1 m LiDAR. Image not to scale. A = Elevated Eastern Fan, B = Low laying fan and historic lake environment, C = Glacial geomorphology and glacial deposits

3.1.1 Zone A –Alluvial Fan

The eastern and southern portion of the site is located on an elevated, gently inclined slope comprising distal fan alluvium, see Photograph 3.1 below. The fan alluvium originates from the western slopes of the Remarkables, and immediate area.

In the southwestern corner of Zone A, the Southern and Southwestern creek channels have incised through the Fan Alluvium and Glacial deposits in response to the lowering of Lake Wakatipu. The Southwestern creek was dry during the assessment and is likely ephemeral in nature. The creek banks are moderately to steeply inclined, with grassed vegetation suggesting a less active environment. The Southern creek was flowing at the time of the assessment. The Southern creek banks are very steeply inclined and locally subvertical. Vegetation is often sparse, with colluvial wedges forming at the toe of slopes indicating shallow failure, erosion and regression of slope crests is ongoing in the present environment, see Photograph 3.2 below.

The northern creek flows along the northern boundary of Lot 8 in a modified channel.

Photograph 3.1: Standing on the alluvial fan looking east towards the Remarkable Range and the head of the fan.
Photograph 3.2: The deeply incised southern flow channel through the alluvial fan then glacial till deposits.

3.1.2 Zone B – Low Lying North western Area

Zone B is located in the north-west portion of the site. The ground surface is near flat to sloping very gently towards the west. Investigations in this area encountered laminated silt (lake sediments) and beach deposits at shallow depths indicating the depositional environment has been influenced by the historically higher level of Lake Wakatipu.

3.1.3 Zone C – Glacial Till/Outwash Deposits

Zone C runs along the elevated western portion of the site with surface topography comprising of undulating, irregular hummocky features, see Photograph 3.3 below. The deposition environment and geomorphology is glacial in origin.

Numerous drainage channels are present. Ponding surface water (natural and man-made) is present and illustrates the dense relatively impermeable nature of the glacial till deposits.

Several glacial boulders (4+ m diameter) are present at surface level . Smaller boulders have been stockpiled by the farmer in places.

From the western crest of the zone the slope falls moderately towards Lake Wakatipu. A series of beach ridges running parallel to the western boundary of the site represent stranded shorelines associated with the lowering of Lake Wakatipu.

Photograph 3.2: Site photo of Zone C characterised by locally elevated irregular and undulating hummocky topography.

4 Geotechnical Investigations

An engineering geological site appraisal has been undertaken with confirmatory subsurface investigations. Inspection and investigations were undertaken between October and December 2024 and comprised the following:

- Desktop review of existing geotechnical data on the GeoSolve database, publicly available historical aerial photos and geological reporting;
- Geomorphological mapping of the proposed development and surrounding area;
- 3 boreholes with associated SPT testing and piezometer installation were advanced to a maximum depth of 19.85 m below ground level (bgl) (BH01-BH03).
- 47 test pits with associated Scala penetrometer testing were advanced to a maximum depth of 5.0 m bgl (TP01-TP47);
- 41 Cone Penetrometer tests (CPTs) were advanced to a maximum depth of 20.38 m bgl.

In addition to the above, two boreholes completed by GeoSolve in 2022 (BH1-22 and BH2-22) and have been included in this assessment.

Test pits and boreholes were not undertaken in the northwestern portion of the site due to the land currently either in crop or comprising an active runway.

The investigation locations are shown on Figure 1, Appendix A, and the logs are included in Appendix B.

5 Subsurface Conditions

5.1 Geological Setting

The site is located within the Wakatipu basin, a feature formed by successive glaciations throughout the late-Quaternary culminating approximately 18 ka[1]. Ice retreat left deposits of moraine, till, outwash gravels and pond sediments over ice–scoured schist bedrock.

The lake sediments and beach gravels which underly the north western area of the site were deposited during higher lake levels in post glacial period. The Lake deposits are overlain by younger alluvial fan materials derived from the adjacent Remarkables Mountains or re-worked glacial outwash material. The alluvial fan deposits blanket eastern and northern areas of the site, whilst older glacial deposits in elevated western areas remain exposed.

5.1.1 Active Faulting

No active fault traces are known to exist in the immediate vicinity of the site. However, numerous active faults have been identified within the region (Motutapu, NW Cardrona, Nevis, Pisa, Moonlight Faults). The nearest known active fault, the Nevis Fault, is located 19 km east of the site. The recurrence intervals for active faults in the region are assessed to be in the order of 5,500 to 120,000 years[4].

Significant seismic risk exists in the Lakes District Region from a rupture of the Alpine Fault[5] which is located approximately 85 km NW of the site. Strong ground shaking in the Lakes District region is expected during a rupture of the Alpine Fault. Recent research[6] suggests there is a 75% probability of an Alpine Fault earthquake occurring within the next 50 years and an 82% probability that the next earthquake on the Alpine Fault will be of M_w8 or greater.

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[1] Turnbull, I.M. (2000) Geology of the Wakatipu area. Lower Hutt: Institute of Geological & Nuclear Sciences. *Institute of Geological & Nuclear Sciences 1:250,000 geological map 18* 72 p.

[4] Barrell, D.J., (2019). General distribution and characteristics of active faults and folds in the Queenstown Lakes and Central Otago districts, Otago. GNS Science Consultancy Report 2018/207. Published: March 2019

[5] Orchiston, C., Davies, T., et al. (2016) Alpine Fault Magnitude 8 Hazard Scenario. https://af8.org.nz/

[6] Howarth, J.D., *et al.* (2021). Spatiotemporal clustering of great earthquakes on a transform fault controlled by geometry. Nature Geoscience; doi: 10.1038/s41561-021-00721-4

5.2 Site Stratigraphy

The subsurface stratigraphy observed in the test pits and boreholes comprises:

- 0.1-0.7 m of Topsoil (all test pits and boreholes), overlying;
- 0.2-1.0 m of Uncontrolled Fill (TP4, 36, and 41), overlying;
- 0.1-1.2 m of Loess (TP1, 2, 16, 20, 21, 24, 27, 29, 32, 33, 34, 37, 38, 39, 44, 46 only), overlying;
- 0.6-4.8 m + of Alluvial Fan Deposits (TP3, 5, 9, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 35, 40, 41, 42, 43, 45 and 46, and BH1, 2, and 3), interbedded with;
- 0.9-2.3 m + of Beach Deposits (TP34, 35, and 36), interbedded with;
- 0.2-0.5 m of Colluvium (TP22, 25, 26, 27, 28, 29, 31, 32, 33, 37 and 39), overlying;
- 0.9-3.0 m + of Glacial Pond Sediment (TP10, 11, 12, 22 and 23, and BH2), overlying;
- 0.3-1.0 m of Weathered Glacial Till (TP1, 2, 30, and 44), overlying;
- 0.7-9.85 m + of Outwash Deposits (TP4, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 27, 28, 29, 31, 32, 43, and 45, and BH2 and 3), overlying and interbedded within;
- 0.3-9.75 m+ of Glacial Till (TP1, 2, 3, 4, 9, 14, 15, 21, 24, 25, 26, 28, 30, 33, 37, 38, 39, 43, 44, 46, and 47, and BH1, 2 and 3).

Topsoil was observed at the surface of all test pits and boreholes and covers the bulk of the site. The topsoil typically comprised organic silty SAND with trace rootlets.

Uncontrolled Fill was observed below the topsoil in TP4, 36, and 41 to a maximum depth of 1.3 m bgl and typically comprised medium dense silty sandy fine to coarse GRAVEL, sandy fine to medium GRAVEL with a trace of silt and medium to coarse GRAVEL with a trace of sand and silt. Small fragments of steel pipe were observed within the uncontrolled fill in TP4. The uncontrolled fill encountered is inferred to be from historic farm related landscaping.

Loess typically comprising loose to medium dense silty fine SAND with trace rootlets and organics, fine to medium SAND with minor to trace silt and trace to no gravel, rootlets and organics and firm sandy SILT with trace gravel and organics was observed in 16 of the test pits to a maximum depth of 1.5 m bgl.

Alluvial Fan Deposits were observed in 20 of the test pits and all 3 boreholes to a maximum depth of 7.35 m however the base of the deposits was not encountered in several of the test pits. The depths of the alluvial fan deposits generally decreased towards the west away from the source area of the Remarkables. The alluvial fan deposits typically comprised varying fractions of interbedded SILT, SAND and GRAVEL. A 500 mm thick deposit of medium dense 600 mm diameter BOULDERS was encountered in TP41.

Beach Deposits were observed in TP34, 35 and 36, in the northwest corner of the site, underlying the alluvial fan deposits. The base of the beach deposits was not encountered in TP34 and 35. The beach deposits typically comprised medium dense to dense, sandy fine to coarse GRAVEL with trace to no cobbles.

Up to 0.5 m of Colluvium was observed in TP22, 25, 26, 27, 28, 29, 31, 32, 33, 37 and 39 generally underlying the topsoil and/or loess to a maximum depth of 1.0 m bgl. The colluvium typically comprised varying fractions of SILT, SAND and GRAVEL.

Glacial Pond Sediments were encountered in TP10, 11, 12, 22 and 23, and BH2 and typically comprised stiff SILT, medium dense to hard SAND in varying interbedded fractions of the silt and sand. Gravel deposits were also present.

Over 9.85 m of Outwash Deposits were observed in 18 of the test pits and 2 of the boreholes, predominantly in the western and southwestern portions of the site. The outwash deposits encountered typically comprised medium dense to dense, SAND and GRAVEL with a cobble and boulder fraction in some locations.

Over 9.75 m of Glacial Till was observed in 21 of the test pits and 2 of the boreholes, generally underlying the alluvial fan deposits in the eastern area of the site and interbedded within and by the outwash deposits in the western and southwestern area of the site. The glacial till was typically observed to comprised medium dense to dense SAND and very stiff to hard SILT, with varying fractions of cobbles and boulders.

Lake Sediments were encountered in BH2-22 between 22.4 and 27.2 m bgl underlying alluvial fan deposits and overlying glacial till and comprised stiff SILT .

Full descriptions of the observed subsurface stratigraphy can be found in the test pit and borehole logs contained in Appendix B. Inferred ground models for the site can be found in the cross-sections provided in Appendix A. Figure 1a, Appendix A, shows the general distribution of surface geology across the site.

5.3 Groundwater

The regional groundwater table was measured in standpipe piezometers constructed in the boreholes (BH1 - BH3 and BH1-22 – BH2-22). Boreholes locations are shown on the Investigation Site Plan, Appendix A Figure 1a. Table 5.1 below summarizes the measured ground water levels.

Table 5.1: Site groundwater levels as observed in borehole piezometers.

Piezometer	Date Measured	Groundwater Depth m BGL	Groundwater m RL (NZVD2016)
BH1-22	2nd September 2022	14.8	339.2
	16th December 2024	13.4	340.6
	17th January 2024	15.4	338.6
BH2-22	2nd September 2022	5.1	386.9
	17th January 2024	4.3	387.7
BH1	16th December 2024	13.1	360.9
	17th January 2024	14.4	360.5
BH2	17th January 2024	10.5	380.5
BH3	17th January 2024	Dry	-

Groundwater seepages were encountered in several of the test pits in the eastern area of the site. All the test pits which encountered ground water seepages are location in elevated areas of the alluvial fan adjacent to the eastern site boundary. Seepage depths are summarised in Table 5.2 below. A preliminary zone of shallow seepage is identified on Figure 1b Appendix A. BH2-22 is present in this area and also encountered relatively shallow groundwater.

Table 5.2: Groundwater seepages as observed in test pits.

Test Pit	Geology at Seepage Level	Groundwater Depth (m BGL)
TP7	Alluvial Fan Deposits	4.2
TP9	Alluvial Fan Deposits	3.1
TP14	Outwash Deposits	4.0
TP40	Alluvial Fan Deposits	1.3
TP41	Alluvial Fan Deposits	2.6
TP42	Alluvial Fan Deposits	1.9
TP47	Contact between Alluvial Fan Deposits and Glacial Till	0.9*
*Test pit was located immediately adjacent to flowing creek		

6 Natural Hazards Assessment

The subject site is shown to be within or nearby to mapped natural hazard areas as shown on QLDC Hazard mapping. Further, interpretation of the geomorphological mapping and aerial photography has concluded that the following natural hazards may affect the proposed development area:

- Slope stability
- Liquefaction
- Alluvial fan, debris flow and flooding
- Rock fall
- Rock avalanche
- Strong ground motion associated with a seismic event.
- Lake seiche

The alluvial fan, debris flow, flooding, rock fall, rock avalanche and lake seiche hazards have been specifically assessed in the GeoSolve report referenced 220556.02 dated 17th January 2025, and are not covered in this report. Internal natural hazards including liquefaction and slope stability are addressed below.

6.1 Seismic

A severe seismic risk is present in the region as discussed in Sections 5.1 and 5.1.1. Appropriate allowance should be made for seismic loading during detailed design of subdivision earthworks and any associated structures.

6.2 Liquefaction

6.2.1 General

The majority of the site, in particular Topographic Zones A and C are mapped as LIC 1 (P) [7] / Classification A[8] on the QLDC hazard maps, indicating a probably low risk of liquefaction. The north-western extent of the site (Topographic Zone B) is mapped as LIC 2 (P) / Class B indicating a possibly moderate risk of liquefaction. The QLDC hazard mapping is shown below in Figure 6.1.

For assessing liquefaction susceptibility there are three key parameters:

- Level of shaking – Queenstown is located in an area of high seismic risk relatively to other parts of New Zealand. Therefore, a detailed assessment of liquefaction is required.
- Composition and density of the soil – the soils are variable across the site. Significant areas of soil could liquefy from a composition and density perspective.
- Soil saturation – Soils require to be fully saturated to liquefy. Two areas of differing soil saturation have been. Elevated eastern areas have a perched groundwater level approximately between 2 and 6 m depth. The remainder of the site does not have a perched groundwater level. Regional groundwater levels have been measured to be at least 10 to 15 m depth.

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[7] Tonkin and Taylor (2012) Queenstown Lakes District - Liquefaction Hazard Assessment

[8] GNS (2019) Liquefaction Susceptibility - Regional Analysis

Figure 1b, Appendix A, identifies the approximate extent of the eastern perched water zone. Therefore most of the site, where there is no perched groundwater level, will have at least 10 m of dry non liquefiable crust. In these areas the liquefaction risk will be low for a standard shallow foundation structure (i.e. MBIE TC1 equivalent). The perched groundwater level is highly variable with seepages running through more permeable deposits in the alluvial fan. Further geotechnical investigations and assessment can be undertaken to better define the seepage behaviour, however, for this assessment we have undertaken a detailed assessment using the CPTs and assuming different shallow groundwater levels.

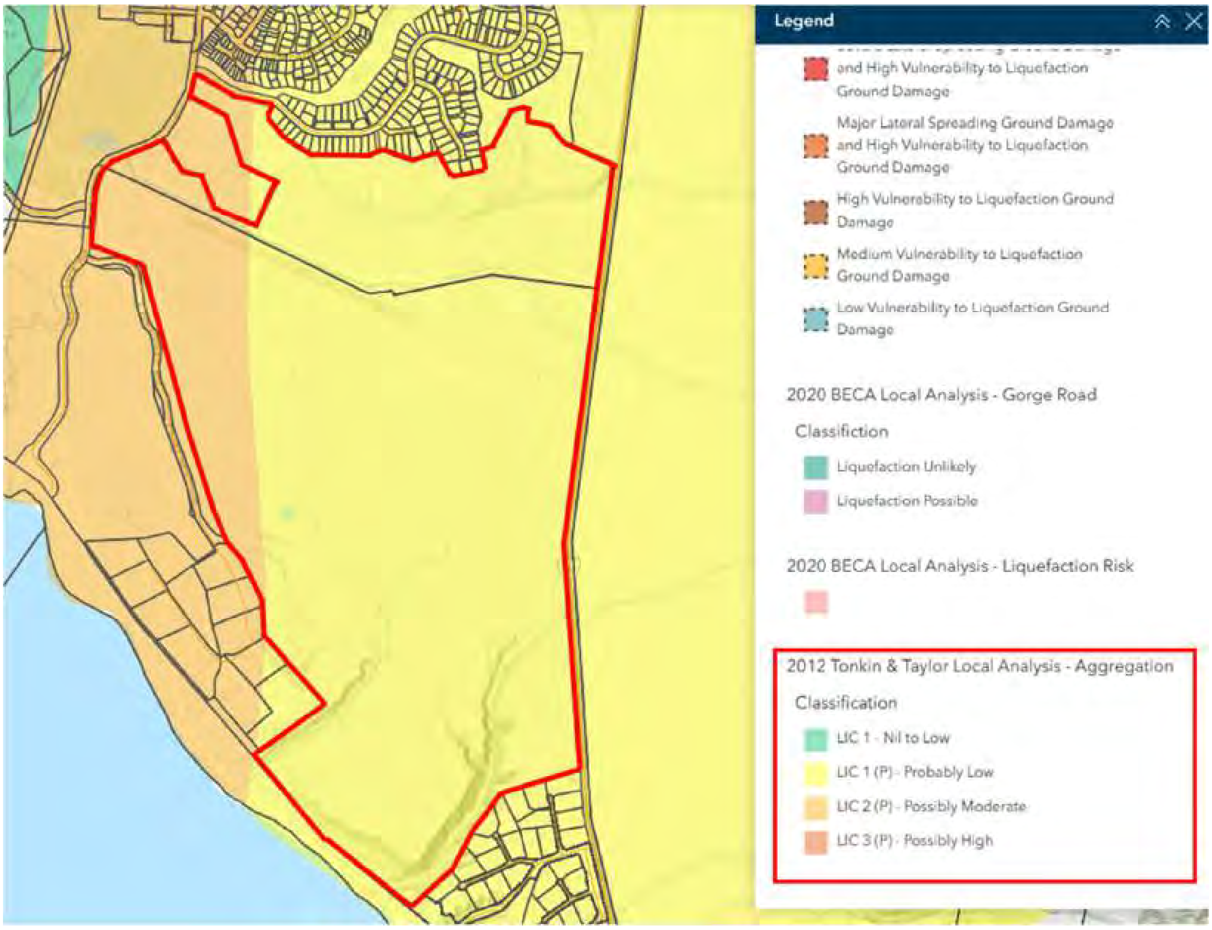

Figure 6.1: Liquefaction hazard mapping. Image retrieved from QLDC GIS Natural Hazards Map on 17t^{h} January 2024. The site boundary is shown in red.

6.2.2 Design Earthquakes

As it is proposed to form a mixed use development including a school, five earthquakes scenarios have been assessed in accordance with NZS 1170 – Structural Design Actions[9] for an Importance Level 2 and 3 structures with a 50-year design life.

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[9] NZS 1170-5 (2004) Structural Design Actions, Part 5: Earthquake Actions – New Zealand.

Peak horizontal ground accelerations and effective magnitudes were calculated using the procedure from Module 1 of the Earthquake Geotechnical Engineering Practice in New Zealand[10]. Table 6.1 below summarises the scenarios considered.

Table 6.1: Earthquake accelerations and effective magnitudes for liquefaction assessment

Scenario	Performance Requirements	Annual Probability of Exceedance	Peak Horizontal Ground Acceleration (PGA)	Effective Magnitude
Serviceability Limit State (SLS)	*Avoid damage that would prevent the structure being used as originally intended without repair.*	1/25	0.10 g	6.5
Intermediate Event – IL2	*No requirements but assists in considering affects as per liquefaction planning guidelines*	1/100	0.20 g	6.5
Intermediate Event – IL3	*No requirements but assists in considering affects as per liquefaction planning guidelines*	1/250	0.31 g	6.5
Ultimate Limit State (ULS) – IL2	*Avoid collapse of the structural system.*	1/500	0.41 g	6.5
Ultimate Limit State (ULS) – IL3	*Avoid collapse of the structural system.*	1/1000	0.53 g	6.5

6.2.3 Liquefaction Analysis

Analysis was undertaken on the CPT soundings using the Boulanger & Idriss (2014)[11] method to calculate the factor of safety against liquefaction and Zhang et al (2002)[12] to calculate liquefaction-induced reconsolidation settlement. As no laboratory testing has been undertaken in this analysis, a soil classification index (I_c) cut off of 2.6 and a fines correction coefficient (C_{fc}) of 0 has been adopted. No thin layer correction has been applied.

As discussed above only the CPTs in the upper platform where shallow groundwater is present have been analysed which include CPT8, 12-16, 20-24 and 26, which achieved variable depths of between 2.3 and 13.9 m. The deeper CPTs are considered more representative.

Groundwater in this zone is variable and at the time of writing this report the extent of full saturation of the soil profile has not been fully defined. Therefore, we have undertaken a

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[10] NZGS and MBIE (2021) Earthquake Geotechnical Engineering Practice, Module 1

[11] Boulanger, R.W. & Idriss, I.M. (2014). CPT and SPT Based Liquefaction Triggering Procedures. Department of Civil & Environmental Engineering, University of California.

[12] Zhang, G., Robertson, P.K., Brachman, R.W.I. (2002). Estimating liquefaction-induced ground settlements from CPT for level ground.

sensitivity assessment for different saturation depths to highlight potential risk. Further assessment will be required for future stages of work.

For this assessment we have compared calculated indexed liquefaction induced consolidation settlement and the liquefaction severity number (LSN) for different groundwater depths. The different groundwater depths consider the above five events. As part of this we have considered three of the most credible groundwater levels at this area of the site of 2 m, 4 m and 6 m. These results are summarised in Appendix C.

The results show that:

- Limited liquefaction occurs in the SLS and the IL2 intermediate design event in all groundwater cases. Therefore, for standard structures the risk for these events is low.
- If the groundwater/point of full saturation is at 2 m depth the IL3 intermediate design event does show that liquefaction is occurring but LSN and indexed settlement infer that moderate damage is expected. If the groundwater/point of saturation is one of the deeper cases limited/minor liquefaction risk is expected. An IL3 structure would require specific engineering design, so a development perspective in all cases there would be numerous design options to accommodate this risk.
- If the groundwater/point of full saturation is at 2 m depth liquefaction is calculated to occur in the ULS design event which could be moderate to major. However, if the groundwater was at lower depths minor to moderate liquefaction risk would be expected.
- Based on the variability of the groundwater levels and lack of free faces in close proximity to the site we consider that lateral spreading will not govern any liquefaction design. However, this should be re-assessed when the extent of earthworks, and presence of any proposed channels/basins, is understood.

6.2.4 Further Work

Soil laboratory testing has not been undertaken to confirm the soil classification index cut off and the fines correction factor. GeoSolve have undertaken testing in other areas in the greater Queenstown area which did show reduction in liquefaction risk if testing was undertaken. Therefore, soil laboratory testing could be undertaken to better define these parameters.

The alluvial fan deposits are highly interbedded. Research and experience in the eastern suburbs of Christchurch show that standard assessments with no correction provide relatively conservative results. GeoSolve have undertaken shear wave velocity testing in some greater Queenstown sites in similar interbedded soils which also have shown reduction of liquefaction risk and justification for using a thin layer correction for the CPT based assessment. Therefore, the current assessment is considered conservative and further assessment could be undertaken to better define these effects.

6.2.5 Liquefaction Analysis Summary

- The site has been divided into two zones, the upper terrace where there is a perched groundwater table, and the remainder of the site where there is no perched groundwater table and a minimum non-liquefiable crust of 10 m is expected.
- Given the relatively deep regional groundwater level, where there is no perched groundwater, the liquefaction risk has been assessed to be low to very low or MBIE TC1 equivalent for most of the site.

- In the elevated eastern area of the site, where perched groundwater is present, the liquefaction risk has been assessed as medium vulnerability.
  As there is no SLS liquefaction risk and no to minor intermediate risk, it is likely that common specifically designed foundation solutions could be developed to mitigate any liquefaction effects, such as robust foundation slabs similar to MBIE TC2 slabs.
- The above assessment is appropriate for Resource Consent and has shown that development is possible and the liquefaction risk over most the site is relatively low. However, further assessment is recommended for further stages of the development to better refine the liquefaction risk and zoning. These further assessments would incorporate proposed development plans including any proposed earthworks, channels, basins or other areas which could increase liquefaction induced lateral spreading risk.
- We have identified some aspects of potential conservatism in the liquefaction risk given the soil types observed. Further refinement of these could be considered in further assessment stages.

6.3 Slope Stability

6.3.1 General

A slope stability assessment has been undertaken based on site observations and review of the test pit and borehole data. No signs of shallow or deep-seated slope instability are evident within the site with the exception of the southern creek channels where localised shallow instability, stream bank erosion and slope crest regression is evident.

No proposed earthworks plan have been provided to date and the assessment has therefore considered the existing topography only.

6.3.2 Slope Crest Stability

Crest slope regression is likely to be ongoing for the southwestern terrace slope and the southern creek channels. Accordingly, a detailed slope stability assessment has been undertaken on several representative cross sections using the software programme Slope/W.

Cross sections H, I, J, K, L, M, N, O, P Q, R, S have been analysed, the locations of which are shown on Figure 1a, Appendix A. Proposed development around the margins of the channels comprises individual house residential building lots.

The following slope stability cases have been analysed:

- Static Case – No seismic loading;
- Serviceability Limit State (SLS) – (equivalent to a 1 in 25-year event).
- Ultimate Limit State (ULS) – major regional earthquake (equivalent to a 1 in 500-year event). Stability should be sufficient to prevent loss of life following an event of this magnitude.

Building surcharge loads have been applied where applicable. The analysis assumes dry conditions based on the groundwater levels measured in the piezometers. The soil parameters used in the analysis are provided in Table 7.1 below. The target Factors of Safety used for the analysis are shown in Table 6.2 below.

Table 6.2: Target Factors of Safety

Stability Case	Target Factor of Safety
Static	>1.5
Seismic SLS	>1.2
Seismic ULS	No target, magnitude of ground displacements to be estimated

The analysis results indicate the analysed slopes do not meet the required Factors of Safety with respect to all three cases. Building setbacks will be required to achieve the required factors of safety for residential development. Preliminary building setback distances are provided in Table 6.3 below and are shown on Appendix A Figure 1a.

Table 6.3: Building setback dimensions to achieve required Factors of Safety.

Cross Section	Side of Creek	Stability Case		
		Static (Min FoS 1.5)	Seismic SLS (Min FoS 1.2)	Seismic ULS (<5-10 mm ground displacement)
		Minimum setback from crest of slope (m)		
H	NW	5	5	5
	SE	5	5	5
I	NW	7	7	7
	SE	5	5	5
J	NW	5	5	5
	SE	5	5	5
K		5	5	5
L		13	13	14
M		17	17	17
N		20	20	21
0	NW	5	5	5
	SE	5	5	5
p	NW	6	6	7
	SE	5	5	5
Q	E	5	5	5
	W	11	11	11
R	SW	4	5.0	6
	NE	7	8	9
S		15	15	16

Several results returned values of less than 5 m, however, a minimum set-back of 5 m is provided in Table 6.5.

The setbacks provided for the ULS case may need to increase if 0 mm displacement is required. The setbacks provided have been rounded up to the nearest metre.

The setbacks do not preclude development nearer the slope crest, however, any future building development inside the building setback will require specific engineering design and standard foundations may not be applicable.

As noted above, the stability assessment is for the current ground surface. If future proposed earthworks result in modification of the ground surface in the assessed areas slope stability results may differ from those presented in Table 6.5. The need for further assessment should be reviewed once earthworks plans are available during the detailed

design stage. The Geotechnical Completion Report, typically issued upon completion of the earthworks, will also need to incorporate the results and setback recommendations.

7 Engineering Considerations

7.1 General

The recommendations and opinions contained in this report are based upon ground investigation data and mapping obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

7.2 Geotechnical Parameters

Table 7.1 provides a summary of the recommended geotechnical design parameters for the soil materials expected to be encountered during earthworks and future building platforms.

Table 7.1: Recommended geotechnical design parameters

Unit	Thickness as encountered in 2024 investigation (m)	Bulk density γ (kN/m^3)	Effective cohesion c' (kPa)	Effective friction ϕ' (deg)	Elastic modulus **E** (kPa)	Poissons ratio ν
Topsoil	0.1-0.7	To be removed from engineered fill subgrade and proposed lots unless specifically designed.				
Uncontrolled Fill	0.2-1.0					
Loess	0.1-1.2	17	0	32	5,000	0.3
Alluvial Fan Deposits	0.6-4.8+	18	0	30-32 (30 when silty)	5,000-10,000	0.3
Beach Deposits	0.9-2.3+	18	0	33	5,000-10,000	0.3
Colluvium	0.2-0.5	18	0	32	5,000	0.3
Lake Sediment	-	18	0	28	5,000	0.3
Glacial Pond Sediment	0.9-3.0+	17	0	32	5,000	0.3
Outwash Deposits	0.7-9.85+	19	0	34-38	20,000	0.3
Glacial Till	0.3-9.75+	18	0	35-39	20,000	0.3

7.3 Site Preparation

During the earthworks operations all topsoil, organic matter, uncontrolled fill, and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 4431 and NZS 3604.

Owing to the moderately erodible nature of some of the soils present across the site, sediment control measures should be instigated during earthworks construction. QLDC Guidelines for environmental management plans should be consulted by a suitably qualified person for site management.

7.4 Engineered Fill

All fill that is utilised as bearing for foundations or to form batter slopes should be placed and compacted in accordance with the recommendations of NZS 4431:2022 and certification provided to that effect. The alluvial fan deposits, outwash deposits and glacial till are suitable for used as engineered fill on site (during good weather and in accordance with an earth fill specification). Boulders and cobbles over 100 mm in size will need to be screened from engineered fill sources. An earth fill specification should be provided prior to the commencement of earthworks.

We recommend topsoil stripping and subsequent earthworks be undertaken only when a suitable interval of fair weather is expected.

7.5 Excavations

No proposed contours have been provided to date however it is understood that a cut and fill earthworks will be required to form the proposed development.

Preliminary recommended slope batters are provided in Table 7.2 below. The recommendations should be reviewed by GeoSolve following provision of proposed earthwork plans during the detailed design stage.

All proposed batter slopes higher than 4 m or required to be steeper than the recommended angles will require specific engineering assessment by GeoSolve during the detailed design stage.

Table 7.2: Recommended maximum slope batters for temporary and permanent slopes

Material type	Recommended maximum batter for temporary slopes	Recommended maximum batter for permanent slopes up to 4 m high
Topsoil, Uncontrolled Fill, Beach Deposits	1(v):1.5(h)	1(v):3(h)
Loess, Alluvial Fan Deposits, Colluvium, Glacial Pond Sediment, Weathered Glacial Till	1(v):1.5(h)	1(v):2.5(h)
Glacial Till, Outwash Deposits	1(v):1(h)	1(v):2(h)

Remediation options such as soil nails, retaining or geogrid reinforcement can be considered to ensure appropriate Factors of Safety are met. Development setbacks from slope crests can also be considered. The requirement for stabilisation measures can be reviewed during the detailed design stage of the development.

Steeper batters than those outlined above may be appropriate in specific areas. Case-by case assessment will need to be undertaken to confirm the use of steeper batters.

7.6 Groundwater Issues

The regional groundwater table is expected to lie well below the finished development. Dewatering or other groundwater-related construction issues are therefore unlikely to be extensively required. Perched seepages have been identified in some eastern areas of the site at depths of 1-5 m, see Table 1 above and Figure 1b, Appendix A. Groundwater is expected to be encountered in excavations completed in this area. Seepage volumes and locations are expected to reflect precipitation and snow melt, and will therefore vary on a seasonal basis.

Seepages observed during construction will require to be captured by subsoil drains and outlet to an appropriate location such as landscaping areas or into the reticulated stormwater system. Consideration should be given to subsoil drainage if excavation is proposed in eastern areas of the site.

7.7 Foundations

Following the removal of topsoil and uncontrolled fill, it is expected that predominantly alluvial fan deposits will be encountered in Zone A, beach deposits, lake sediments or alluvial fan deposits within Zone C, and colluvium, weathered glacial till, glacial pond sediment, glacial till or outwash deposits within Zone C.

7.7.1 Zones A & B

Zones A and B are expected to be underlain by beach deposits, lake sediments and/or alluvial fan deposits. These deposits will provide a reduced bearing capacity and do not meet the ‘good ground’ bearing capacity requirements as outlines in NZS3604. Specific engineering design will be required for lots containing these soils to provide appropriate foundations solutions.

Preliminary assessment indicates robust foundation slabs similar to MBIE TC2 slabs may be required, depending on further detailed assessment of the liquefaction risk.

7.7.2 Zone C

Zone C is expected to be underlain by colluvium, glacial pond sediment, glacial till or outwash deposits. These materials provide a mix of ‘good ground’ and not ‘good ground’ with respect to bearing capacity as outlined in NZS3604. Specific engineering design will be required for lots containing these soils to provide appropriate foundations solutions.

7.8 Site Subsoil Category

For detailed design purposes it is recommended that the magnitude of seismic acceleration be estimated in accordance with the recommendations provided in NZS1170.5:2004.

Based on the ground conditions observed during the site investigations and existing data from the surrounding area, we consider the site subsoil class in terms of NZS1170.5:2004 Clause 3.1.3 to be Class D (deep soil site).

7.9 QLDC Land Development and Subdivision Code of Practice

Section 2.4.4 of the QLDC Land Development and Subdivision Code of Practice (QLDC CoP) requires the developer of any subdivision to appoint a geo-professional to carry out the following functions from the planning to construction phases of the subdivision:

a) Check regional and district plans, records, and requirements prior to commencement of geotechnical assessment;

b) Prior to the detailed planning of any development, to undertake a site inspection and such investigations of subsurface conditions as may be required, and to identify geotechnical hazards affecting the land, including any special conditions that may affect the design of any pipelines, underground structures, or other utility services;

c) Before construction commences, to review the drawings and specifications defining any earthworks or other construction and to submit a written report to the TA on the foundation and stability aspects of the project (if required);

d) Before and during construction, to determine the extent of further geo-professional services required (including geological investigation);

e) Any work necessary to manage the risk of geotechnical instability during the construction process;

f) Before and during construction, to determine the methods, location, and frequency of construction control tests to be carried out, determine the reliability of the testing, and to evaluate the significance of test results and field inspection reports in assessing the quality of the finished work;

g) During construction, to undertake regular inspection consistent with the extent and geotechnical issues associated with the project;

h) On completion, to submit a written report (i.e. Geotechnical Completion Report) to the Territorial Authority (TA) attesting to the compliance of the earthworks with the specifications and to the suitability of the development for its proposed use including natural ground within the development area. Where NZS 4431 is applicable, the reporting requirements of that Standard shall be used as a minimum requirement.

This resource consent level report can be considered to have completed items a) and b) from the above list. Once resource consent for the subdivision has been granted a geo-professional will need to be appointed by the developer to review the earthworks drawings and specifications prior to finalising the documentation for tendering and/or construction, and to oversee the construction phase of the project including certification of fill and provide a Geotechnical Completion Report (GCR) and Schedule 2A in accordance with the QLDC CoP.

The GCR and Schedule 2A should detail the results of site observations, testing and monitoring during earthworks construction, confirm the stability of the finished earthworks, and identify any specific geotechnical design requirements that must be addressed in order to construct a building on site. Any identified specific design requirements will then be registered on the subject lots' 'certificate of title' and will need to be addressed during the building consent process.

The geo-professional completing the GCR and Schedule 2A which includes the certification of fill should in all cases be engaged by the developer not the contractor. It is also advisable that the geo-professional review the earthworks contract to assist in managing the developers risk and ensuring that the contract is clear with respect to geotechnical risks and responsibilities during construction.

The use of this report and any of its findings or recommendations as part of the GCR and Schedule 2A may only be used with our prior review and written agreement.

7.10 Further Works

It is recommended that the recommendations of this report are reviewed following provision of earthworks drawings.

8 Neighbouring Structures

Neighbouring Properties: No adverse geotechnical implications apply for neighbouring properties during construction.

Aquifers: No aquifer resource will be adversely affected by the development.

Erosion and Sediment Control: The site presents some potential to generate silt runoff, and this would naturally drain downslope.

We recommend advice be sought from a qualified specialist where compliance with local and regional erosion and sediment control regulations is uncertain. Compliance with QLDC environmental management guidelines will be required.

Noise: Rock-breaking and/or blasting is unlikely to be required.

Dust: Regular dampening of soil materials with sprinklers should be effective if required.

Vibration: No vibration induced settlement is expected in these soil types.

9 Applicability

This report has been prepared for the sole use of our client, RCL Henley Downs Limited with respect to the particular brief and on the terms and conditions agreed with our client. It may not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

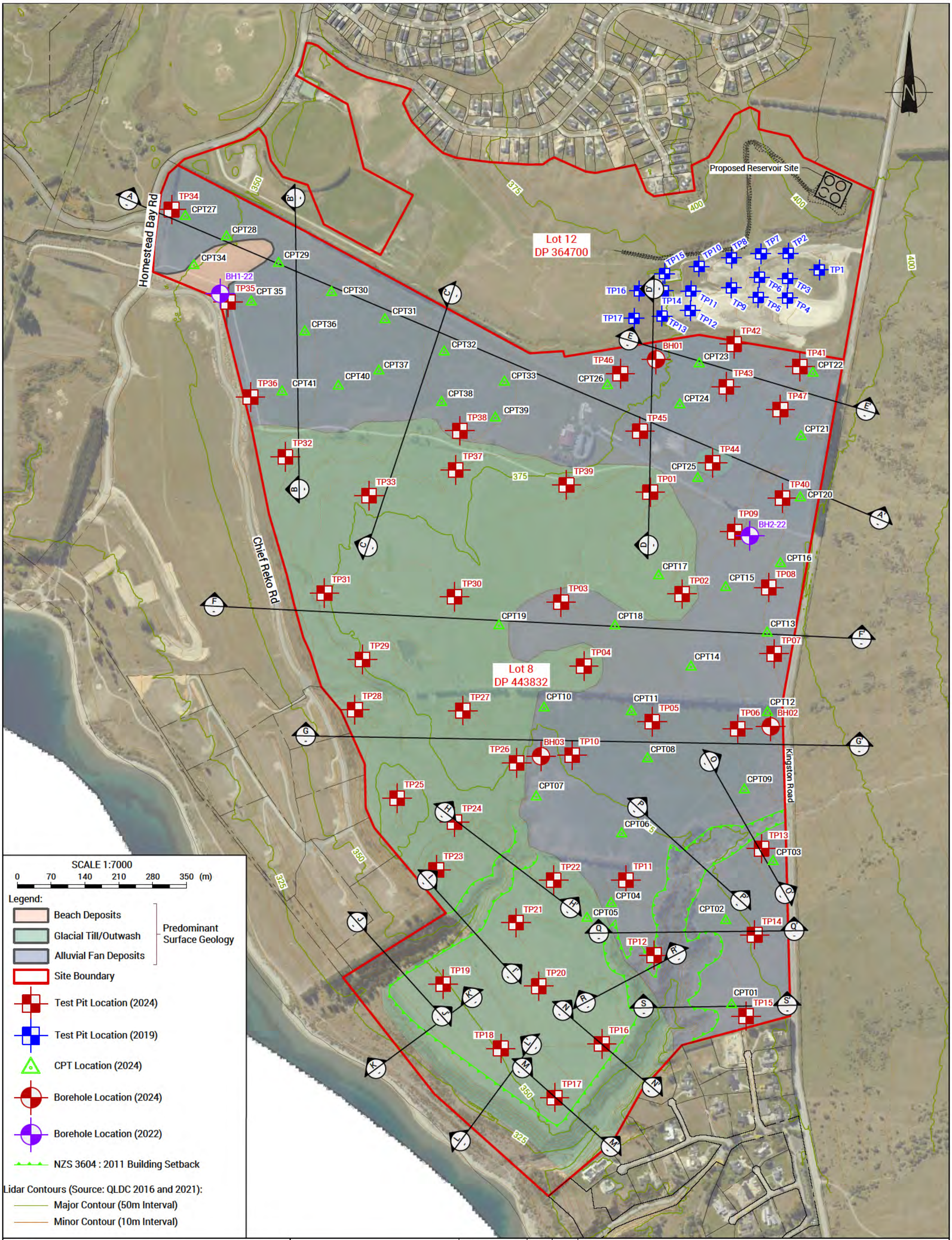
Investigations have been undertaken at discrete locations in accordance with the brief provided. It must be appreciated that the nature and continuity of subsoil conditions away from the investigation locations cannot be guaranteed.

During construction, all earthworks should be examined by an inspector or engineer competent to confirm that subsurface conditions encountered throughout are compatible with the findings of this report. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Report prepared by:	Reviewed for GeoSolve Ltd by:
[redacted]	[redacted]
....	....
Jack Mynett-Johnson Engineering Geologist	Paul Faulkner Principal Engineering Geologist

Appendices:
Appendix A – GeoSolve Drawings
Appendix B – Investigation Logs
Appendix C – Liquefaction Results

Appendix A: GeoSolve Drawings



SCALE 1:7000

0 70 140 210 280 350 (m)

Legend:

🟧	Beach Deposits	Predominant Surface Geology
🟩	Glacial Till/Outwash	
🟦	Alluvial Fan Deposits	
🟥	Site Boundary	
✚	Test Pit Location (2024)	
✚	Test Pit Location (2019)	
△	CPT Location (2024)	
◐	Borehole Location (2024)	
◐	Borehole Location (2022)	
▲	NZS 3604 : 2011 Building Setback	

Lidar Contours (Source: QLDC 2016 and 2021):

—	Major Contour (50m Interval)
—	Minor Contour (10m Interval)

Notes:
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220556.01-I.dwg

SCALES (AT A3 SIZE):
1:7000

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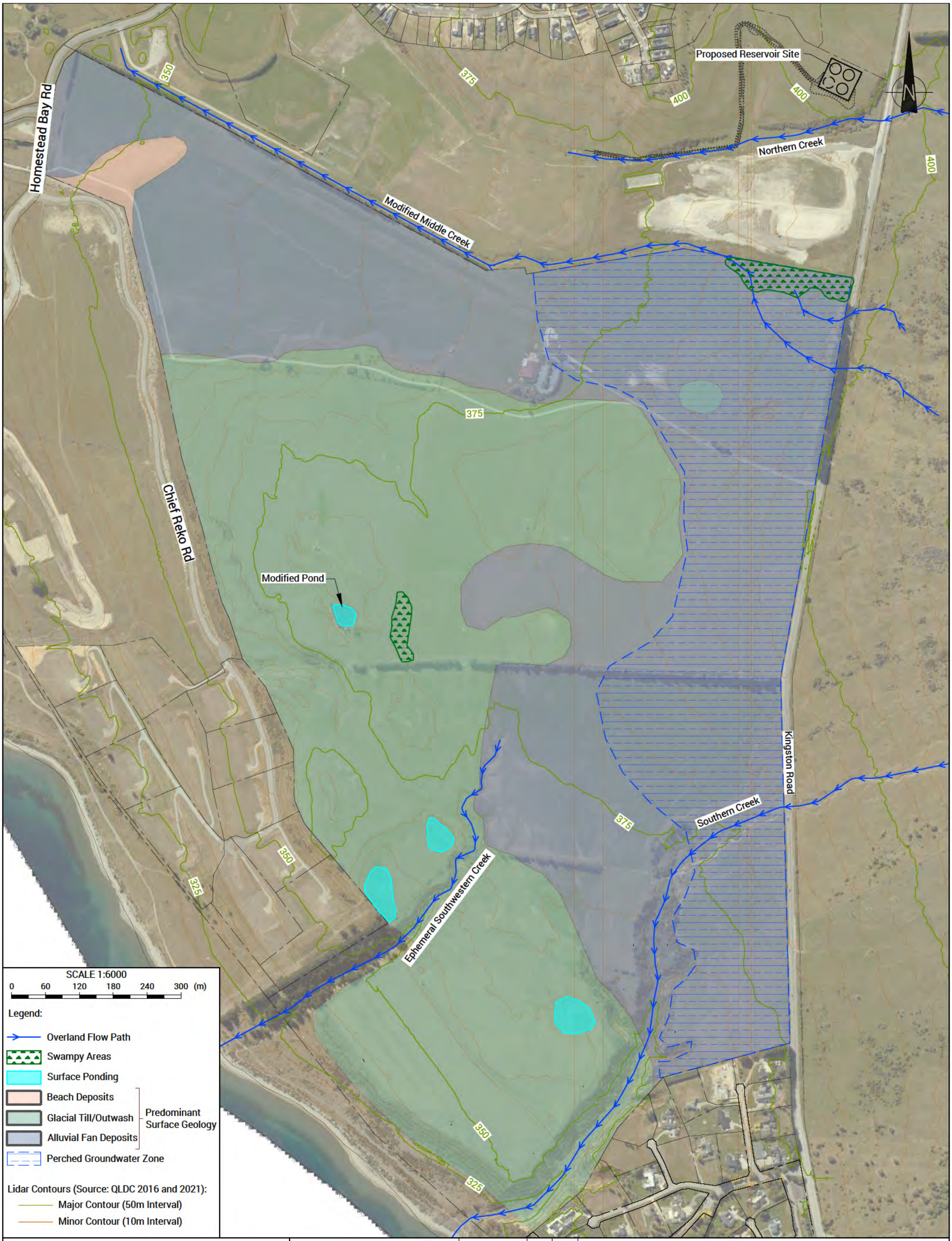
Geotechnical Assessment (GI)

Investigation Site Plan

FIG No:
Appendix A, Figure 1a

Rev:
A



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SCALES (AT A3 SIZE): 1:6000

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Geotechnical Assessment (GI)

Geomorphology Plan

FIG No: Appendix A, Figure 1b

Rev: A

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SCALES (AT A3 SIZE):
1:8000

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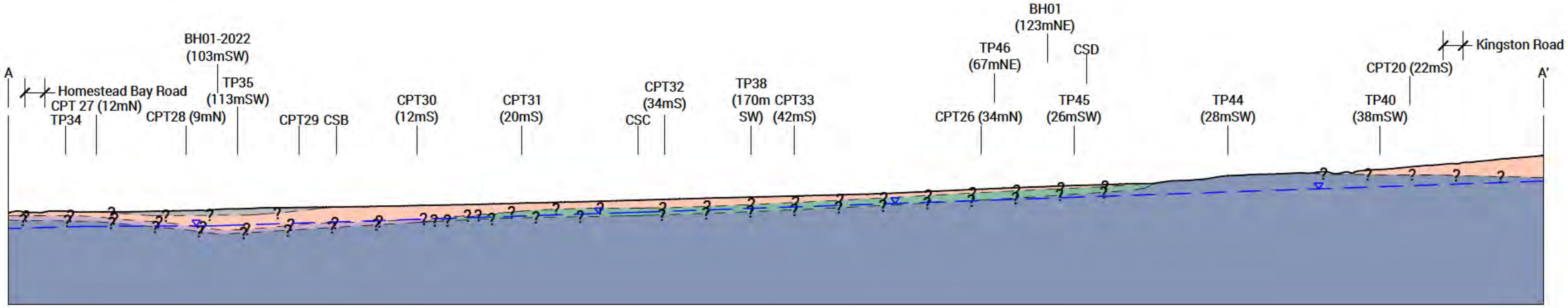
Geotechnical Assessment (GI)

ORC Borehole Plan

FIG No:
Appendix A, Figure 1c

Rev:
A



SCALE 1:5000
0 50 100 150 200 250 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- ⬜ Beach Deposits
- 🟪 Lake Sediment
- 🟩 Outwash Deposits
- 🟦 Glacial Till
- - -▽- - Indicative Groundwater Level

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SCALES (AT A3 SIZE): 1:5000
PROJECT No: 220556.01

RCL Homestead Bay Limited
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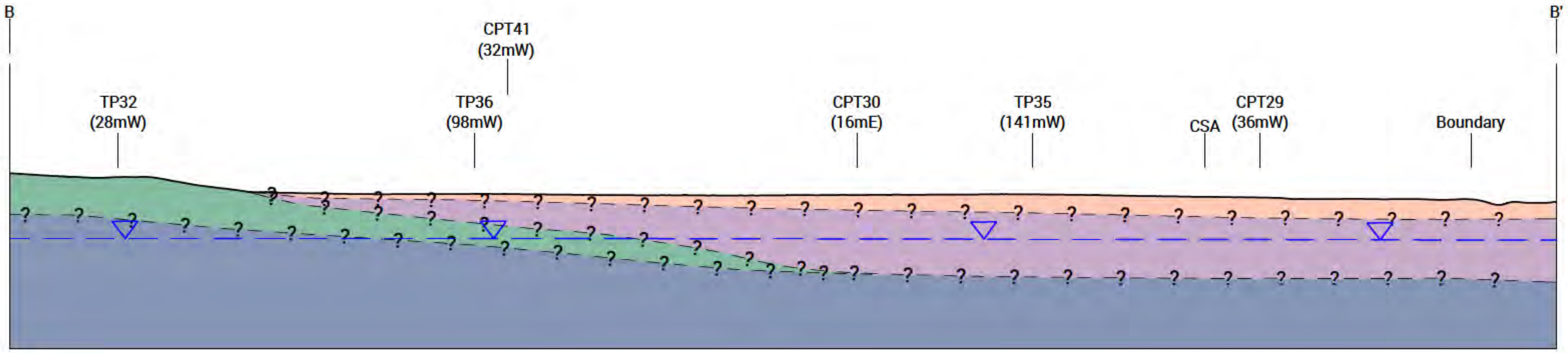
Geotechnical Assessment
Cross Section A

FIG No: Appendix A, Figure 2a
REV. A



SCALE 1:2000

0 20 40 60 80 100 (m)

Notes:

1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

🟧 Alluvial Fan Deposit

🟪 Lake Sediment

🟩 Outwash Deposits

🟦 Glacial Till

- -▽- - Indicative Groundwater Level

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RCL Homestead Bay Limited

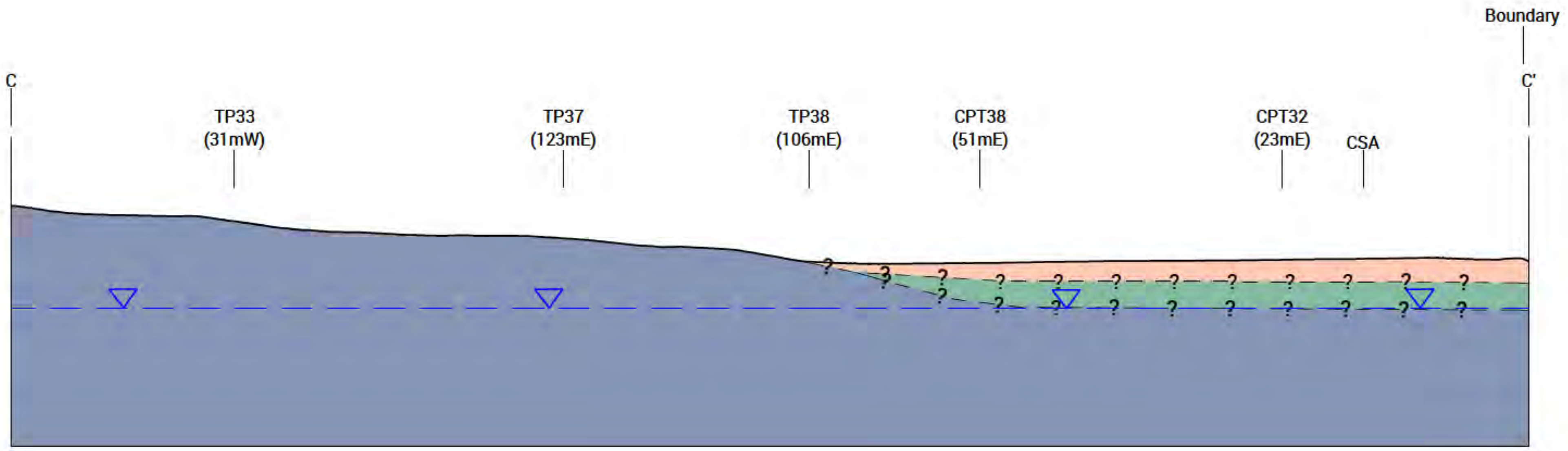
Homestead Bay

Geotechnical Assessment

Cross Section B

FIG No: Appendix A, Figure 2b

REV. A



SCALE 1:2000

0 20 40 60 80 100 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- 🟩 Outwash Deposits
- 🟦 Glacial Till
- – –▽– – Indicative Groundwater Level

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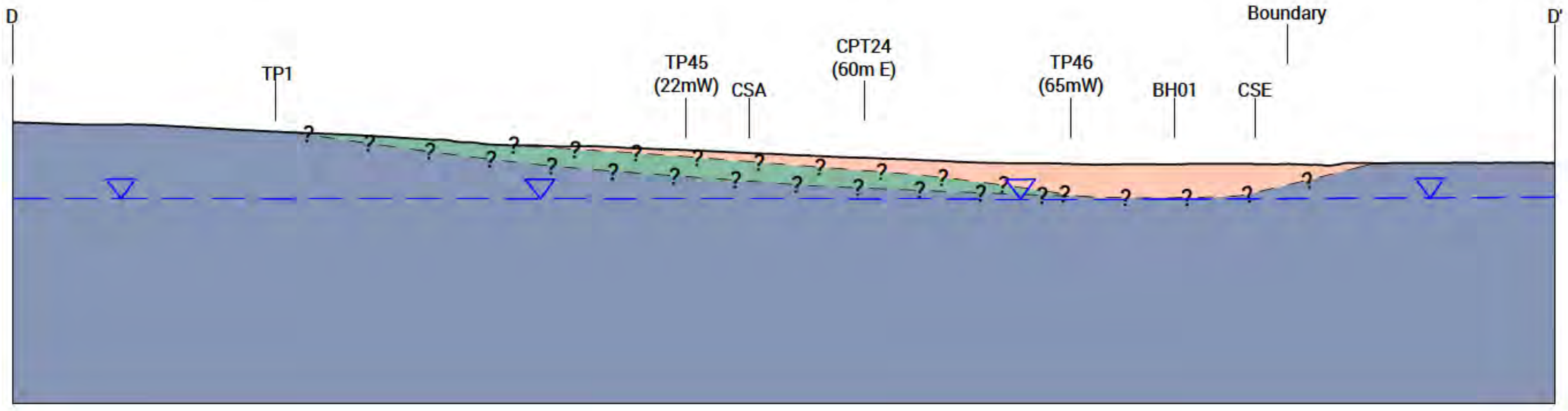
Geotechnical Assessment
Cross Section C

FIG No: Appendix A, Figure 2c

REV. A



SCALE 1:2000
0 20 40 60 80 100 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
🟧 Alluvial Fan Deposit
🟩 Outwash Deposits
🟦 Glacial Till
- -▽- - Indicative Groundwater Level

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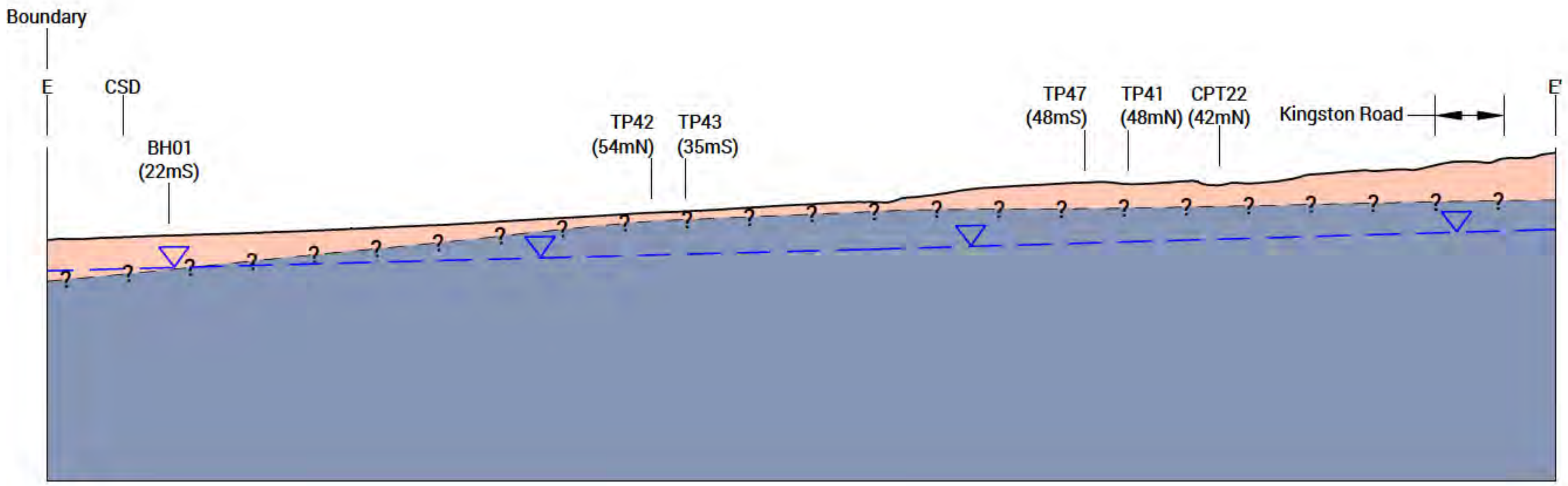
RCL Homestead Bay Limited
Homestead Bay
Geotechnical Assessment
Cross Section D

FIG No: Appendix A, Figure 2d
REV. A



SCALE 1:2000

0 20 40 60 80 100 (m)

Notes:
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Legend:

▨ Alluvial Fan Deposit

▨ Glacial Till

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SCALES (AT A3 SIZE): 1:2000

PROJECT No: 220556.01

RCL Homestead Bay Limited

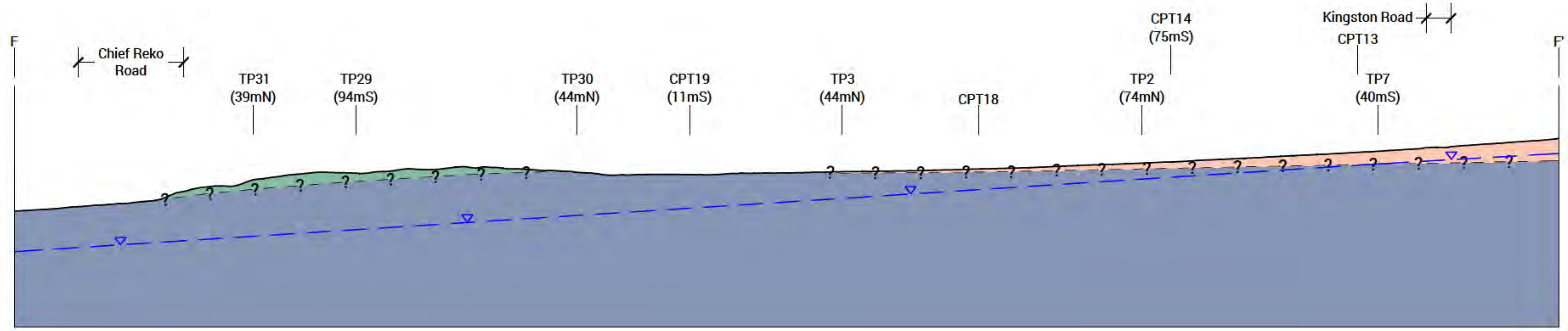
Homestead Bay

Geotechnical Assessment

Cross Section E

FIG No: Appendix A, Figure 2e

REV. A



SCALE 1:4000

0 40 80 120 160 200 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- 🟩 Outwash Deposits
- 🟦 Glacial Till
- --▽-- Indicative Groundwater Level

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SCALES (AT A3 SIZE): 1:4000

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RCL Homestead Bay Limited

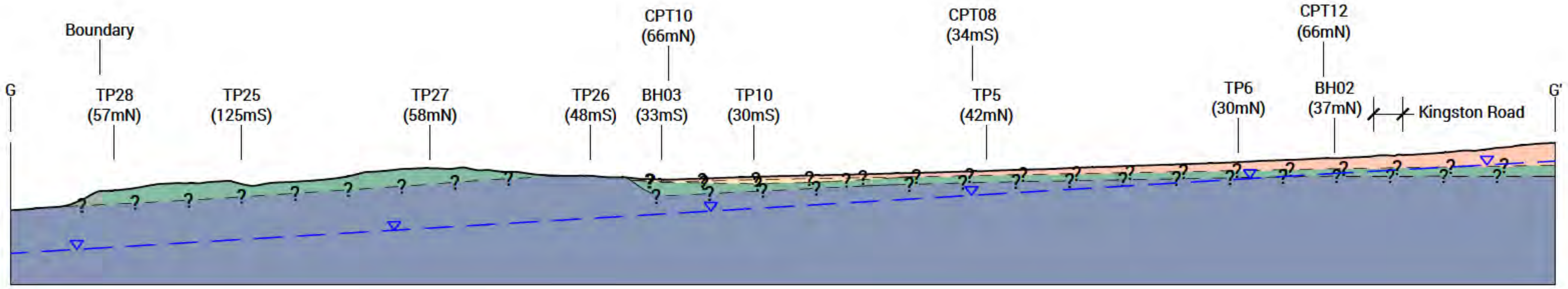
Homestead Bay

Geotechnical Assessment

Cross Section F

FIG No: Appendix A, Figure 2f

REV. A



SCALE 1:4000

0 40 80 120 160 200 (m)

Notes:

1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

- 🟥 Alluvial Fan Deposit
- 🟨 Glacial Pond Sediment
- 🟩 Outwash Deposits
- 🟦 Glacial Till
- – –▽– – Indicative Groundwater Level

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CADFILE:
220556.01-I (WF).dwg

SCALES (AT A3 SIZE):
1:4000

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RCL Homestead Bay Limited

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Geotechnical Assessment

Cross Section G

FIG No:
Appendix A, Figure 2g

REV.
A

SCALE 1:1000

0 10 20 30 40 50 (m)

Notes:

1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

🟩 Outwash Deposits

🟦 Glacial Till

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SCALES (AT A3 SIZE): 1:1000

PROJECT No: 220556.01

RCL Homestead Bay Limited

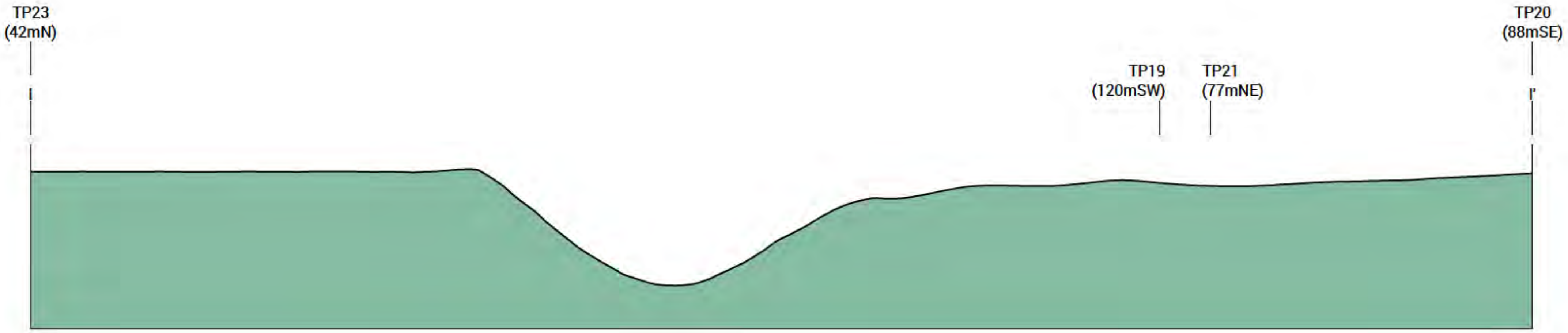
Homestead Bay

Geotechnical Assessment

Cross Section H

FIG No: Appendix A, Figure 2h

REV. A



SCALE 1:750
0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
🟩 Outwash Deposits

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SCALES (AT A3 SIZE): 1:750
PROJECT No: 220556.01

RCL Homestead Bay Limited
Homestead Bay
Geotechnical Assessment
Cross Section I

FIG No: Appendix A, Figure 2i
REV. A

SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:

1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

🟩 Outwash Deposits

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SCALES (AT A3 SIZE):
1:750

PROJECT No:
220556.01

RCL Homestead Bay Limited

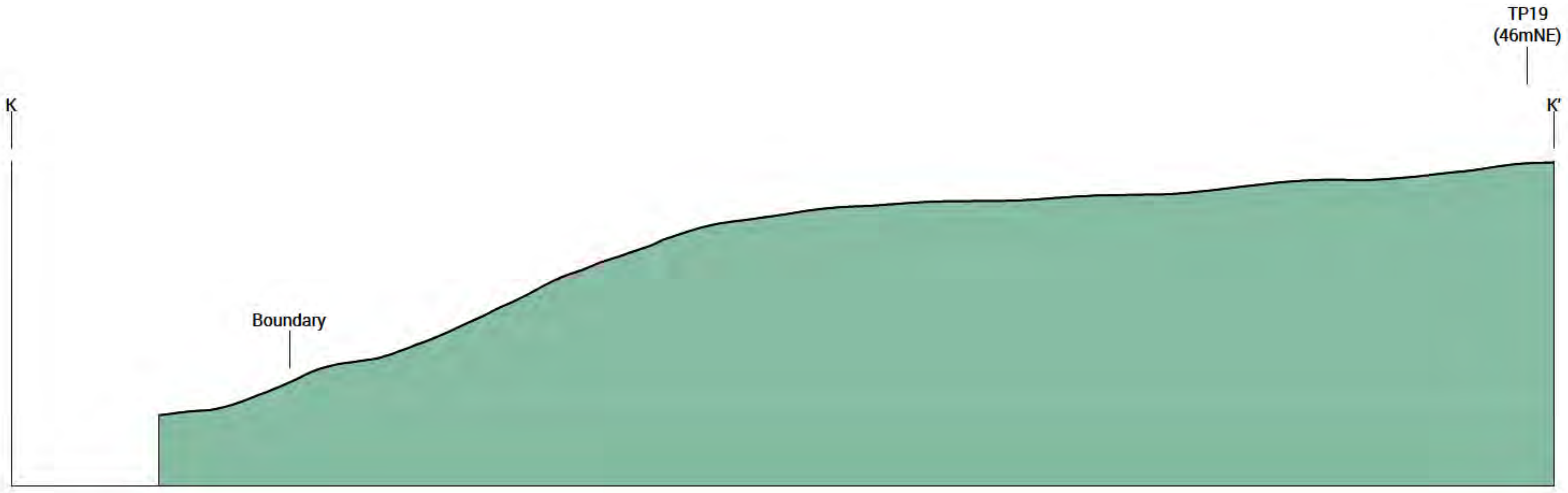
Homestead Bay

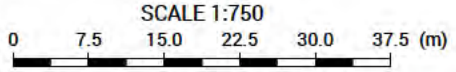
Geotechnical Assessment

Cross Section J

FIG No:
Appendix A, Figure 2j

REV.
A





Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
🟩 Outwash Deposits

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CADFILE:
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SCALES (AT A3 SIZE):
1:750

PROJECT No:
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RCL Homestead Bay Limited

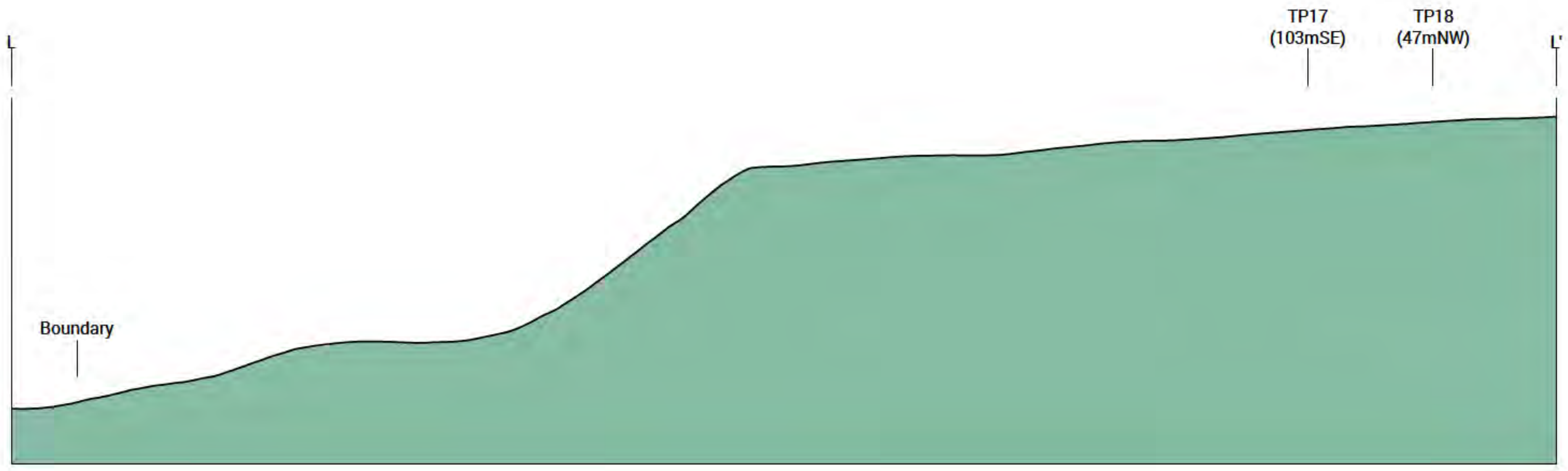
Homestead Bay

Geotechnical Assessment

Cross Section K

FIG No:
Appendix A, Figure 2k

REV.
A



Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
🟩 Outwash Deposits

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APPROVED	PF	Jan.25

CADFILE:
220556.01-I (WF).dwg

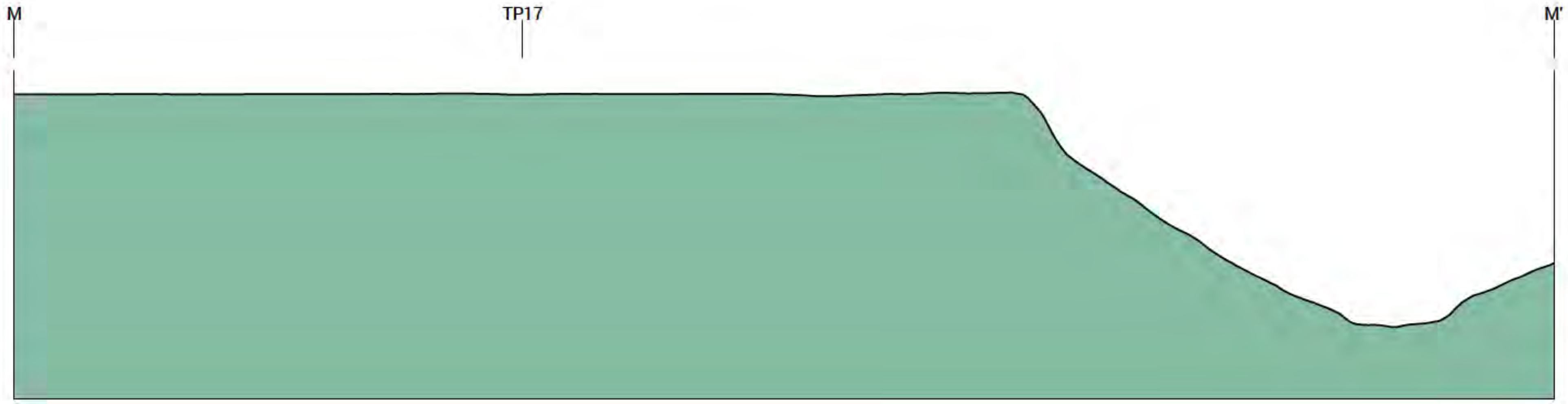
SCALES (AT A3 SIZE):
1:750

PROJECT No:
220556.01

RCL Homestead Bay Limited
Homestead Bay
Geotechnical Assessment
Cross Section L

FIG No:
Appendix A, Figure 2I

REV.
A



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

🟩 Outwash Deposits

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SCALES (AT A3 SIZE): 1:750

PROJECT No: 220556.01

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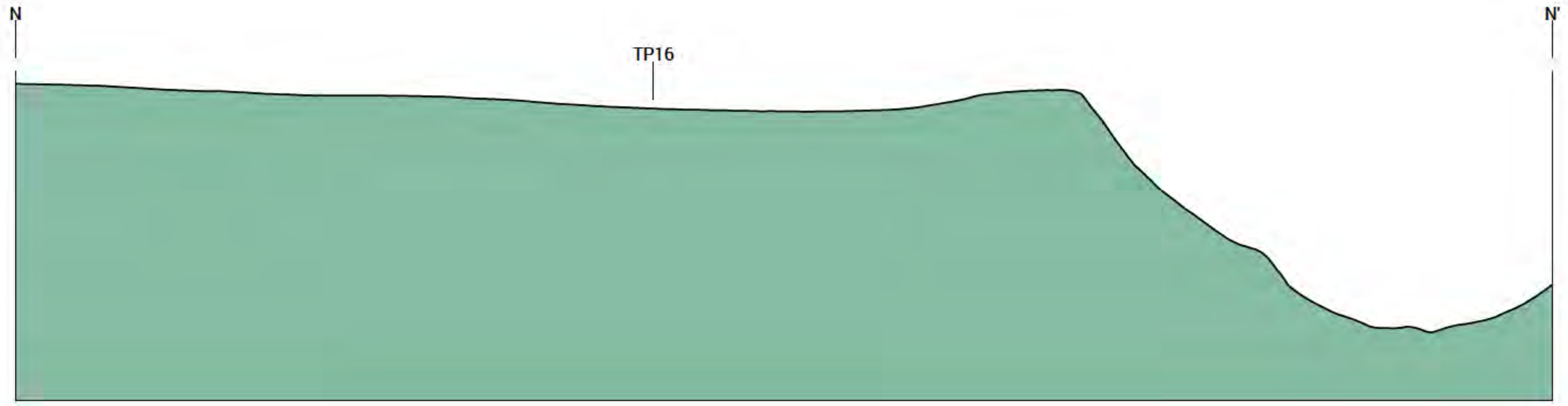
Homestead Bay

Geotechnical Assessment

Cross Section M

FIG No: Appendix A, Figure 2m

REV. A



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
🟩 Outwash Deposits

GEOSOLVE

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DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:750

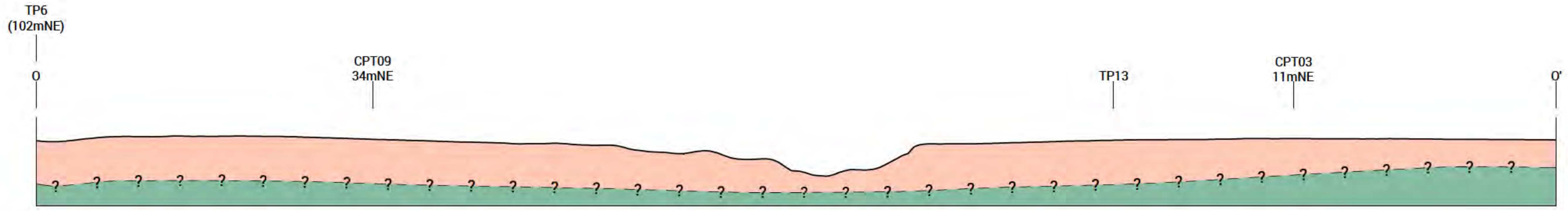
PROJECT No: 220556.01

RCL Homestead Bay Limited

Homestead Bay
Geotechnical Assessment
Cross Section N

FIG No: Appendix A, Figure 2n

REV. A



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- 🟩 Outwash Deposits

GEOSOLVE

Level 1, 70 MacAndrew Road, South Dunedin
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DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:750

PROJECT No: 220556.01

RCL Homestead Bay Limited

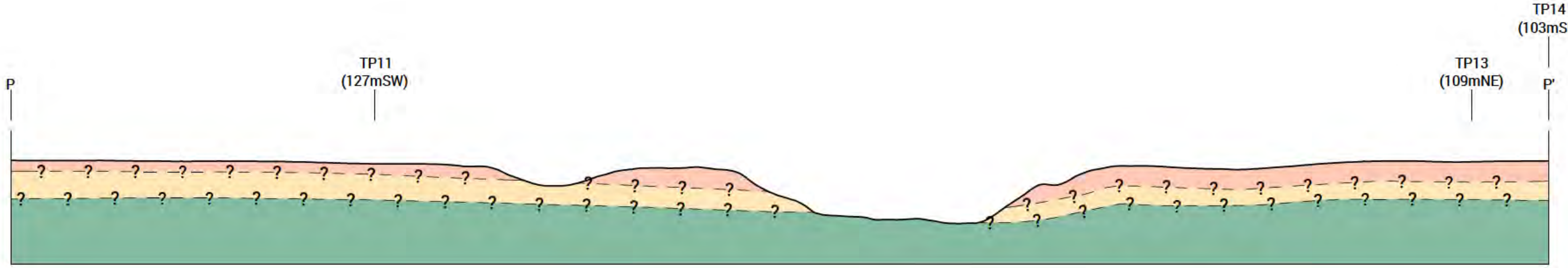
Homestead Bay

Geotechnical Assessment

Cross Section O

FIG No: Appendix A, Figure 2o

REV. A



SCALE 1:750

0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟥 Alluvial Fan Deposit
- 🟩 Outwash Deposits
- 🟦 Glacial Till

GEOSOLVE

Level 1, 70 MacAndrew Road, South Dunedin
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DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:750

PROJECT No: 220556.01

RCL Henley Downs Limited

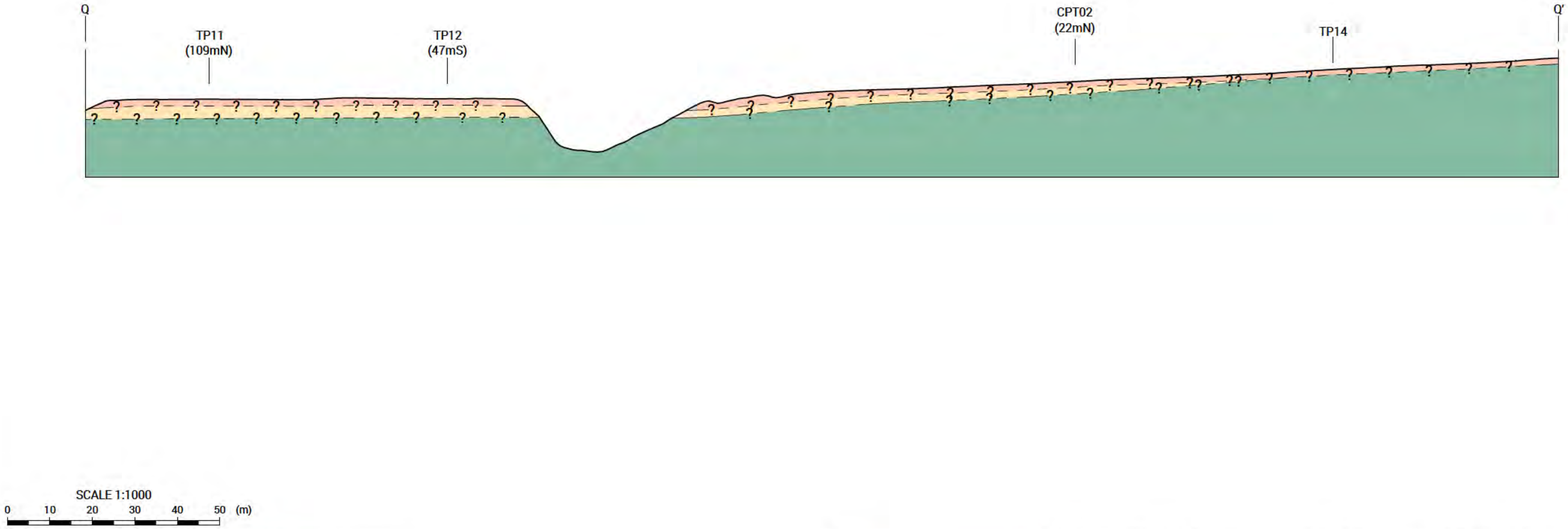
Homestead Bay

Geotechnical Assessment

Cross Section P

FIG No: Appendix A, Figure 2p

REV. A



Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- 🟨 Glacial Pond Sediment
- 🟩 Outwash Deposits

GEOSOLVE

Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:1000

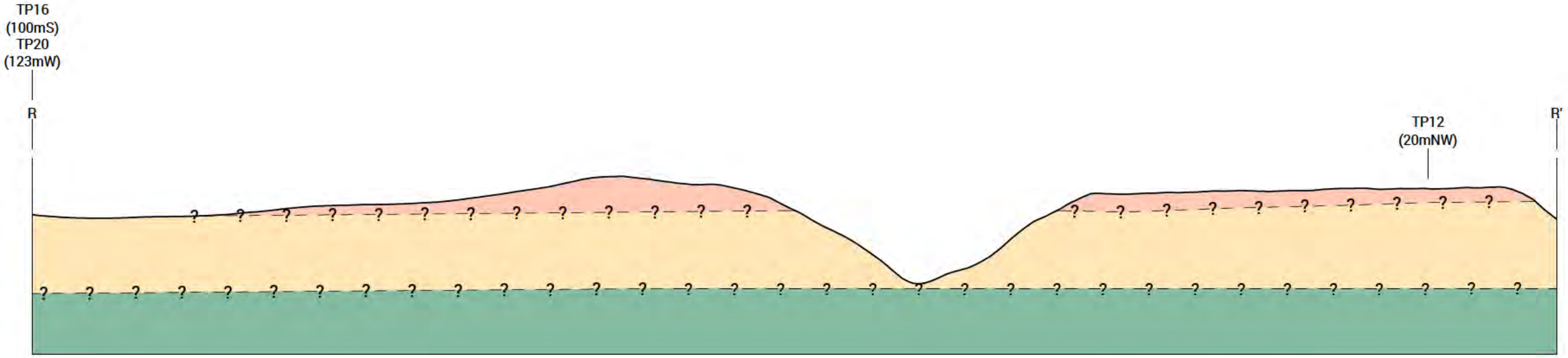
PROJECT No: 220556.01

RCL Homestead Bay Limited

Homestead Bay
Geotechnical Assessment
Cross Section Q

FIG No: Appendix A, Figure 2q

REV. A



SCALE 1:500

0 5 10 15 20 25 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟥 Alluvial Fan Deposit
- 🟨 Glacial Pond Sediment
- 🟩 Outwash Deposits

GEOSOLVE

Level 1, 70 MacAndrew Road, South Dunedin
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DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:500

PROJECT No: 220556.01

RCL Homestead Bay Limited

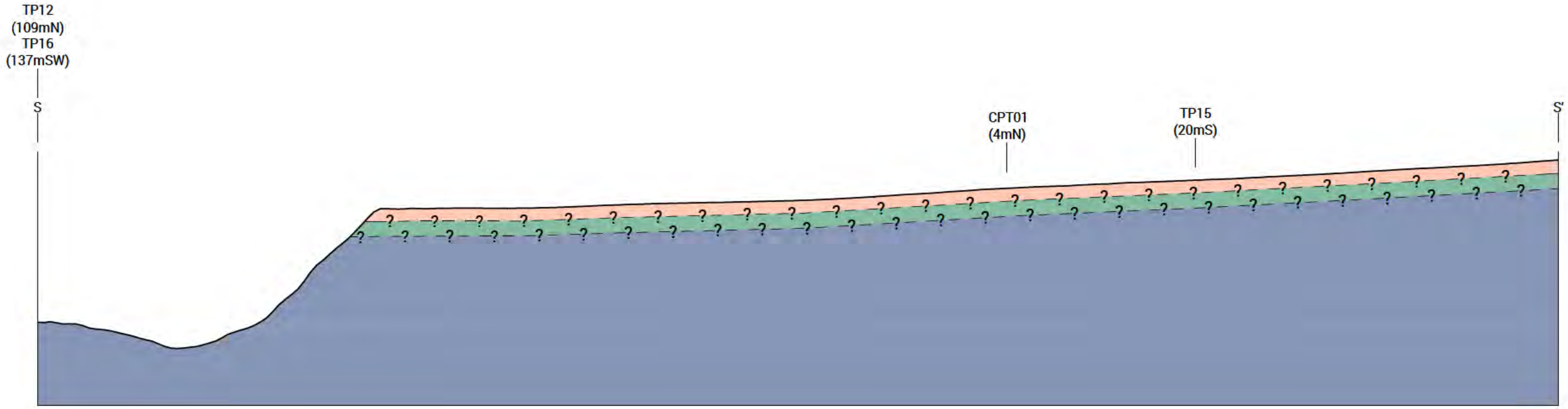
Homestead Bay

Geotechnical Assessment

Cross Section R

FIG No: Appendix A, Figure 2r

REV. A



SCALE 1:750
0 7.5 15.0 22.5 30.0 37.5 (m)

Notes:
1. These drawings have been prepared for the benefit of RCL Henley Downs Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:
- 🟧 Alluvial Fan Deposit
- 🟩 Outwash Deposits
- 🟦 Glacial Till

GEOSOLVE

Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

DRAWN	WCG	Jan.25
DRAFTING CHECKED	WF/JMJ	Jan.25
APPROVED	PF	Jan.25

CADFILE: 220556.01-I (WF).dwg

SCALES (AT A3 SIZE): 1:750

PROJECT No: 220556.01

RCL Homestead Bay Limited

Homestead Bay

Geotechnical Assessment

Cross Section S

FIG No: Appendix A, Figure 2s

REV. A

Appendix B: Investigation Data

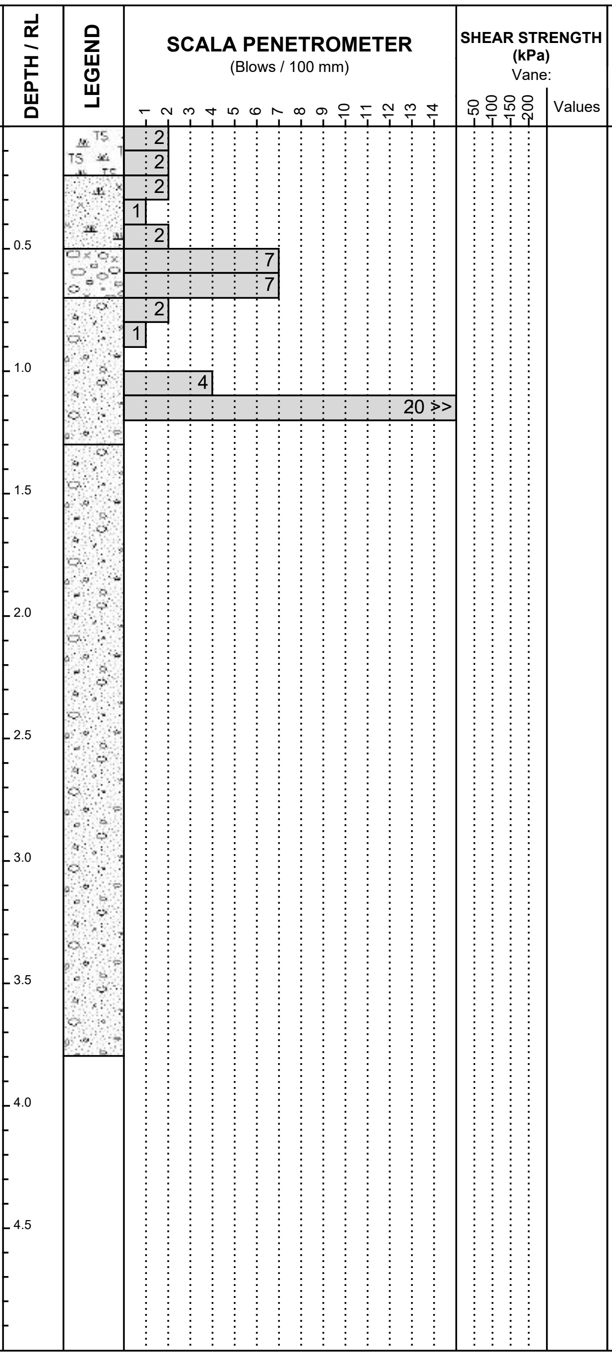
TEST PIT LOG

HOLE NO.: TP01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 22/10/2024
COORDINATES: 1265689.0 mE, 4998600.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 22/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty SAND, trace rootlets, brown.		0.20 m	Groundwater Not Encountered
LOESS	Silty fine SAND, with rootlets and organic inclusions, brownish orange, massive. Loose, moist.		0.50 m	
WEATHERED GLACIAL TILL	Sandy fine to coarse GRAVEL, with minor to some silt and trace cobbles, orange, massive. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.		0.70 m	
	Fine SAND, with trace to minor gravel and trace silt, 500 mm diameter boulder at 1.20 m, orange and grey, massive. Loose to medium dense, moist to wet.		1.30 m	
GLACIAL TILL	Fine to medium SAND, with minor gravel and trace cobbles and boulders up to 500 mm in diameter, light grey, massive. Dry to moist, gravels are fine to coarse, subrounded to rounded.		3.80 m	
	End Of Hole: 3.80 m			



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.: TP02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1265764.0 mE, 4998393.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

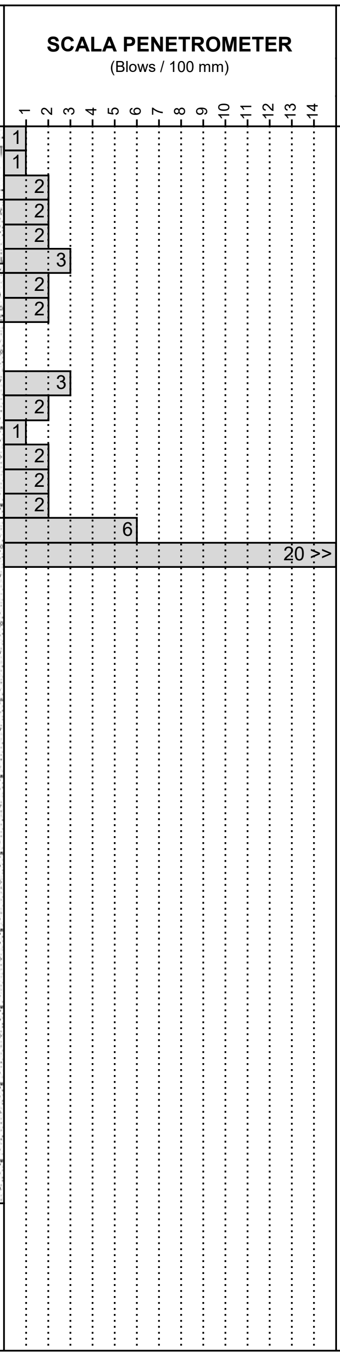
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Organic silty SAND, trace rootlets, orange and brown.	0.30 m
LOESS	Silty fine SAND, with rootlets and organic inclusions, brownish orange, massive. Loose, moist.	0.60 m
WEATHERED GLACIAL TILL	Sandy fine to coarse GRAVEL, with minor silt and trace cobbles, orange and grey, massive. Loose to medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	0.80 m
	Fine SAND, with trace to minor gravel and trace silt and boulders up to 400 m in diameter, orange and grey, massive. Loose, moist, gravels are fine to medium, subrounded to rounded.	1.60 m
GLACIAL TILL	Fine to coarse SAND, with minor gravel, trace cobbles and boulders up to 300 mm in diameter, light grey, massive. Dense, dry to moist, gravels are fine to coarse, subrounded to rounded.	4.40 m
	End Of Hole: 4.40 m	

SAMPLES | **DEPTH / RL** | **LEGEND**

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 | Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP03

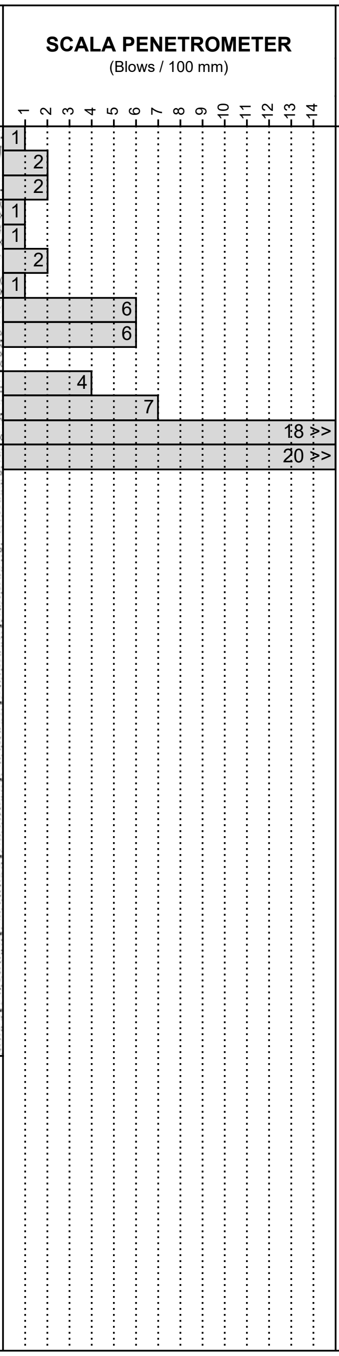
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1265515.0 mE, 4998365.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty SAND, trace rootlets, brown.		0.30 m	Groundwater Not Encountered
ALLUVIAL FAN DEPOSITS	SILT, with trace organic inclusions, grey. Firm, moist.		0.70 m	
	Sandy, silty fine to coarse GRAVEL, brown and grey, chaotic. Medium dense, moist to wet, gradual top and bottom contacts, gravels are subrounded to rounded. Sand is coarse.		1.00 m	
	Sandy fine to coarse GRAVEL, orange, chaotic. Medium dense, moist, immediate contact at base, gravels are subrounded to rounded. Sand is coarse.		1.30 m	
GLACIAL TILL	Fine to coarse SAND, with minor gravel and trace cobbles and boulders, grey, massive, with orange banding decreasing with depth. Dense, moist, gravels are fine to coarse, subrounded to rounded.		3.80 m	
	End Of Hole: 3.80 m			



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP04

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

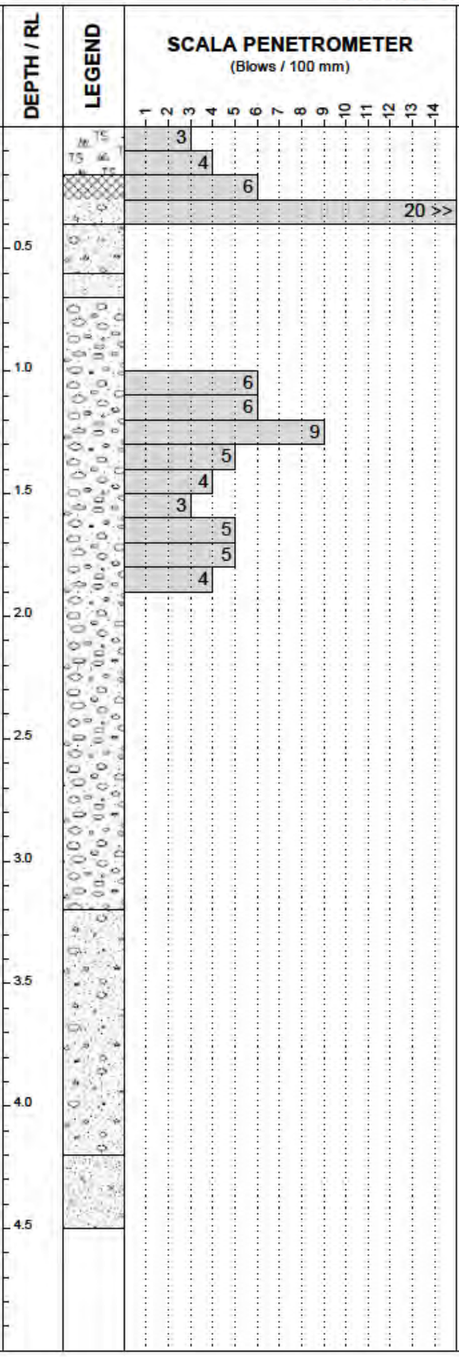
SITE LOCATION: Queenstown
COORDINATES: 1265567.0 mE, 4998235.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 22/10/2024
END DATE: 22/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic silty SAND, trace rootlets, brown.	0.20 m
UNCONTROLLED FILL	Silty, sandy fine to coarse GRAVEL, with fragments of steel, dark orange. Dry to moist, gravels are rounded. Sand is fine to medium .	0.40 m
OUTWASH DEPOSITS	Fine to coarse SAND, with minor gravel and trace silt, grey and orange, loosely bedded. Medium dense, moist, gravels are fine to coarse, rounded.	0.60 m
	Coarse SAND, grey, bedded. Medium dense, moist.	0.70 m
	Sandy fine to coarse GRAVEL, trace cobbles, with some beds of gravel with trace sand, grey and orange, bedded. Medium dense, moist, dipping between 5-10° towards 222°, gravels are subrounded to rounded. Sand is fine to coarse.	3.20 m
	Gravelly fine to coarse SAND, with beds of coarse sand, grey, bedded. Medium dense, moist, dipping between 5-10° towards 222°, gravels are fine to coarse, subrounded to rounded.	4.20 m
GLACIAL TILL	Silty SAND, with trace gravel, grey. Medium dense, moist to wet, horizontal contact, gravels are fine to medium, subrounded to rounded.	4.50 m
	End Of Hole: 4.50 m	

SAMPLES | **DEPTH / RL** | **LEGEND** | **SCALA PENETROMETER** (Blows / 100 mm) | **SHEAR STRENGTH** (kPa) Vane: | Values | **WATER**



50
100
150
200

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit collapsing in coarser gravels

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP05

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 22/10/2024
COORDINATES: 1265714.0 mE, 4998126.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with trace to minor fine sand, dark grey, with brown staining, trace laminations. Firm, moist, low plasticity.	1.50 m
	Sandy SILT, dark grey, trace laminations. Firm to stiff, moist, low plasticity, sand is fine.	4.50 m
	End Of Hole: 4.50 m	

SCALA PENETROMETER (Blows / 100 mm)

DEPTH / RL	Blows
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	2
0.4–0.5	2
0.5–0.6	2
0.6–0.7	2
0.7–0.8	2
0.8–0.9	2
0.9–1.0	
1.0–1.1	1
1.1–1.2	1
1.2–1.3	2
1.3–1.4	2
1.4–1.5	3
1.5–1.6	4
1.6–1.7	4
1.7–1.8	4
1.8–1.9	4

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP06

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 22/10/2024

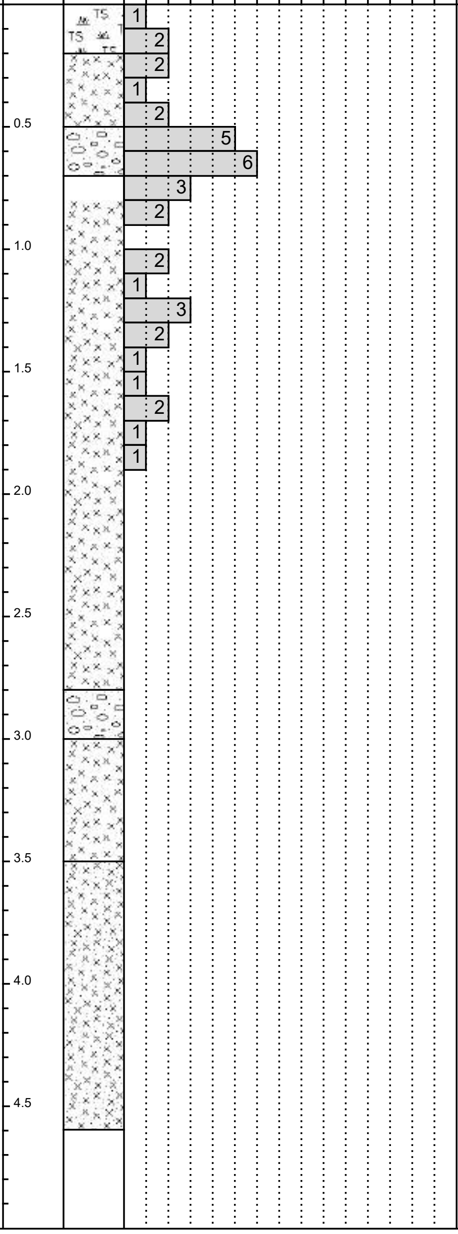
COORDINATES: 1265891.0 mE, 4998119.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with trace gravel and fine sand, dark grey, laminated. Firm, moist, low plasticity.	0.50 m
	Sandy fine to coarse GRAVEL, dark grey. Medium dense, moist, gravels are rounded. Sand is medium to coarse.	0.70 m
	SILT, with trace gravel and fine sand, dark grey, with brown mottling. Loose to medium dense, moist.	2.80 m
	Sandy fine to coarse GRAVEL, with trace cobbles and boulders up to 200 mm in diameter, dark grey. Moist, gravels are rounded. Sand is medium to coarse.	3.00 m
	SILT, with trace gravel and fine sand, dark grey, with brown mottling, trace laminations. Loose to medium dense, moist.	3.50 m
	Sandy SILT, grey. Firm to stiff, moist to wet, low plasticity, sand is fine.	4.60 m
	End Of Hole: 4.60 m	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP07

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 22/10/2024
COORDINATES: 1265959.0 mE, 4998281.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 22/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown. 0.20 m	
ALLUVIAL FAN DEPOSITS	SILT, with trace to minor fine sand, dark grey. Firm to stiff, moist, low plasticity. 0.40 m	
	Silty fine to coarse GRAVEL, trace sand, dark grey. Medium dense, moist, gravels are subrounded to rounded. 0.65 m	
	Sandy fine to coarse GRAVEL, with trace silt, dark grey. Medium dense, moist, gravels are subrounded to rounded. 0.70 m	
	SILT, with minor fine sand, dark grey. Firm to stiff, moist, low plasticity. 1.20 m	
	Sandy fine to coarse GRAVEL, trace silt, dark grey. Medium dense, moist, dipping at 5° towards 225°, gravels are subrounded to rounded. 1.60 m	
	SILT, with minor fine sand, dark grey. Firm to stiff, moist, low plasticity. 3.50 m	
	Sandy SILT, grey. Firm to stiff, moist to wet, low plasticity, sand is fine. 4.20 m	
	Sandy fine to coarse GRAVEL, trace silt, dark grey. Medium dense, saturated, dipping at 5° towards 225°, gravels are subrounded to rounded. 4.40 m	◁ 22/10/2024
	Sandy SILT, grey. Firm to stiff, saturated, low plasticity, sand is fine. 4.80 m	
	End Of Hole: 4.80 m	

SAMPLES

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

DEPTH / RL	SCALA PENETROMETER (Blows / 100 mm)
0.0–0.1	1
0.1–0.2	1
0.2–0.3	2
0.3–0.4	1
0.4–0.5	2
0.5–0.6	3
0.6–0.7	3
0.7–0.8	3
0.8–0.9	1
0.9–1.0	
1.0–1.1	1
1.1–1.2	1
1.2–1.3	3
1.3–1.4	10
1.4–1.5	9
1.5–1.6	3
1.6–1.7	3
1.7–1.8	3

PHOTO(S)

REMARKS

Target depth achieved. Pit walls collapsing below 4.2 m

WATER

▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.: TP08

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

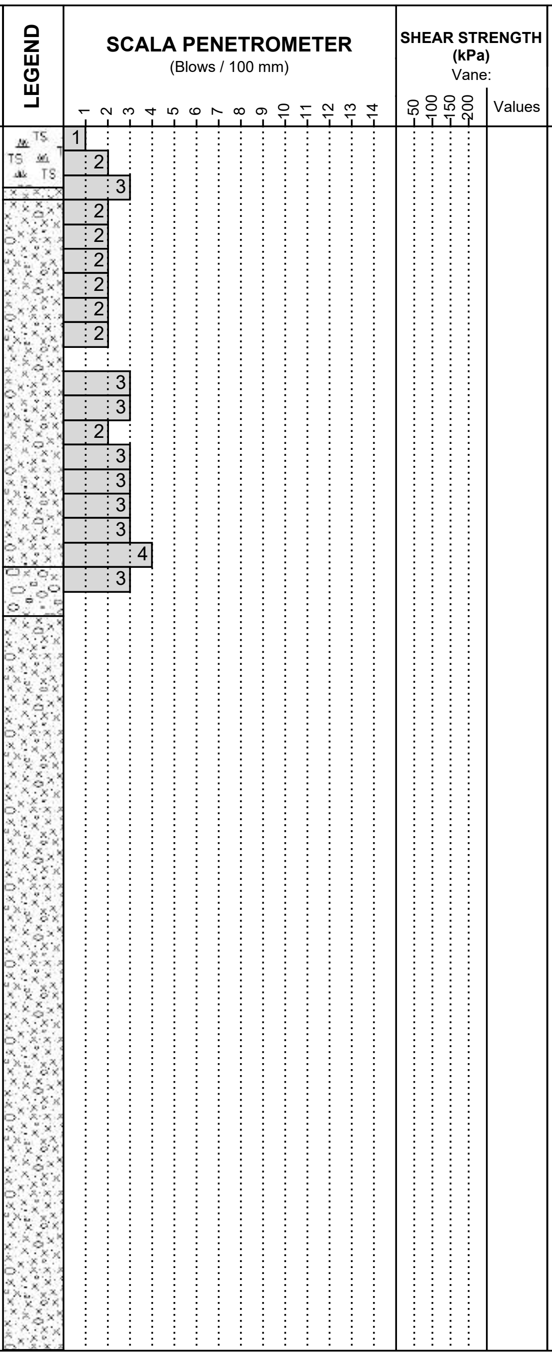
SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 22/10/2024

COORDINATES: 1265942.0 mE, 4998418.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)		SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.25 m			Groundwater Not Encountered
ALLUVIAL FAN DEPOSITS	Sandy SILT, with trace gravel, light grey. Stiff, moist.	0.30 m			
	SILT, with trace to minor sand, dark grey, discontinuous 100 mm sandy gravel layer at 1.50 m. Firm to stiff, moist, sand is fine.	1.80 m		0.5 1.0 1.5	
	Sandy fine to coarse GRAVEL, with minor silt, dark grey. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	2.00 m		2.0	
	SILT, with some fine sand, grey with brown mottling, occasional discontinuous sandy gravel layers. Stiff, moist.			2.5 3.0 3.5 4.0 4.5	
	End Of Hole: 5.00 m	5.00 m			



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

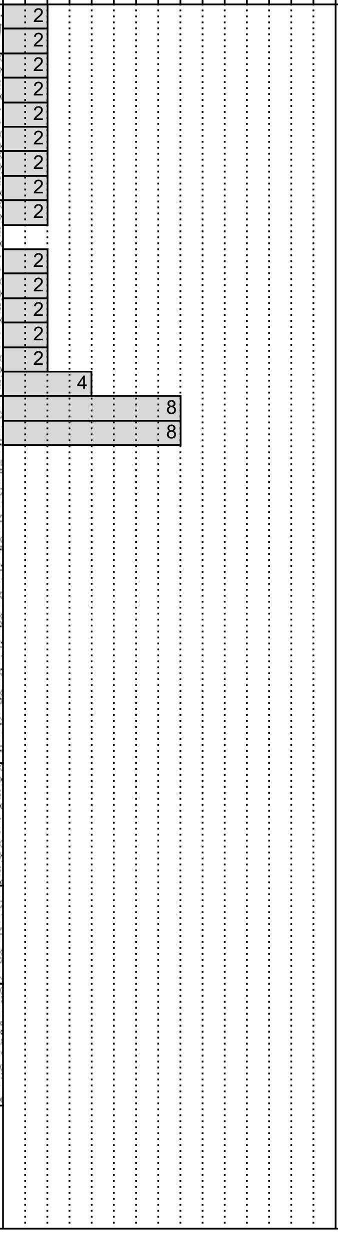
HOLE NO.: TP09

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 22/10/2024
COORDINATES: 1265867.0 mE, 4998529.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 22/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with minor fine sand, dark grey. Firm, moist, low plasticity.	0.60 m
	Sandy SILT, with trace gravel, light grey. Firm, moist, gravels are fine to medium, subrounded to rounded. Sand is fine.	0.80 m
	SILT, with minor sand, dark grey, mottled orange. Firm, moist, low plasticity, sand is fine.	1.60 m
	Sandy fine to coarse GRAVEL, with trace silt, cobbles and boulders, dark grey, mottled orange. Medium dense, saturated, gravels are subrounded to rounded. Sand is fine to coarse.	3.10 m
	SILT, with minor sand, grey. Firm, saturated, low plasticity, sand is fine.	3.60 m
	Sandy fine to coarse GRAVEL, with trace silt, cobbles and boulders, dark grey, mottled orange. Medium dense, saturated, gravels are subrounded to rounded. Sand is fine to coarse.	4.00 m
GLACIAL TILL	SILT, with trace to minor sand and gravel, light grey. Very stiff, moist, sand is fine to medium. Gravels are fine and subrounded.	4.50 m
	End Of Hole: 4.50 m	

SCALA PENETROMETER (Blows / 100 mm)



Depth (m)	Blows / 100 mm
0.0–0.1	2
0.1–0.2	2
0.2–0.3	2
0.3–0.4	2
0.4–0.5	2
0.5–0.6	2
0.6–0.7	2
0.7–0.8	2
0.8–0.9	2
1.0–1.1	2
1.1–1.2	2
1.2–1.3	2
1.3–1.4	2
1.4–1.5	2
1.5–1.6	4
1.6–1.7	8
1.7–1.8	8

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: In flow at 3.10 m, 22/10/2024

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP10

CLIENT: RCL Homestead Bay Ltd

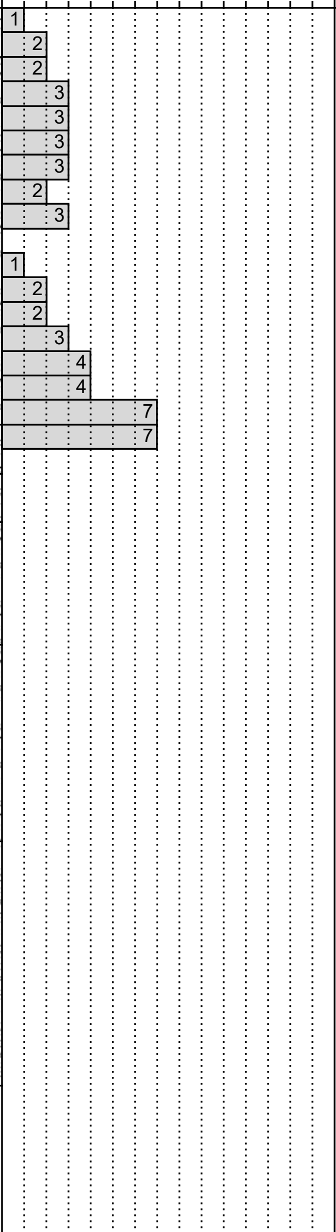
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 23/10/2024
COORDINATES: 1265552.0 mE, 4998050.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 23/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with minor sand, dark grey. Firm, dry to moist, low plasticity, sand is fine.	1.70 m
	Sandy fine to coarse GRAVEL, with trace silt, dark brownish grey. Moist, gravels are subrounded. Sand is fine.	1.90 m
	Sandy fine to coarse GRAVEL, trace silt, brownish grey. Medium dense, moist, gravels are mostly fine to medium and subrounded.	2.10 m
GLACIAL POND SEDIMENT	SILT, with trace fine sand, grey. Stiff, dry, low plasticity, friable.	2.60 m
	SILT, trace rootlets, grey, massive. Very stiff, dry, low plasticity, powdery texture.	3.40 m
	Fine SAND, with minor silt and trace gravel, white and grey, massive. Hard, moist, gravels are medium to coarse, rounded.	4.40 m
	End Of Hole: 4.40 m	

SCALA PENETROMETER (Blows / 100 mm)



0.0–0.1 m	1
0.1–0.2 m	2
0.2–0.3 m	2
0.3–0.4 m	3
0.4–0.5 m	3
0.5–0.6 m	3
0.6–0.7 m	3
0.7–0.8 m	2
0.8–0.9 m	3
1.0–1.1 m	1
1.1–1.2 m	2
1.2–1.3 m	2
1.3–1.4 m	3
1.4–1.5 m	4
1.5–1.6 m	4
1.6–1.7 m	7
1.7–1.8 m	7

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:21:05 am

TEST PIT LOG

HOLE NO.: TP11

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 23/10/2024

COORDINATES: 1265674.0 mE, 4997797.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Organic sandy SILT, trace rootlets, blackish brown.	0.20 m
ALLUVIAL FAN DEPOSITS	SILT, with trace fine sand, brownish grey. Firm, dry to moist, low plasticity.	0.50 m
	SILT, with trace fine sand, greyish brown. Firm, dry to moist, low plasticity.	1.60 m
GLACIAL POND SEDIMENT	Fine SAND, with trace silt, light grey and orange banding, minor laminations, interbedded with 10-50 mm of silt bands. Medium dense, moist.	4.60 m
	End Of Hole: 4.60 m	

SCALA PENETROMETER (Blows / 100 mm)

DEPTH / RL	Blows
0.0–0.1	1
0.1–0.2	1
0.2–0.3	2
0.3–0.4	2
0.4–0.5	2
0.5–0.6	3
0.6–0.7	3
0.7–0.8	3
0.8–0.9	3
0.9–1.0	
1.0–1.1	2
1.1–1.2	1
1.2–1.3	2
1.3–1.4	2
1.4–1.5	2
1.5–1.6	6
1.6–1.7	6
1.7–1.8	7
1.8–1.9	7

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP12

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1265739.0 mE, 4997644.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 23/10/2024
END DATE: 23/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Base depth
TOPSOIL	Organic sandy SILT, trace rootlets, dark brown.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, with trace fine sand, brownish grey. Firm, dry to moist, low plasticity.	0.60 m
	SILT, with trace fine sand, grey. Firm, dry to moist, low plasticity.	0.70 m
	SILT, with trace fine sand, with organic staining, brown. Firm, dry to moist, low plasticity.	0.75 m
	SILT, with trace fine sand, grey. Firm, dry to moist, low plasticity.	1.40 m
GLACIAL POND SEDIMENT	Sandy fine to medium GRAVEL, grey, bedded. Loose to medium dense, dry to moist, gravels are subrounded to rounded. Sand is medium to coarse.	1.60 m
	Fine SAND, with trace silt, light grey, minor laminations within silt. Loose to medium dense, dry to moist, pockets of sandy gravel at base contact.	3.10 m
	Sandy, fine to coarse GRAVEL, grey, bedded. Medium dense, dry to moist, gravels are subrounded to rounded. Sand is fine to coarse.	3.50 m
	Silty, fine SAND, grey, bedded. Medium dense, dry to moist.	4.40 m
	End Of Hole: 4.40 m	

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	2
0.1–0.2	3
0.2–0.3	3
0.3–0.4	3
0.4–0.5	3
0.5–0.6	2
0.6–0.7	3
0.7–0.8	3
0.8–0.9	3
1.0–1.1	2
1.1–1.2	3
1.2–1.3	3
1.3–1.4	3
1.4–1.5	3
1.5–1.6	3
1.6–1.7	3
1.7–1.8	3
1.8–1.9	3

SHEAR STRENGTH (kPa) Vane: Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP13

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

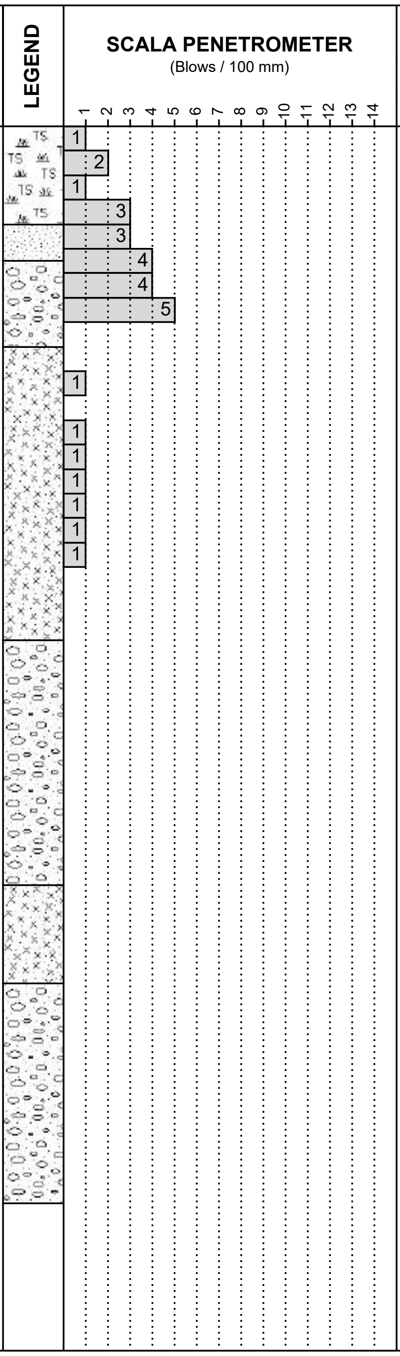
SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 23/10/2024

COORDINATES: 1265951.0 mE, 4997874.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Sandy organic SILT, trace rootlets, blackish brown.		0.40 m
ALLUVIAL FAN DEPOSITS	Fine to medium SAND, with trace silt and organic inclusions, greyish brown. Loose, moist.		0.55 m
	Sandy GRAVEL, trace silt and rootlets, greyish brown. Loose, moist.		0.90 m
	SILT, with trace to minor sand, greyish brown. Firm, moist to wet, low plasticity, sand is fine.		2.10 m
	Sandy fine to coarse GRAVEL, trace silt and cobbles, greyish brown. Medium dense, moist, dipping gently to 261°, gravels are subrounded. Sand is fine to coarse.		3.10 m
	SILT, with trace to minor sand, greyish brown. Firm, moist to wet, low plasticity, sand is fine.		3.50 m
	Sandy fine to coarse GRAVEL, trace silt and cobbles, greyish brown. Medium dense, moist, dipping gently to 261°, gravels are subrounded. Sand is fine to coarse.		4.40 m
	End Of Hole: 4.40 m		



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

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TEST PIT LOG

HOLE NO.: TP14

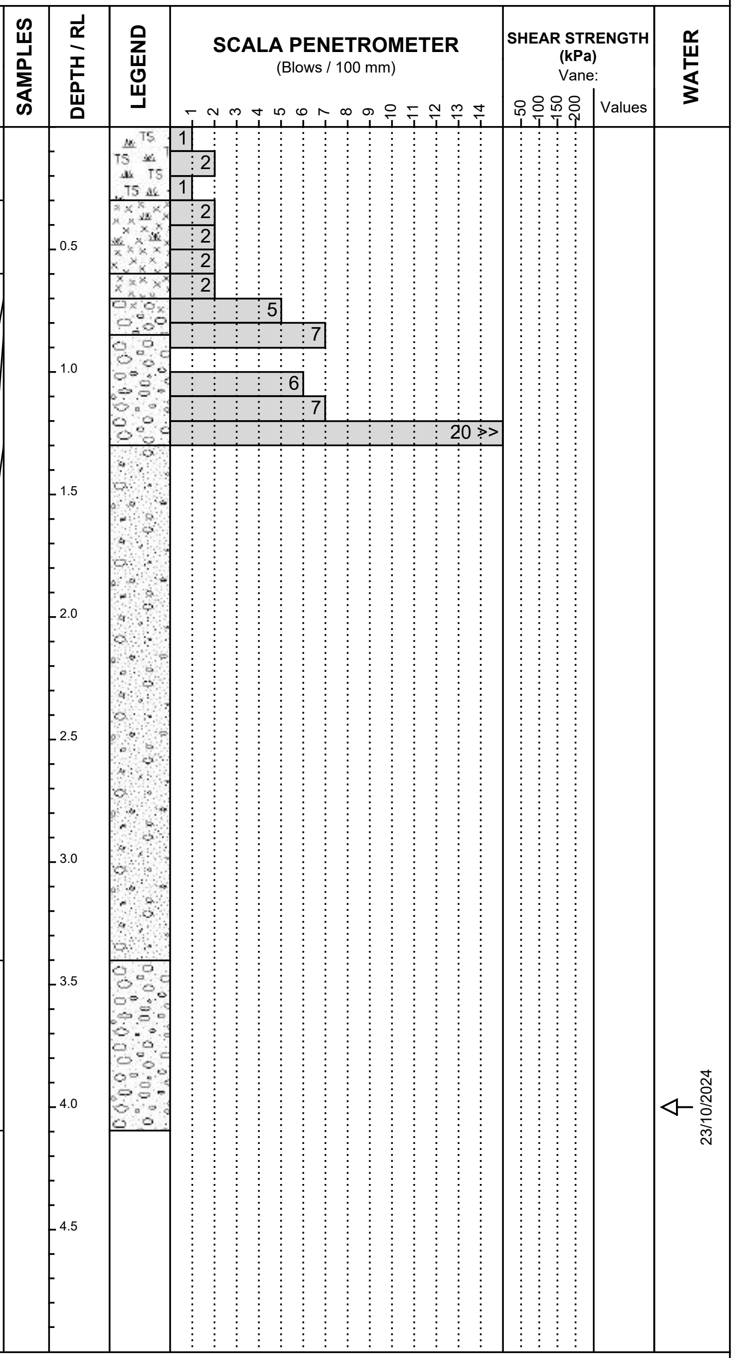
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	23/10/2024
COORDINATES:	1265945.0 mE, 4997695.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	23/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Sandy organic SILT, minor rootlets, blackish brown.	0.30 m
ALLUVIAL FAN DEPOSITS	Slightly organic SILT, blackish brown. Firm, moist, low plasticity.	0.60 m
	SILT, with trace sand and gravel, brown orange. Firm, moist, low plasticity, sand is fine. Gravels are fine to medium, subrounded.	0.70 m 0.85 m
	Sandy, silty fine to coarse GRAVEL, with trace cobbles and boulders up to 400 mm in diameter, brown orange. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to coarse.	1.30 m
	Sandy, fine to coarse GRAVEL, with trace silt, brown orange. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to coarse.	
GLACIAL TILL	Fine to coarse SAND, with minor gravel, trace cobbles and boulders up to 400 mm in diameter, light whitish grey, massive. Dense, dry to moist, gravels are subrounded to rounded.	3.40 m
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, trace cobbles and boulders up to 500 mm in diameter, orange grey, massive. Medium dense to dense, dry to moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.10 m
	End Of Hole: 4.10 m	



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:21:25 am

TEST PIT LOG

HOLE NO.: TP15

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	23/10/2024
COORDINATES:	1265934.0 mE, 4997527.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	23/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Sandy organic SILT, minor rootlets, blackish brown.	0.30 m
ALLUVIAL FAN DEPOSITS	SILT, trace sand and organic inclusions, greyish brown. Firm, moist, low plasticity, sand is fine.	0.50 m
	Sandy, silty, fine GRAVEL, brownish grey. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to medium.	0.60 m 0.70 m 0.80 m
	Silty, fine SAND, grey. Medium dense, moist.	
	Sandy, silty, fine GRAVEL, brownish grey. Medium dense, moist, gravels are subangular to subrounded. Sand is fine to medium.	
	Fine SAND, with minor silt, grey. Loose, wet, sand is fine.	1.30 m
	Silty, fine SAND, grey. Medium dense, wet.	1.70 m
	Fine to medium SAND, grey, bedded. Loose, wet.	2.00 m
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL, with trace cobbles and boulders up to 400 mm in diameter, brown, bedded. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.40 m
GLACIAL TILL	Fine to medium SAND, with minor gravel, whitish grey, massive. Dense, dry to moist, gravels are fine to coarse, rounded.	4.80 m
	End Of Hole: 4.80 m	

SCALA PENETROMETER (Blows / 100 mm)

1
1
2
2
2
4
2
4
2
1
3
2
3
3
3
3
3
3

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

TEST PIT LOG

HOLE NO.: TP16

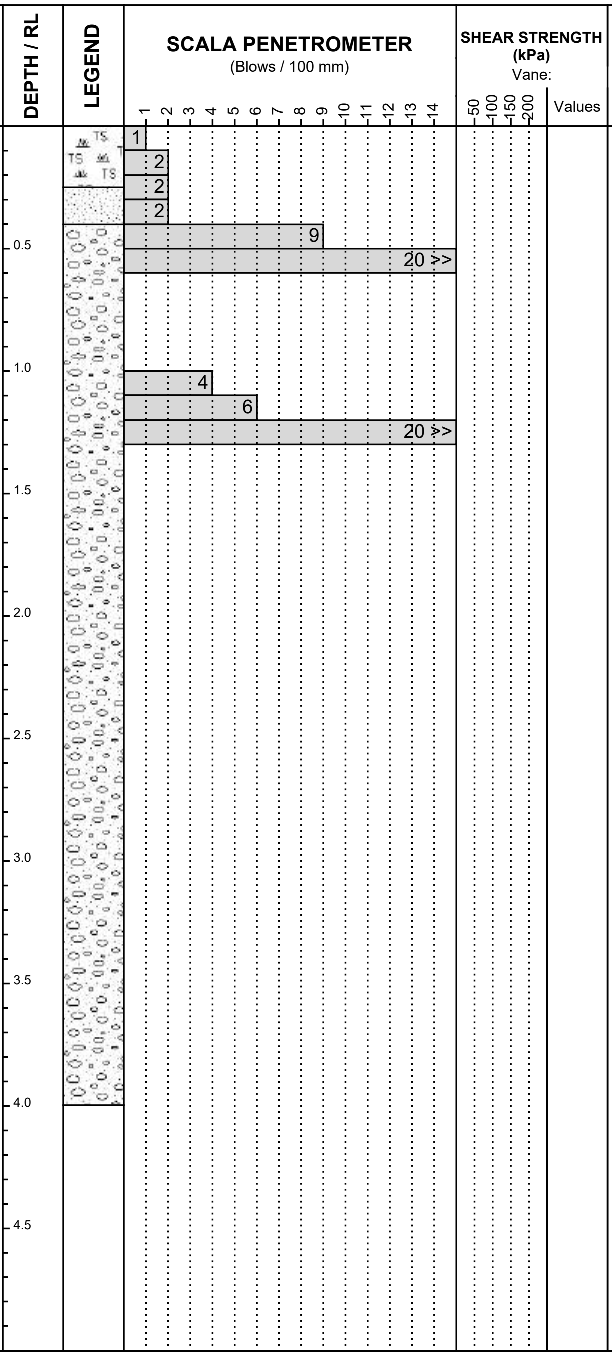
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	23/10/2024
COORDINATES:	1265639.0 mE, 4997457.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	23/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth	WATER
TOPSOIL	Sandy organic SILT, minor rootlets, brown.	0.25 m	Groundwater Not Encountered
LOESS	Fine SAND, with trace silt, rootlets and organic inclusions, orange. Firm, moist.	0.40 m	
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 500 mm in diameter, orange, interbedded with sandy layers. Medium dense, moist, gravels are subrounded to rounded. Sand is fine to coarse.	4.00 m	
	End Of Hole: 4.00 m		



Depth (m)	Scala (Blows / 100 mm)
0.0–0.1	1
0.1–0.2	2
0.2–0.3	2
0.3–0.4	2
0.4–0.5	9
0.5–0.6	20 >>
1.0–1.1	4
1.1–1.2	6
1.2–1.3	20 >>

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

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TEST PIT LOG

HOLE NO.: TP17

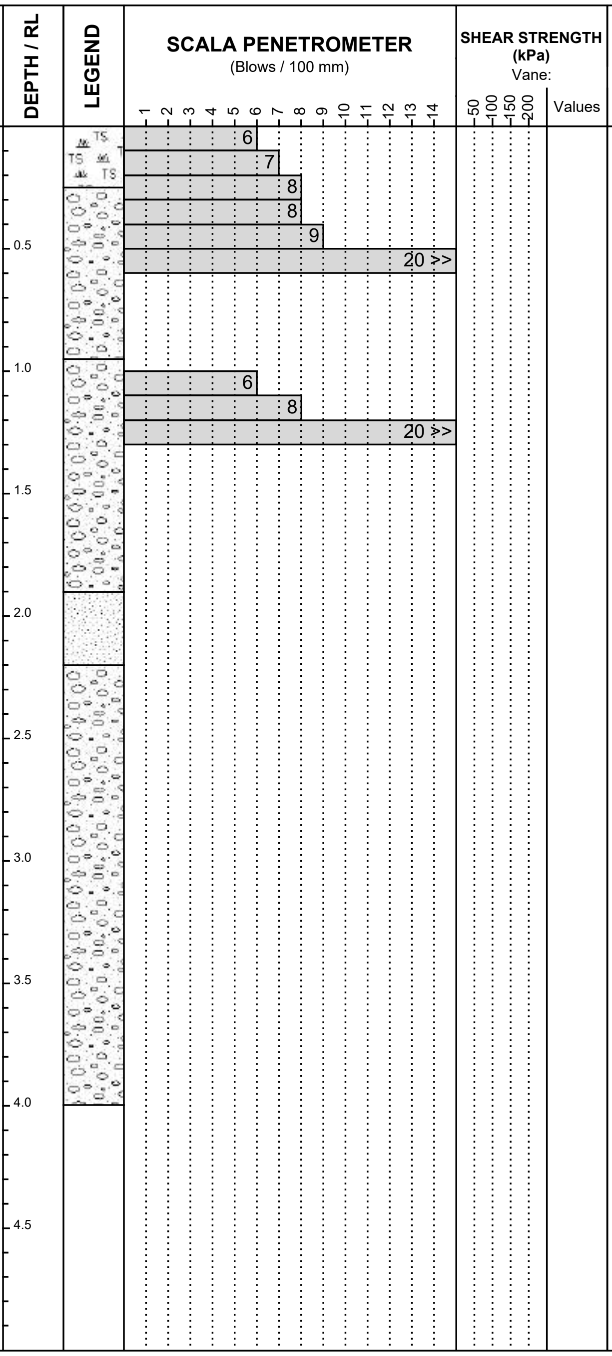
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 23/10/2024
COORDINATES: 1265503.0 mE, 4997339.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 23/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	**MATERIAL DESCRIPTION** (See Classification & Symbology sheet for details)	**SAMPLES**	**DEPTH / RL**	**WATER**
TOPSOIL	Gravelly organic SILT, with trace sand and rootlets, brown. Dry to moist, gravels are fine to medium.		0.25 m	Groundwater Not Encountered
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, trace rootlets, orange, bedded. Medium dense, dry to moist, gravels are subrounded. Sand is fine to coarse.		0.95 m	
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.		1.90 m	
	Fine to medium SAND, grey, bedded. Medium dense, moist.		2.20 m	
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 150 mm in diameter, grey, bedded. Moist, gravels are subrounded. Sand is fine to coarse.		4.00 m	
	End Of Hole: 4.00 m			



PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

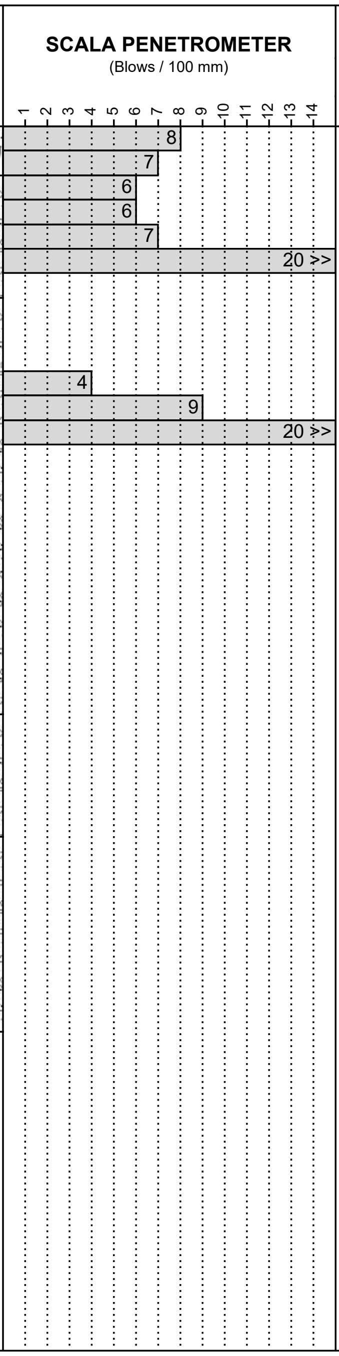
HOLE NO.: TP18

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 23/10/2024
COORDINATES: 1265426.0 mE, 4997339.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 23/10/2024
LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
TOPSOIL	Gravelly organic SILT, with trace sand and rootlets, brown. Dry to moist, gravels are fine to medium.	0.20 m
OUTWASH DEPOSITS	Sandy, fine to coarse GRAVEL, trace rootlets, orange, bedded. Medium dense, dry to moist, gravels are subrounded. Sand is fine to coarse.	0.70 m
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.	2.40 m
	Sandy, fine to coarse GRAVEL, grey, bedded. Dense, dry to moist, sand is fine to coarse.	2.90 m
	Sandy, fine to coarse GRAVEL, with trace cobbles and boulders up to 300 mm in diameter, grey and orange, bedded. Dense, dry to moist, gravels are subrounded. Sand is fine to coarse.	3.70 m
	End Of Hole: 3.70 m	

SAMPLES | DEPTH / RL | LEGEND



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP19

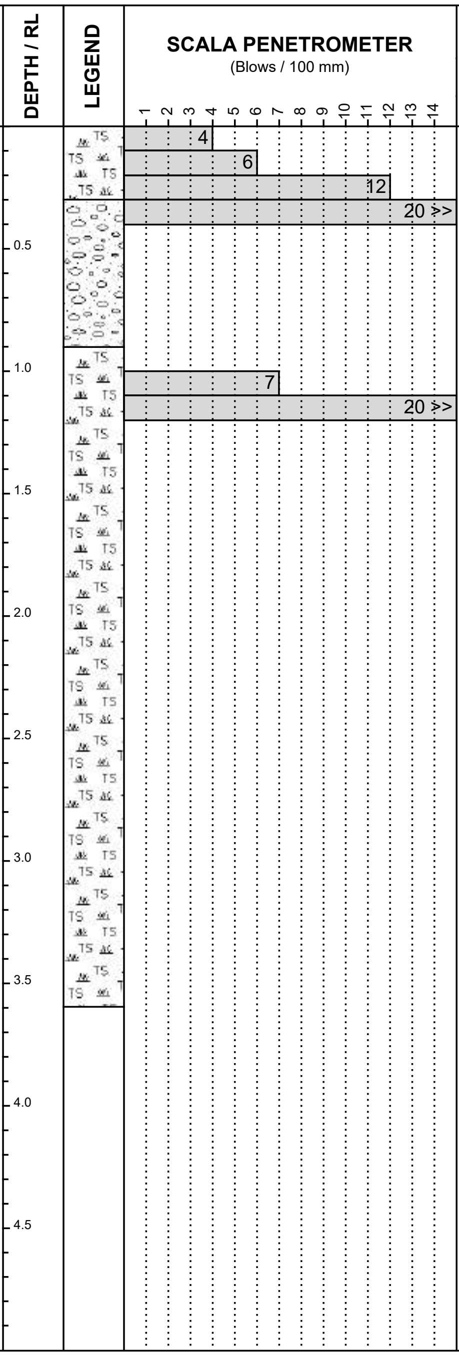
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	24/10/2024
COORDINATES:	1265305.0 mE, 4997565.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	24/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist.		0.30 m	Groundwater Not Encountered
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL, trace rootlets within the top 200 mm, with trace cobbles and boulders up to 300 mm in diameter, orange, bedded. Medium dense, dry to moist, gravels are subangular to subrounded. Sand is fine to coarse.		0.90 m	
	Sandy fine to coarse GRAVEL, interbedded with sand, with trace cobbles and boulders up to 200 mm in diameter, grey and orange, bedded. Medium dense, dry to moist, gravels are subangular to subrounded. Sand is fine to coarse.		3.60 m	
	End Of Hole: 3.60 m			



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Pit walls stable, remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP20

JOB NO.: 220556.01

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Queenstown

COORDINATES: 1265503.0 mE, 4997570.0 mN (NZTM2000)

LOCATION METHOD: Handheld GPS

ELEVATION: Existing ground level

CONTRACTOR: Base Contracting

EQUIPMENT: 13T

ACCURACY: ± 3 m

OPERATOR: Jeremy

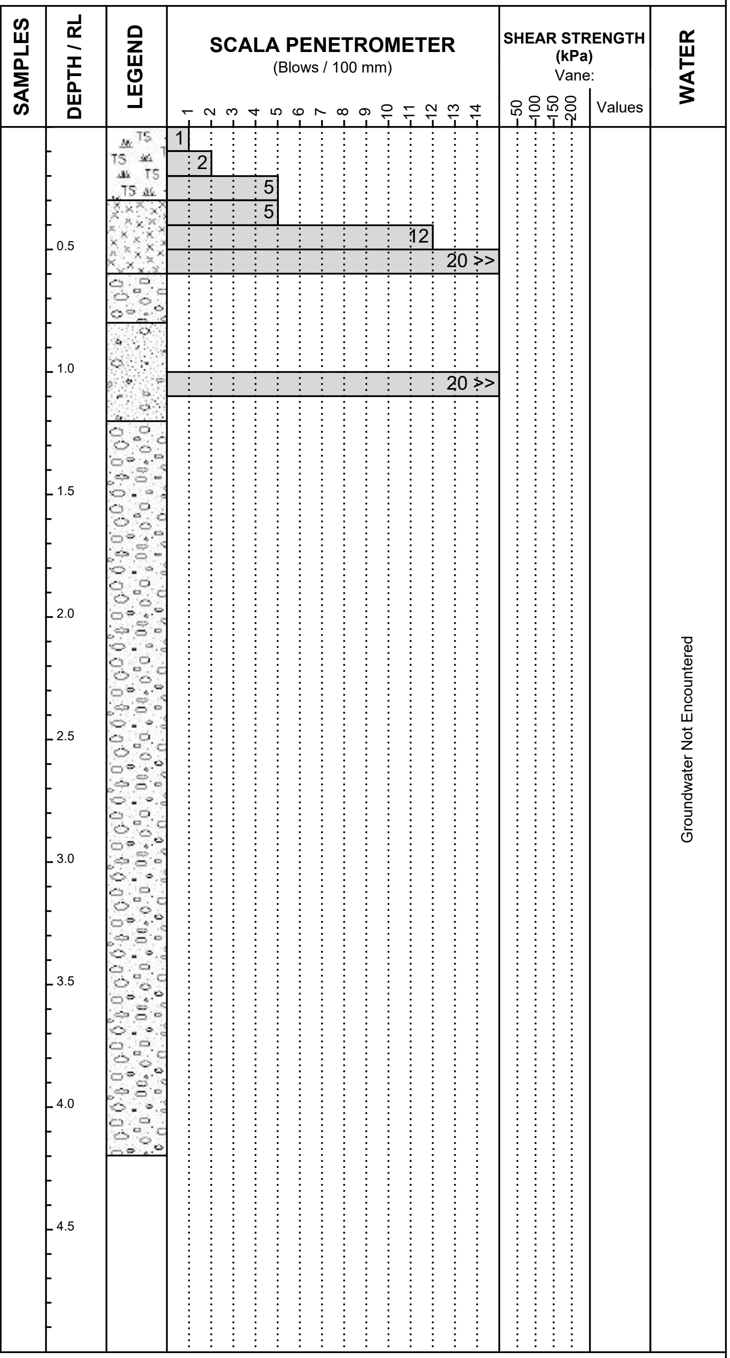
START DATE: 24/10/2024

END DATE: 24/10/2024

LOGGED BY: JMJ

CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist.	0.30 m
LOESS	Sandy SILT with a trace of gravel and organics, brownish/orange. Low plasticity, moist, sand, fine; gravel, fine to medium, subrounded.	0.60 m
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with a trace of silt, brownish/orange. Medium dense, moist, gravel, subrounded; sand, fine to coarse.	0.80 m
	Gravelly fine to coarse SAND with a trace of silt and cobbles, grey. Dense, moist, sand, mostly fine to medium; gravel, fine to coarse, rounded to subrounded.	1.20 m
	Sandy fine to coarse GRAVEL with trace cobbles and boulders, grey, interbedded sandy layers. Medium dense, moist, bedded, gravel, subrounded; sand, fine to coarse.	4.20 m
	End Of Hole: 4.20 m	



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

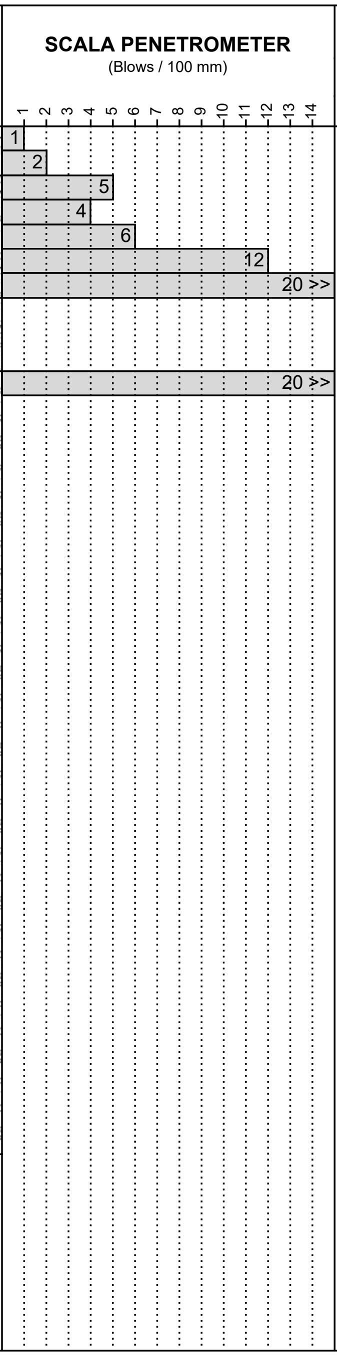
▼	Standing Water Level
▷	Out flow
◁	In flow

TEST PIT LOG

HOLE NO.:	TP21
JOB NO.:	220556.01
CLIENT:	RCL Homestead Bay Ltd
PROJECT:	Homestead Bay Geotechnical
SITE LOCATION:	Queenstown
COORDINATES:	1265451.0 mE, 4997699.0 mN (NZTM2000)
LOCATION METHOD:	Handheld GPS
ELEVATION:	Existing ground level
CONTRACTOR:	Base Contracting
EQUIPMENT:	13T
ACCURACY:	± 3 m
OPERATOR:	Jeremy
START DATE:	24/10/2024
END DATE:	24/10/2024
LOGGED BY:	JMJ
CHECKED DATE:	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Gravelly organic SILT, with trace rootlets, blackish brown. Moist.		0.20 m	Groundwater Not Encountered
LOESS	Sandy SILT with a trace of gravel and organics, brownish/orange. Low plasticity, moist, sand, fine. Gravel, fine to medium, subrounded.		0.70 m	
GLACIAL TILL	Gravelly fine to coarse SAND with a trace of silt and cobbles, grey. Dense, moist, sand, mostly fine to medium. Gravel, fine to coarse, rounded to surrounded. Boulders up to 200 mm.		1.00 m	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles and boulders, grey, interbedded sandy layers. Medium dense, moist, bedded, gravel, subrounded. Sand, fine to coarse.		4.20 m	
	End Of Hole: 4.20 m			

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:22:08 am

TEST PIT LOG

HOLE NO.: TP22

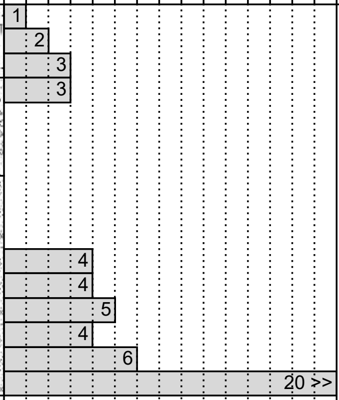
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1265527.0 mE, 4994805.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level
CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy
START DATE: 24/10/2024
END DATE: 24/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Base depth	WATER
TOPSOIL	Sandy organic SILT with a trace rootlets, dark brown. Moist.	0.30 m	Groundwater Not Encountered
COLLUVIUM	Sandy fine to coarse GRAVEL with minor silt and a trace of rootlets and organics, orange. Medium dense, moist, chaotic, gravel, subrounded. Sand, fine to medium.	0.70 m	
GLACIAL POND SEDIMENT	Fine SAND, light orange, interbedded 200 mm with silty sand beds. Medium dense, moist to wet.	1.60 m	
OUTWASH DEPOSITS	Fine to medium SAND with some gravel and a trace of silt, grey. Dense, moist, bedded, gravel, fine to medium, subrounded to rounded.	2.60 m	
	Sandy fine to coarse GRAVEL with a trace of cobbles, dark grey. Medium dense, moist, bedded, gravel, rounded to subrounded. Sand, medium to coarse.	3.40 m	
	Gravelly coarse SAND, grey. Medium dense, wet, bedded, gravel, fine to coarse, rounded to subrounded.	4.40 m	
	End Of Hole: 4.40 m		

SAMPLES: none. SHEAR STRENGTH (kPa) Vane: Values — none.

SCALA PENETROMETER
(Blows / 100 mm)



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP23

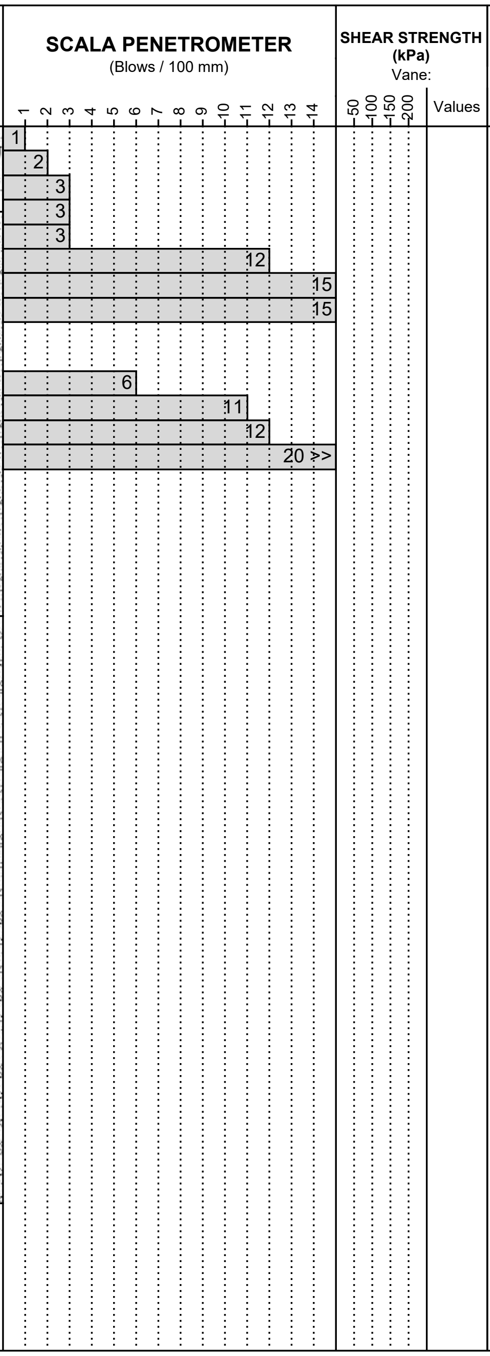
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 24/10/2024
COORDINATES: 1265281.0 mE, 4997801.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 24/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Sandy organic SILT with a trace rootlets, dark brown. Moist, strong organic odour. 0.35 m			Groundwater Not Encountered
GLACIAL POND SEDIMENT	Silty fine SAND with a trace of gravel, grey. Medium dense to dense, wet, minor laminations, gravel, fine to medium, subrounded. 2.00 m		0.5 1.0 1.5 2.0	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with a trace of silt, cobbles and boulders, orange/grey. Medium dense, moist, bedded, gravel, subrounded to rounded. Sand, fine to coarse; boulders up to 250 mm. 4.40 m		2.5 3.0 3.5 4.0	
	End Of Hole: 4.40 m		4.5	



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP24

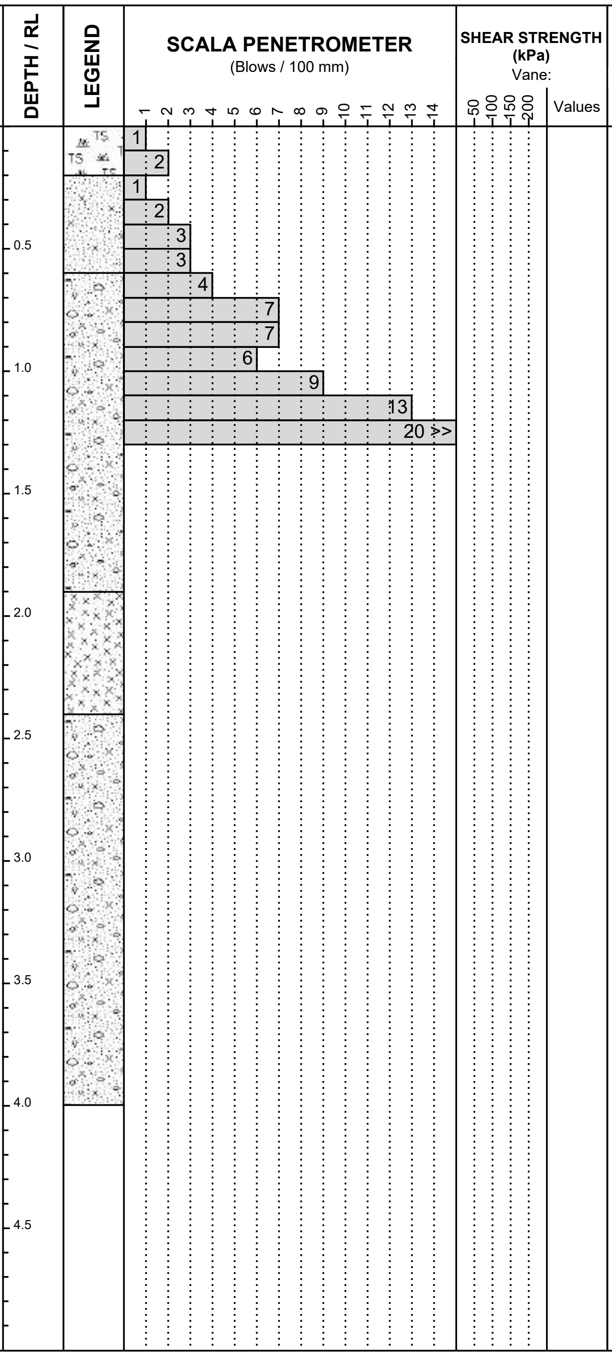
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	25/10/2024
COORDINATES:	1265315.0 mE, 4997901.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	25/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine. 0.20 m		Groundwater Not Encountered
LOESS	Silty fine SAND with a trace of roots and organics, orange. Wet. 0.60 m		
GLACIAL TILL	Fine to medium SAND with minor silt and gravel with a trace of cobbles, grey/orange banding, interbedded siltier layers. Medium dense, moist, gravel, fine to coarse, subrounded. 1.90 m		
	Sandy SILT, light grey. Hard, dry, sand, fine. 2.40 m		
	Fine to coarse SAND with minor silt and gravel with a trace of cobbles and boulders, grey, interbedded siltier layers. Medium dense, moist, gravel, fine to coarse, subrounded. Boulders up to 750 mm diameter. 4.00 m		
	End Of Hole: 4.00 m		



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP25

CLIENT: RCL Homestead Bay Ltd

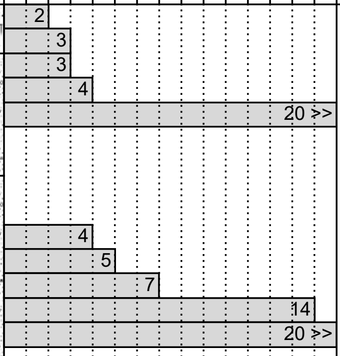
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES: 1265193.0 mE, 4997945.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Sandy organic SILT with minor gravel and trace rootlets, brown. Wet, sand, fine; gravel, fine to coarse, subrounded to subangular.		0.20 m	Groundwater Not Encountered
COLLUVIUM	Fine to coarse SAND with minor gravel and a trace of silt and organics, grey/orange. Medium dense, moist, chaotic, gravel, fine to coarse, surounded. 0.6 m: two 20 mm thick brown beds near basal contact		0.70 m	
GLACIAL TILL	Fine to coarse SAND with minor gravel and a trace of cobbles and silt, grey with orange streaks. Medium dense, dry to moist, sand, mostly fine to medium; gravel, fine to coarse, subrounded to rounded.		1.80 m	
	Gravelly fine to coarse SAND with a trace of silt and cobbles, grey/brown, interbedded siltier layers. Dense, dry to moist, gravel, fine to coarse, subrounded to rounded. Boulders up to 200 mm diameter.		4.20 m	
	End Of Hole: 4.20 m			

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

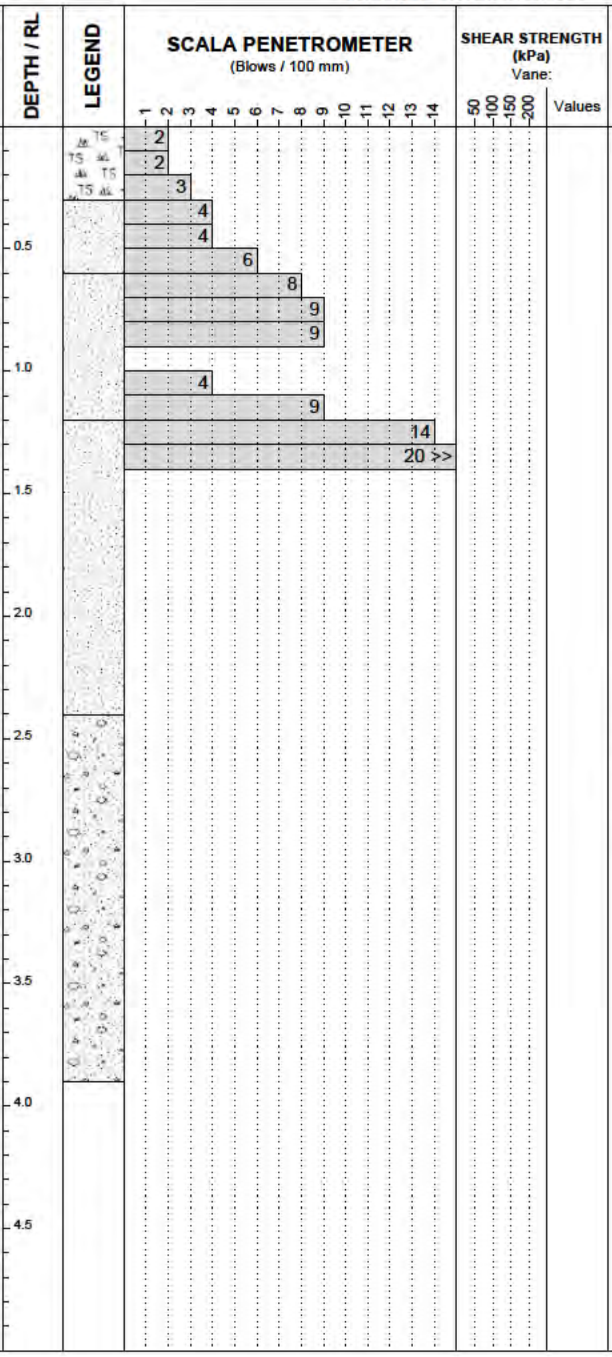
HOLE NO.: TP26

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 25/10/2024
COORDINATES: 1265437.0 mE, 4998029.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 25/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Sandy organic SILT with trace rootlets, brown. Moist, sand, fine.	0.30 m
COLLUVIUM	Silty fine SAND with a trace of gravel and organics, orange. Loose to medium dense, moist, chaotic.	0.60 m
GLACIAL TILL	Fine to coarse SAND with a trace of silt, gravel, cobbles and boulders, grey with orange banding. Medium dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	1.20 m
	Fine to coarse SAND with a trace of silt, gravel, cobbles and boulders, light grey, interbedded siltier layers. Medium dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	2.40 m
	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, grey. Dense, moist to wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	3.90 m
	End Of Hole: 3.90 m	

SAMPLES



WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP27

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

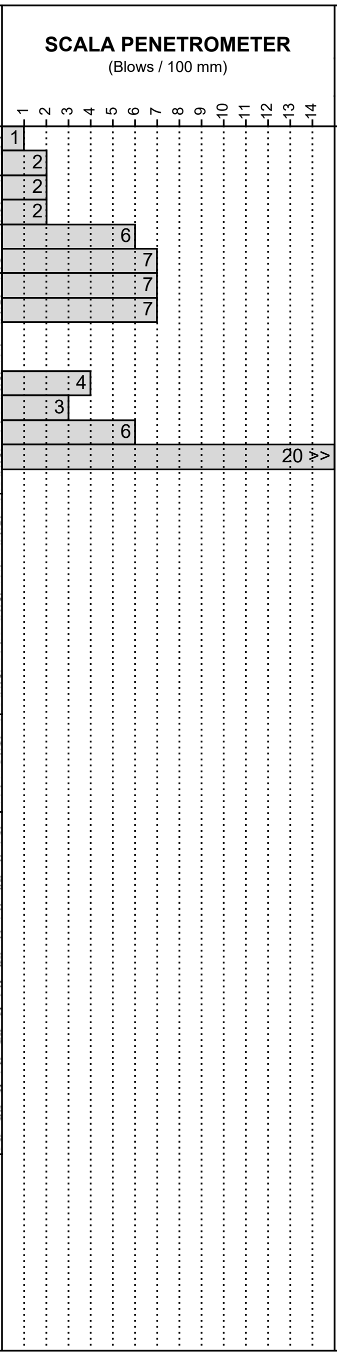
SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES: 1265322.0 mE, 4998132.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine.	0.20 m
LOESS	Silty fine SAND with a trace of rootlets and organics, orange. Loose to medium dense, moist to wet.	0.40 m
COLLUVIUM	Sandy fine to coarse GRAVEL with minor silt and trace organics, orange/grey. Medium dense, moist to wet, chaotic, gravel, fine to coarse, subrounded; sand, fine to coarse.	0.60 m
OUTWASH DEPOSITS	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, grey/orange, interbedded siltier layers. Medium dense to dense, moist to wet, gravel, fine to coarse, subrounded. Boulders up to 250 mm diameter.	1.50 m
	Gravelly fine to coarse SAND with a trace of silt, cobbles and boulders, orange/grey, interbedded siltier layers. Dense, moist, gravel, fine to coarse, subrounded. Boulders up to 400 mm diameter.	2.40 m
	Gravelly SAND with a trace of silt, cobbles and boulders, grey. Dense, moist to wet, gravel, fine to coarse, subrounded Boulders up to 400 mm diameter.	2.80 m
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey/brown. Medium dense, moist, bedded, gravel, fine to coarse, subrounded. Boulders up to 300 mm.	4.20 m
	End Of Hole: 4.20 m	

SAMPLES

LEGEND

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Pit walls collapsing from 2.8 m. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

TEST PIT LOG

HOLE NO.: TP28

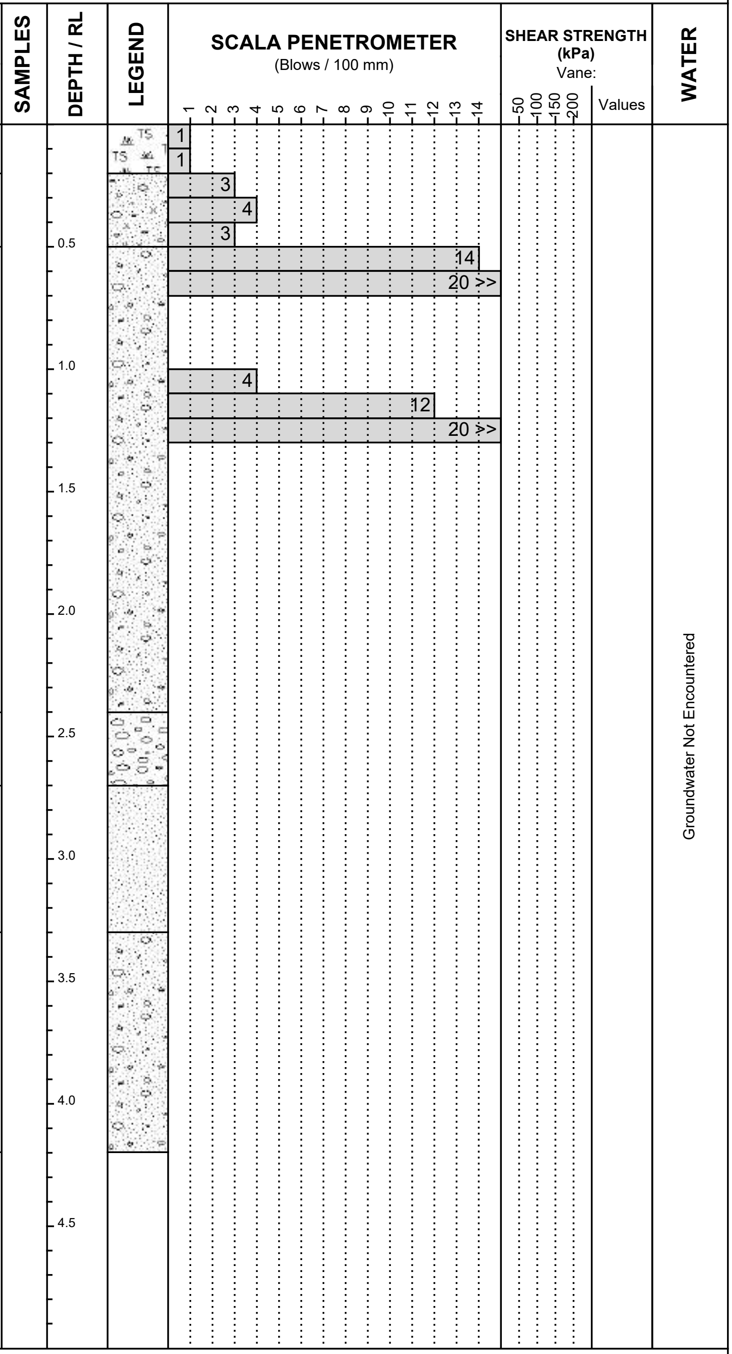
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES: 1265098.0 mE, 4998124.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Sandy organic SILT with trace of rootlets, dark brown. Dry to moist, sand, fine. 0.20 m
COLLUVIUM	Fine to coarse SAND with minor gravel and silt with a trace of organics, orange. Medium dense, moist to wet, chaotic, gravel, fine to coarse, subrounded. 0.50 m
OUTWASH DEPOSITS	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, orange/grey. Dense, moist, gravel, fine to coarse, subrounded. Boulders up to 400 mm. 2.40 m
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, moist, bedded, sand, fine to coarse; gravel, subrounded. Boulders up to 250 mm. 2.70 m
GLACIAL TILL	Fine SAND, grey. Medium dense, dry to moist. 3.30 m
	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, orange/grey. Dense, moist, gravel, fine to coarse, subrounded. Boulders up to 400 mm. 4.20 m
	End Of Hole: 4.20 m



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP29

CLIENT: RCL Homestead Bay Ltd

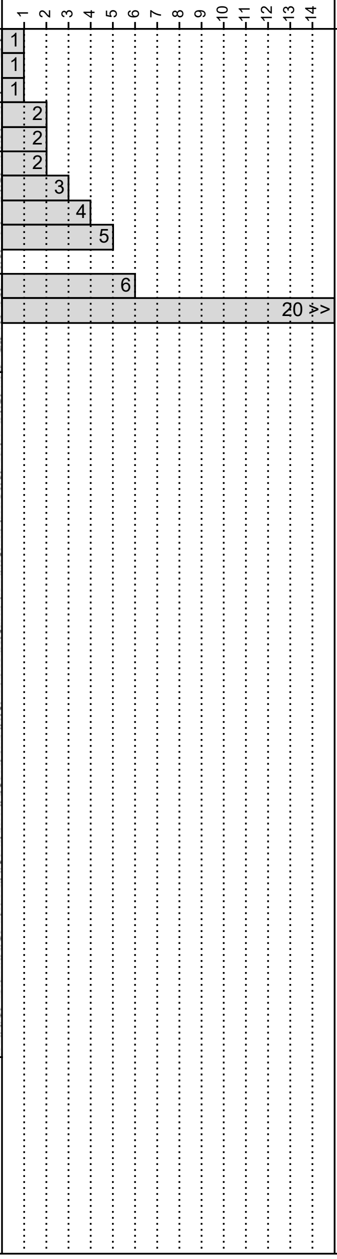
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES:	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Moist.		0.30 m	
LOESS	Silty fine SAND with a trace of organics, orange. Loose to medium dense, moist to wet.		0.50 m	
COLLUVIUM	Gravelly fine to medium SAND with minor to trace silt and a trace of cobbles, orange. Loose to medium dense, moist, chaotic, gravel, fine to coarse, subrounded to rounded.		1.00 m	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles, orange and grey, interbedded sandy gravels and fine sands. Medium dense, moist, bedded, gravel, subrounded to rounded; sand, fine to coarse.		1.40 m	Groundwater Not Encountered
	Gravelly fine to coarse SAND with trace cobbles, dark grey. Dense, moist, bedded, gravel, rounded to subrounded; sand, medium to coarse.		4.20 m	
	End Of Hole: 4.20 m			

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP30

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

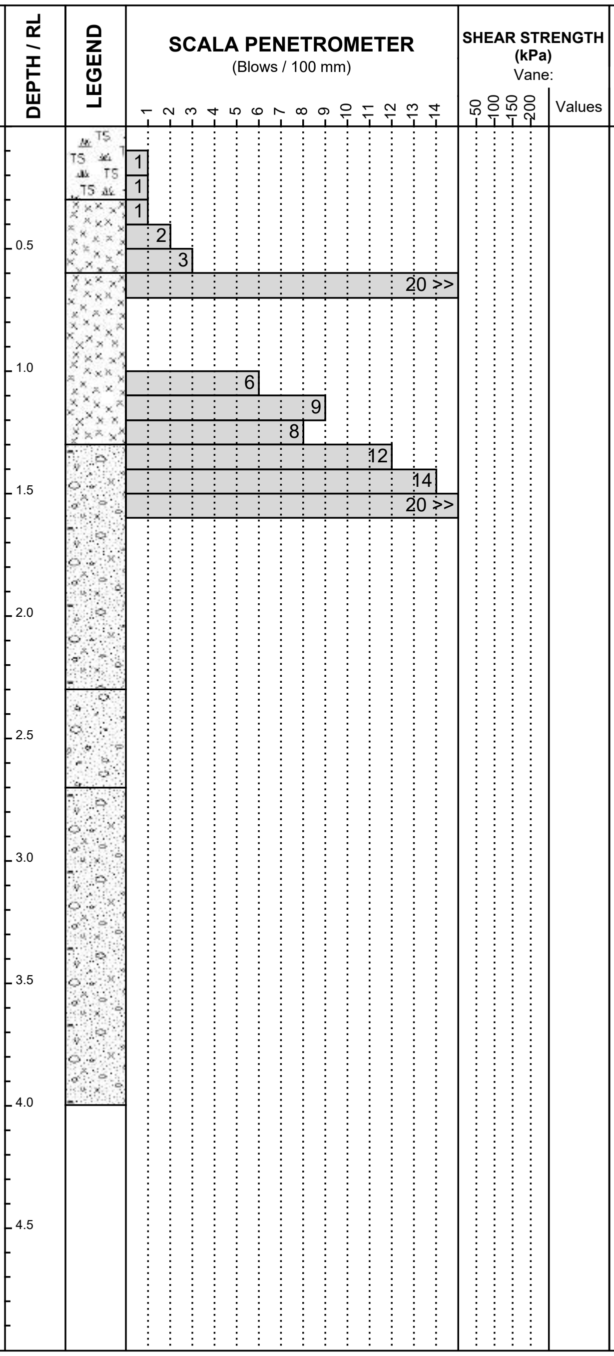
SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 25/10/2024

COORDINATES: 1265294.0 mE, 4998366.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 25/10/2024

LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic SILT with a trace of rootlets, brown. Moist to wet, low plasticity. 0.30 m		
WEATHERED GLACIAL TILL	SILT with minor to trace of sand, trace organics and rootlets, light orange/brown. Firm, wet, low plasticity, sand, fine. 0.60 m		
GLACIAL TILL	SILT, grey with orange streaks. Stiff to very stiff, wet, low plasticity. 1.30 m		Groundwater Not Encountered
	Gravelly fine to coarse SAND with minor to no silt and trace cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded. 2.30 m		
	Fine to coarse SAND with some gravel, dark grey . Dry to moist, gravel, fine to coarse, subrounded. Sand and gravel mostly fine to medium, trace coarse. 2.70 m		
	Gravelly fine to coarse SAND with minor to no silt and trace cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded. 4.00 m		
	End Of Hole: 4.00 m		



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

GEOSOLVE ENGINEERING CONSULTANTS

TEST PIT LOG

HOLE NO.: **TP31**

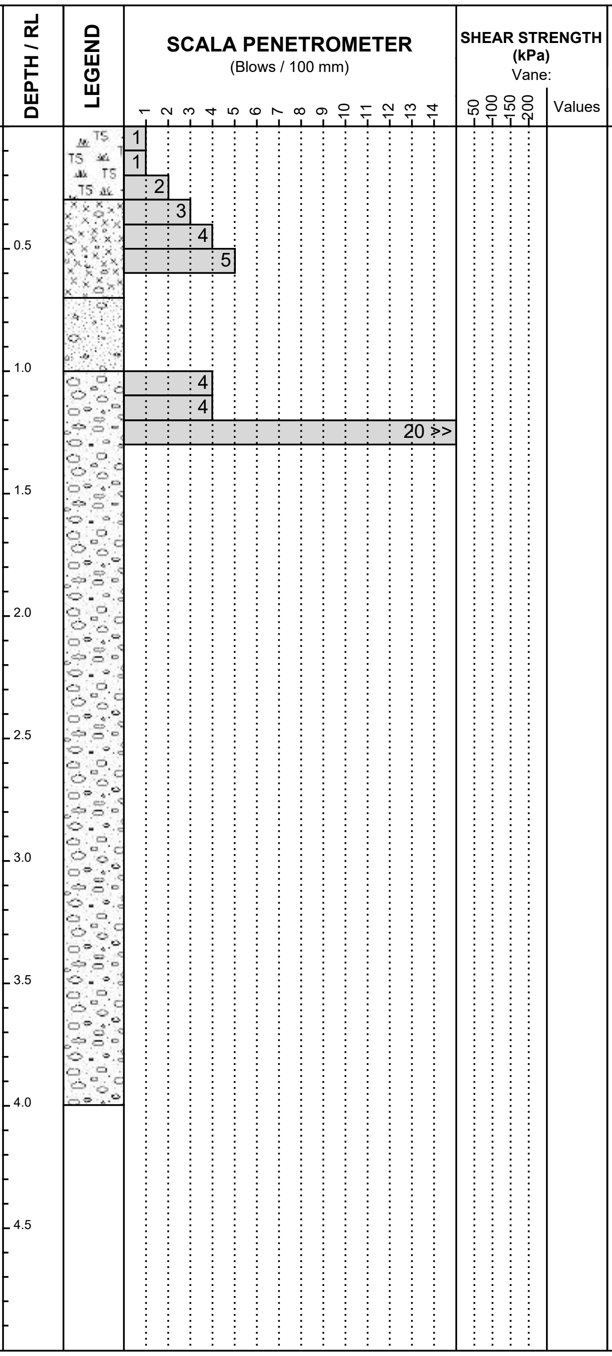
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: **220556.01**

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	25/10/2024
COORDINATES:	1265025.0 mE, 4998362.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	25/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	WATER
TOPSOIL	Organic SILT with trace rootlets, brown. Moist, low plasticity. 0.30 m		Groundwater Not Encountered
COLLUVIUM	Sandy SILT with minor gravel and trace organics, orange. Firm, moist, low plasticity, sand, fine to coarse, mostly fine. Gravel, fine to coarse, subrounded. 0.70 m		
OUTWASH DEPOSITS	Fine to coarse SAND with some gravel and a trace of silt and cobbles, grey. Dense, moist, gravel, fine to coarse, subrounded. Sand is mostly fine. 1.00 m		
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, dark grey. Dense, moist, bedded, gravel, subrounded to rounded; sand, fine to coarse, mostly medium to coarse. Boulders up to 250 mm in diameter. 4.00 m		
	End Of Hole: 4.00 m		



PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP32

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

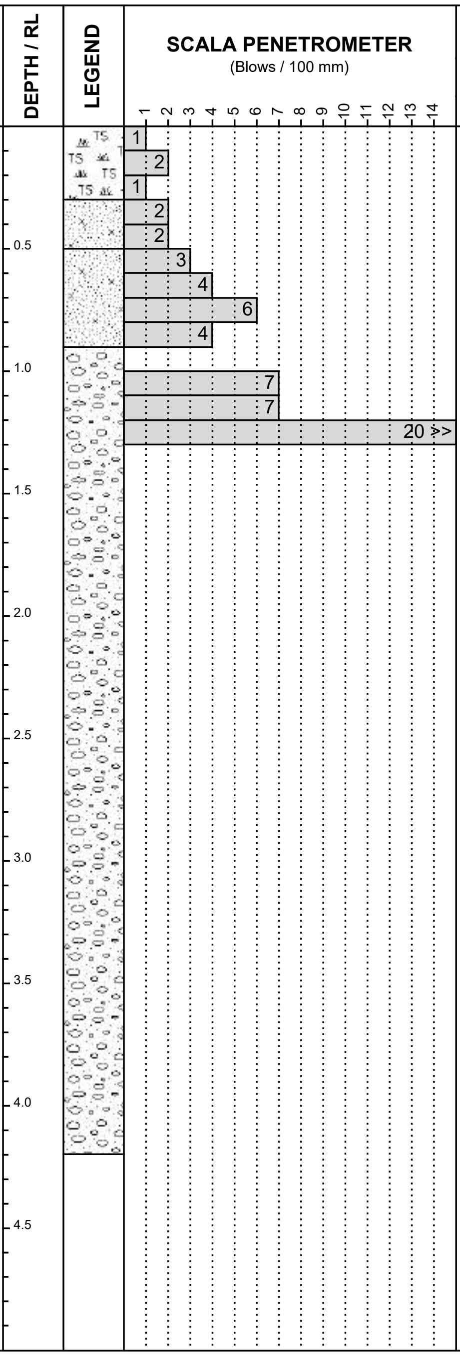
JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 25/10/2024
COORDINATES: 1264932.0 mE, 4998640.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 25/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with trace rootlets, dark brown. Wet.	0.30 m
LOESS	Silty fine SAND with trace organics, orange. Loose, wet.	0.50 m
COLLUVIUM	Gravely fine SAND with minor silt and trace cobbles, orange/brown orange. Medium dense, wet, chaotic, gravel fine to coarse, subrounded to rounded.	0.90 m
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles and boulders, orange/grey becoming grey. Dense, moist, bedded, gravel, subrounded to rounded. Sand, fine to coarse, mostly medium to coarse. Boulders up to 250 mm diameter.	4.20 m
	End Of Hole: 4.20 m	

SAMPLES

DEPTH / RL



SHEAR STRENGTH (kPa)
Vane:
50
100
150
200
Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level

▷ Out flow

◁ In flow

TEST PIT LOG

HOLE NO.: TP33

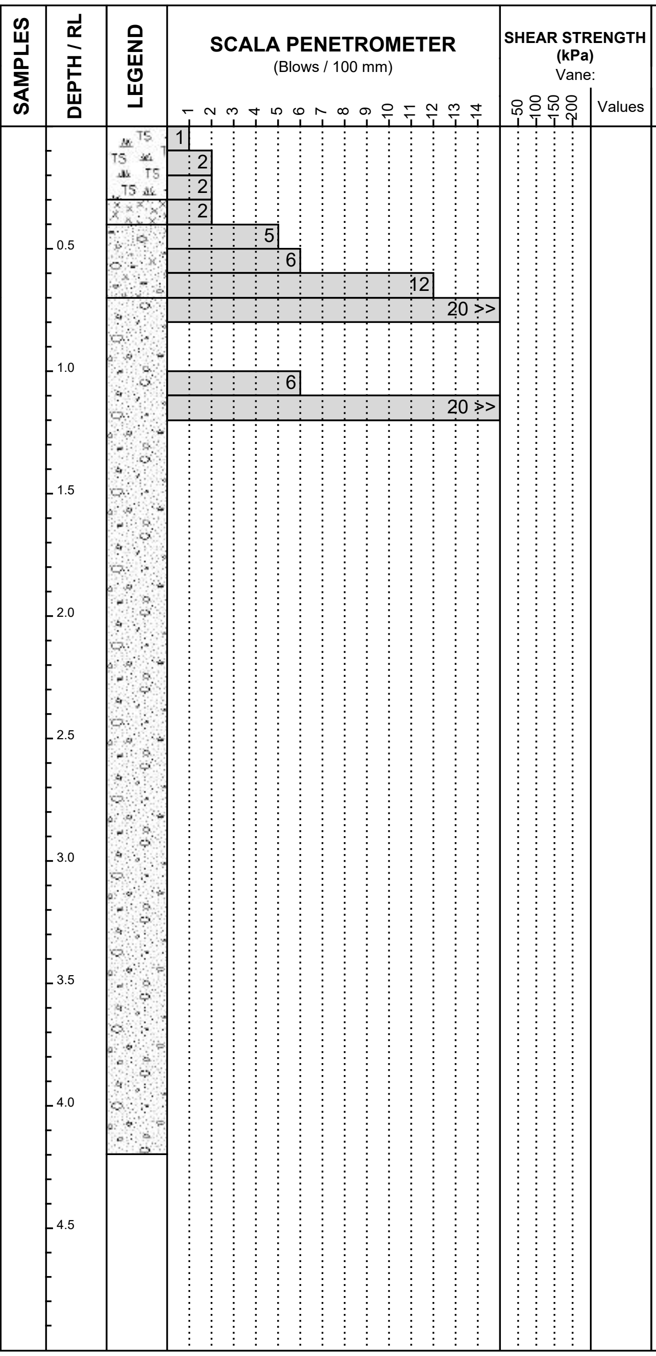
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	25/10/2024
COORDINATES:	1265108.0 mE, 4998567.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	25/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with trace rootlets, dark brown. Moist.	0.30 m
LOESS	Sandy SILT with a trace of gravel and organics, orange. Firm, moist, low plasticity, sand, fine; gravel, fine to coarse, subrounded.	0.40 m
COLLUVIUM	Gravelly fine to carse SAND with minor silt, orange. Medium dense, moist, gravel, fine to coarse, subrounded to rounded.	0.70 m
GLACIAL TILL	Gravelly fine to coarse SAND with trace silt and cobbles, orange/grey, beds of medium to coarse sand. Dense, moist, sand, rarely coarse; gravel, fine to coarse, subrounded to rounded.	4.20 m
	End Of Hole: 4.20 m	



WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- Standing Water Level
- Out flow
- In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:23:06 am

TEST PIT LOG

HOLE NO.: TP34

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

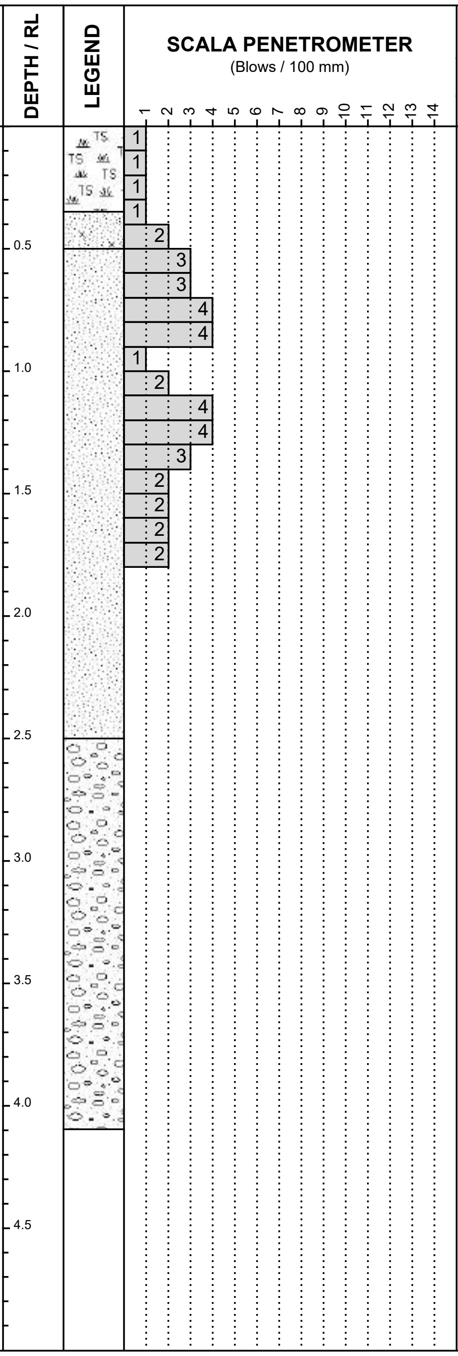
SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 29/10/2024

COORDINATES: 1264674.0 mE, 4999141.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024

LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ

ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	WATER
TOPSOIL	Organic SILT with minor sand and gravel with a trace of rootlets, dark brown. Wet, sand, fine to medium; gravel, fine to coarse, subrounded to rounded. 0.35 m	Groundwater Not Encountered
LOESS	Fine SAND with minor silt and a trace of gravel and organic inclusions, orange, dipping towards 094°. Loose to medium dense, moist. 0.50 m	
ALLUVIAL FAN DEPOSITS	Fine SAND with trace rootlets, grey/orange becoming grey. Loose, moist. 2.50 m	
	Sandy fine to coarse GRAVEL with trace cobbles, grey/orange. Medium dense, moist, bedded, gravel, subrounded; sand, fine to coarse. 4.10 m	
	End Of Hole: 4.10 m	



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP35

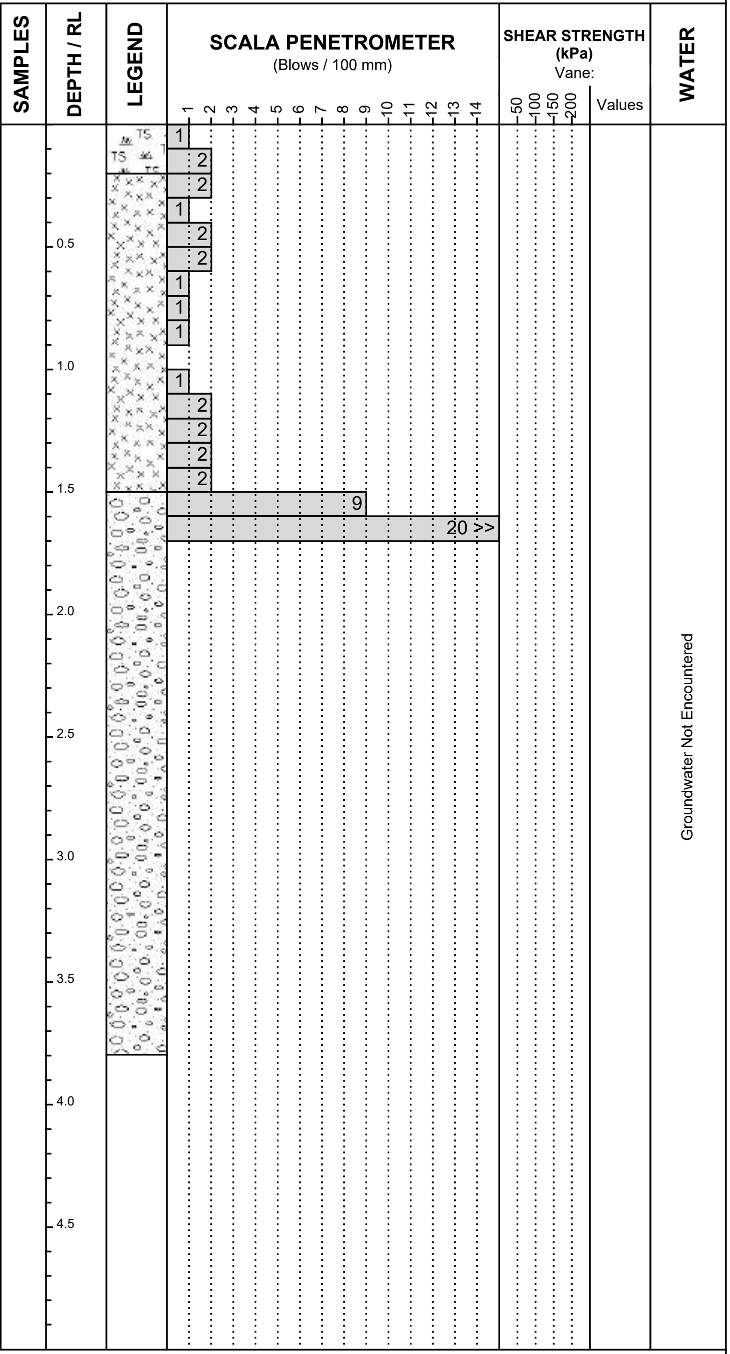
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1264800.0 mE, 4998955.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 29/10/2024
END DATE: 29/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Organic SILT with minor roots and rootlets, dark brown. Wet. 0.20 m
ALLUVIAL FAN DEPOSITS	SILT with a trace rootlets in upper 400 mm, brownish grey. Firm, moist, low plasticity. 1.50 m
	Sandy fine to coarse GRAVEL, brownish grey. Medium dense, wet, gravel, subrounded; sand, fine to coarse, mostly medium to coarse. 3.80 m
	End Of Hole: 3.80 m



PHOTO(S)

REMARKS

End of test, test pit walls collapsing. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP36

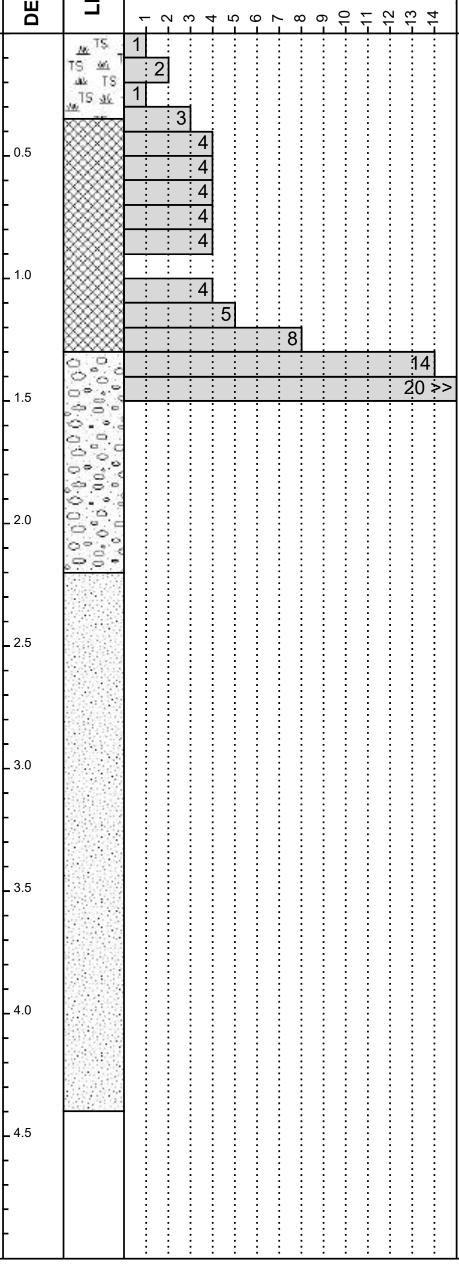
JOB NO.: 220556.01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 29/10/2024
COORDINATES: 1264854.0 mE, 4998761.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 29/10/2024
LOCATION METHOD: GIS\Web map viewer	**ACCURACY:** ± 5 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	WATER
TOPSOIL	Organic SILT with minor rootlets, black. Wet.		0.35 m	TS	
UNCONTROLLED FILL	Sandy fine to medium GRAVEL with a trace of silt, brown/grey, rootlets in upper 300 mm. Medium dense, wet, uniform, gravel, subangular; sand, fine to coarse, mostly medium to coarse.		1.30 m		
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL, grey/orange, interbedded sandier layers increasing near basal contact. Dense, wet, bedded, gravel, subrounded; sand, fine to coarse.		2.20 m		Groundwater Not Encountered
	Fine SAND with a trace of silt and rootlets, grey. Medium dense, moist.		4.40 m		
	End Of Hole: 4.40 m				

SCALA PENETROMETER
(Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200 | Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP37

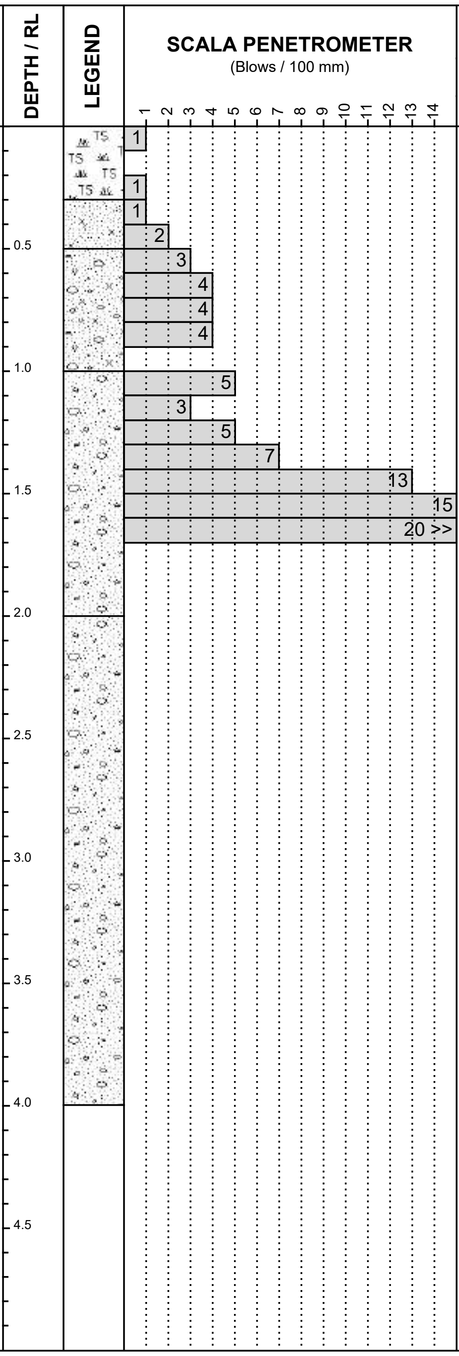
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 29/10/2024
COORDINATES: 1265285.0 mE, 4998628.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 29/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Wet.		0.30 m	Groundwater Not Encountered
LOESS	Fine SAND with minor silt and a trace of organics, orange/brown. Loose, wet.		0.50 m	
COLLUVIUM	Gravelly fine SAND with minor silt, orange/brown. Medium dense, wet, gravel, fine to medium, subrounded to subangular.		1.00 m	
GLACIAL TILL	Fine to medium SAND with some gravel and a trace of silt, orange/grey. Medium dense, moist, gravel, fine to coarse, mostly fine to medium, subrounded.		2.00 m	
	Fine to medium SAND with some gravel and a trace of silt and cobbles/boulders, orange/grey. Dense, moist, gravel, fine to coarse, mostly fine to medium, subrounded. Boulders up to 300 mm diameter, subrounded.		4.00 m	
	End Of Hole: 4.00 m			



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

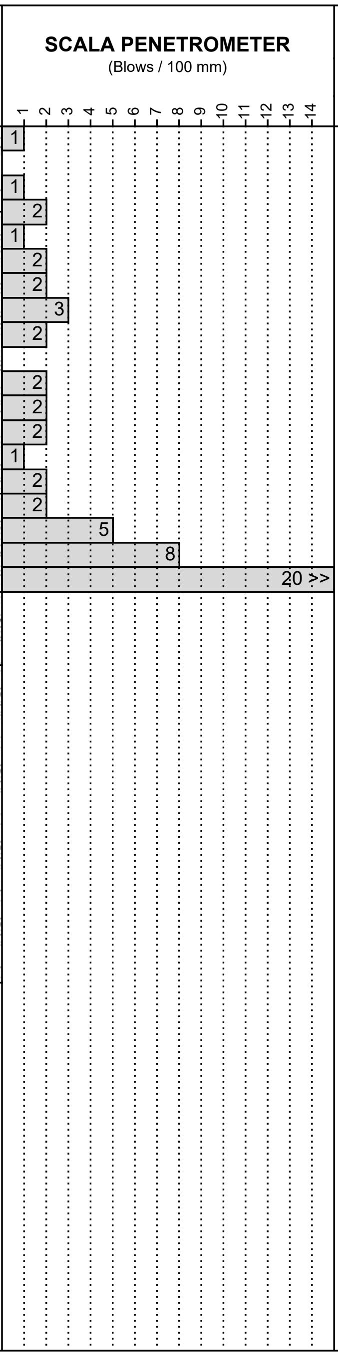
HOLE NO.: TP38

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1265290.0 mE, 4998710.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: GIS\Web map viewer
ACCURACY: ± 5 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with a trace of rootlets, dark brown. Wet.		0.35 m	Groundwater Not Encountered
LOESS	Fine to medium SAND with a trace of silt and organics, light yellow/grey. Loose, wet, sand, mostly fine. Organic content decreases with depth.		1.50 m	
GLACIAL TILL	Fine to medium SAND with minor silt and a trace of gravel, light yellow/grey. Medium dense, wet, gravel, fine to coarse, subrounded.		1.90 m	
	Gravelly fine to coarse SAND with trace cobbles and boulders, brownish grey. Medium dense to dense, wet, gravel, fine to coarse, subrounded. Boulders up to 200 mm diameter.		2.20 m	
	Fine to coarse SAND with some gravel and trace cobbles and boulders, grey, zones of medium to coarse sand. Dense, moist, sand, mostly fine to medium; gravel, fine to coarse, mostly fine to medium. Boulders up to 250 mm.		3.50 m	
	End Of Hole: 3.50 m			

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane:

50 100 150 200 | Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

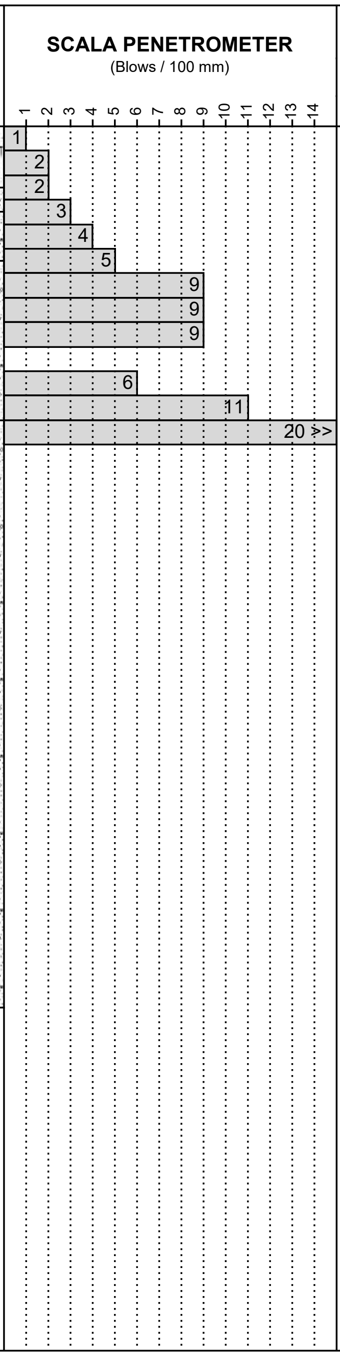
TEST PIT LOG

HOLE NO.: TP39

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 29/10/2024
COORDINATES: 1265515.0 mE, 4998607.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 29/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic silty SAND with trace rootlets, brown. Moist.		0.25 m	Groundwater Not Encountered
LOESS	Fine SAND with a trace of silt and organics, orange. Loose to medium dense, moist to wet.		0.35 m	
COLLUVIUM	Gravelly fine to medium SAND with a trace of silt, orange. Medium dense, moist to wet, gravel, fine to coarse, subrounded.		0.55 m	
GLACIAL TILL	Fine to medium SAND with some gravel and a trace of silt, grey/brown. Medium dense to dense, moist to wet, gravel, fine to coarse, subrounded.		1.20 m	
	Fine to medium SAND with some gravel and trace cobbles and boulders, grey. Dense, moist, gravel fine to coarse, subrounded.		3.60 m	
	End Of Hole: 2.60 m			



SHEAR STRENGTH (kPa)
Vane:
50 100 150 200
Values

PHOTO(S)

REMARKS

Target depth achieved. Scala penetrometer unable to penetrate. Pit walls remaining vertical

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:23:34 am

TEST PIT LOG

HOLE NO.: TP40

JOB NO.: 220556.01

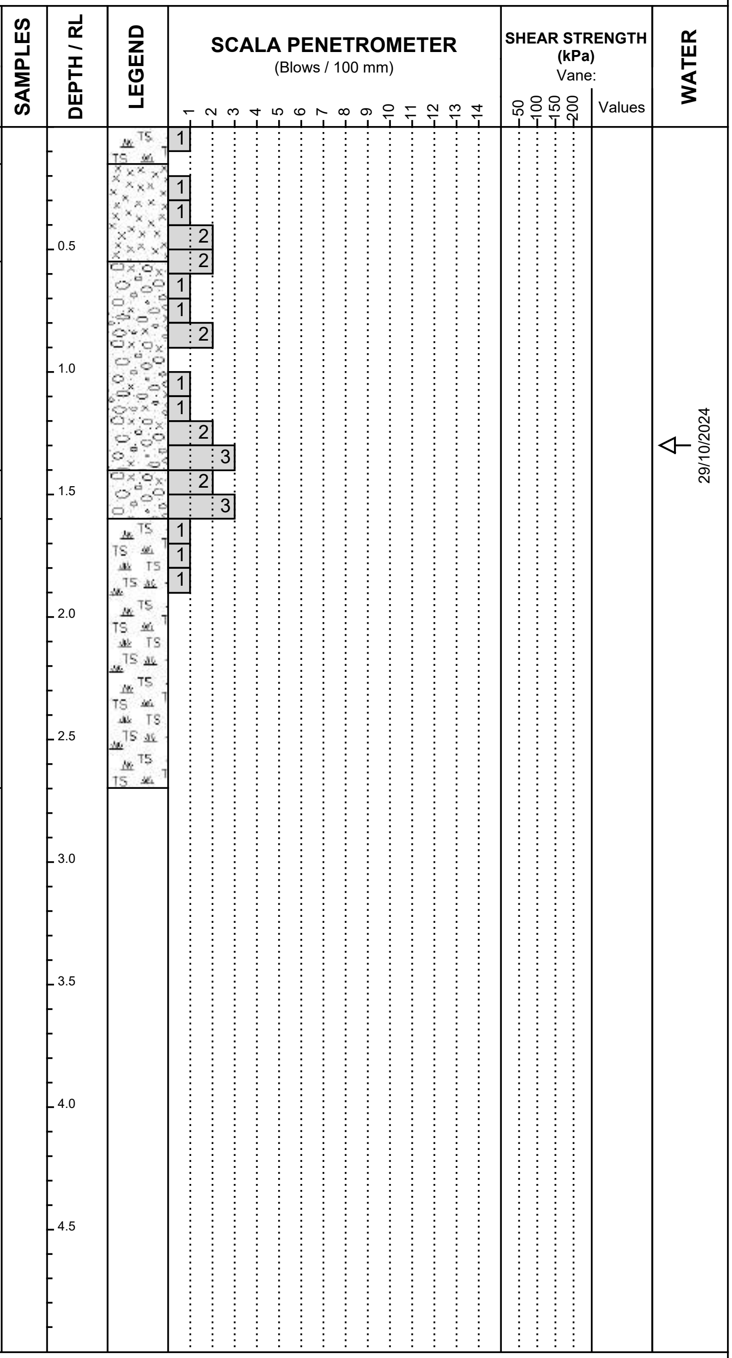
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

SITE LOCATION: Queenstown
COORDINATES: 12659656.0 mE, 4998600.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 29/10/2024
END DATE: 29/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)
TOPSOIL	Organic SILT with trace rootlets, black. Wet. 0.15 m
ALLUVIAL FAN DEPOSITS	SILT with minor to trace sand, blackish/brown. Firm, wet, sand, fine. Moderately sensitive . 0.55 m
	Silty fine SAND and sandy SILT, dark brown/grey. Firm, wet. Saturated from 0.9 m, well interbedded with discontinuous gravelly beds, sand, fine. Moderately sensitive silts . 1.40 m
	Silty fine to coarse GRAVEL with minor sand, dark brown/grey. Saturated , sand, fine to medium. 1.60 m
	Silty fine SAND and andy SILT, dark brown/grey. Firm, saturated, interbedded with discontinuous gravelly beds, sand, fine. Moderately sensitive silts. 2.70 m
	End Of Hole: 2.70 m



PHOTO(S)

REMARKS

End of test, test pit walls collapsing. Seepages through out the pit walls, some with high outflow. Water level remaining at 1.3 m bgl, 15 minutes after completion of test pit excavation

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP41

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
COORDINATES: 1265986.0 mE, 4998873.0 mN (NZTM2000)
LOCATION METHOD: Handheld GPS
ELEVATION: Existing ground level

CONTRACTOR: Base Contracting
EQUIPMENT: 13T
ACCURACY: ± 3 m
OPERATOR: Jeremy

START DATE: 29/10/2024
END DATE: 29/10/2024
LOGGED BY: JMJ
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with trace rootlets, black. Saturated. 0.10 m		4		
UNCONTROLLED FILL	Medium to coarse GRAVEL with a trace of sand and silt, blackish grey. Medium dense, saturated, gravel, subrounded; sand, fine to medium. 0.40 m		9		
ALLUVIAL FAN DEPOSITS	SILT with minor sand, grey. Firm, wet , sand, fine. Moderately sensitive. 1.40 m		1 1 2 2		
	Gravelly fine to medium SAND with a trace of silt, grey. Medium dense, wet, gravel, fine to coarse, subrounded. 1.70 m				
	Boulders in gravelly SAND matrix, grey. Medium dense, wet, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 2.20 m				
	SILT with minor sand, grey. Firm, wet, sand, fine. Moderately sensitive. 2.60 m				
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, saturated, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 2.80 m				◁ 29/10/2024
	SILT with minor sand, grey. Firm, saturated, sand, fine. Moderately sensitive. 4.00 m				
	Sandy fine to coarse GRAVEL with a trace of cobbles and boulders, grey. Medium dense, saturated, gravel, fine to coarse, subrounded; sand, fine to coarse. Boulders up to 600 mm diameter. 4.20 m				
	End Of Hole: 4.20 m				

PHOTO(S)

REMARKS

Target depth achieved

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP42

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown

CONTRACTOR: Base Contracting

START DATE: 30/10/2024

COORDINATES: 1265848.0 mE, 4998934.0 mN (NZTM2000)

EQUIPMENT: 13T

END DATE: 30/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 3 m

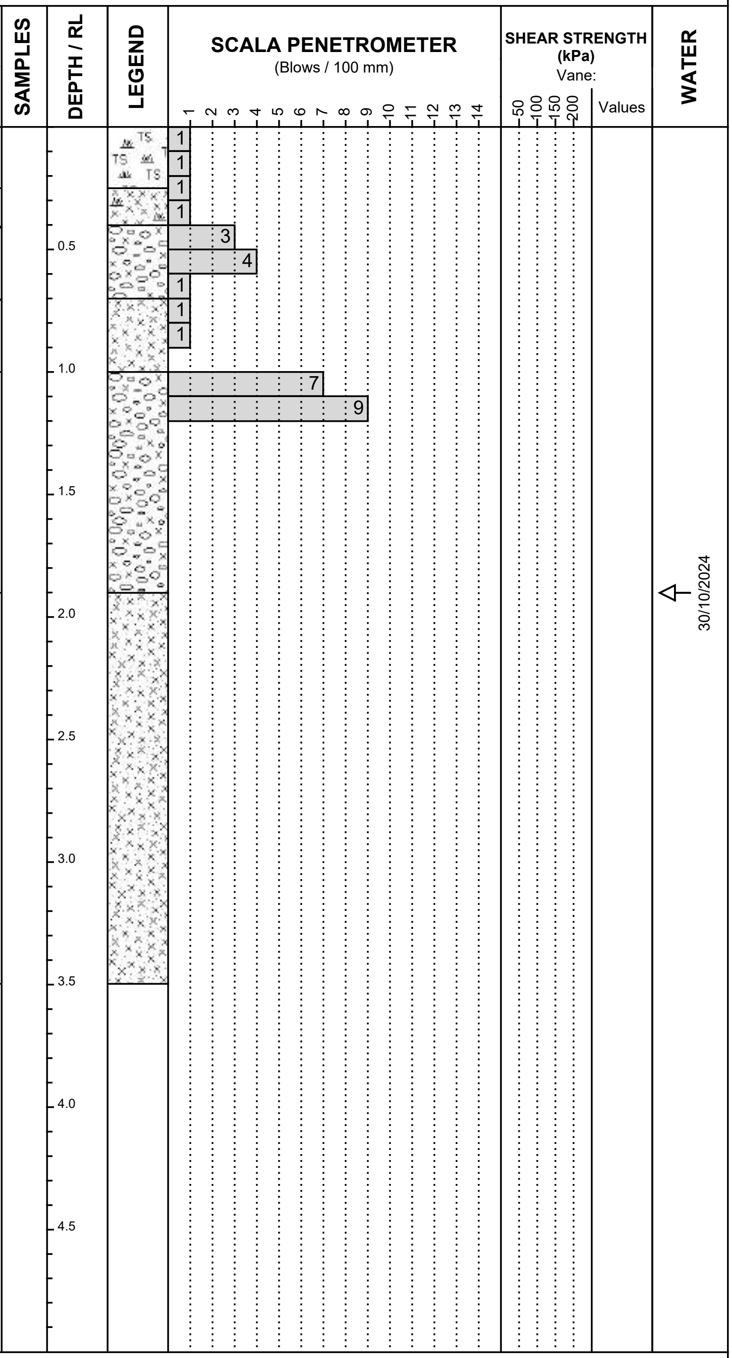
LOGGED BY: JMJ

ELEVATION: Existing ground level

OPERATOR: Jeremy

CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
TOPSOIL	Organic SILT with trace rootlets, black. Wet.	0.25 m
ALLUVIAL FAN DEPOSITS	Slightly organic SILT with minor sand, dark black and grey. Firm, moist to wet, low plasticity, sand, fine. Non sensitive.	0.40 m
	Silty fine to coarse GRAVEL with trace sand and cobbles, dark grey. Firm, wet, gravel, subrounded to rounded; sand, fine to medium.	0.70 m
	Sandy SILT, grey. Stiff, wet, sand, fine. Slightly sensitive.	1.00 m
	Silty fine to coarse GRAVEL with trace sand and cobbles, dark grey. Medium dense, saturated, gravel, subrounded to rounded; sand, fine to medium.	1.90 m
	Sandy SILT, grey. Stiff, saturated, sand, fine. Slightly sensitive.	3.50 m
	End Of Hole: 3.50 m	



PHOTO(S)

REMARKS

Pit collapsing below water table, test terminated. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:23:49 am

TEST PIT LOG

HOLE NO.: TP43

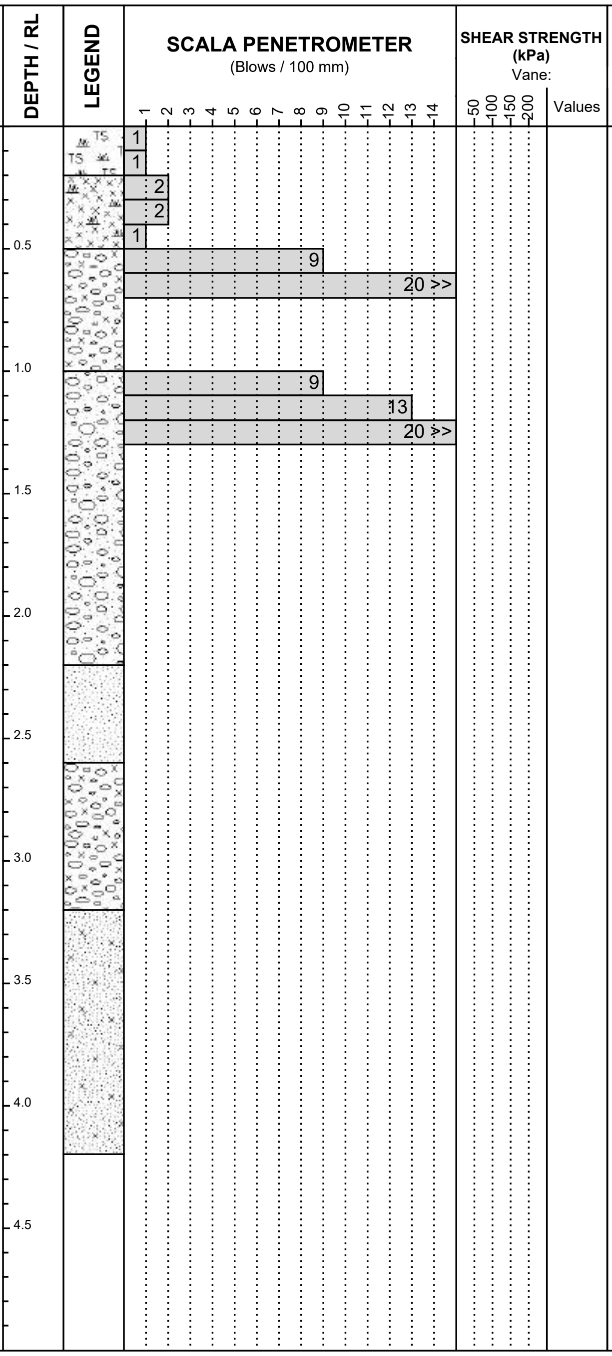
CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 30/10/2024
COORDINATES: 1265836.0 mE, 4998825.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 30/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	WATER
TOPSOIL	Organic SILT with trace rootlets, black. Wet.		0.20 m	Groundwater Not Encountered
ALLUVIAL FAN DEPOSITS	Slightly organic SILT with minor sand, dark black/grey. Firm, moist, low plasticity , sand, fine. Non-sensitive.		0.50 m	
	Silty fine to coarse GRAVEL with a trace of sand, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium.		1.00 m	
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with minor cobbles and trace boulders, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium. Boulders up to 150 mm diameter.		2.20 m	
	Fine SAND with a trace of gravel, grey. Medium dense, moist, gravel, fine to coarse, surrounded.		2.60 m	
	Silty fine to coarse GRAVEL with a trace of sand, dark grey. Medium dense, moist, gravel, subrounded to subangular; sand, fine to medium.		3.20 m	
GLACIAL TILL	Silty fine to medium SAND with a trace of gravel, light orange/grey. Medium dense, moist, gravel, fine to coarse, mostly fine to medium, rounded.		4.20 m	
	End Of Hole: 4.20 m			



PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

TEST PIT LOG

HOLE NO.: TP44

CLIENT: RCL Homestead Bay Ltd

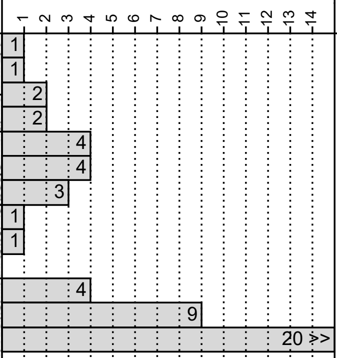
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Queenstown	**CONTRACTOR:** Base Contracting	**START DATE:** 30/10/2024
COORDINATES: 1265815.0 mE, 4998666.0 mN (NZTM2000)	**EQUIPMENT:** 13T	**END DATE:** 30/10/2024
LOCATION METHOD: Handheld GPS	**ACCURACY:** ± 3 m	**LOGGED BY:** JMJ
ELEVATION: Existing ground level	**OPERATOR:** Jeremy	**CHECKED DATE:** 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic silty fine SAND with trace of rootlets, dark brown. Moist.	0.25 m
LOESS	Silty fine SAND with a trace of organics, orange. Loose to medium dense, moist, gravel, fine to coarse, rounded.	0.40 m
WEATHERED GLACIAL TILL	Sandy silty fine to coarse GRAVEL, orange. Medium dense, wet to saturated, gravel, subrounded to subangular; sand, fine to medium.	0.70 m
	Fine to coarse SAND with minor gravel and silt, light grey. Loose, wet, gravel, fine to coarse, subrounded; sand, mostly fine.	1.00 m
GLACIAL TILL	Gravelly fine to coarse SAND with a trace of silt and cobbles/boulders, light grey. Dense, dry to moist, gravel, fine to coarse, mostly fine to medium, subrounded. Boulders up to 300 mm diameter.	1.60 m
	Fine to coarse SAND with minor gravel and a trace of silt, cobbles and boulders, light grey. Dense, dry to moist, gravel, fine to coarse, mostly fine to medium, subrounded. Boulders up to 300 mm diameter.	3.70 m
	End Of Hole: 3.70 m	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:24:00 am

TEST PIT LOG

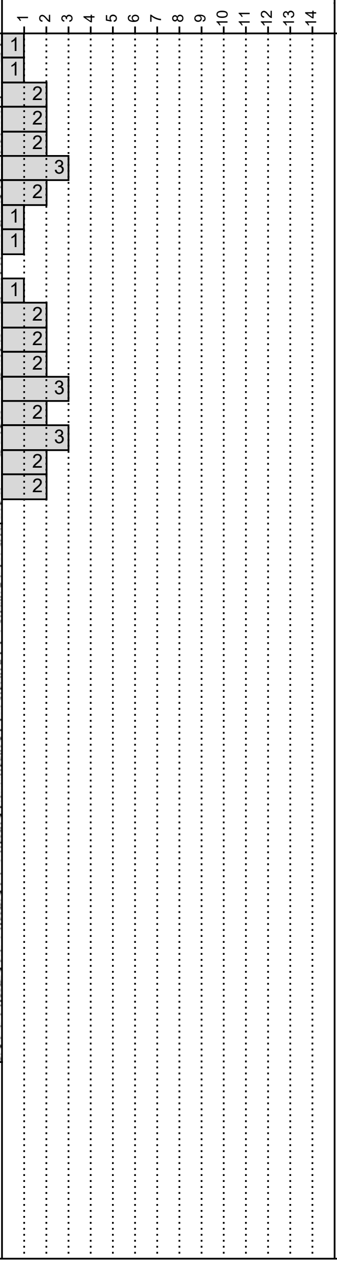
HOLE NO.: TP45

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 30/10/2024
COORDINATES: 1265662.0 mE, 4998725.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 30/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic silty fine SAND with trace rootlets, blackish/brown. Moist.	0.30 m
ALLUVIAL FAN DEPOSITS	Silty fine SAND with trace organics, dark grey. Loose, moist.	0.50 m
	Silty sandy GRAVEL with trace rootlets, dark grey, lenses out to 213°. Medium dense, moist, sand, fine to medium. Gravel, fine to medium, subrounded.	0.60 m
	SILT with minor sand, grey. Firm, moist, low plasticity, sand, fine.	2.00 m
OUTWASH DEPOSITS	Sand fine to coarse GRAVEL with minor cobbles and trace boulders, grey, interbedded bands of fine sand. Medium dense, moist, bedded, gravel, rounded to subrounded; sand, fine to coarse. Boulders up to 300 mm diameter.	4.20 m
	End Of Hole: 4.20 m	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 22/01/2025 10:24:04 am

TEST PIT LOG

HOLE NO.: TP46

CLIENT: RCL Homestead Bay Ltd

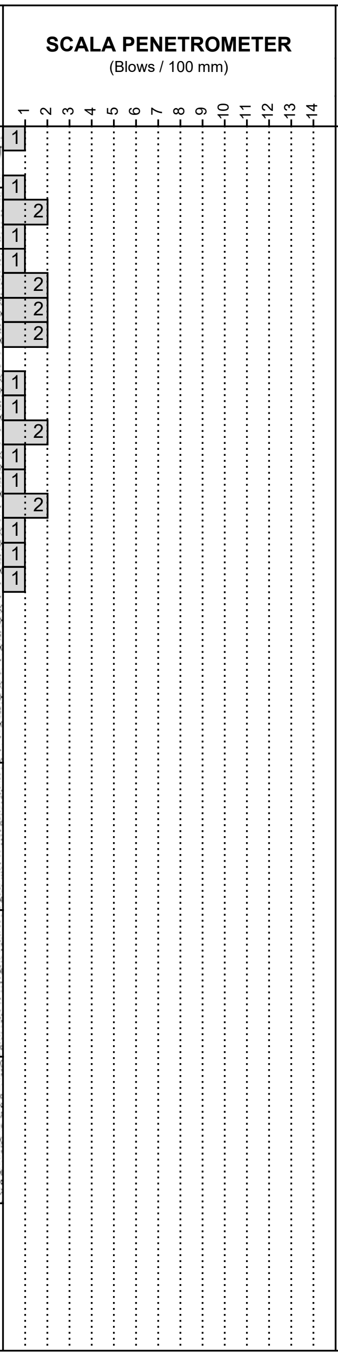
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION:	Queenstown	**CONTRACTOR:**	Base Contracting	**START DATE:**	30/10/2024
COORDINATES:	1265622.0 mE, 4997884.0 mN (NZTM2000)	**EQUIPMENT:**	13T	**END DATE:**	30/10/2024
LOCATION METHOD:	Handheld GPS	**ACCURACY:**	± 3 m	**LOGGED BY:**	JMJ
ELEVATION:	Existing ground level	**OPERATOR:**	Jeremy	**CHECKED DATE:**	20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH / RL
TOPSOIL	Organic silty fine SAND with trace rootlets, blackish/brown. Moist.	0.25 m
LOESS	Fine SAND with a trace of rootlets, light grey. Loose, dry to moist.	0.50 m
ALLUVIAL FAN DEPOSITS	Silty fine SAND with trace organics, dark grey. Loose, moist.	0.70 m
	SILT with minor sand, brownish/grey. Firm, moist, low plasticity, sand, fine.	2.60 m
	Fine SAND with minor silt, grey. Loose, moist.	3.20 m
	Silty fine SAND with trace organics, dark grey. Loose, moist.	3.80 m
GLACIAL TILL	Sandy SILT with minor gravel, grey/orange. Stiff, moist, sand, fine; gravel, fine, subrounded.	4.40 m
	End Of Hole: 4.40 m	

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Target depth achieved. Ground water not encountered, pit walls vertical. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

TEST PIT LOG

HOLE NO.: TP47

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Queenstown
CONTRACTOR: Base Contracting
START DATE: 30/10/2024
COORDINATES: 1265950.0 mE, 4998783.0 mN (NZTM2000)
EQUIPMENT: 13T
END DATE: 30/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 3 m
LOGGED BY: JMJ
ELEVATION: Existing ground level
OPERATOR: Jeremy
CHECKED DATE: 20/01/2025

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
TOPSOIL	Organic SILT with minor rootlets, dark brown. Soft, saturated.	0.30 m
ALLUVIAL FAN DEPOSITS	Silty fine to medium SAND, dark grey. Loose, wet.	0.40 m
	Sandy fine to medium GRAVEL with trace rootlets, dark grey. Loose, wet, gravel, subrounded; sand, coarse.	0.50 m
	SILT with a trace of sand, grey. Soft, wet, low plasticity, sand, fine.	0.60 m
	Sandy fine to coarse GRAVEL with minor silt and trace of cobbles and boulders, grey. Loose, saturated, gravel, subrounded; sand, fine to coarse; boulders up to 300 mm.	0.90 m
GLACIAL TILL	Fine to medium SAND with minor silt and gravel, with trace of cobbles and boulders, light orange/grey, dipping 224°/10°. Dense, wet, gravel, fine to coarse, rounded to subrounded. Boulders up to 400 mm diameter.	3.30 m
	End Of Hole: 3.30 m	

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows
0.0–0.1	1
0.2–0.3	1
0.3–0.4	3
0.4–0.5	6
1.0–1.1	4
1.1–1.2	4
1.2–1.3	3
1.3–1.4	8
1.4–1.5	20 >>

SHEAR STRENGTH (kPa) Vane: Values

WATER: ◁ In flow at 0.90 m – 30/10/2024

PHOTO(S)

REMARKS

End of test, maximum excavator reach, hole collapsing. Scala penetrometer unable to penetrate

WATER

▼ Standing Water Level
▷ Out flow
◁ In flow

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO

ELEVATION: 374m (NZVD2016)
ACCURACY: ± 1m
DRILLER: Matthew

START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
TOPSOIL	Organic SILT with trace gravel and rootlets, dark brown. Gravels are fine to medium, angular to subrounded. 0.30 m								Cement 0.3m
ALLUVIAL FAN DEPOSITS	SILT, with trace gravel, with lenses of sand and organic inclusions, brownish grey. Soft, moist, low plasticity, gravels are fine, subangular to subrounded. Sand is fine to medium. 0.75 m			0.5 / 373.5					Bentonite
	Silty fine SAND with trace gravel and organic inclusions , brownish grey. Loose, moist, non-plastic, gravels are fine to medium, subangular to rounded. 0.85 m		100						
	SILT with trace gravel, with lenses of sand and organic inclusions, brownish grey. Soft, moist, low plasticity, gravels are fine to medium, subangular to subrounded. Sand is fine to medium. 1.10 m			1.0 / 373.0					
	Silty fine SAND with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded. 1.30 m								
	Gravelly fine to medium SAND with minor silt, light grey. Loose, moist, gravels are fine subangular to rounded. 1.55 m			1.5 / 372.5		SPT (S) 1.50m 1, 1 / 2, 2, 2, 2 450mm N=8			
	Silty fine SAND with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded. 1.70 m								
	SILT with trace sand and gravel. With trace organic inclusions and rootlets, brownish grey, mottled orange and brown. Firm, moist , low plasticity, sand is fine. Gravels are fine and subrounded to rounded. 1.85 m		100		●				
	Silty fine SAND with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded. 1.95 m			2.0 / 372.0					
	CORELOSS. 2.30 m								
	SILT with trace sand, light grey. Firm, dry, low plasticity, sand is fine. 2.50 m		83	2.5 / 371.5					
	Silty fine SAND with some gravel, brownish grey. Loose, moist, gravels are fine to medium, subangular to subrounded. 2.75 m								
	Sandy fine to coarse GRAVEL with minor silt, brownish grey. Loose, moist, gravels are subangular to subrounded. Sand is fine to medium. 3.00 m								

TCR (%): 25 50 75
SPT N-VALUE: 10 20 30 40

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: **BH01**

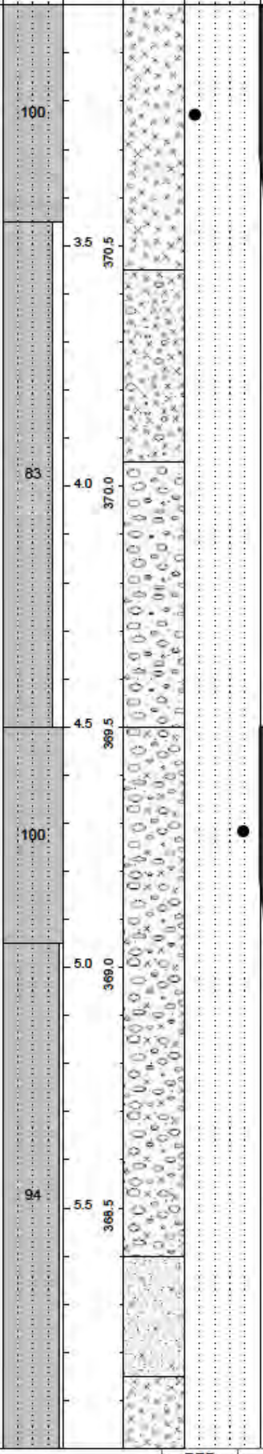
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

JOB NO.: **220556.01**

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO

ELEVATION: 374m (NZVD2016)
ACCURACY: ± 1m
DRILLER: Matthew

START DATE: 21/10/2024
END DATE: 22/10/2024
LOGGED BY: WF
CHECKED DATE: 07/01/2025



UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	SILT, grey. Soft, moist, low plasticity. 3.55 m		100			●	SPT (S) 3.00m 2, 2 / 2, 2, 2, 1 450mm N=7			Bentonite
	SILT with some sand and minor gravel, brownish grey. Firm, moist , low plasticity, sand is fine. Gravels are fine, subrounded to rounded . 3.95 m			3.5 370.5						
	Sandy fine to coarse GRAVEL with trace silt, brownish grey. Medium dense, moist, gravels are angular to rounded. Sand is fine to coarse. 4.50 m		83	4.0 370.0						
	Sandy, fine to coarse GRAVEL with some silt, grey. Dense, moist, gravels are angular to rounded. Sand is fine to coarse. 5.60 m		100 94	4.5 369.5 5.0 369.0 5.5 368.5		●	SPT (S) 4.50m 8, 10 / 8, 8, 10, 13 450mm N=39		▼ 22/10/2024	
	Silty fine SAND with trace fine gravel, brownish grey, mottled orange. Medium dense, moist, gravels are subrounded to rounded. 5.85 m									
	SILT with some sand and trace gravel, brownish grey, mottled orange. Firm, moist, low plasticity, sand is fine. Gravels are fine, subrounded to 6.65 m									

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

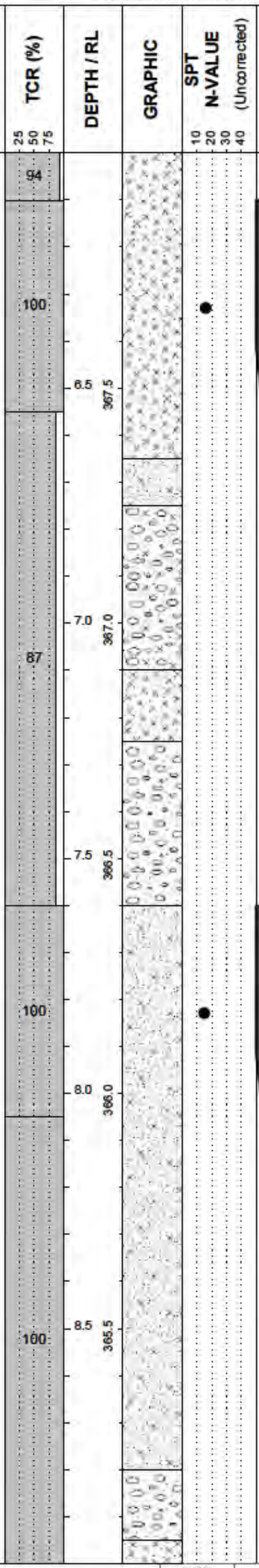
SOIL LOG

HOLE NO.: **BH01**

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: **220556.01**

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: 374m (NZVD2016)
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	rounded . 6.65 m		SPT (S) 6.10m 3, 2 / 4, 4, 4, 4 450mm N=16			Bentonite
	Silty fine SAND, brownish grey. Medium dense, wet, low plasticity. 6.75 m					
	Sandy fine to medium GRAVEL, with some silt, grey. Medium dense, wet, gravels are subangular to rounded. Sand is fine to coarse. 7.10 m					
	SILT with some sand and trace gravel, brownish grey, mottled orange. Firm, moist, low plasticity, sand is fine. Gravels are fine, subrounded to rounded . 7.25 m					
	Sandy fine to coarse GRAVEL with trace silt , grey. Medium dense, moist, gravels are subangular to subrounded. 7.60 m					
	Silty fine to coarse SAND with trace gravel, brownish grey, with slight orange mottling. Medium dense, wet, sand is predominantly fine to medium. Gravels are fine, subrounded. 8.80 m		SPT (S) 7.60m 3, 5 / 4, 3, 4, 4 450mm N=15			
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL with trace silt , grey. Medium dense, moist, gravels are subangular to subrounded. 8.95 m					
	9.10 m					



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

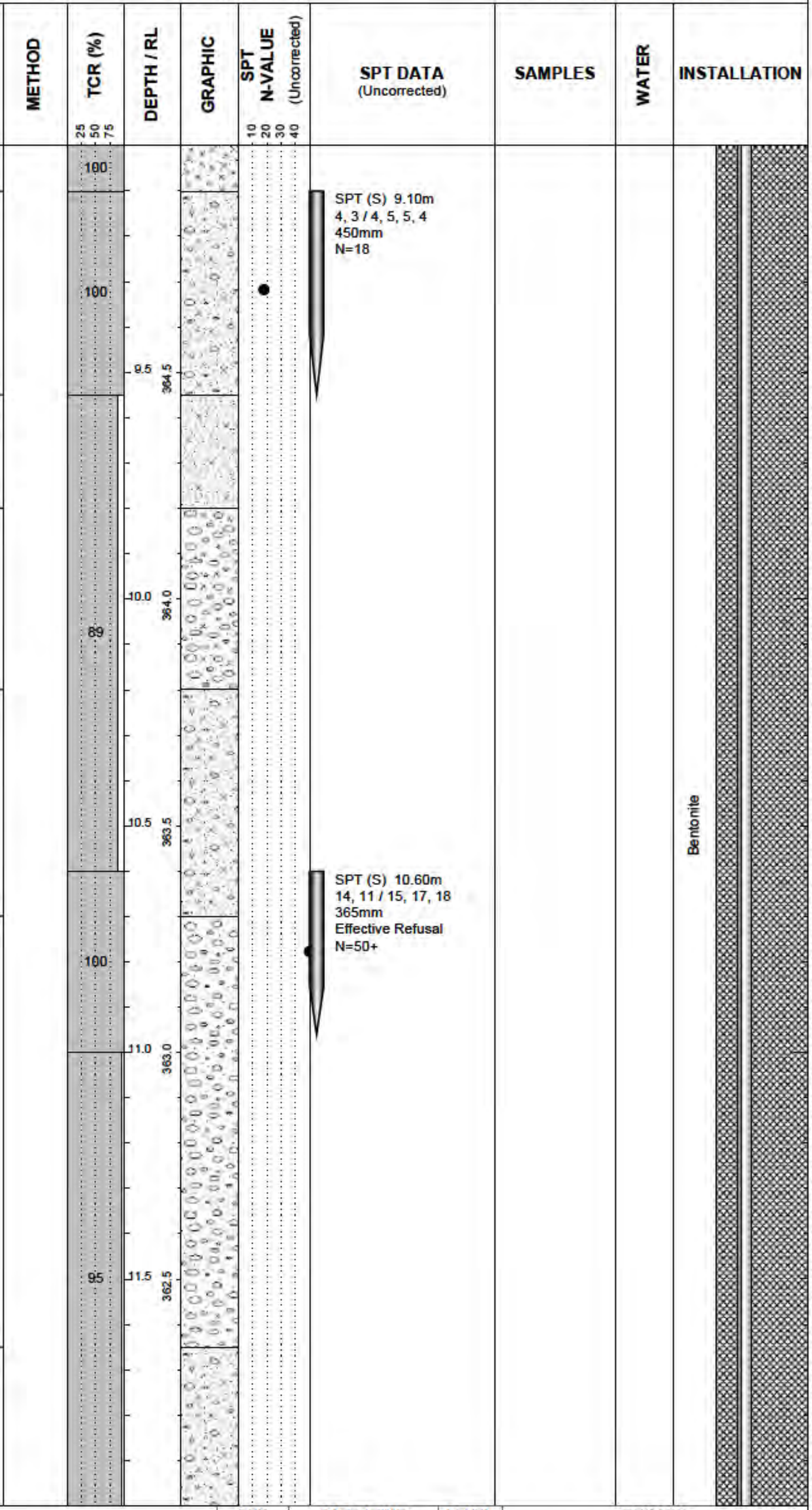
SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: 374m (NZVD2016)
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	
ALLUVIAL FAN DEPOSITS	SILT with minor sand, brownish grey, mottled orange. Firm, moist, low plasticity, sand is fine.	9.10 m
	Silty, gravelly fine to coarse SAND, brownish grey. Medium dense, moist, gravels are fine to medium subangular to subrounded.	9.55 m
	Silty fine to coarse SAND, with trace fine gravel, brownish grey. Medium dense, moist, non-plastic, sand is predominantly fine to medium. Gravels are subrounded.	9.80 m
	Silty sandy fine to coarse GRAVEL, grey. Medium dense, moist, sand is fine to medium.	10.20 m
GLACIAL TILL	Fine to medium SAND, with some silt and gravel, light brownish grey. Dense, moist, gravels are fine to coarse, subangular to subrounded.	10.70 m
	Sandy fine to medium GRAVEL, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse.	11.65 m
	Gravelly fine to medium SAND with minor silt, light greyish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded.	12.60 m



SPT (S) 9.10m
4, 3 / 4, 5, 5, 4
450mm
N=18

SPT (S) 10.60m
14, 11 / 15, 17, 18
365mm
Effective Refusal
N=50+

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: 374m (NZVD2016)
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Gravelly fine to medium SAND with minor silt, light greyish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded. 12.60 m		95 100	12.5 361.5			SPT (S) 12.20m 17, 16 / 11, 9, 14, 16 445mm Effective Refusal N=50+			Bentonite
	Sandy fine to medium GRAVEL with trace silt, grey. Very dense, moist, gravels are subangular to subrounded. Sand is fine to coarse. 13.30 m		93	13.0 361.0						
	Gravelly fine to medium SAND with trace silt, light grey. Very dense, moist, gravels are fine to medium, subangular to rounded. 14.00 m		100	13.5 360.5			SPT (S) 13.70m 11, 17 / 24, 26 225mm Effective Refusal N=50+			
	Sandy SILT with some gravel, brownish grey with slight orange mottling. Very stiff, moist, low plasticity, sand is fine. Gravels are fine to coarse, subangular to rounded. 15.00 m		95	14.0 360.0 14.5 359.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:15 am

GEOSOLVE

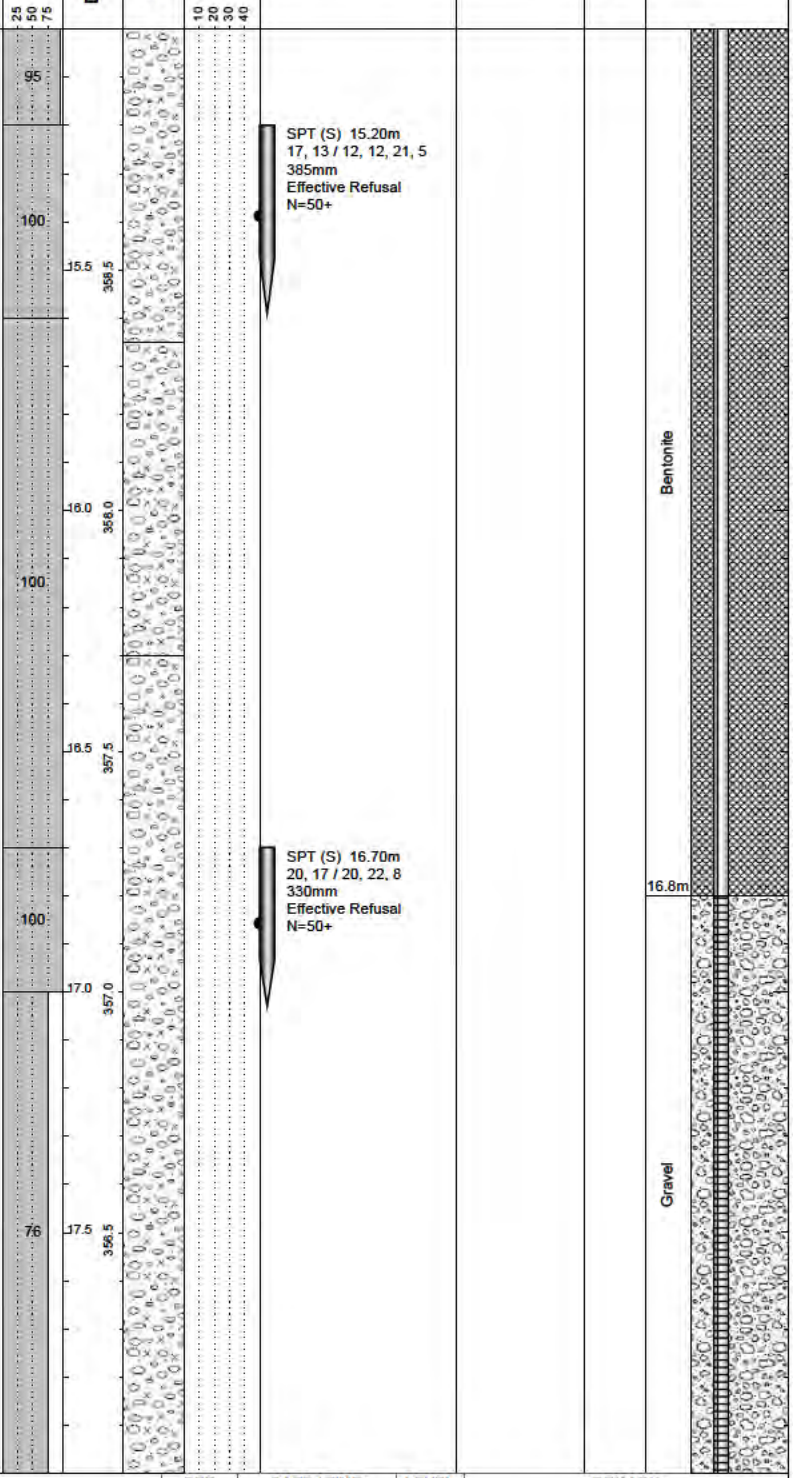
SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 21/10/2024
CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)
ELEVATION: 374m (NZVD2016)
END DATE: 22/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	Sandy fine to coarse GRAVEL with trace minor silt, grey and brown. Very dense, dry, gravels are subangular to rounded. Sand is fine to coarse. 15.65 m		95 100	15.5 358.5			SPT (S) 15.20m 17, 13 / 12, 12, 21, 5 385mm Effective Refusal N=50+			Bentonite
	Sandy fine to coarse GRAVEL with some silt, grey brown. Very dense, moist, gravels are subangular to rounded. Sand is fine to medium. 16.30 m		100	16.0 358.0						
	Sandy fine to coarse GRAVEL with minor silt, whitish grey. Very dense, dry, gravels are angular to rounded. Sand is fine to coarse. 19.95 m		100 76	16.5 357.5 17.0 357.0 17.5 356.5			SPT (S) 16.70m 20, 17 / 20, 22, 8 330mm Effective Refusal N=50+			16.8m Gravel



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:15 am

SOIL LOG

HOLE NO.: BH01

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 21/10/2024

CO-ORDINATES: 1265689.0mE, 4998875.0mN (NZTM2000)

ELEVATION: 374m (NZVD2016)

END DATE: 22/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matthew

CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL with minor silt, whitish grey. Very dense, dry, gravels are angular to rounded. Sand is fine to coarse. 19.95 m		76 100 100 100	18.5 355.5 19.0 355.0 19.5 354.5			SPT (S) 18.30m 29, 21 115mm Effective Refusal N=50+ SPT (S) 19.80m 26, 24 125mm Effective Refusal N=50+			Gravel 19.8m
	End Of Hole: 19.95m			20.0 354.0 20.5 353.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:15 am

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO

ELEVATION: 391m (NZVD2016)
ACCURACY: ± 1m
DRILLER: Matthew

START DATE: 22/10/2024
END DATE: 23/10/2024
LOGGED BY: WF
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
TOPSOIL	Organic SILT with trace gravel and rootlets, dark brown. Gravels are fine to medium, angular to subrounded. 0.30 m									Cement 0.3m
ALLUVIAL FAN DEPOSITS	Slightly organic gravelly, sandy SILT, dark brownish grey. Soft, wet, low plasticity, gravels are fine to coarse, angular to rounded. Sand is fine. 0.70 m			0.5 390.5						Bentonite
	Slightly organic sandy SILT with trace gravel, brownish grey. Soft, wet, low plasticity, sand is fine. Gravels are fine to medium, subangular to rounded. 1.15 m		82	1.0 390.0						
	Silty fine SAND with some gravel, grey. Loose, wet, non-plastic, gravels are fine to medium subangular to rounded. 2.00 m		100	1.5 389.5		●	SPT (S) 1.50m 3, 2 / 2, 3, 3, 2 450mm N=10			
	Sandy fine to coarse GRAVEL with some silt, grey. Loose, moist to wet, gravels are angular to subrounded. Sand is fine to coarse. 2.30 m			2.0 389.0						
	Fine to medium SAND with some silt and trace gravel, grey brown. Loose, moist, gravels are fine to medium, subangular. 3.80 m		50	2.5 388.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

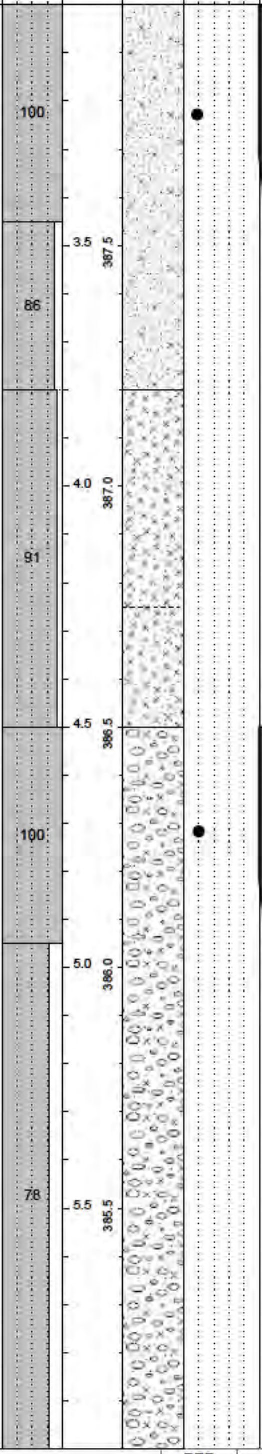
SOIL LOG

HOLE NO.: **BH02**

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: **220556.01**

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: 391m (NZVD2016)
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
ALLUVIAL FAN DEPOSITS	[CONT] Fine to medium SAND with some silt and trace gravel, grey brown. Loose, moist, gravels are fine to medium, subangular. 3.80 m		100 86	3.5 387.5			SPT (S) 3.00m 2, 2 / 2, 2, 2, 3 450mm N=9			Bentonite
	SILT with some sand and trace gravel, brownish grey, with slight orange mottling. Soft, moist, low plasticity, sand is fine to medium. Gravels are fine to medium subangular to subrounded. 4.3m - 4.5m: becoming sandy 4.50 m		91	4.0 387.0 4.5 386.5						
	Silty fine SAND with gravel, brownish grey. Loose, moist, non-plastic, gravels are fine. 6.00 m		100 78	5.0 386.0 5.5 385.5			SPT (S) 4.50m 2, 1 / 2, 3, 2, 3 450mm N=10			



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:20 am

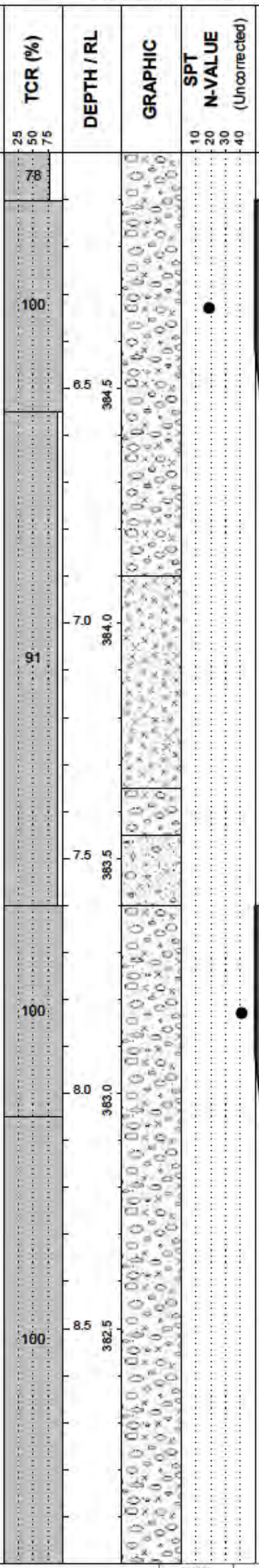
SOIL LOG

HOLE NO.: BH02

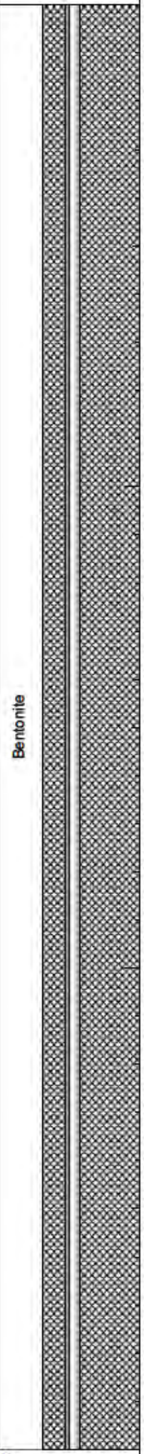
CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: 391m (NZVD2016)
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	SPT DATA (Uncorrected)	SAMPLES	WATER
ALLUVIAL FAN DEPOSITS	Sandy fine to coarse GRAVEL with some silt, grey. Medium dense, moist, gravels are subangular to rounded. Sand is fine to coarse. 6.90 m		SPT (S) 6.10m 3, 3 / 4, 4, 6, 5 450mm N=19		
	Sandy SILT, grey, brown. Firm, moist, low plasticity, sand is fine. 7.35 m				▼ 23/10/2024
OUTWASH DEPOSITS	Silty, sandy fine to coarse GRAVEL, grey. Medium dense, moist, gravels are subangular to subrounded. 7.45 m				
	Silty, gravelly fine to medium SAND, grey. Medium dense, wet, non-plastic, gravels are fine to medium subangular to subrounded. 7.60 m				
	Sandy fine to coarse GRAVEL, with trace to some silt, grey. Medium dense to dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 9.10 m		SPT (S) 7.60m 3, 8 / 10, 8, 8, 15 450mm N=41		



INSTALLATION



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

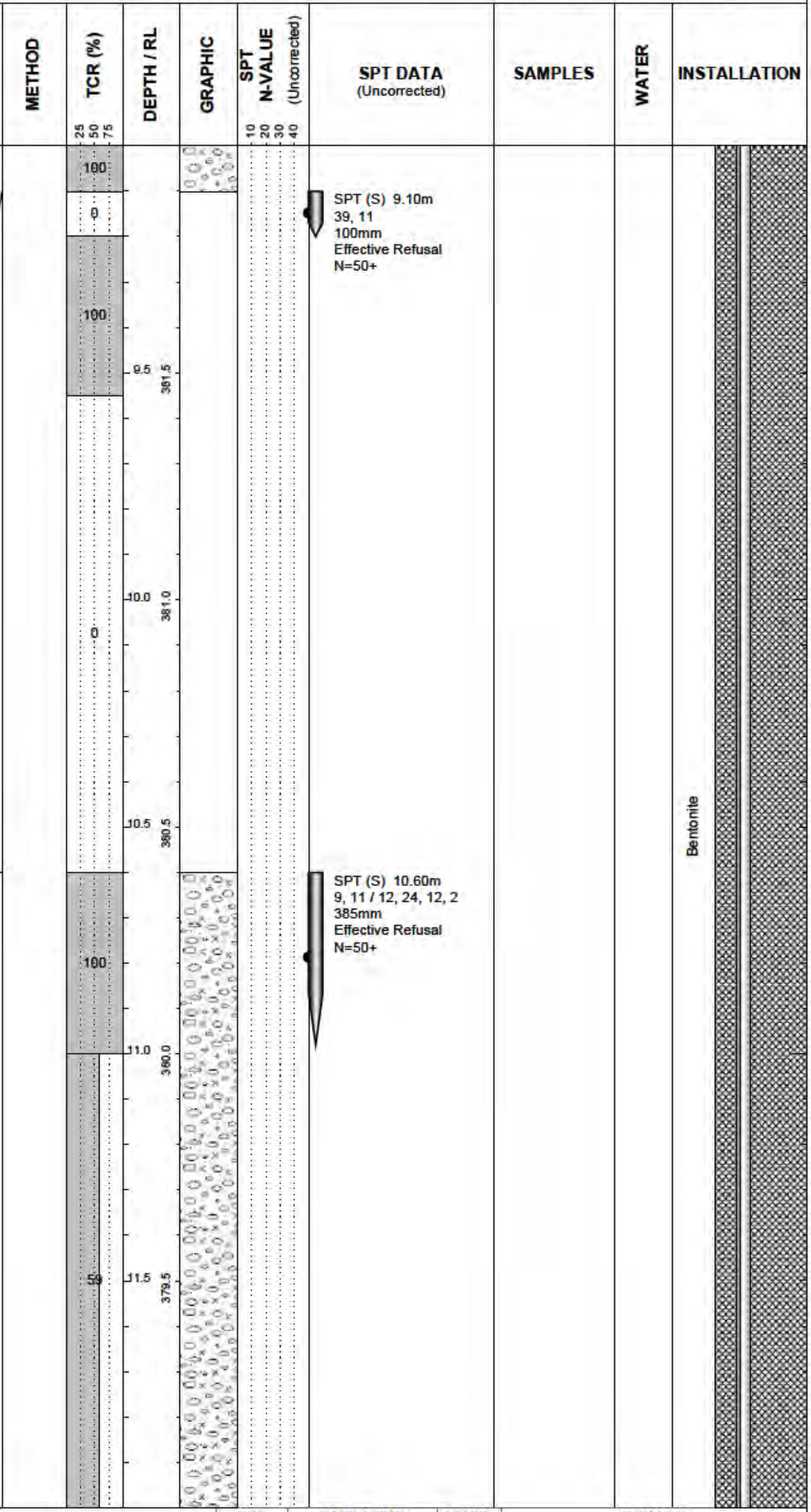
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill **RIG:** FRASTE XL 170 DUO

ELEVATION: 391m (NZVD2016)
ACCURACY: ± 1m
DRILLER: Matthew

START DATE: 22/10/2024
END DATE: 23/10/2024
LOGGED BY: WF
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	DEPTH
OUTWASH DEPOSITS	[CONT] Sandy fine to coarse GRAVEL, with trace to some silt, grey. Medium dense to dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse.	9.10 m
	CORELOSS.	10.60 m
	Sandy fine to coarse GRAVEL with trace to some silt, grey. Very dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse.	12.00 m



SPT DATA (Uncorrected)

SPT (S) 9.10m
39, 11
100mm
Effective Refusal
N=50+

SPT (S) 10.60m
9, 11 / 12, 24, 12, 2
385mm
Effective Refusal
N=50+

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

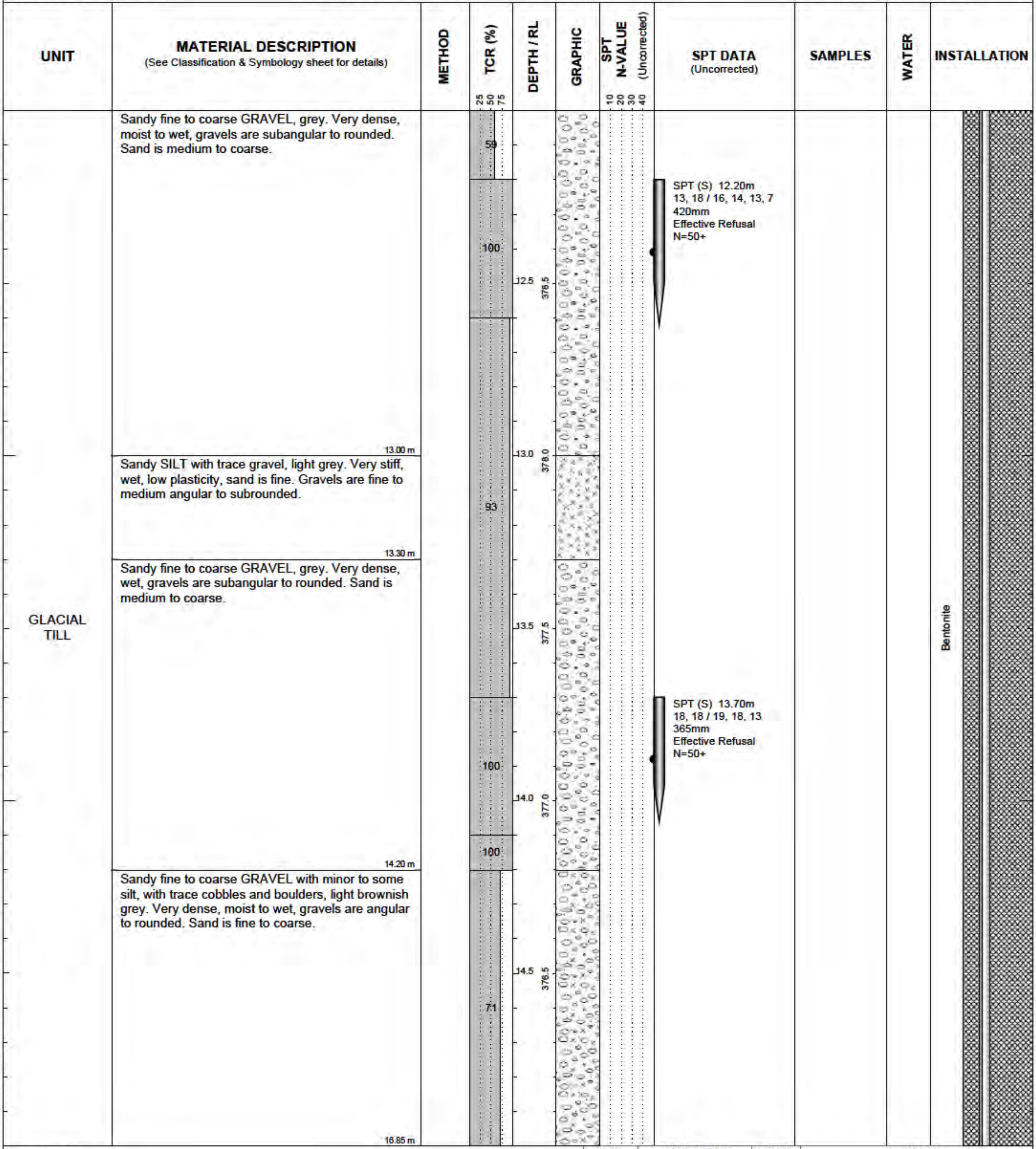
Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:20 am

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: 391m (NZVD2016)
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025



UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SPT DATA (Uncorrected)
GLACIAL TILL	Sandy fine to coarse GRAVEL, grey. Very dense, moist to wet, gravels are subangular to rounded. Sand is medium to coarse. 13.00 m	SPT (S) 12.20m 13, 18 / 16, 14, 13, 7 420mm Effective Refusal N=50+
	Sandy SILT with trace gravel, light grey. Very stiff, wet, low plasticity, sand is fine. Gravels are fine to medium angular to subrounded. 13.30 m	
	Sandy fine to coarse GRAVEL, grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 14.20 m	SPT (S) 13.70m 18, 18 / 19, 18, 13 365mm Effective Refusal N=50+
	Sandy fine to coarse GRAVEL with minor to some silt, with trace cobbles and boulders, light brownish grey. Very dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 16.85 m	

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: 391m (NZVD2016)
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL with minor to some silt, with trace cobbles and boulders, light brownish grey. Very dense, moist to wet, gravels are angular to rounded. Sand is fine to coarse. 16.85 m		71 100 96 100	15.5 375.5 16.0 375.0 16.5 374.5			SPT (S) 15.20m 10, 14 / 15, 19, 16 370mm Effective Refusal N=50+ SPT (S) 16.70m 10, 40 140mm Effective Refusal N=50+			Bentonite 16m Gravel
	Silty, fine to coarse GRAVEL with trace to some sand and trace cobbles, bluish grey and brown. Very dense, wet, gravels are fine to coarse angular to subangular. Sand is medium to coarse . 17.50 m		63	17.0 374.0						
	Gravelly SILT, with some sand and clay content, greyish brown. Stiff, wet, low plasticity, gravels are fine to coarse, subangular to rounded. 17.70 m		100	17.5 373.5						
	Sandy SILT with minor gravel, greenish, greyish brown. Very stiff, moist, non-plastic, sand is fine. Gravels are fine to medium, subrounded. 18.00 m									

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: BH02

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 22/10/2024
CO-ORDINATES: 1265959.0mE, 4998127.0mN (NZTM2000)
ELEVATION: 391m (NZVD2016)
END DATE: 23/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	SILT with some sand and gravel, greenish brown, bluish grey, slightly laminated and fissured. Hard, dry, non-plastic, sand is fine. Gravels are fine to coarse subangular to rounded. With iron oxidation staining and calcrete nodules. 18.30 m		100							Gravel
	Gravelly SILT with minor sand, greenish brown, bluish grey, slightly laminated. Very stiff, moist to wet, low plasticity, gravels are fine to coarse. Sand is fine. With iron oxidation staining and calcrete nodules. 19.20 m		100 100	18.5 372.5 19.0 372.0			SPT (S) 18.30m 50 60mm Effective Refusal N=50+			19m
	End Of Hole: 19.20m			19.5 371.5 20.0 371.0 20.5 370.5						

REMARKS
Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: 373m (NZVD2016)
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
TOPSOIL	Organic SILT with trace gravel and rootlets, dark brown. Gravels are fine to medium, angular to subrounded. 0.70 m			0.5 / 372.5						Cement 0.3m
ALLUVIAL FAN DEPOSITS	SILT with trace fine sand and gravel, and some organic inclusions, light greyish brown, with orange brown speckling. Soft, moist to wet, low plasticity. 1.60 m		100	1.0 / 372.0 1.5 / 371.5			SPT (S) 1.50m 2, 3 / 27, 23 245mm Effective Refusal N=50+			Bentonite
GLACIAL POND SEDIMENT	Gravelly SILT with minor sand and trace rootlets, light greyish brown, with orange brown speckling . Stiff, wet, low plasticity, gravels are fine to medium, angular to subrounded. Sand is fine to medium. 1.90 m		100							
OUTWASH DEPOSITS	Sandy fine to coarse GRAVEL with trace cobbles, grey. Dense, moist, gravels are subangular to rounded. Sand is fine to medium. 2.10 m			2.0 / 371.0						
	Silty, sandy fine to coarse GRAVEL, greyish brown. Dense, moist , gravels are subangular to rounded. Sand is medium. 2.30 m		100							
	Sandy fine to coarse GRAVEL with minor silt, light greyish brown. Dense, moist , gravels are subangular to rounded. Sand is medium. 2.50 m			2.5 / 370.5						
	Silty, sandy fine to coarse GRAVEL, light grey and brown. Very dense, wet, Gravels are angular to rounded. Sand is fine to coarse. 3.70 m		100							

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

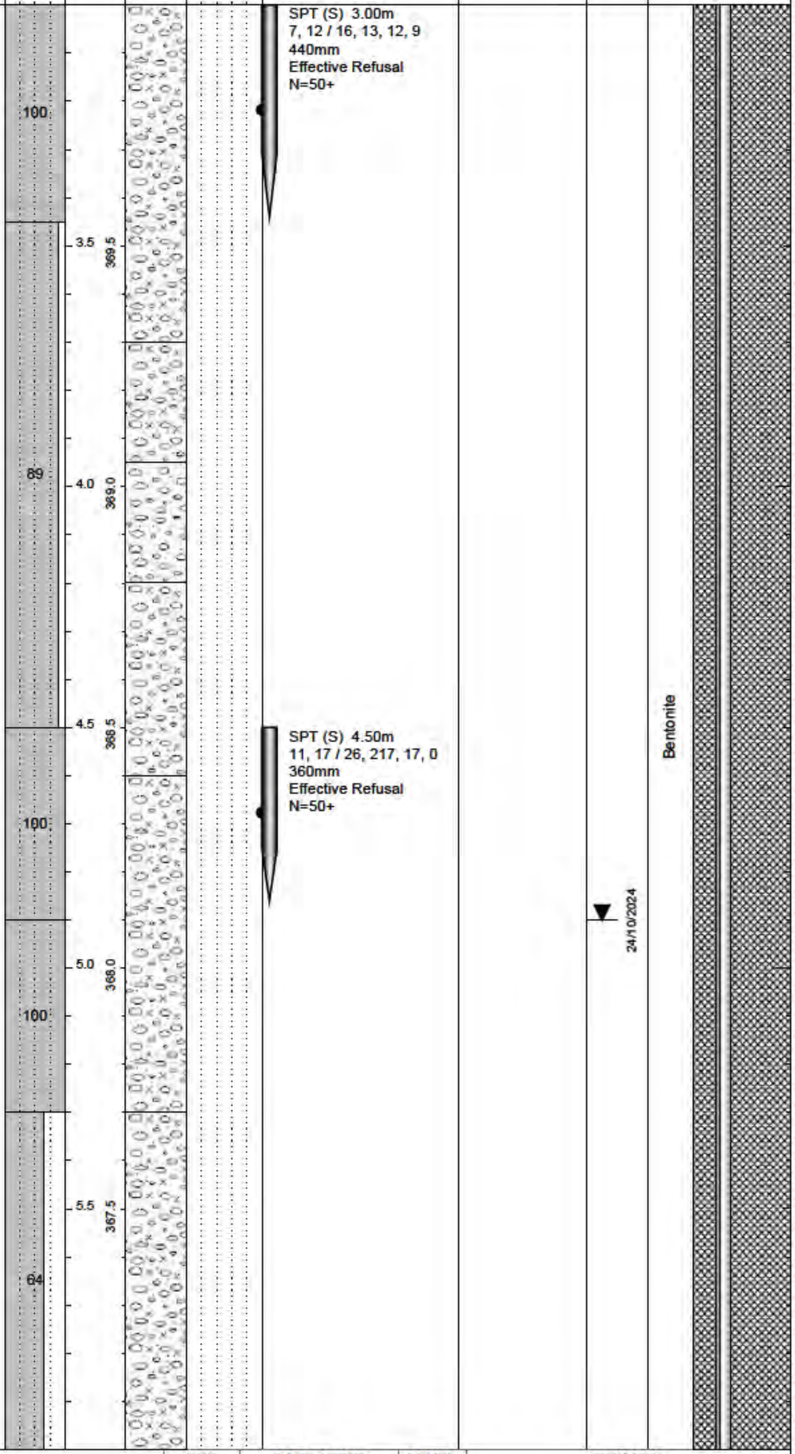
SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: 373m (NZVD2016)
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
OUTWASH DEPOSITS	[CONT] Silty, sandy fine to coarse GRAVEL, light grey and brown. Very dense, wet, Gravels are angular to rounded. Sand is fine to coarse. 3.70 m		100	3.5 369.5	SPT (S) 3.00m 7, 12 / 16, 13, 12, 9 440mm Effective Refusal N=50+			Bentonite
	Sandy fine to coarse GRAVEL with some silt, grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 3.95 m							
	Sandy fine to coarse GRAVEL, grey. Very dense, moist, gravels are subangular to rounded . 4.20 m		89	4.0 369.0				
	Sandy fine to coarse GRAVEL with some silt, grey, slightly brown. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 4.60 m			4.5 368.5	SPT (S) 4.50m 11, 17 / 26, 217, 17, 0 360mm Effective Refusal N=50+			
	Sandy fine to medium GRAVEL with minor silt, grey and brown. Very dense, moist, gravels are angular to subrounded. 5.30 m		100 100	5.0 368.0			24/10/2024	
	Sandy, fine to coarse GRAVEL with trace to some silt, and trace cobbles, grey, brown and orange. Dense to very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 6.60 m		64	5.5 367.5				



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd

PROJECT: Homestead Bay Geotechnical

JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371

START DATE: 23/10/2024

CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)

ELEVATION: 373m (NZVD2016)

END DATE: 24/10/2024

LOCATION METHOD: Handheld GPS

ACCURACY: ± 1m

LOGGED BY: WF

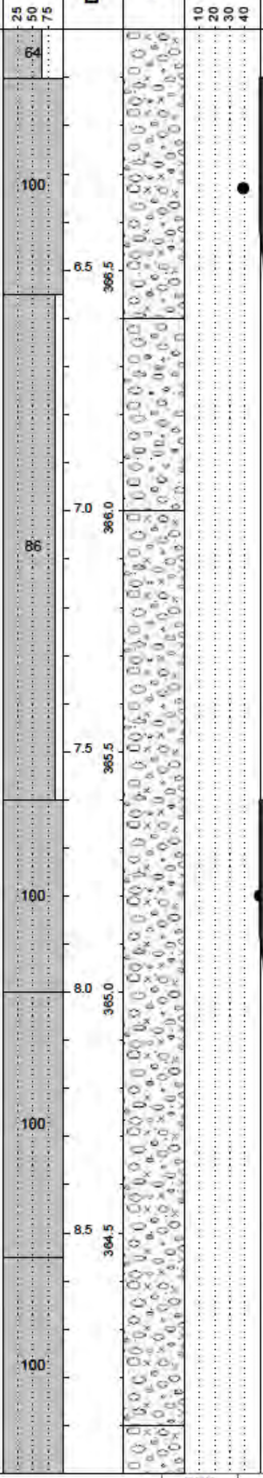
CONTRACTOR: Pro Drill

RIG: FRASTE XL 170 DUO

DRILLER: Matthew

CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
OUTWASH DEPOSITS	[CONT] Sandy, fine to coarse GRAVEL with trace to some silt, and trace cobbles, grey, brown and orange. Dense to very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 6.60 m		64 100	6.5 366.5	SPT (S) 6.10m 8, 9 / 10, 10, 10, 9 450mm N=39			Bentonite
	Sandy, fine to coarse GRAVEL with trace silt, grey brown. Very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 7.00 m			7.0 366.0				
	Sandy fine to coarse GRAVEL with minor to some silt, and trace cobbles, grey, brown and orange. Very dense, moist, gravels are angular to rounded. Sand is fine to coarse. 8.90 m		86 100 100 100	7.5 365.5 8.0 365.0 8.5 364.5	SPT (S) 7.60m 11, 15 / 16, 14, 16, 4 395mm Effective Refusal N=50+			
	Sandy fine to coarse GRAVEL with some silt , grey, brown, bluish grey and orange. Very dense 9.85 m							



REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: 373m (NZVD2016)
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%) 25 50 75	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
OUTWASH DEPOSITS	moist, gravels are subangular to rounded. Sand is fine to coarse. 9.85 m		100 100	9.5 363.5			SPT (S) 9.10m 19, 23 / 22, 28 290mm Effective Refusal N=50+			Bentonite
	Sandy, fine to coarse GRAVEL with trace silt and cobbles, grey brown. Very dense, moist, gravels are angular to subrounded. 10.15 m		100	10.0 363.0						
	Gravelly fine to medium SAND with trace silt, brown. Very dense, moist, gravels are fine to coarse, predominantly fine to medium, and subangular to subrounded. 10.50 m									
	Silty gravelly fine to medium SAND, grey, brown and orange. Very dense, moist, gravels are fine to coarse subangular to subrounded . 10.60 m			10.5 362.5						
	Sandy fine to coarse GRAVEL with minor silt, grey brown. Very dense, moist, gravels are angular to subrounded . 11.45 m		100 56	11.0 362.0			SPT (S) 10.60m 23, 29 / 17, 18, 15 365mm Effective Refusal N=50+			
GLACIAL TILL	Sandy fine to coarse GRAVEL with minor to some silt, grey, brown, bluish grey and orange. Very dense, moist, gravels are fine to coarse, angular to rounded. Sand is fine to coarse. 12.10 m		100	11.5 361.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

GEOSOLVE

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: 373m (NZVD2016)
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	GRAPHIC	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL with minor to some silt, grey, brown, bluish grey and orange. Very dense, moist, gravels are fine to coarse, angular to rounded. Sand is fine to coarse. 12.10 m		100							Bentonite
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown. Very dense, moist, gravels are angular to subrounded. Sand is medium to coarse. 12.50 m		100	12.5 360.5			SPT (S) 12.20m 38, 12 105mm Effective Refusal N=50+			
	Silty, sandy fine to coarse GRAVEL, light greenish grey. Very dense, moist to wet, gravels are angular to rounded. Sand is medium to coarse. 13.00 m									
	Medium to coarse SAND with some gravel, grey, brown. Very dense, moist to wet, gravels are fine to medium, subrounded. 13.10 m		100	13.0 360.0						
	Sandy fine to coarse GRAVEL with some silt, grey, brown and orange. Very dense, moist to wet, gravels are subangular to rounded. Sand is fine to coarse. 13.40 m									
	Medium to coarse SAND with some gravel, grey, brown. Very dense, moist to wet, gravels are fine to medium, subrounded. Sand is predominantly coarse. 13.55 m			13.5 359.5						
	Sandy fine to coarse GRAVEL with some silt, grey, brown and orange. Very dense, moist to wet, gravels are subangular to rounded. Sand is fine to coarse. 13.70 m									
	Silty, sandy fine to medium GRAVEL, light greenish grey and brown. Very dense, moist to wet, gravels are subangular to subrounded. Sand is fine to coarse. 14.05 m		100	14.0 359.0			SPT (S) 13.70m 22, 24 / 43, 7 235mm Effective Refusal N=50+			
	Sandy fine to medium GRAVEL with trace silt, light greenish grey and brown. Very dense, moist to wet, gravels are subangular to subrounded. Sand is medium to coarse. 14.20 m									
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist, gravels are angular to rounded. Sand is medium to coarse. 15.50 m		91	14.5 358.5						

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
LOCATION METHOD: Handheld GPS
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
ELEVATION: 373m (NZVD2016)
ACCURACY: ± 1m
DRILLER: Matthew
START DATE: 23/10/2024
END DATE: 24/10/2024
LOGGED BY: WF
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	Depth
GLACIAL TILL	[CONT] Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist, gravels are angular to rounded. Sand is medium to coarse.	15.50 m
	Silty, sandy, fine to medium GRAVEL, light greyish brown, with dark brown speckling. Very dense, wet, gravels are subangular to subrounded.	15.60 m
	Silty, sandy fine to coarse GRAVEL, brownish grey. Very dense, wet, gravels are angular to subrounded. Sand is fine to medium.	15.75 m
	Sandy fine to coarse GRAVEL with some silt, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse.	15.85 m
GLACIAL TILL	Gravelly medium to coarse SAND with trace silt, grey and brown. Very dense, moist, gravels are fine to medium, subangular to subrounded.	15.95 m
	Sandy fine to coarse GRAVEL with some silt, grey and brown. Very dense, moist, gravels are subangular to subrounded. Sand is medium to coarse.	16.05 m
	Gravelly fine to coarse SAND with trace silt, orangish brown. Very dense, moist, gravels are fine to coarse, subangular to rounded.	16.45 m
	Sandy fine to coarse GRAVEL with minor to some silt, with trace decayed organic matter, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse.	18.05 m

TCR (%) (25 50 75): 91, 100, 100, 100, 100, 88

DEPTH	RL
15.5	357.5
16.0	357.0
16.5	356.5
17.0	356.0
17.5	355.5

SPT N-VALUE (Uncorrected) 10 20 30 40

SPT DATA (Uncorrected)

SPT (S) 15.20m
19, 31
75mm
Effective Refusal
N=50+

SPT (S) 16.70m
24, 22 / 31, 19
280mm
Effective Refusal
N=50+

INSTALLATION

Bentonite
16.8m
Gravel

REF	DATE / TIME	LEVEL	REMARK

REMARKS

Target depth achieved

Generated with CORE-GS by Geroc - Combined Soil + Rock - 9/01/2025 10:44:24 am

SOIL LOG

HOLE NO.: BH03

CLIENT: RCL Homestead Bay Ltd
PROJECT: Homestead Bay Geotechnical
JOB NO.: 220556.01

SITE LOCATION: Kingston Road, Drift Bay 9371
START DATE: 23/10/2024
CO-ORDINATES: 1265487.0mE, 4998045.0mN (NZTM2000)
ELEVATION: 373m (NZVD2016)
END DATE: 24/10/2024
LOCATION METHOD: Handheld GPS
ACCURACY: ± 1m
LOGGED BY: WF
CONTRACTOR: Pro Drill
RIG: FRASTE XL 170 DUO
DRILLER: Matthew
CHECKED DATE: 07/01/2025

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	METHOD	TCR (%)	DEPTH / RL	SPT N-VALUE (Uncorrected)	SPT DATA (Uncorrected)	SAMPLES	WATER	INSTALLATION
GLACIAL TILL	[CONT] Sandy fine to coarse GRAVEL with minor to some silt, with trace decayed organic matter, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse. 18.05 m 18.20 m		88						Gravel
	Gravelly medium to coarse SAND with trace silt, greenish grey and brown. Very dense, wet, gravels are fine to medium, subangular to subrounded.		100			SPT (S) 18.30m 25, 25 120mm Effective Refusal N=50+			
	Sandy fine to coarse GRAVEL with minor to some silt, with trace cobbles, greenish grey and orangish brown. Very dense, wet, gravels are angular to rounded. Sand is fine to coarse. 18.90 m		65	18.5 / 354.5					
	Sandy, fine to medium GRAVEL, greenish grey. Very dense, wet, gravels are subangular to rounded. Sand is medium to coarse. 19.05 m			19.0 / 354.0					
	Gravelly medium to coarse SAND with trace silt, greenish grey and brown. Very dense, wet, gravels are fine to medium, subangular to subrounded. 19.30 m								
	Gravelly, medium to coarse SAND, grey and brown. Very dense, moist, gravels are fine to medium, subangular to subrounded. 19.40 m		100						
GLACIAL TILL	Sandy fine to coarse GRAVEL, with some silt, grey and brown. Very dense, moist, gravels are subangular to rounded. 19.50 m			19.5 / 353.5					
	Medium to coarse SAND with some silt, grey and brown. Very dense, moist. 19.65 m								
	Silty, sandy fine to coarse GRAVEL, greenish grey and purplish brown and orange. Very dense, moist to wet, gravels are angular to rounded. Sand is medium to coarse. 19.85 m		100			SPT (S) 19.80m 50 50mm Effective Refusal N=50+			19.8m
	End Of Hole: 19.85m			20.0 / 353.0					
				20.5 / 352.5					

TCR (%) scale: 25 50 75
SPT N-VALUE scale: 10 20 30 40

REMARKS

Target depth achieved

REF	DATE / TIME	LEVEL	REMARK

Appendix C: Liquefaction Results

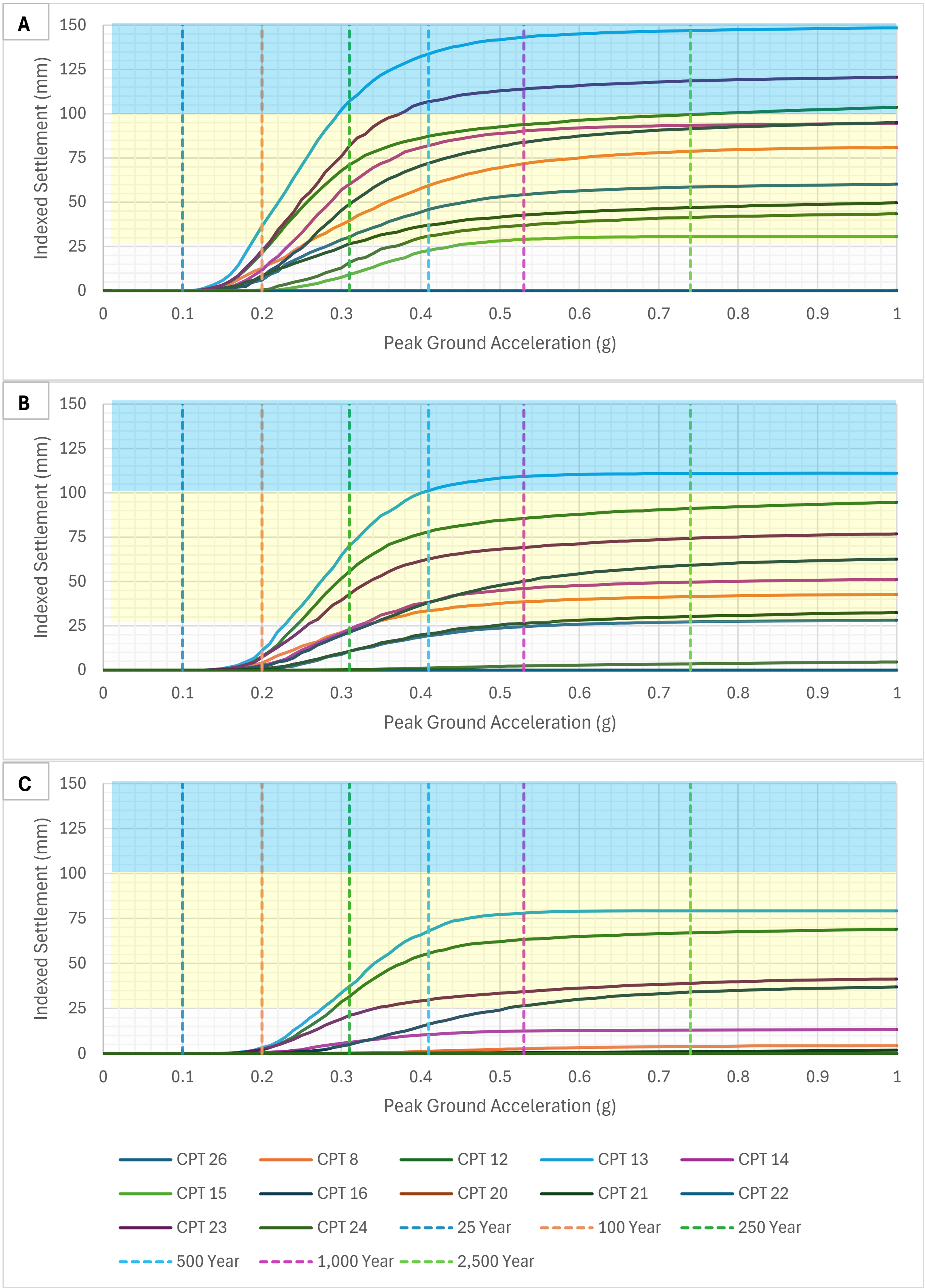


Figure 1: Indexed reconsolidation settlement vs peak ground acceleration. A, B and C are assumed groundwater levels of 2, 4 and 6 m below ground level respectively

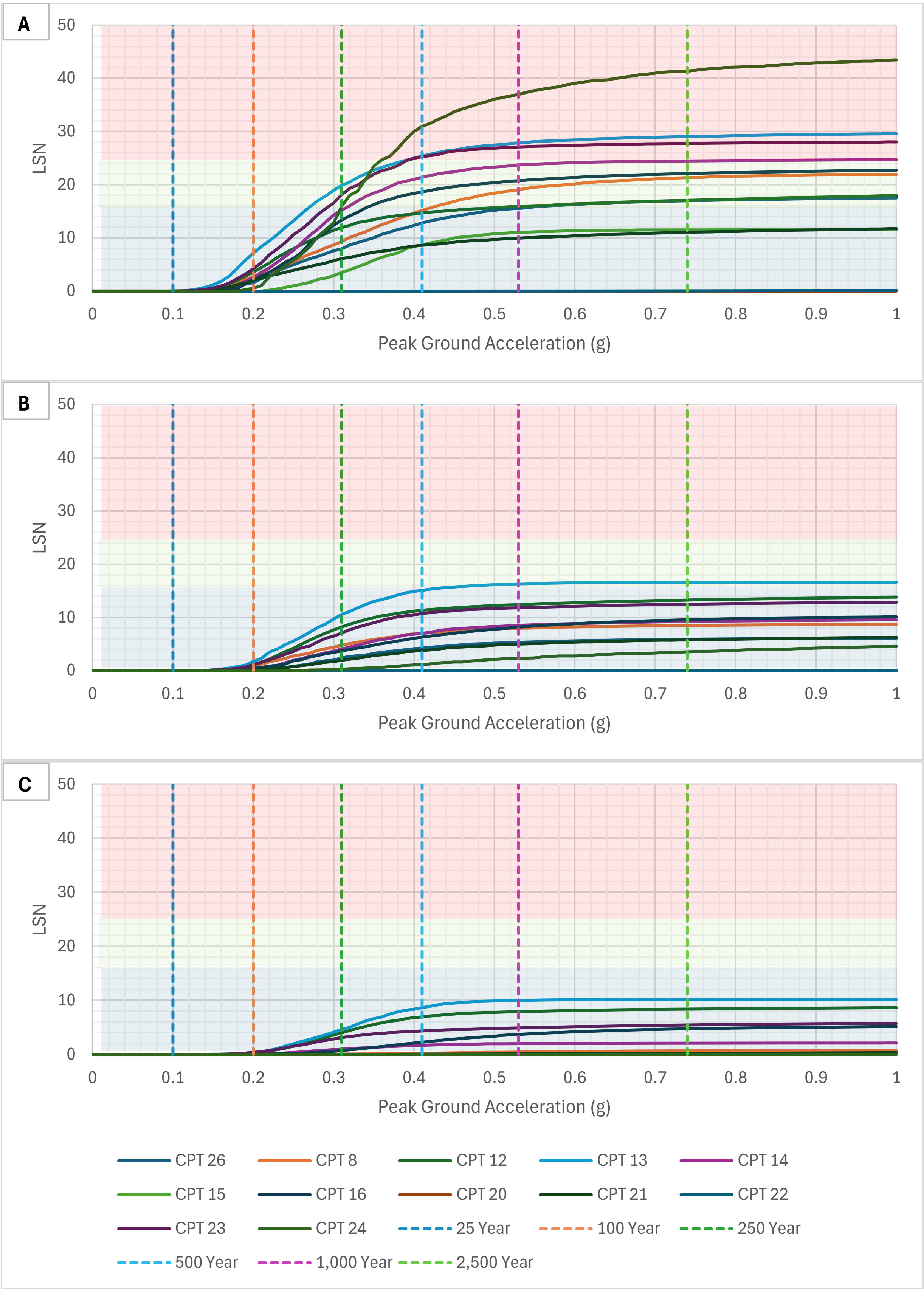


Figure 2: Liquefaction severity number vs peak ground acceleration. A, B and C are assumed groundwater levels of 2, 4 and 6 m below ground level respectively

APPENDIX C

LWP (LANDWATERPEOPLE) Memo

Memorandum

To: Brian Ellwood (LEI), Dan Wells (RCL Group), Amanda Leith (Remarkable Planning)

From: Ned Norton (LWP)

Date: 20 March 2025

Subject: Assessment of sensitivity and water quality criteria for Lake Wakatipu and its tributary streams, and of risks to manage for the treatment and discharge of wastewater from Homestead Bay housing development

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Executive summary

Background

- The Homestead Bay development is proposing to manage wastewater through treatment and discharge to land on site, rather than piping and disposing of wastewater elsewhere.
- The waterways that could potentially receive treated contaminants include groundwater underlying the Homestead Bay development site, two unnamed watercourses, Māori Jack Stream and its ephemeral tributaries, and Lake Wakatipu (Figure 1).

Purpose

- The purpose of this memo is to assess the potential effects of nutrients (nitrogen and phosphorus) because these are important wastewater contaminants for stream and lake effects, and because managing these effects will be a key factor influencing the consideration of design options for wastewater treatment (LEI 2025). I have also provided the relevant stream and lake water quality criteria for the microorganism indicator *E. coli,* which is generally more straight-forward to treat in reticulated wastewater than nutrients.

Methods

- Relevant water quality standards are primarily from the Regional Water Plan (RWP) Schedule 15. However, there are also relevant criteria defined in the conditions of an existing consent granted by Otago Regional Council (ORC) to discharge treated wastewater to land from the neighbouring Jacks Point resort development (a copy is provided in Attachment 1), in circumstances which could also potentially result in treated contaminants reaching Māori Jack Stream and Lake Wakatipu (Figure 1).
- I have also considered the water quality standards invoked in the Water Conservation (Kawarau) Order 1997 (WCO). For the purposes of this memo, whenever my assessment meets the relevant RWP Schedule 15 limits this can also be considered compliance with the relevant WCO water quality standards (for Class AE, CR, F and FS waters).

- For each of the potentially affected waterways I have detailed the following: i) current state; ii) relevant regulatory water quality standards; iii) relative sensitivity and risks for the different receiving waters; and iv) monitoring considerations.

- The *Homestead Bay Consent Level Design Wastewater Land Application* report (LEI 2025) describes a proposed two-part “treatment train” system that includes a wastewater treatment plant (WWTP) that receives raw reticulated wastewater influent and treats it to produce effluent of a defined standard before then discharging that effluent to land treatment areas (LTA). The LEI (2025) report describes several WWTP options and a network of proposed available LTAs. While the two-part system is confirmed, the choice of specific WWTP type and supplier, and the sequencing of the use of identified LTAs is not yet finalized.

- The developer (RCL Group) wishes to maintain some flexibility around the final system configuration for multiple reasons including confirmation of the consented treatment standard and being able to optimally match treatment capacity to a series of development time-stages. This memo therefore does not assess a final detailed treatment train configuration but instead sets out receiving water design criteria and assesses the likelihood that the treatment train system options described in the consent-level design report (LEI 2025) could meet those criteria.

- I expect this memo could form an attachment to the Assessment of Environmental Effects (AEE) part of the application for resource consents. This Executive Summary contains a summary of all the main conclusions and recommendations. Justification for these is provided in the remainder of the memo for readers wanting technical detail.

Groundwater

- Groundwater at the site is not especially sensitive relative to the other waterways because the existing and predicted future concentrations of nitrogen in groundwater are well within national drinking water standards (section 4.2). The main risk is groundwater carrying residual post-treatment nutrients to Māori Jack Stream and Lake Wakatipu.

- The existing Jacks Point consent conditions set a precedent trigger criterion requiring investigation actions if median groundwater nitrate-nitrogen concentrations at monitoring bore P1 increase by 1.5 mg/L (see section 4.2). The consent level design report (LEI 2025) suggests this criterion is likely to be achieved and the trigger for action avoided.

- The design of the treatment system will be driven primarily by other treatment performance requirements for nutrients in Māori Jack Stream and Lake Wakatipu.

Unnamed water courses

- The two unnamed water courses (Figure 1) are ephemeral - meaning they have surface water for only short periods of time during and after heavy rainfall – and they have no aquatic ecological value (see section 5.1). The risk of adverse effects on these watercourses is low (see section 5.3).

- In my opinion it would be appropriate for the RWP Schedule 15 limits for tributaries of Lake Wakatipu to not apply to these two unnamed ephemeral watercourses, or to the other two ephemeral grassed-swale Jacks Point tributaries labelled in Figure 1 (see section 5.2 and 6.3).

Māori Jack Stream

- Māori Jack Stream has ecological value that has been graded in the *Jacks Point Freshwater Ecological Assessment* (e3S 2022) as "fair" to "poor" based on macroinvertebrate sampling results (section 6.1).

- My assessment recognises three distinct sections of Māori Jack Stream that have different characteristics and values (see section 6.2):

  i) A "lower section" extends from Lake Wakatipu approximately 100 m upstream and has a gravel bed with intermittent surface flow that is normally disconnected from Lake Wakatipu by a gravel beach barrier built by wind generated wave action. This section appears to commonly support only a few small (less than 1 m) stagnant ponds in summer with significant algae growths.

  ii) A "mid-section" extends a further approximately 750 upstream to the Lodge Road bridge and I describe this section as a wetland with a very narrow meandering intermittent and largely soft-sediment channel mostly obscured by sedgeland and other native vegetation and exotic weeds, but with occasional stagnant or sluggish pools. There is evidence of anaerobic wetland microbiological activity that likely facilitates nutrient transformation processes and limited open water pool areas susceptible to nuisance or harmful algae.

  iii) An "upper section" extending above Lodge Road bridge comprising essentially two main grassed swale depression channels (labelled Jacks Point tributaries in Figure 1) that are ephemeral and have no aquatic ecology value at all.

- I recommend the RWP Schedule 15 limits for tributaries of Lake Wakatipu (see Table 1) should apply only to the lower section of Māori Jack Stream and only during periods when there is connected surface baseflow down to (but not necessarily through) the gravel beach barrier. These limits should not apply during periods with stagnant ponds or during flood flows.

- I recommend the RWP Schedule 15 limits do not apply to the mid-section with predominantly wetland character, or to the upper section ephemeral swales.

- I suggest the RWP Schedule 15 limits for tributaries of Lake Wakatipu set an expectation for very high water quality and I note the improvement necessary to meet these limits in Māori Jack Stream will be a long-term aspiration that is not within the control of Homestead Bay developers alone. The greater volume of diluting water introduced to groundwater by the Homestead Bay treatment system may somewhat reduce nutrient concentrations in Māori Jack Stream but may be insufficient on its own to consistently achieve the Schedule 15 limit concentrations. I recommend that consent conditions for Homestead Bay recognise the long-term aspiration of the Schedule 15 limits but, to be consistent with the way this situation is handled in Jacks Point consent condition 20(c)c and d (see Attachment 1), set a condition requiring that the Homestead Bay development does not increase the e3S (2022) baseline concentration for the Schedule 15 limit parameters in Table 1.

- My assessment is that the treatment system options laid out in the consent level design report (LEI 2025) should be able to meet the criteria I've described above when the system is operating normally.

- I recommend that regular monitoring of both dissolved and total forms of nitrogen and phosphorus is undertaken in both the lower section (when flowing) and the mid-section wetland, to build information for understanding nutrient transport and transformation through Māori Jack Stream, as part of the integrated monitoring programme I have described at a high level in section 8.

Lake Wakatipu

- Lake Wakatipu is undoubtedly the receiving environment with the greatest public interest. The lake has exceptionally good water quality (section 7.1) and the area is iconic, at least in part due to the lake's water clarity and colour, which are part of the visual amenity, recreation and natural character values of the area.

- There is good monitoring data to demonstrate the very high-quality current state of Lake Wakatipu (i.e., well into the "A band"[1]). This is due to ORC's historic regular sampling and the relatively recently installed (2023) permanent mid-lake monitoring buoy that will enable better future analysis of quality at different depths and of any future trends through time (section 7.1).

- There is limited available Wakatipu-specific research, and therefore some uncertainty, about how sensitive the lake might be to nutrient increases (section 7.4). The available research literature is also equivocal about the extent to which climate change may worsen water quality and potentially exacerbate the effect of any future nutrient load increases (section 9). A Deep Lakes Technical Advisory Group (TAG) has recently been established and is advising ORC to inform judicious management of Lake Wakatipu and other Otago lakes generally (section 7.4).

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[1] The "A band" is the highest quality category on an A-B-C-D band scale defined in the National Policy Statement for Freshwater Management (NPS-FM, 2020) and for lakes generally the A band means "*lake ecological communities are healthy and resilient, similar to natural reference conditions*"

- My own observations made specifically for assessing the Homestead Bay project suggest the potential for nuisance or ecologically harmful growths of algae in Homestead Bay is constrained by the combination of currently low nutrient concentrations and a very windy environment generating waves that prevent accrual of algae in all but the most sheltered and stable microhabitats (e.g., behind near shore boulders) (section 7.1). However, my site observations also show the potential for problem algae growths if nutrient levels or wind exposure were to change significantly (section 7.1). These observations illustrate a degree of sensitivity and emphasize the importance of ensuring a well-designed and reliably operated wastewater treatment and discharge system.

- I recommend the RWP Schedule 15 limits for Lake Wakatipu (see Table 5) should apply in consent conditions that require monitoring at three sites 5 m out from the shoreline in Homestead Bay, the same as currently required for the existing Jacks Point consent conditions (section 7.2). I suggest that these sites should be sampled more regularly than has been the case to date for the Jacks Point consent – possibly monthly for a period of three years – to generate a more reliable baseline state and relationship with the mid-lake monitoring buoy operated by ORC.

- My assessment of effects of the small (approximately 10%) increase in current nitrogen and phosphorus load to the lake from the Homestead Bay project area, is that the increases are very small at a whole of lake scale (in the order of 0.035% of current total lake load for total nitrogen (TN) and 0.017% for total phosphorus (TP)). These increases are so small as to be insignificant and undetectable once fully mixed and considered at the whole of Lake Wakatipu scale (section 7.5).

- I then assessed the possibility of localized effects in the near shore mixing zone area of Homestead Bay and I concluded that there would be no noticeable or even measurable adverse effects on aquatic ecosystems or visual aesthetic values resulting from the very small theoretical increase in extent of lake mixing volume required to assimilate the expected small increase in TN load from the Homestead Bay development (section 7.6).

- I also assessed the likelihood that treatment systems laid out in the consent level design report (LEI 2025) could meet the RWP Schedule 15 limit for TN of 0.1 mg/L in samples taken 5 m from the lakeshore; i.e., allowing for the same 5 m mixing zone as currently prescribed in the Jacks Point consent (section 7.6). This assessment was to help inform what consent conditions to propose. My conclusions on this are:

  i) I am moderately confident of meeting the 0.1 mg/L limit at 5 m, for 80% of samples collected periodically over a rolling 5-year period, this latter statistical basis for compliance being the RWP stated requirement. I wouldn't be surprised if some samples exceed 0.1 mg/L before sufficient mixing occurred during brief calm periods, but this seems unlikely to breach the RWP allowance for environmental variability (i.e., 20% of samples can exceed 0.1 mg/L). I don't think this allowance for variability would give rise to any discernible adverse effects given the short duration of calm periods evident in wind data (Appendix 4).

ii) Even during calm periods when the 0.1 mg/L limit may occasionally be exceeded at 5 m from shoreline, I am confident that the 0.1 mg/L limit would almost always be met within a distance of 25 m from the shoreline.

iii) I think it is appropriate to propose the same 5 m sampling locations as prescribed in the existing Jacks Point consent condition 20, but to increase the sampling requirement to a periodic frequency (e.g., monthly initially), at least until a relationship can be established between compliant 5 m lake sampling results and compliant WWTP effluent results (see section 8).

- My analysis of the risk of cyanobacterial blooms suggests that risk is currently low in the middle of the lake (i.e., at 'surveillance' level) but slightly higher in the near-shore area of Homestead Bay, and would potentially increase into the 'alert level' if there were extended periods of calm wind conditions of 5 knots or less (section 7.7). However, my analysis of the available wind data then showed that calm wind conditions are rare and seldom last even a whole day (Appendix 4). The naturally windy nature of Homestead Bay and indeed the whole of Lake Wakatipu is a mitigating factor that helps reduce risk of blooms.

Monitoring

- I have provided general monitoring recommendations for groundwater (section 4.4), the unnamed and ephemeral watercourses (section 0). Māori Jack Stream (section 6.5) and Lake Wakatipu (section 7.6). I have also described the three main aspects I think should be included in an integrated monitoring programme (section 8). My suggestions are similar to the existing Jacks Point consent monitoring requirements but with some important differences particularly for monitoring of Māori Jack Stream. The detail for this monitoring programme will need to be developed in tandem with designing a proposed set of consent conditions, in collaboration with the project engineers and planners.

Climate change

- The literature I reviewed presented uncertain and somewhat equivocal conclusions but generally suggested that climate change could potentially make existing water quality in Lake Wakatipu worse and more sensitive to any increase in nutrient loads (section 7.4 and section 9). This reinforces the importance of a well-designed and operated Homestead Bay wastewater system, together with a comprehensive monitoring programme that triggers early warning of problems and pre-considered response actions.

Summary conclusions

- This memo shows it is plausible to maintain the very high existing water quality that meets regional plan limits in Lake Wakatipu (RWP Schedule 15; see Table 5), while treating and discharging wastewater from the Homestead Bay development on site rather than piping the wastewater for disposal elsewhere. The assessment also shows it is plausible to at least maintain existing water quality in Māori Jack Stream.

- Consent conditions could be set that include a water quality monitoring programme and comparison with the limits and triggers recommended in this memo (sections 8, 6 and 7), to provide assurance that the wastewater treatment system will be constructed and operated to perform as predicted. The monitoring programme could also provide on-going assurance that the RWP limits are being achieved in Lake Wakatipu and that water quality in Māori Jack Stream is at least being maintained.

1. Introduction and purpose

RCL Group is planning to develop residential sections at Homestead Bay and has engaged Lowe Environmental Impact (LEI) to assist with designing a wastewater treatment and disposal system. RCL engaged LWP to help understand the relative sensitivities and risks associated with potential receiving water environments for the treated wastewater so that LEI could consider various options for the system design. LEI has subsequently prepared a report describing options and a proposed consent-level design for the wastewater land treatment system (LEI 2025).

The purpose of this memo has been to inform selection of a preferred consent-level design option(s) and provide information to assist with progressing an application for the necessary discharge permits. I expect this memo could inform, and be an attachment to, the Assessment of Environmental Effects (AEE) part of the permit application.

The possible receiving environments for wastewater include land within the Homestead Bay site and underlying groundwater, and potentially two unnamed surface watercourses, Māori Jack Stream and Lake Wakatipu. Māori Jack Stream is also known as Jacks Point Stream and is a tributary to Lake Wakatipu; it has two ephemeral tributaries that resemble grassed swales (Figure 1).

2. Background

The Homestead Bay development is located across Lot 8 Deposited Plan 443832 and Lot 12 Deposited Plan 364700.

The Homestead Bay development is the third significant housing development along Queenstown's State Highway 6 southern corridor, adding to the earlier nearby housing developments at Jacks Point and Hanley's Farm. While the Hanley's Farm development pipes its wastewater to the Queenstown Lakes District Council (QLDC) wastewater treatment plant that discharges to the Shotover River, the Jacks Point development holds discharge permits from Otago Regional Council (ORC) for an existing discharge of wastewater to land in the catchment of Māori Jack Stream, a tributary of Lake Wakatipu.

The Jacks Point development is largely complete although the Village area is currently under development (which is to connect to Council's reticulated wastewater) and housing construction continues in some areas.

The Homestead Bay development will occupy an area neighbouring the Jacks Point residential area to the south and will utilize land treatment areas (LTAs) in the catchment of Māori Jack Stream alongside those already used for land application of Jacks Point effluent (Figure 1). The main areas of proposed disposal are within Lot 12 with additional areas proposed around the subdivision of Lot 8.

The Homestead Bay land (indicated by the red outline containing coloured catchment areas in Figure 1) is currently used for cattle and sheep grazing, with some winter forage crop and barley grown.

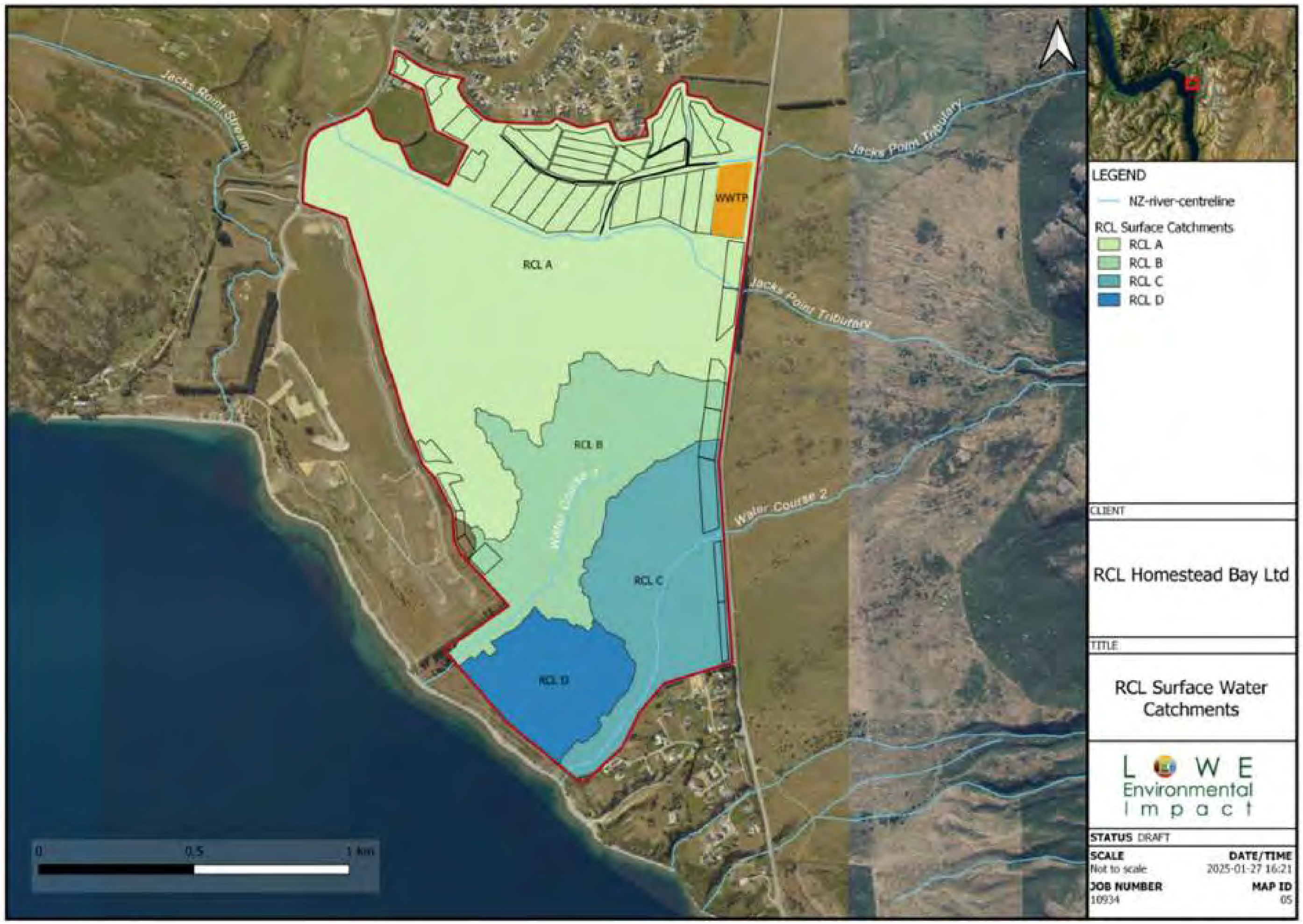

Figure 1: Location plan showing outline of Homestead Bay development block land (red outline) next to the southern edge of existing Jacks Point residential subdivision (housing visible top centre of satellite image). Coloured areas show the topographically estimated surface water catchments within the development block; these are labelled RCL A for Māori Jack Stream catchment, RCL B and C for unnamed ephemeral watercourse catchments, and RCL D for a largely flat area sloping generally towards the lake. Note that Māori Jack Stream is also known as Jacks Point Stream as labelled here; it has two ephemeral tributaries labelled here that resemble grassed swales. Māori Jack Stream is a tributary to Lake Wakatipu (dark blue area bottom left of satellite image).

3. Method and structure of this assessment

An assessment of the potential effects on the possible receiving waters is laid out in the following sections in order of typical water and potential contaminant travel pathways: i.e., starting with groundwater, then the unnamed surface water courses, Māori Jack Stream and then Lake Wakatipu.

For each water body I have considered:

i) current state;
ii) any relevant regulatory water quality standards or guidelines;
iii) the sensitivity of the receiving water and therefore any risks to manage; and
iv) how monitoring could be used to manage risks.

My identification of appropriate receiving environment standards has been largely a matter of interpreting the relevant limits set out in ORC's regional water plan (RWP Schedule 15), while also considering any more specific locally relevant criteria that were set in the wastewater consent conditions for the existing Jacks Point sub-division.

However, the Water Conservation (Kawarau) Order 1997 (WCO) is also relevant and defines a set of water purpose classes (Class AE, CR, F and FS)[2] that apply to Lake Wakatipu. The WCO invokes a set of old and largely narrative water quality standards defined in Schedule 3 of the Resource Management Act (RMA) for these purpose classes. I reviewed the relevant Schedule 3 water quality standards to confirm my view that the RWP Schedule 15 limits are a more modern and waterbody specific set of receiving water concentration standards for achieving the purpose classes in the WCO (1997). Therefore, in this memo whenever I describe an assessment against the RWP Schedule 15 criteria, that assessment can be considered to also give effect to the requirements of the WCO (1997) water quality standards.

As requested by RCL and LEI the main focus of this assessment is nitrogen, as a wastewater contaminant that is challenging to treat and contain, and which has known potential impacts on waterways both as a toxicant and a nutrient stimulating the growth of potentially harmful algae and aquatic plants in streams and lakes.

Other important wastewater contaminants include phosphorus (which is the second of two essential major plant nutrients) and a range of pathogenic microorganisms typically indicated by the indicator bacteria *E. coli.* Both these latter contaminants are typically easier to treat and contain via land disposal as described in the wastewater engineering design options report (LEI 2025). I have included phosphorus alongside nitrogen in my assessment. I have commented only briefly on *E. coli* in places where it seemed relevant for considering system design options; I assume that treatment for microorganisms will be effective to the extent that no *E. coli* is lost from

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[2] These are acronyms for waters being managed for Aquatic Ecosystem, Contact Recreation, Fishery and Fish Spawning purposes respectively (Schedule 3 RMA).

the treatment system to streams or the lake. I have not assessed microbiological health risks to people associated with disposal of treated effluent to land near residential housing or of drinking water supplies. I understand that modern wastewater treatment and land application methods commonly address such risks and these have been considered by LEI (2025) in developing engineering design options.

I have used available desktop information for this assessment, including written observations and photographs of water and ecological sampling sites visited by others, in particular a draft report by a recognized expert freshwater ecologist at Water Ways Consulting (Allibone 2023) and an ecological baseline report prepared by recognized experts at e3Scientific Limited (e3S 2022).

I visited the Homestead Bay development site on 29 January 2025 and observed the unnamed streams, Māori Jack Stream and the length of Lake Wakatipu shoreline downgradient of the development area (i.e., from the Māori Jack Stream lake outlet to the jetty at the end of Lakeshore Drive in Drift Bay). I was also shown around the Homestead Bay development area by a lead author of the LEI wastewater design options report (LEI 2025). This included observing the existing nearby Jacks Point residential development and its existing wastewater treatment and land discharge application systems, as well as candidate areas for the proposed future Homestead Bay wastewater treatment and land application system (i.e., as indicated in Figure 1).

4. Groundwater

4.1 Current State

From my discussions with the authors of the LEI (2025) report I understand there are currently at least two groundwater bores that have been sampled for nitrate nitrogen in or near the Homestead Bay development block. These are labelled P3 and P4 in the ORC wastewater discharge permit held by the Jacks Point Residents and Owners Association Inc for the existing Jacks Point development (see Attachment 1).

Bore P4 is located upgradient of both the Jacks Point development and the Homestead Bay development block and can be considered to represent background reference quality for groundwater that arises under the gravel fans of the Remarkables mountain range and is presumed to flow generally westward under the development areas.

- P4 has a bore water level around 6 to 8m below ground level and has very low nitrate concentrations in the order of 0.1 mg/L (B. Ellwood, LEI; pers comm.).

Bore P3 is located generally downgradient of the Jacks Point development wastewater land disposal areas, near the southern border of that development and indeed inside the neighboring Homestead Bay development block (Lot 12) (see Attachment 1). P3 was drilled to monitor the wastewater discharge of Jacks Point land application area (named N1/N4 on the Jacks Point discharge permit); it can be considered indicative of the likely soil and groundwater conditions in that area. P3 was drilled to a depth of 40m with dry grey silt and no perched or water-bearing layers encountered down to the groundwater at 29.8m below ground level.

- P3 also has very low nitrate concentrations in the order of 0.1 mg/L (B. Ellwood, LEI; pers comm.).

A groundwater nitrate concentration of 0.1 mg/L is very low - in the order of concentrations that would generally be expected in a natural state unimpacted by human activities.

4.2 Regulatory objectives or standards for groundwater

The currently operative Regional Plan: Water for Otago (RWP) groundwater chapter sets narrative objectives to "*Sustain the recognized uses of Otago's groundwater*" (9.3.1) and "*Maintain the quality of Otago's groundwater*" (9.3.3).

The RWP Schedule 15 Table 15.3 anticipates setting numeric nitrogen concentration limits for aquifers, but the table is currently blank with the note "*to be populated following aquifer studies".* Accordingly, there are currently no specified limits for this in the RWP.

Looking at other relevant standards for context, the Drinking Water Standards for New Zealand (DWSNZ) Maximum Acceptable Values (MAV) for nitrate nitrogen is 11.3 mg/l and for *E. coli* is of less than 1 in 100 ml of sample.

Some regional councils have set or proposed setting more precautionary concentrations in their regional plans, such as half of MAV (5.7 mg/L) for drinking water. Furthermore, the national bottom line of 2.4 mg/L for nitrate toxicity in rivers (National Policy Statement for Freshwater Management (NPSFM) 2020) is to protect invertebrate and fish from toxicity effects in rivers (including groundwater-fed streams).

The Jacks Point wastewater discharge permit granted by ORC sets a trigger for action if the median groundwater nitrate-nitrogen concentration measured at monitoring bore P1 (see Attachment 1) increases by 1.5 mg/L or is 1.5 mg/l or more greater than upgradient bore P4 (Consent condition 20b). The location for bore P1 is inside the Homestead Bay development block but has not yet been drilled and only needs to be drilled (under consent condition 15b) if bore P3 increases by 1.5 mg/L compared to it's baseline or the upgradient bore P4 concentration of 0.1 mg/L. Hence, my reading of these conditions is that the critical trigger for groundwater in the Jacks Point wastewater discharge permit will be between 1.5 and 1.6 mg/L.

The actions required by the Jacks Point consent holder if the P1 trigger is exceeded include undertaking an ecological study to be compared with the baseline ecological study (the e3S 2022 report). The actions also include making comparisons with various concentration limits set in both Māori Jack Stream and Lake Wakatipu (described in following sections) and if those comparisons show the limits are breached then the consent holder must prepare a report and Remedial Action Plan (consent conditions 20(a) to (e)).

In summary, my opinion is that a groundwater nitrate-nitrogen concentration of 1.5 mg/L is an important system design consideration for two reasons:

i) There is a degree of precedent expectation by ORC for groundwater quality which has been set by the 1.5 mg/L groundwater trigger level in the Jacks Point wastewater discharge permit.

ii) Any breach of that trigger resulting from the Homestead Bay development discharge could have potentially negative implications for the Jacks Point consent holder.

4.3 Sensitivity and risk

The groundwater beneath the Homestead Bay development area is not especially sensitive to nutrients because the existing low nitrate concentrations (0.1 mg/L) are well below the concentrations usually considered for avoiding toxicity effects described in the section above (i.e., DWSNZ human drinking MAV 11.3 mg/L; precautionary half MAV 5.7 mg/L; NPS-FM ecological toxicity national bottom line 2.4 mg/L). The Jacks Point consent trigger of 1.5 mg/L is also below all these criteria and I understand from the LEI (2025) consent level design report that this trigger concentration can be readily achieved by the available design options.

The main risk of nutrients from Homestead Bay development relates to potentially contaminated groundwater travelling to re-emerge in Māori Jack Stream and Lake Wakatipu, as described in following sections 5 to 7. Treatment and discharge performance for nitrogen and phosphorus is likely to be driven primarily by requirements in those receiving environments.

4.4 Monitoring groundwater

It is sensible to propose groundwater monitoring both upgradient and downgradient of the Homestead Bay wastewater treatment and land application areas, similar in concept to that laid out in the existing Jacks Point consent conditions but with some notable differences that will be discussed later in this memo. This would provide part of an early detection system to identify any problems before contaminants travel and cause effects in Māori Jack Stream or Lake Wakatipu.

An integrated monitoring programme that includes groundwater, streams and Lake Wakatipu is described later in section 8.

5. Unnamed Water Courses

5.1 Current State

There are two unnamed watercourses running through Lot 8 of the Homestead Bay development block (Figure 1). I understand these are referred to elsewhere in the Homestead Bay consent application documents as the southwest and southern channels. These have been visited, photographed and described by a recognized expert freshwater ecologist (who is known to me) from Water Ways Consulting in a report (Allibone 2023). I have used the Allibone (2023) report and also visited the unnamed tributaries myself on 29 January 2025.

In summary, these two water courses are ephemeral – meaning they have surface water for only short periods of time – probably only flowing during and after heavy rainfall and then drying quickly. Water Course 1 has terrestrial grasses growing in the channel, indicating that temporary flow is seldom powerful enough to scour a bare channel, while Water Course 2 shows evidence of more frequent powerful scouring flows that prevent terrestrial vegetation establishing in the lower 400m of channel in the Homestead Bay block.

There are two other notable ephemeral water courses running across Lot 12 of the Homestead Bay development block that have been labelled Jacks Point tributaries in Figure 1. These arise on the steep flanks of the Remarkables range but the sections passing through the development block are essentially grassed swales that flow to Māori Jack Stream. I visited and photographed these 'Jacks Point tributaries' and they are described as part of the next section on Maori Jack Stream.

None of these ephemeral water courses support any fish or stream macroinvertebrates. Therefore, none of them has aquatic ecological value.

Water quality for these ephemeral water courses is only relevant to the extent that any contaminants in the bed will be carried into Lake Wakatipu during temporary flood events. Both unnamed water courses in Lot 8, particularly Water Course 2 (Southern Channel), contribute eroded sediment (fine sediment, gravel and cobbles) to the lake during flood flows – a natural process. It appears that the ephemeral Jacks Point tributaries contribute little sediment to the lake as sediment becomes trapped in the grassed swale channels and the downstream wetland comprising the mid-section of Māori Jack Stream (see next section 6).

The lack of fine sediment and dominance of gravel and cobbles at the mouths of all these water courses and along the lake shore is indicative evidence of high energy temporary flood flows that recede rapidly. It appears that any fine sediment in flood flows is carried out into the lake rather than settling on the lower water course channel and lake shore. It is also evident that regular wind-driven wave action prevents accumulation of finer sediment on the lake shore.

5.2 Regulatory objectives or standards for unnamed tributaries

It is debatable whether any regulatory water quality objectives or standards apply to the two unnamed water courses or ephemeral Jacks Point tributaries given their limited temporary flow and nil aquatic stream ecological value. The operative RWP sets concentration limits for tributaries to Lake Wakatipu but my interpretation of the glossary of the plan and those RWP Schedule 15 limits is they apply to tributaries that are continually (or possibly intermittently) flowing but not ephemeral. It seems appropriate to me that the Schedule 15 limits would not apply to the ephemeral water courses I observed in the Homestead Bay development site, including both the unnamed ephemeral water courses (Southern and Southwest channels) and those labelled Jacks Point tributaries in Figure 1.

5.3 Sensitivity and risk

From a water quality perspective, the ephemeral water courses described here are not sensitive at all. The risks associated with any re-emergence of land-treated and groundwater-diluted nutrients are low because of the limited aquatic ecological value. I think the design of a wastewater treatment and disposal system for nitrogen and phosphorus should be driven primarily by requirements in Lake Wakatipu. The ephemeral grassed swale Jacks Point tributaries which slope to the wetland mid-section of Māori Jack Stream would be a post-treatment buffer between the treatment wastewater land application areas and the lake.

5.4 Monitoring of unnamed water courses

If the eventually chosen system design utilizes land treatment application areas (LTAs) predominantly in the Māori Jack Stream catchment as illustrated by the area labelled “RCL A” in Figure 1, with only small LTA areas in the catchments of the unnamed ephemeral tributaries (areas labelled RCL B and C in Figure 1), then I don’t think there is a need for any monitoring of the two unnamed ephemeral water courses. I think regular surveillance monitoring of treated effluent quality and the flow rate applied to the small land areas (RCL B and C in Figure 1) will be sufficient to match quality and flow rates to the pre-identified (LEI 2025) infiltration capacity of those areas, along with visual surveillance to avoid any surface ponding or overland flow.

The ephemeral grass swale Jacks Point tributaries are downgradient adjacent to existing LTAs for the existing Jacks Point development treated wastewater. It would be useful for Homestead Bay to monitor groundwater in these areas to develop a baseline prior to adding any nearby future Homestead Bay treated wastewater land application. This is because some of the proposed Homestead Bay LTAs are essentially alongside some existing Jacks Point application areas and it may be difficult or impossible to differentiate between sources of any contribution of nutrients to groundwater in this area in future if a pre-Homestead Bay baseline is not established first.

An integrated monitoring programme that includes groundwater, streams and Lake Wakatipu is described later in section 8.

6. Māori Jack Stream

6.1 Current State reported for “freshwater ecological baseline” in 2022

A report has been prepared by e3Scientific Limited (e3S) titled “*Jacks Point Freshwater Ecological Assessment*” (e3S 2022) for the Jacks Point Residents and Owners Association as part of a requirement of their wastewater discharge permit conditions set by ORC. That report presents the results of the required “*freshwater ecological baseline study*”, including water quality and macroinvertebrate sampling and site observations of Māori Jack Stream and near-shore conditions of Lake Wakatipu in that vicinity by a recognized freshwater ecologist on 22 February 2022. I have relied on this publicly available e3S (2022) report. I have also visited these sites myself (on 29 January 2025) to confirm that I agree with the conclusions regarding current state and aquatic ecological value.

In summary the e3S (2022) report describes Māori Jack Stream as:

- A perennial, partially subterranean stream, with (at that time) only the lower reaches having visible, slow-flowing surface water on the western side of Māori Jack Road, roughly 600m upstream from the edge of Lake Wakatipu.
- Having no surface connectivity to the lake (at that time) but flows beneath the sand/cobble shoreline approximately 20m from the lake edge in Homestead Bay.

- Supporting macroinvertebrate communities with health indices indicative of ‘fair’ to ‘poor’ water quality. (The soft-bottomed MCI scores ranged from 68 to 92 and EPT % abundance from 0% to 11%: In NPSFM (2022) terms these results indicate a current state of C to D band).
- Supporting some slight periphyton growth and very little macrophyte growth.
- Having no records of fish held on the New Zealand Freshwater Fish Database (although the presence of habitat suggests fish could be present and common bullies were observed in the lake near shore).
- Having ‘fair’ to ‘poor’ water quality as evidenced by macroinvertebrate sampling and water quality results as reproduced in Attachment 2.

6.2 Current state observations in 2025 – nutrient transport and cycling

Māori Jack Stream: Lower section – intermittent gravel bed with stagnant ponds

When I visited Māori Jack Stream on 29 January 2025 there was no surface flow connection to the lake and only a series of small stagnant pools (less than 1 m wide) scattered along the lower 100m section of riverbed. The most downstream of these stagnant pools was approximately 25 m from the lake edge and separated from the lake water by a gravel beach barrier that is currently at least 1m high built by historic wave action throwing gravel and cobbles up the shore. There was a pile of dry driftwood resting landward of the beach barrier which had clearly been transported down Māori Jack Stream, but not into the lake, in a past significant flood and/or thrown from the lake over the beach barrier by wave action. (Figure 2).

I would describe this lower section of Māori Jack Stream as ‘intermittent’, but whether it is technically ‘intermittent’ or ‘perennial partially subterranean’, it is clear that groundwater in the bed must flow under the beach barrier to the lake and there is only occasionally surface flow connection to the lake during times when stream flow is great enough to either overtop or break through the substantial gravel beach barrier. It looks as if this surface flow connection would only occur during and possibly for a short period after very significant flood events, until the flood flow recedes and for a time until the prevailing wind action has rebuilt the gravel beach barrier.

During my site visit the stagnant pools in the gravel bed of this lower section of Māori Jack Stream were nearly 100% covered with a mix of filamentous green algae and floating *Azolla* (water fern) species (Figure 3). This is what I would expect to see in stagnant summer pools of intermittent streams with even a low level of nutrient enrichment in their catchments. I regularly see filamentous green algae growths like these in stagnant pools or side channels even in intermittent stream reaches in near pristine catchments, just with less total algal biomass where nutrient supplies are less. In Māori Jack Stream it is likely that nutrient supply to these pools is higher than natural background levels, contributed by the existing farming, urban development and golf course in the upstream catchment. I suspect the type of growth observed on 29 January 2025 (and as also seen in photos by e3S (2022) during their field visit on 22 February 2022) is common in summer and has been so for many years under the historic farming land use in the catchment. Without any historic records it is not possible to estimate by how much algal biomass might have increased as land use has changed.

The algae that grows in these stagnant pools uses soluble nutrients in the water like nitrate derived from wastewater, fertilizer and animals in the catchment, and the dissolved reactive form of phosphorus (DRP) to grow and produce biomass. The more algae biomass grows the more dissolved nutrients get used up and the less nitrate and DRP remains in the pools (i.e. the concentrations of nitrate and DRP in the pools reduce). However, when samples of stagnant pool water are analysed in the laboratory for Total Nitrogen (TN), this includes all the nitrogen bound into organic substances such as the algae biomass. Hence, we would expect TN to be higher and nitrate to be lower in these pools. Indeed, we do see that TN and TP are relatively high and nitrate and DRP relatively low in the Māori Jack Stream baseline sample results reported by e3S (2022) and reproduced in Attachment 2. This observation becomes important when we consider the relevance of dissolved versus total nutrient receiving water standards in the next section.

Figure 2: Photos of Māori Jack Stream - Lower section – intermittent and disconnected from the lake by a beach gravel barrier built by wave action. There is no surface water in these photographs. The visible dry driftwood has been left stranded at the bottom of the gravel channel following recession of the last high water level flood event.

Figure 3: Photos of Māori Jack Stream - Lower section – gravel bed with intermittent stagnant ponds. The most downstream stagnant pond is visible at bottom right of left photo, with close-up shown in right photo.

Māori Jack Stream – Mid section –wetland areas with narrow meandering channel and pools

In the mid-section of Māori Jack Stream – from approximately 100m upstream of the lake edge up to approximately the bridge at Lodge Road 850 m from the lake edge – the stream changes character. In this section there is no gravel bed readily visible; instead, the water channel is very narrow meandering virtually invisible from a distance through a band of wetland vegetation and damp soil confined within incised banks covered with native shrubs and exotic grasses and weeds. Less light reaches the water channel in this section and there is less conspicuous algal growth although still some in occasional pools (Figures 4a and 4b).

I would describe this mid-section of Māori Jack Stream as more or less a wetland with a very narrow meandering intermittent and soft-sediment channel and occasional pools. The e3S (2022) baseline report describes *Carex* sedgeland and mixed shrubland in this section and reports yellow/orange tannin colour in the water and a sulphur odour, which I also observed and which I believe is consistent with likely anaerobic wetland microbiological activity. Anaerobic microbial activity in wetlands produces the characteristic odour of hydrogen sulphide and iron oxidizing bacteria produce the orange colour when they oxidise reduced iron at the interface between anaerobic groundwater and the air at the wetland surface. Anaerobic areas of wetlands can generate a natural microbially facilitated process called dentification, where nitrate is converted ultimately to N_2 nitrogen gas that is released back to the atmosphere as part of the well-known nitrogen cycle. From the perspective of reducing the amount of nitrogen reaching Lake Wakatipu this wetland process is generally favourable; indeed, wetlands are often deliberately constructed as part of wastewater treatment chains to remove nitrogen. However, the capacity of wetlands to permanently remove phosphorus is limited (unless wetland plant biomass is harvested) and anaerobic wetland processes can even naturally release dissolved forms of phosphorus that would otherwise in aerobic environments have remained bound to soil and be unavailable for nuisance algae growth downstream in the lake.

On balance, I think the anaerobic wetland section of Māori Jack Stream is likely to be favourable, because phosphorus can be more easily treated earlier in the wastewater treatment chain and the wetland areas will complement the early-chain engineered removal of nitrogen by removing further nitrogen to the atmosphere via denitrification.

Figure 4a: Photos of Māori Jack Stream – Mid section –wetland areas with narrow meandering obscured channel (left photo) and occasional pools (right photo).

Figure 4b: Photos of Māori Jack Stream – Mid section –wetland areas with narrow meandering channel and pools.

Māori Jack Stream - Upper section – including “Jacks Point Tributaries” swales

The upper section of Māori Jack Stream above approximately the bridge at Lodge Road I would describe as essentially two main grassed swale depression channels (both labelled ‘Jacks Point Tributary’ in Figure 1) with a series of contributing sloping grassed depressions (Figure 5). These grassed swale tributaries are all ephemeral (i.e., only flow temporarily after rainfall) and have absolutely no aquatic ecological value at all (Figures 5a, 5b and 5c).

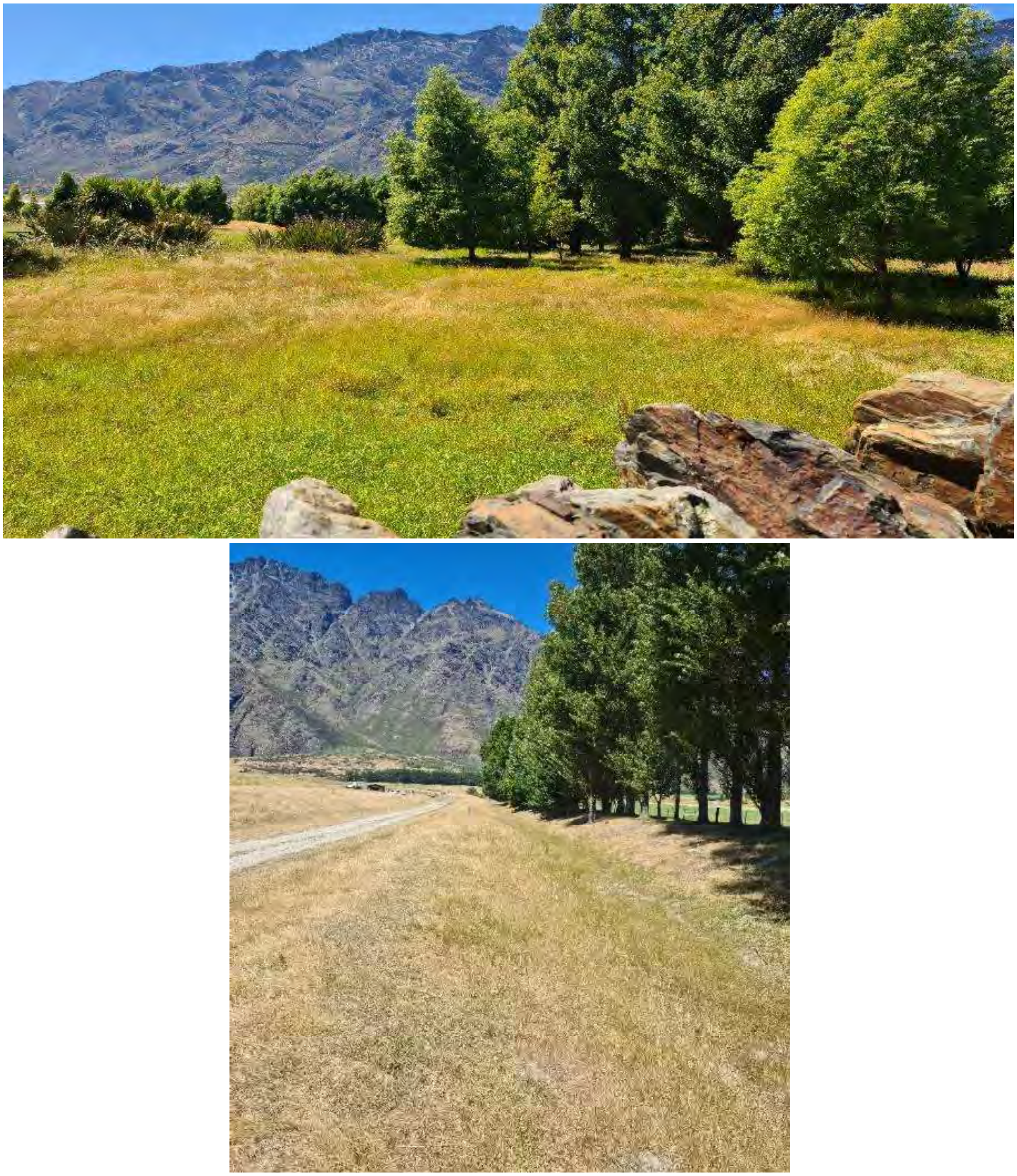

Figure 5a: Photos of Māori Jack Stream – Upper section – swales above Lodge Road.

Figure 5b: Photos of Māori Jack Stream – Upper section – “Jacks Point Tributaries” swales.

Figure 5c: Photos of Māori Jack Stream – Upper section – “Jacks Point Tributaries” swales.

6.3 Regulatory objectives or standards for Māori Jack Stream

The operative RWP sets concentration limits for tributaries to Lake Wakatipu as shown in Table 1 below. As stated above, my interpretation of the glossary of the plan is that those RWP Schedule 15 limits apply to tributaries that are continually or intermittently flowing, such as the lower and mid sections of Māori Jack Stream described above, but not the ephemeral upper sections above the bridge at Lodge Road nor the two water courses labelled 'Jacks Point tributaries' in Figure 1.

Schedule 15 of the RWP clarifies that these limits are deemed to be achieved when "…*80% of samples collected at a site, when flows are at or below median flow, over a rolling 5-year period, meet or are better than the limits*".

I think it is important to note that these RWP limits for Lake Wakatipu tributaries are expressed (appropriately in my view) in the form of dissolved nutrients (i.e., nitrate-nitrogen, ammoniacal nitrogen and dissolved reactive phosphorus (DRP)) rather than for total nitrogen (TN) and total phosphorus (TP). For the situation in Māori Jack Stream, it is the dissolved forms of these nutrients that are relevant for potentially causing toxicity for aquatic life and/or being available as nutrients that can stimulate nuisance or harmful blooms of periphyton algae in Māori Jack Stream. The total forms of these nutrients (TN and TP) are relevant in lakes generally and the RWP Schedule 15 limits for Lake Wakatipu are appropriately expressed as TN and TP as discussed further later in section 7.2 (see Table 5).

I also note for context that the RWP limits for Wakatipu tributaries shown in Table 1 are very high-quality limits for streams and rivers; they are set for the group of generally high-quality streams and rivers defined as "Receiving Water Group 3" in Schedule 15 of the RWP. The limits for nitrate-nitrogen, ammoniacal nitrogen and DRP for these waterbodies are well into the A-band (very high quality) defined in the NPSFM for these three attributes. Just to illustrate how high quality (low concentration) the Wakatipu tributary limits (Table 1) are, I note that the RWP does recognize another group of water bodies called "Receiving Water Group 1" that are located generally in the more modified lower plains areas of Otago (see RWP Map 15.1), and which for various reasons have water quality limits set at lower (albeit still very good) quality (i.e., higher concentration) in Schedule 15. I am not saying these Receiving Water Group 1 limits should apply to Wakatipu tributaries; I am merely pointing this out to illustrate that the Table 1 limits are of such a high quality that they will be more easily achieved in largely unmodified Wakatipu tributaries (the majority), but are aspirational for the few more heavily modified streams like Māori Jack Stream. For context the "Receiving Water Group 1" limits are 0.444 mg/L for nitrate nitrogen, 0.1 mg/L for ammoniacal nitrogen and 0.026 mg/L for DRP compared to the much lower concentrations in Table 1).

Table 1: Limits for tributaries of Lake Wakatipu in RWP Schedule 15 (Table 15.2.3)

nitrate-nitrogen	0.075 mg/L
ammoniacal nitrogen	0.01 mg/L
dissolved reactive phosphorus	0.005 mg/L
E. coli	50 cfu/100 ml
turbidity	3 NTU

The Jacks Point discharge permit condition 20(c) sets concentration triggers for Māori Jack Stream that may be relevant as a precedent for Homestead Bay consent conditions, as shown in Table 2 below. Note that these triggers express the total forms of nutrients (TN and TP) and are identical to the limits for these attributes set for Lake Wakatipu water in the RWP Schedule 15 which reflect the very high water quality of Lake Wakatipu (i.e., the numbers in Table 2 are well into the A-band for lakes defined in the NPSFM for these three attributes).

The Jacks Point discharge consent condition 20(c)c triggers (Table 2) are more stringent (more difficult to achieve) than I would usually expect to see in a modified intermittent stream with ‘fair’ to ‘poor’ water quality and aquatic ecological value like Māori Jack Stream. They are more stringent even than the RWP Schedule 15 limits set for very high quality “Group 3” rivers that I described above (Table 1) and considerably more stringent than the RWP Schedule 15 limits set for fairer quality “Group 1” rivers.

While I was not involved with the Jacks Point development consent conditions it looks to me as if these consent condition triggers have been set with a focus on ensuring those same concentrations are met in Lake Wakatipu without any allowance for mixing and dilution of the stream at the edge of the lake. This is inconsistent with Jacks Point lake water quality conditions 20(a) and 20(c)b which allow for a 5 m mixing zone that I will discuss further in section 7. I also think this is an unnecessarily cautious approach and it creates the unfortunate effect of setting unrealistic expectations for water quality in Māori Jack Stream. The e3S (2022) water quality sampling (data provided in Attachment 2) showed that median baseline nutrient concentrations in Māori Jack Stream in the 2021/22 summer were at least five times higher than the Table 2 triggers for TN and 23 times higher for TP. I therefore think the consent condition triggers shown in Table 2 below are unhelpful and consequently I don’t recommend these be repeated for Māori Jack Stream in the Homestead Bay consent. They are however appropriate limits to set in relating to Lake Wakatipu as discussed further later in section 7.

Table 2: Triggers defined for Māori Jack Stream in Jacks Point consent condition 20(c)c

E. coli	10 cfu/100 ml
total phosphorus	0.005 mg/L
total nitrogen	0.1 mg/L

It appears that the authors of the Jacks Point consent conditions suspected the triggers in Table 2 might be difficult to achieve because they provided an alternative compliance pathway. Condition 20(c) and (d) apply these triggers to be achieved by 80% of samples or alternatively, if the Table 2 triggers were exceeded in the “*baseline study*“ (i.e., the e3S 2020 study referenced above), then the new condition trigger under (d) becomes a 20% or more increase on the baseline study concentrations.

My assumption is that Condition 20(d) is being relied upon for compliance and my calculations using the baseline data in Attachment 2 provide that the relevant triggers being utilized (20% on the baseline) are shown in Table 3.

Table 3: Calculated triggers for Māori Jack Stream in Jacks Point consent condition 20(c)d

Indicator	Median baseline result from the e3S 2022 report	Condition 20(c)d triggers (median baseline e3S +20%)
E. coli	12 cfu/100 ml	14 cfu/100 ml
total phosphorus	0.116 mg/L	0.1392 mg/L
total nitrogen	0.53 mg/L	0.636 mg/L

The action required by the Jacks Point Residents and Owners Association consent holder if the triggers in conditions 20(c)f, 20(d) and 20(e) are breached is detailed in Condition 20(f). In short, the consent holder must prepare a report and Remedial Action Plan that sets out the methods and timeframes for improving water quality to meet the triggers.

I think the baseline-modified triggers shown in the third column of Table 3 are more useful and appropriate for application to Māori Jack Stream than the unrealistic ones shown in Table 2. However, they are still not ideal in my opinion as they express the nutrients in total form, which is certainly relevant for Lake Wakatipu but problematic in the case of application to Māori Jack Stream. The total forms of nutrients (TN and TP) in Māori Jack Stream will include nitrogen and phosphorus bound up in any algae biomass in the water as well as any residual dissolved nitrate-nitrogen and ammoniacal nitrogen not yet taken up by the algae. Given the substantial algal biomass that grows in the small stagnant ponds of the intermittent lower section of Māori Jack Stream (see photos in Figure 3), which I believe is likely to continue to be a regular common occurrence with or without the Homestead Bay development, I would expect to continue to see water quality sample results with generally high TN and TP (and consequentially low dissolved nutrient forms) but with results fluctuating widely between sampling occasions due to variability with intermittent flow, algal accrual and the complex nutrient transformations I described in section 6.2 that are likely occurring immediately upstream in the wetland section of Māori Jack Stream.

I don't think such a sampling regime will provide a reliable or timely indication of any adverse effects or operational problems with Homestead Bay wastewater management that need an early-triggered management response. By the time any problem is able to be detected against background variability in nutrient forms in Māori Jack Stream the problem should have already been indicated by monitoring the treatment plant effluent outputs and land application areas, and by on-going surveillance monitoring of the most important and sensitive receiving environment in the near shore waters of Lake Wakatipu.

I do think it is useful to continue sampling Māori Jack Stream and getting laboratory analyses for both dissolved and total forms of nutrients, but primarily to assist with interpretation of monitoring results from a wider Homestead Bay monitoring programme as discussed further later.

Summary recommendations for Māori Jack Stream water quality consent criteria

In summary, I think the trigger criteria in Jacks Point consent condition 20(c)c (Table 2) should not be used for Homestead Bay but should be replaced. The most relevant water quality criteria for Māori Jack Stream are the statutorily applicable RWP Schedule 15 dissolved nutrient limits set for the “Group 3” Lake Wakatipu tributaries (Table 1). In Māori Jack Stream these concentrations will be a long-term aspiration given that current baseline water quality in Māori Jack Stream (e3S 2022) has higher concentrations of ammoniacal nitrogen, DRP and *E. coli* (see Attachment 2). An appropriate interim target for the Homestead Bay consent conditions would be zero increase to the median and 80th percentile e3S (2022) baseline concentrations for Table 1 contaminants; I think this is achievable given the Homestead Bay treatment system will introduce more diluting groundwater and hence likely reduce instream concentrations even though total loads of nutrients exported from the site are estimated to increase in the order of 10% (LEI 2025).

In addition, because Māori Jack Stream is an intermittently flowing stream I think the Table 1 limits (and an interim target of no increase on e3S 2022 baseline concentrations) are of limited relevance in any stagnant disconnected pools and should only apply during times when Māori Jack Stream has a continuous surface water flow through its lower-most 100 m section to the landward edge of the gravel beach barrier, but not necessarily connected through the barrier to the lake (i.e., during times of continuous baseflow in the lower 100 m section but not a flood flow).

Finally, I think the Table 1 limits are of questionable relevance and should not apply in the mid-section of Māori Jack Stream (from 100 m upstream of the lake up to the Lodge Road bridge) because this section has essentially wetland characteristics, minimal risk of nutrients stimulating ecologically harmful periphyton blooms and unlikely contact recreation value. However, I do think it is useful to continue monitoring the wetland mid-section of Māori Jack Stream for dissolved and total nutrient forms to aid future interpretation of monitoring results from a wider Homestead Bay monitoring programme.

6.4 Sensitivity and risk

Māori Jack Stream is a highly modified environment with modest ecological value in its lower intermittent section and middle wetland section (e.g., graded in e3S (2022) as “fair” to “poor” based on macroinvertebrate sampling results). It has no aquatic ecological value in its upper ephemeral swale section above Lodge Road bridge. It is unlikely that the Homestead Bay wastewater discharge will worsen current ecological quality, and in that respect Māori Jack Stream is not sensitive to the level of nutrients expected.

However, Māori Jack Stream is a tributary of Lake Wakatipu and as such is classified in “Receiving Water Group 3” which has very high-quality concentration limits set in Schedule 15 of the RWP (see section 6.3). While these high-quality limits are likely to be achievable in the majority of Wakatipu tributaries, which have pristine or much less modified catchments (i.e., no or minimal urban or intensive agricultural land use), these limits will be challenging and require long-term improvement to be met consistently in Māori Jack Stream. I think meeting these limits would require very low levels of run-off from both the urban and rural land uses in the catchment, enhanced riparian vegetation and probably more flow. The Homestead Bay wastewater treatment system will introduce a greater volume of water to the local groundwater system which may slightly reduce nitrogen concentrations in Māori Jack Stream (LEI 2025), but other stream enhancements are beyond the control of Homestead Bay development alone. It is also possible that nutrient transformations naturally occurring in the wetland mid-section of Māori Jack Stream will naturally release dissolved forms of phosphorus that will continue to make it challenging to meet the Schedule 15 phosphorus limits for Wakatipu tributaries.

For all the above reasons I think an appropriate objective for the Homestead Bay project could be to avoid any worsening of current water quality and aquatic ecological value in Māori Jack Stream, and to enable enhancement where possible through contributing to greater groundwater volume and riparian vegetation management within the project's control. The recommendations I made for consent conditions in section 6.3 above are consistent with this objective.

6.5 Monitoring of Māori Jack Stream

Regular monitoring of Māori Jack Stream water quality is warranted for two reasons. First, to enable comparison of baseline (e3S 2022) water quality and the RWP Schedule 15 limits for Wakatipu tributaries (Table 1) with water quality sampled in the lower-most 100 m stream section, during times when there is continuous surface baseflow (but not flood flow) through that section to the gravel beach barrier. Second, to help understand nutrient transport and transformation processes occurring down Māori Jack Stream and whether these affect the amount and form of nutrients sourced from Homestead Bay development wastewater arriving at Lake Wakatipu. This will aid future interpretation of monitoring results from a wider Homestead Bay monitoring programme.

An integrated monitoring programme that includes groundwater, streams and Lake Wakatipu is described later in section 8.

7. Lake Wakatipu

7.1 Current State

Otago Regional Council has been monitoring the state of water quality in Lake Wakatipu for many years by manually visiting and sampling sites at various depths, including since 2016 at a site called "*Lake Whakatipu Open Water 10m*" located near the middle of the lake out from Homestead Bay. There is now a permanent monitoring buoy at this site with instruments logging water quality at multiple depths through the water column. Results summaries and simple trend analyses are available on the Land Air Water Aotearoa (LAWA)[3] website and the data can be seen in near real time on the Limnotrack[4] website. Lake Wakatipu water quality state and trends have also been documented for that site and several other sites in the ORC's latest "*State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022*" report (Ozanne et al., 2023).

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[3] LAWA website: Land, Air, Water Aotearoa (LAWA) - Lake Whakatipu Open Water 10m

[4] Limnotrack website: LIMNOTRACK

In short, Lake Wakatipu water quality is very good. In the simple 'state band' terms of the NPSFM (2022) it is currently well into 'A band' for every compulsory lake attribute monitored (Table 4). Lake Wakatipu has a Trophic Level Index (TLI) score of 1.4 (microtrophic) or "Very Good" on the LAWA website (accessed 11 December 2024); the TLI score is an indicator of lake health and is determined from a suite of water quality measurements.

Table 4: Current state (median) Lake Wakatipu water quality at the "Open Water 10m" central lake site off Homestead Bay (source Ozanne et al., 2023 and LAWA 11 December 2024)

	Current state according to NPSFM 2022 State Band system (numeric threshold for A band in brackets)	Current median concentration at "Open Water 10m" site	
		mg/m3	mg/L
Total Nitrogen (TN)	A (<160 mg/m3)	53	0.053
Total Phosphorus (TP)	A (<10 mg/m3)	1	0.001
Algae Chlorophyll *a* (Chl. *a*)	A (<2 mg/m3)	0.555	0.00055
Ammoniacal Nitrogen	A (<0.03 mg/L)	1.4	0.0014
		Units as indicated	
E. coli	A (<130 n/100mL)	1 *E. coli*/100mL	-
Clarity (Secchi disc depth)	A Not an NPSFM 2022 attribute. LAWA A band is > 7m secchi depth	>10 m (4.5-25 m)	-

The e3S (2022) report also provided a "*freshwater ecological baseline study*" of the near-shore conditions of Lake Wakatipu in the vicinity of where Māori Jack Stream meets Homestead Bay. In summary the e3S (2022) report described:

- Very good water quality at the three sites they sampled 5 m out from the lakeshore at 0.5 m depth (see e3S lake sample site locations and results copied into Attachment 3). The TN, TP and chlorophyll *a* concentration at these lake edge sites (median TN and TP of 110 and 2 mg/m3 respectively) are all a little higher than for the mid lake monitoring site shown in Table 4, but still within 'A band' state.

- Lake TLI scores calculated ranging from 1.33 to 2.47 across the four sampling occasions (November 2021, December 2021, January 2022, February 2022) for each of the three lake-edge sample sites. These results reflect microtrophic to oligotrophic conditions or "very good" lake health – similar to the TLI score of 1.7 referenced from the LAWA site for 2020 as reported in e3S (2022) and similar to the TLI of 1.3 that I sourced from the LAWA website in December 2024.

- No periphyton or macrophyte growth at any of the sample locations. The e3S (2022) report commented that: "*This is most likely due to the higher wave energy that this area absorbs in these shallow (<1 m) depths. During southerly winds, a substantial fetch can be produced with increased wave energy along this stretch of shoreline. Because of this, much of the near-shore substrate along the margins is clean and bare with the continual movement."* The e3S (2022) photographs at the monitoring locations show exceptionally clear water and clean gravel and cobble bed substrate.

- While no macrophytes were observed in the shallow margins, unsurprisingly given the described exposure of the margins to wind-driven waves, the e3S report did also comment that: "*Previous studies have shown that in the deeper water of the sample area, large areas of macrophyte beds are present (Miller, 2018). These beds include native milfoils (which were observed floating) and 8 species of native/endemic plants, one of which is the quillwort (Isoetes kirkii), listed as 'endemic, at risk – declining' (Miller, 2018)."*

- Several native fish were recorded as present in the lake on the NZFFD including longfin eel/ tuna (*Anguilla dieffenbachii*), kōaro (*galaxias brevipinnis*), and common bully/ pako (*Gobiomorphus cotidianus*). Exotic fish species are also present including the rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*) and Chinook salmon (*O. tshawytscha*) (NIWA, 2022; ORC, 2016). No formal assessment was made of fish by e3S (2022) but they observed a common bully (*Gobiomorphus cotidianus*) in the shallows.

Further to the e3S (2022) observations ORC recently commissioned a report to assess the condition of macrophytes in three Otago lakes including Lake Wakatipu (Winton and David, 2024). They found that:

- Lake Whakatipu had decreased slightly from an "excellent" ecological condition in 2020 to a "high" condition in 2024 (with a LakeSPI Index score of 72.8% in 2024).

- Lake Whakatipu possessed a diverse native vegetation (Native Condition Index 77%) but had moderate impacts from the invasive *Elodea canadensis* (Invasive Impact Index 29%).

I visited the site on 29 January 2025 and observed the condition of the lake from shore by walking the length of shoreline between Māori Jack Stream confluence and the jetty at the end of Lakeshore Drive in Drift Bay (a distance of approximately 1.8 km). This section is the full extent of lake shoreline that could conceivably receive groundwater and or overland surface run-off contribution to the lake from the Homestead Bay development block. I made observations and took photographs at points along this shoreline. In general, my observations support all the descriptions indicating very high water quality listed above. Some additional observations are:

- Water quality is good (e.g., very clear) and the shoreline cobbles are generally very clean along the whole 1.8 km shoreline observed (e.g., Figure 6).

- While there were no macrophytes growing in the wave-break area near to the shoreline (e.g. within about 5 m), I could see healthy looking dark macrophyte beds in many places 20-50 m from the waters edge depending on depth. As a general observation, the macrophyte beds appeared to occupy habitat deep enough to be out of the harshest near-shore wave breaking zone but shallow enough to be receiving light for healthy growth. I would expect these macrophyte beds are also providing healthy habitat for invertebrates and fish.

- Wind-driven wave action is clearly a key factor contributing to the cleanness of shoreline gravels. Gravel and smaller exposed cobbles will be tumbled and/or abraded by waves, preventing accumulation of significant algae (e.g., Figure 6). However larger cobbles can accumulate thin brown periphyton films where there is sufficient shelter preventing them from tumbling or being abraded by finer gravel and sand (Figure 7). I consider these thin periphyton films are healthy and are primary producers contributing to the base of the food chain for healthy macroinvertebrate and fish communities in the lake (e.g., Figure 7).

- There were just two locations where very narrow (3 m wide) bands of thicker algae growth were visible near shore. These appear to have been enabled at specific locations where there was localised shelter from wave action behind large boulders and a groundwater seep of additional nutrients which I suspect was coming from some unconfirmed source on the terrace directly above the lakeshore at these locations (Figure 8). These locations were very localized and an exception to the generally clean cobbles or presence of only thin healthy films along the majority of the 1.8 km length of shoreline observed.

- This section of lake shoreline is a very exposed and frequently windy location. On the 29 January 2025 during the early part of my site visit (9.30am) the wind recorder at nearby Frankton (Queenstown Airport) showed approximately 4 knots of wind and this had increased to around 17 knots by mid-day. The wind recorder on the mid-lake monitoring buoy off Homestead Bay is a more exposed location and showed a westerly of around 15 knots by mid-morning on this day. At 4 knots in the morning there were small but regular wavelets washing up the shore; by mid-morning at 15 knots there were waves breaking on the-shore and visible white-caps out on the lake. I have obtained the wind data from ORC's mid-lake monitoring buoy and will discuss this further later in this memo (in section 7.6 and Attachment 4) as wind will be a key factor affecting mixing of nutrients in the lake and mitigating the risk of adverse effects.

- The shoreline is a popular place for recreationalists such as walkers, bikers and swimmers, of which I saw several during my field visit. There is a fixed steel pole with a mounted instrument that looks like a wind recorder near the beach a few hundred meters south of Māori Jack Stream. The pole had a website link to the Southern Lakes Windriders Club (www.slwindriders.co.nz) but I have not been able to find data for this location despite the website having live wind data for other southern lake locations. Clearly though it is a location of interest for windriders.

In summary, the available data and observations highlight very high existing water quality in Lake Wakatipu with generally healthy levels of macrophytes, periphyton and phytoplankton algae. The potential for nuisance or ecologically harmful growths of algae is likely constrained by the combination of low nutrient levels and a windy environment that prevents accrual in all but the most sheltered and stable microhabitats (e.g., near shore boulders). However, the observations also show the potential for problem growths if nutrient levels or wind exposure were to change significantly. These observations illustrate a degree of sensitivity and emphasize the importance of ensuring a well-designed and reliably operated wastewater treatment and discharge system.

Figure 6: Photos of the embayment in Homestead Bay showing where Māori Jack Stream enters Lake Wakatipu through the left-hand clump of willow trees to the left of the cars visible centre of top image. The three lake water quality sampling sites defined in the existing Jacks Point consent conditions and sampled by e3S (2022) are taken 5 m out from the water edge in this embayment – one sample directly out from Māori Jack Stream, one approximately 200m to the west (left in top image) and one approximately 200m south (bottom foreground in top image). See also Attachment 3 for aerial location plan. Bottom left image is taken with photographer standing on top of the gravel beach barrier at the disconnected Māori Jack Stream outlet. Bottom right image shows very high lake water clarity directly off Māori Jack Stream.

Figure 7: Panorama photo (top) of the whole section of shoreline viewed from just north of the unnamed watercourse 1 which meets the lake at far left of photo. Unnamed watercourse 2 meets the lake out of view around the point to the left. The bottom photo shows that a (healthy) thin brown diatom film can accumulate (scratched under fingernail) where the shallow cobbles are large enough to resist wave action and provide stable substrate, even with the low intensity existing farming landuse - in this case near unnamed watercourse 2 below catchment area RCL D. This is not nuisance or harmful algae. It provides the base of a food chain for invertebrates and fish. (see Figure 1 for location and note the shoreline is in reality fairly straight at this location – the deep curve in the shoreline here is an artefact of the panoramic field of view).

Figure 8: Photos showing two examples where some very localized (3 m wide strip) growth of green filamentous algae (bright green) and didymo (olive-coloured) can currently occur where there is sufficient shelter from the prevailing wave action (i.e., behind the visible boulder) and where apparently a seep of nutrients may be contributing from some unknown source. Such algae growth occurred in only two very small locations on the straight section of shoreline north of unnamed watercourse 1 and approximately 600-800 m south of Māori Jack Stream. No such algae growth occurred in the sampled embayment of Māori Jack Stream shown in Figure 6.

7.2 Regulatory objectives or standards for Lake Wakatipu

The operative RWP sets concentration limits for Lake Wakatipu as follows:

Table 5: Limits for Lake Wakatipu in RWP Schedule 15 (Table 15.2.5)

Total nitrogen	0.1 mg/L
Ammoniacal nitrogen	0.01 mg/L
Total phosphorus	0.005 mg/L
E. coli	10 cfu/100 ml
Turbidity	3 NTU

These limits are deemed to be achieved when "…*80% of samples collected at a site, over a rolling 5-year period, meet or are better than the limits*".

Further to these regional plan limits, the Jacks Point discharge permit condition 20(c)a sets a monitoring trigger that is relevant as a precedent for possible future Homestead Bay consent conditions. This includes a requirement if "*The average TLI difference between the baseline period* [e.g., the e3S near shore TLI results reported above] *and the most recent monitoring period has increased by one TLI score*".

Furthermore, Condition 20(c)b of the Jacks Point consent triggers include the limits set out in Table 6 below. These are the same as the RWP limits shown in Table 5 except for the description of "water clarity" instead of "turbidity", which have the same meaning in this context. The Jacks Point consent conditions define that these concentrations are to be met at the three sampling locations 5 m out from the lakeshore at 0.5 m depth (see location plan in Attachment 3). This essentially defines an allowable mixing zone of a 'wedge' of water extending 5m out from shore and including the full volume of water between the bed and surface of the lake.

Table 6: Triggers defined for Lake Wakatipu in Jacks Point consent condition 20(c)b

Water clarity	3 NTU
E. coli	10 cfu/100 ml
Total phosphorus	0.005 mg/L
Total nitrogen	0.1 mg/L

Conditions 20(b) and (d) of the Jacks Point consent applies the above limits as triggers to be achieved by 80% of samples. Alternatively, if these limits are exceeded in the "*baseline study*" (i.e., the e3S 2020 study referenced above), then the trigger instead becomes a 20% or more increase on the baseline concentrations.

My assessment is that none of the Jacks Point consent limits were exceeded by the Lake Wakatipu baseline results presented in the e3S 2022 report (see their results in Attachment 3). Consequently, the limits in Table 6 above are the limits that are relevant from compliance of the Jacks Point consent.

The action required by the Jacks Point Residents and Owners Association consent holder if these triggers are breached is they must prepare a report and Remedial Action Plan that sets out the methods and timeframes for improving water quality to meet the triggers.

7.3 Precedent conditions and guidance on mixing zones

While the above mentioned Jacks Point consent conditions set a precedent for an allowable mixing zone extending 5 m from the shore in Homestead Bay, it is also worth noting that ORC has provided guidance in a memo titled "*Mixing zones and Receiving Water Standards*" (Ozanne 2023) to inform the drafting of the ORC's Proposed Otago Land and Water Regional Plan. That memo suggested a reasonable mixing zone for a point source discharge to a lake (i.e., the area and underlying volume within which the specified water quality standards do not have to be met) could be:

(a) "if the discharge location is within 50 m of the lake water edge at any time, a circle with a diameter of 50 m"

The Ozanne (2023) memo described more context around this suggestion, including other requirements such as using the smallest zone necessary, ensuring that no acute toxicity occurs within the mixing zone, and that the mixing zone should be zero when within a drinking water protection zone.

For a discharge of nitrogen and phosphorus in treated wastewater from the proposed Homestead Bay development, at well below toxic concentrations, the 50 m diameter mixing zone circle described above is relevant and larger than the 5 m lake edge mixing zone allowed for in the Jacks Point consent conditions. For a lake edge subsurface groundwater discharge from the Homestead Bay development, such a mixing zone allowance might be a semicircle with a 25m radius out from the shoreline.

7.4 Wider literature on sensitivity and risk

Lake Wakatipu is undoubtedly the Homestead Bay development's receiving environment with the greatest public interest. The lake has exceptionally good water quality and the area is iconic, at least in part due to the lake's water clarity and colour, which contribute significantly to the visual amenity, recreation and natural character of the area.

On the question of how sensitive Lake Wakatipu might be, the Otago Deep Lakes Technical Advisory Group (TAG) recently made the following observations (quoted from TAG 2024):

- *"Otago's highly valued deep-water lakes are changing and this has led to calls from scientists and the community to improve monitoring and to collect technical information that will improve long term management of these systems*." (Note that installation of ORC's long-term monitoring buoys and the formation of the TAG are two of several responses already underway).
- "*Available monitoring data provides some cause for concern, with chlorophyll a concentrations increasing in recent years."… "However, such short-term trends should be interpreted with caution, as they may reflect short- to medium-term patterns influenced by*

natural factors such as climate variation, rather than an underlying increasing trend driven by anthropogenic factors."

- *"Experience from large lakes overseas show that these lakes may not be resilient to change, and appear to be highly vulnerable, yet the fundamental science to underpin meaningful management is lacking."*
- *"The eutrophication experience of Lake Constance and other large, European pre-alpine lakes illustrates that large, deep pre-alpine lakes are not inherently resilient or resistant to eutrophication. In fact, many TAG members believe that they are quite sensitive, although there can be time lags between increasing stressors and lake responses."*

In an update report to ORC's Environmental Science and Policy Committee, Mackey (4 December 2024) explained that:

- *"The Deep Water Lakes Technical Advisory Group (TAG) was formed in April 2024 at the request of the Otago Deep Water Lakes Management Working Group. The TAG's purpose is to provide technical advice to the Management Working Group, primarily regarding potential monitoring and research programmes to enable informed management of lake health."*
- *"The TAG has met monthly and traversed the state of existing knowledge, risks to the lakes, and developed a detailed set of knowledge gaps. This work was presented to the Management Working Group in September (2024)."*
- *"The TAG's focus now moves to developing a range of potential research and modelling programmes that will allow ORC and other stakeholders to better understand the state, trends, pressures, and management needs of the Otago Deep Lakes. These options will be presented to the Management Working Group for consideration in 2025.".*

7.5 My assessment of likely affects on water quality at whole of lake scale

To get an initial sense of the scale of risk posed by the Homestead Bay development I compiled estimates of the loading rates of TN and TP expected to enter the lake post-treatment from the development area (from LEI 2025) and compared these to estimates of current overall TN and TP loads for the whole lake (see Table 7). Note that I used two independent methods to generate alternative estimates for the current TN and TP load for the whole of Lake Wakatipu; this is because methods for estimating loads are notoriously variable and using two independent methods increases confidence in the result. Neither method is considered "correct" – they are both estimates.

For the purposes of this assessment the important result is that both methods show the current total TN and TP load to the lake is very large (609,669 – 964,119 kg/yr for TN and 317,715 – 907,938 kg/yr for TP) compared to the very small increase predicted to arise from the Homestead Bay development area (212 kg/yr for TN and 54 kg/yr for TP) (Table 7).

In percentage terms these results show the post-treatment TN and TP load increases from the proposed Homestead Bay development compared to current whole lake TN and TP loads are a tiny fraction; less than 0.035% of current whole lake load for TN and 0.017% of current whole lake load for TP. These estimated increases are so small as to be insignificant and undetectable once fully mixed and considered at the whole of Lake Wakatipu scale.

Table 7: Estimated approximate loading rates of TN and TP to Lake Wakatipu (kg/yr)

Area	Loading scenario	TN (kg/yr)	TP (kg/yr)	Source (see footnotes)
Homestead Bay development area (180 ha)	Current land use	1,839	~7	1
	Indicative under full residential development – based on the treatment and disposal options as presented in LEI (2025	2,052	62	1
	Indicative increase under proposed development compared to current landuse	212	54	1
	ORC Regional Plan: Water for Otago (RWP) permitted baseline for farming (15 kg N/ha/yr; no controls for P in kg P/ha/yr)	3,038	n/a	1
	Indicative increase under proposed development compared to RWP permitted baseline	-986	n/a	1
Lake Wakatipu catchment area (2,674 km^2 = 267,400 ha) [Lake area = 289 km^2 = 28,900 ha]	Estimate 1: Current estimate using a type of statistical regression modelling (called "random forest" regression) using local water quality data to fit the models.	964,119 (range 324,156 to 2,360,486)	907,938 (range 127,472 to 3,478,417)	2
	Estimate 2: Current estimate by calculation from river flow and monthly water quality sampling at the Kawarau @ Chard Rd monitoring site.	609,669 (range 566,735 to 661,191)	317,715 (range 236,140 to 450,812)	3

1 = LEI (2024).

2= Snelder and Fraser (2023); underlying outputs for Wakatipu from T. Snelder pers. Comm.

3= Snelder et al., (2023); underlying outputs for Kawarau @ Chards monitoring data site obtained from C. Fraser pers. Comm.

7.6 My assessment of likely effects in a near-shore 5m mixing zone in Homestead Bay

Having concluded that the effects from Homestead Bay wastewater would be undetectable at the whole of lake Wakatipu scale, I turned attention to the possibility of localized effects in the near-shore mixing zone area of Homestead Bay. To do this I worked with lead author of the LEI (2025) report (Brian Ellwood) to develop a simple conceptual model of groundwater flowing to mix with lake water near shore and the likely dilution and mixing characteristics.

First, the amount of dilution occurring in the "wedge" of lake water 5 m out from shore and 0.5 m deep can be coarsely estimated by comparing the current TN concentration of groundwater discharging to the lake (approximately 2.4-2.8 mg/L; LEI 2025), with the TN concentrations measured in the 12 lake samples taken by e3S (2022) at sites 5 m out from shore in the summer of 2021- 22; these samples ranged from less than 0.11 to 0.21 mg/L (Attachment 3). Using this simple mass balance approach suggests in the order of 11 to 52 times dilution currently occurs in that 5 m mixing zone. Ten of those twelve e3S (2022) samples measured less than the laboratory detection limit of 0.11 mg/L while 2 samples in November 2021 were higher than the 0.1mg/L TN limit in the RWP (0.21 and 0.17 mg/L TN). The amount of mixing and dilution would obviously vary in time and space with wind and other conditions (see Attachment 4), but this 11 to 52-fold range of dilution is a reasonable approximate estimate.

The Homestead Bay development is estimated to generate an additional 212 kg N/yr to groundwater that discharges to the lake – this is approximately a 10% increase in the current TN load from the whole Homestead Bay development area discharged to the lake (LEI 2025). Because Homestead Bay development will be adding additional volume to the groundwater system associated with the wastewater, we can assume that the TN concentration in the groundwater will be at most the same as current groundwater TN concentration but probably lower. If we conservatively assume the same groundwater TN concentration but need to discharge an additional 10% total TN load, then we will theoretically need a 10% larger lake water mixing zone volume to achieve the same mixed lake TN concentrations currently experienced at the Jacks Point consent monitoring points sampled by e3S 5m out from shore and 0.5m deep.

One way to visualise what this theoretically means is that to gain an extra 10% volume of diluent mixing lake-water, the mixing wedge would need to extend 0.5 m further out from the shore-line so the measuring point in the lake would need to be 5.5 m from shore instead of 5.0 m as under the Jacks Point consent. This is a very small increase in mixing area required and is well within the likely measurement error of dipping a hand-held sample bottle measured 5 m from the lake edge when waves are almost always advancing and receding on the shoreline. In addition, the shoreline lake level itself is fluctuating in the order of 10cm vertically every 25 minutes or so due to the naturally occurring seiche effect that is often referred to colloquially as a Lake Wakatipu "tide" (e.g., see www.newzealand.com/us/feature/lake-wakatipu and Seiche - Wikipedia).

In my opinion there would be no noticeable or even measurable adverse effects on aquatic ecosystems or on visual aesthetic value resulting from this small increase in the extent of lake mixing volume required. Based on the baseline monitoring already undertaken by e3S (2022) and an analysis of the frequency of wind-driven mixing described in Appendix 4, it seems likely that most of the time when the wastewater treatment system is operating normally, compliance with the ORC Plan limit of 0.1 mg/L TN for Lake Wakatipu would be achieved within the existing 5 m sampling design laid out in the Jacks Point consent conditions.

It also seems likely that if occasional exceedances of 0.1 mg/L TN do occur at 5 m from shore due to insufficient mixing, they will be short lived (less than 2 days – see Appendix 4) and would very likely achieve 0.1 mg/L TN, well within a hypothetical 25 m mixing zone. A mixing zone with a radius of 25 m has been described by ORC staff in guidance (Ozanne 2023) as being potentially reasonable for consideration for some diffuse discharges to lakes generally.

7.7 My assessment of risk of nuisance or harmful cyanobacterial blooms

I used a high-level approach to assess susceptibility to cyanobacterial blooms laid out in the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (MfE 2009), including use of a "decision tree" and a set of equations for estimating the probability of blooms in response to four key variables – lake size, concentrations of nitrogen and phosphorus, and wind speed. (see Attachment 5 for details). The results of this analysis are illustrated in Figure 9. The main conclusions are:

i) The risk of cyanobacterial blooms mid lake is currently low during windy (5+ knots) periods (i.e., at surveillance level). It is rare that mean daily (24 hr) windspeed is below 5 knots and maximum daily (24 hr) windspeed is never below 5 knots (see Attachment 4). Risk would approach the "alert level" during any extended calm periods (e.g., wind speed of 1 knot or less) but the data show that mean daily (24 hr) windspeed was never as low as 1 knot during the 20 month period for which data was available (April 2023 to January 2025).

ii) The concentrations of nitrogen and phosphorus near the Homestead Bay shoreline are currently a little higher (though still relatively low), leading to a slightly increased risk of planktonic cyanobacterial blooms – into the "alert level" during rare extended periods of wind conditions of 5 knots or less.

iii) Wind reduces risk. The naturally windy nature of Homestead Bay and indeed the whole of Lake Wakatipu is a mitigating factor that helps reduce the risk of blooms and other eutrophication effects (see Attachment 4 for analysis of wind speed).

iv) If nutrient concentrations were increased at the Homestead Bay shoreline this would increase the risk of localized blooms during any extended, albeit rare, calm periods, as indicated by the hypothetical 1.5x and 2x nutrient concentration increase scenarios shown with green arrows in Figure 9. These hypothetical scenarios are shown only for context to illustrate why treating nutrients is important. Lake edge TN and TP concentrations are not predicted to increase detectably as a result of the Homestead Bay development (see previous section 7.6).

v) The points made in (i) to (v) above all apply to the risk of planktonic blooms (i.e., those occurring in the water column and/or at the lake water surface). The risk of benthic cyanobacterial blooms (i.e., those that grow attached to the lake-bed), or for that matter any nuisance periphyton (e.g., attached algae) or fungus growths near shore in Homestead Bay, is considered low due to the frequent wind-driven wave action, as evidenced by observation of very clean gravels and cobbles in that area as described earlier in this memo..

Overall, the risk of nuisance or harmful algae or cyanobacteria blooms associated with nutrients from the proposed Homestead Bay treatment system are low and confined to a relatively small mixing zone area within 5m of the lake shore where groundwater flows from under the Homestead Bay development site into the lake.

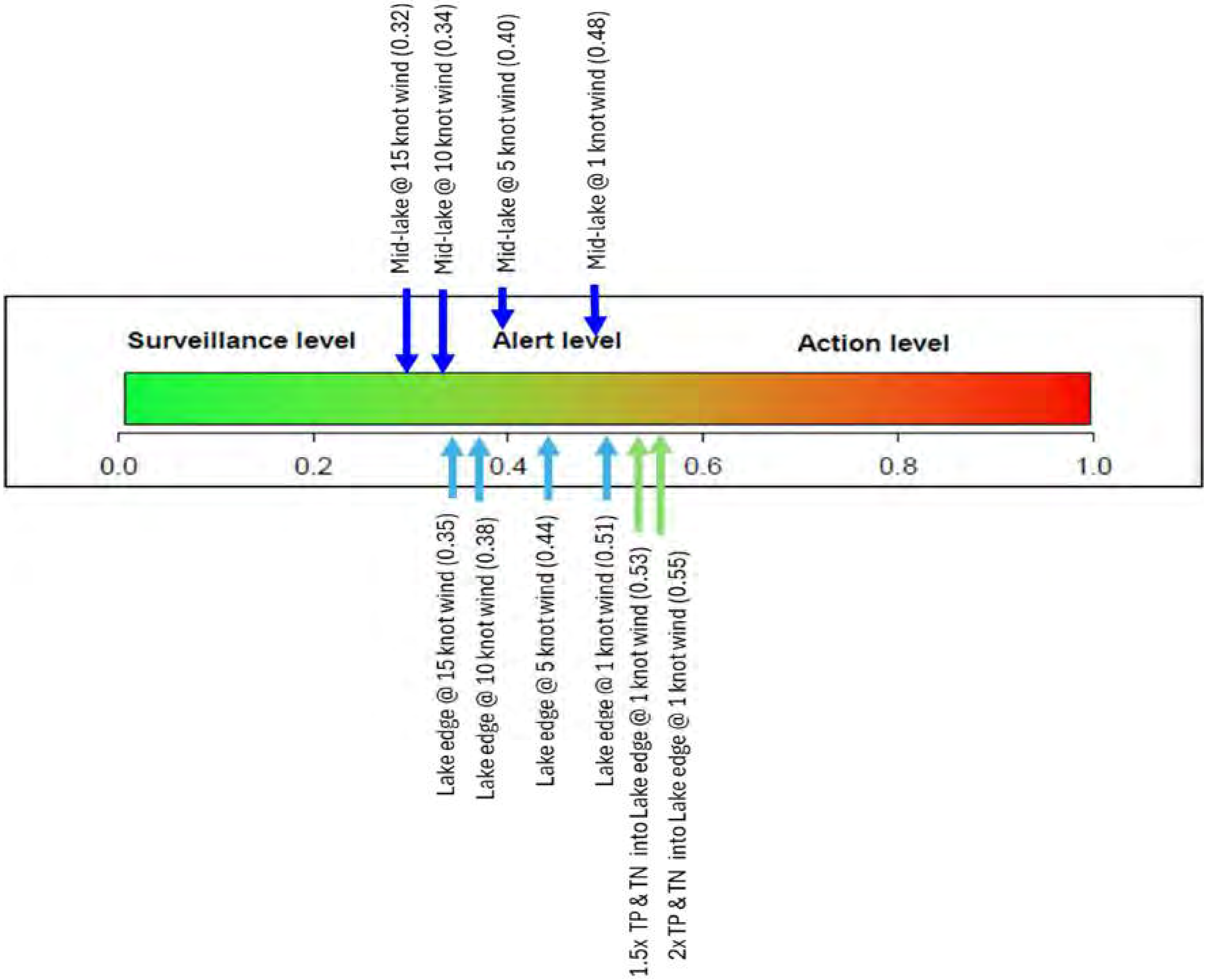

Figure 9: Weighted probability of cyanobacterial bloom formation and associated management response levels (surveillance, alert, action) redrawn from the New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters (MfE 2009) – showing calculated probabilities for current Lake Wakatipu mid-lake water quality (dark blue arrows), current localized Homestead Bay lake-edge quality (light blue arrows) and under hypothetical scenarios of 1.5x and 2x increase in TP and TN concentrations at lake-edge (light green arrows). Effect of wind reducing bloom probability is shown with nominal speeds of 1, 5, 10 and 15 knots.

8. Designing an integrated monitoring programme

I think the monitoring programme should include three inter-related aspects as follows:

1. A “front-end” early warning part of the monitoring programme should include:

    - Regular day-to day surveillance of the quality and flow rate of WWTP effluent leaving the treatment plant prior to land application;
    - Recording application rates for each land application area to avoid exceeding pre-determined maximum infiltration rates;
    - Visual surveillance to avoid any surface ponding or overland flow of effluent;
    - Regular groundwater monitoring at carefully selected sites near and immediately down-gradient of existing and new land application areas, to establish a baseline against which to monitor any change in near-application groundwater. This is recommended as an early warning monitoring system near to the application areas but also to help separate out effects of the Homestead Bay development from Jacks Point should that become necessary in future.

    There should also of course be daily tracking of compliance with the proposed effluent treatment and land application design criteria to provide early warning of operational problems before any contaminants travel and/or accumulate to cause adverse effects in down-gradient receiving groundwater, Māori Jack Stream and/or Lake Wakatipu. In the long-term this daily monitoring of effluent quality and application rate will be the key on-going monitoring to assure on-going good operation and performance of the wastewater treatment system, once the other monitoring components described below have established a clear relationship through time between effluent treatment performance and environmental state in Māori Jack Stream and Lake Wakatipu.

2. A “bottom-end” environmental state monitoring programme should include:

    - On-going assurance that critical outcomes are being achieved in the most sensitive downstream receiving environment of Lake Wakatipu; to be demonstrated by
    - Monthly sampling of the three existing Jacks Point monitoring locations 5 m out from the shoreline in Homestead Bay (see Attachment 3), throughout the development construction period and for at least three years after full completion.

    Once the development is complete and the wastewater treatment system has been performing reliably with an established set of the “front-end” monitoring results (see above) co-related to simultaneously sampled results showing no effects in the lake at Homestead Bay, then it may be appropriate to reduce the lake monitoring frequency to quarterly or annually while continuing thereafter with the “front-end” monitoring to provide assurance of on-going performance. At that stage a regular annual summer visual survey along the lakeshore by an appropriately qualified ecologist could arguably be more reliable for identifying problems than continued infrequent 5 m lakeshore monitoring.

In addition, data from the permanent long-term monitoring buoy operated by ORC at "*Lake Wakatipu Open Water 10m*" located near the middle of the lake out from Homestead Bay can be used to generate a relationship between water quality at that mid-lake site and the near-shore Homestead Bay site data. I would expect monitoring of the Homestead Bay sites 5 m from shore to provide the necessary assurance that Homestead Bay development is not causing any adverse effects. I do not expect any effect from Homestead Bay to be detectable at the long-term mid lake buoy.

3. A third aspect is monitoring of Māori Jack Stream that should include:

    - Monthly sampling of a site in the lower stream section (only when it is flowing and not in flood) to provide assurance that the recommended contaminant concentration triggers are being achieved (i.e., no increase compared to baseline concentrations; see section 6.3); and

    - Monthly sampling of a site in the wetland mid-section of Māori Jack Stream, for a period of three years starting no later than the beginning of construction, to develop a baseline dataset that is temporally related to the sampling in lower Māori Jack Stream described above. The purpose is to gather potentially useful information about nutrient transformations in the wetland mid-section of Māori Jack Stream, given this is a possible transport pathway for contaminants from LTA areas to Lake Wakatipu.

    Samples at both these sites should be analysed for both dissolved and total nutrients and compared to triggers as already described already in section 6.3.

9. Consideration of climate change

Bayer et al., (2012) undertook a detailed scientific study specifically to assess the sensitivity of Lakes Wakatipu and Wanaka to climate change. They used predictions from downscaled global circulation models that suggested an increase in mean air temperature, rainfall and wind speeds under climate change. Their work predicted these would lead to warmer overall lake temperatures and an earlier, longer, and shallower thermal stratification. They suggested these physical changes could potentially affect phytoplankton production (e.g., increased chlorophyll *a* concentration, TLI scores and risk of blooms) as their light limitation would decrease in duration and intensity. However, they suggested deeper mixing caused by increases in wind speed could at least partly negate the reduction of thermocline depth and hence offset the effects of warming.

Trolle et al., (2014) used modelling approaches to investigate the impacts of climate change on phytoplankton response in lakes more generally. They concluded that, amongst other things, climate warming will facilitate higher yields of both cyanobacteria and total phytoplankton biomass (e.g., chlorophyll *a* concentrations) relative to nutrient supply. For example, their modelling suggested that the effects of a mild warming scenario on both total phytoplankton and cyanobacteria biomass was greater than the effects of increasing nutrient loads by 15%.

Taken together these studies suggest that climate change could potentially make existing water quality in Lake Wakatipu worse, as well as more sensitive to any nutrient load increases, but with a high degree of uncertainty. I think this reinforces the importance of:

i) Managing risk by minimizing human-induced nutrient load sources like wastewater, as is proposed for the Homestead Bay treatment and disposal system.

ii) Implementing well-designed monitoring systems, both for early detection of any wastewater treatment problems near their source (i.e., in treated effluent and groundwater) and for on-going monitoring of state and trends in lake water quality.

iii) Planning for what alternative treatment, disposal or other actions would be undertaken in the event that monitoring detects insufficient treatment performance or other unforeseen problems.

10. Conclusion

The analyses presented in this memo show it is plausible to maintain the very high existing water quality that meets regional plan limits in Lake Wakatipu (RWP Schedule 15; see Table 5), while treating and discharging wastewater from the Homestead Bay development entirely on the development site rather than piping the wastewater for disposal elsewhere. The proposed treatment system involves a two-part "treatment train" that includes a wastewater treatment plant (WWTP) followed by discharge of treated effluent to land for further treatment in land treatment areas (LTAs). There are several options for the WWTP design and LTA configuration that can meet the receiving water criteria recommended in this memo, and which could be implemented in a time-staged way to align with development construction stages.

The assessment also shows it is plausible to at least maintain existing water quality in Māori Jack Stream. Water quality in Māori Jack Stream does not currently meet all of the limits set for tributaries of Lake Wakatipu in the regional plan (RWP Schedule 15; see Table 1); those limits aspire to very high water quality that will be challenging to meet consistently in heavily modified streams (i.e., with catchments comprising urban and agricultural land use) and which would probably require stream enhancements (e.g., flow and riparian vegetation improvements) that are beyond the control of the Homestead Bay developers alone. The Homestead Bay development will contribute some additional flow to groundwater that may assist with some dilution of nutrient concentrations in Māori Jack Stream.

Consent conditions could be set that include a water quality monitoring programme and comparison with the limits and triggers recommended in this memo (sections 8, 6 and 7), to provide assurance that the wastewater treatment system will be constructed and operated to perform as predicted. The water quality monitoring programme could also provide on-going assurance that the RWP limits are being achieved in Lake Wakatipu and that water quality in Māori Jack Stream is at least being maintained.

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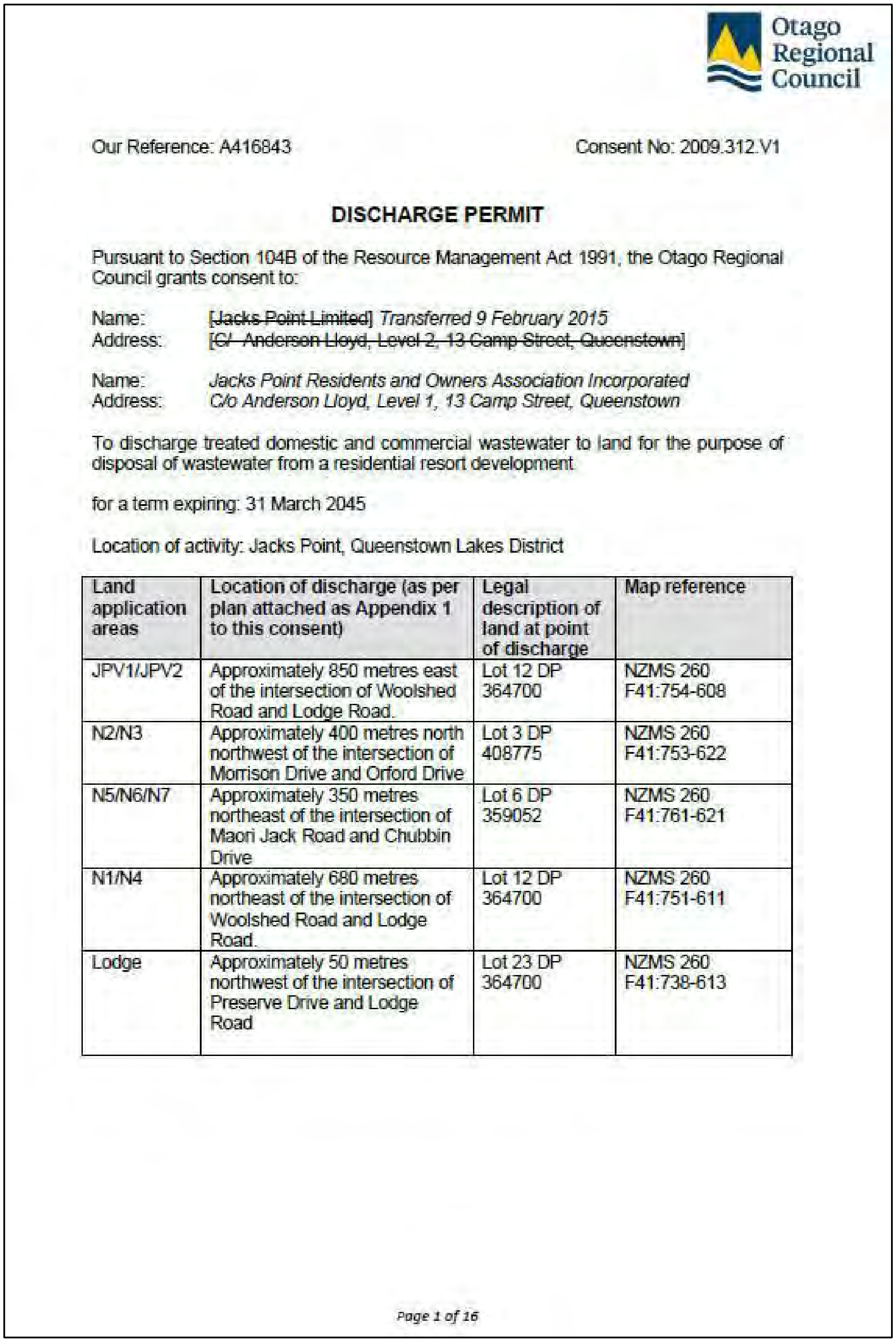
Attachment 1: Copy of Jacks Point Discharge Permit

Note that parts of condition 20 mentioned in this report are highlighted**.**



Otago Regional Council

Our Reference: A416843 Consent No: 2009.312.V1

DISCHARGE PERMIT

Pursuant to Section 104B of the Resource Management Act 1991, the Otago Regional Council grants consent to:

Name: ~~[Jacks Point Limited]~~ *Transferred 9 February 2015*
Address: ~~[C/- Anderson Lloyd, Level 2, 13 Camp Street, Queenstown]~~

Name: *Jacks Point Residents and Owners Association Incorporated*
Address: *C/o Anderson Lloyd, Level 1, 13 Camp Street, Queenstown*

To discharge treated domestic and commercial wastewater to land for the purpose of disposal of wastewater from a residential resort development

for a term expiring: 31 March 2045

Location of activity: Jacks Point, Queenstown Lakes District

Land application areas	**Location of discharge (as per plan attached as Appendix 1 to this consent)**	**Legal description of land at point of discharge**	**Map reference**
JPV1/JPV2	Approximately 850 metres east of the intersection of Woolshed Road and Lodge Road.	Lot 12 DP 364700	NZMS 260 F41:754-608
N2/N3	Approximately 400 metres north northwest of the intersection of Morrison Drive and Orford Drive	Lot 3 DP 408775	NZMS 260 F41:753-622
N5/N6/N7	Approximately 350 metres northeast of the intersection of Maori Jack Road and Chubbin Drive	Lot 6 DP 359052	NZMS 260 F41:761-621
N1/N4	Approximately 680 metres northeast of the intersection of Woolshed Road and Lodge Road.	Lot 12 DP 364700	NZMS 260 F41:751-611
Lodge	Approximately 50 metres northwest of the intersection of Preserve Drive and Lodge Road	Lot 23 DP 364700	NZMS 260 F41:738-613

Page 1 of 16

Conditions
Specific

1. This consent shall not be exercised until 2004.793_V1 has been surrendered.

2. If this consent is not given effect to within a period of ten years from the date of commencement of this consent, this consent shall lapse under Section 125 of the Resource Management Act 1991.

3. The total volume of effluent discharged shall not exceed 1,374 cubic metres per day.

4. The rate of application shall not exceed 12 millimetres per day for all land application areas.

5. The discharge shall only be treated domestic and commercial wastewater, as described in the consent application submitted to the Consent Authority on 2 September 2009 and the variation application submitted on 18 January 2019.

6. The treatment and disposal system shall be constructed and installed in accordance with the details and plans supplied with the consent application submitted to the Consent Authority on 2 September 2009, further information dated 14 October 2009 and 11 November 2009 and the variation application submitted on 18 January 2019 including further information dated 11 July 2019, 23 October 2019, 20 February 2020, 7 July 2020, 24 August 2020, 15 March 2021 and 09 April 2021, and as per the plan attached as Appendix 1 to this consent. If there are any inconsistencies between the above information and the conditions of this consent, the conditions of this consent will prevail. The treatment and disposal system shall comprise as a minimum:

   (i) grease traps at the outlets of all restaurants, cafés and commercial food producing facilities on the site;
   (ii) interceptor tanks (STEP/STEG system) at each building producing wastewater or, where appropriate, interceptor tanks for a cluster of systems;
   (iii) re-circulating textile packed bed reactor treatment plants with a minimum retention time of 24 hours;
   (iv) upgraded wastewater treatment plants and cut and carry management regime as per the variation application submitted on 18 January 2019 when the total volume of effluent discharged exceeds 425 cubic metres per day for more than five days in a calendar year;
   (v) sub-surface land application areas that total a minimum of 12 hectares and that are designed and operated so that the discharge is distributed evenly over each land application area; and
   (vi) a cut and carry management regime on the Lodge, N2/N3 and N5/N6/N7 land application areas and a grazed management regime on N1/N4 and JPV1/JPV2 land application areas.

7. The land application areas shall be marked out by any means that ensures the extent of them are identifiable on the ground surface, and shall remain marked out for the term of the consent.

8. (a) The land application areas shall not be used:
      (i) for roading whether sealed or unsealed;

(ii) as a hardstanding area;
(iii) for erecting buildings or any non-effluent systems structures;
(iv) for activities that require intensively managed grass surfaces (e.g. grass tennis courts or bowling greens or golf tees and greens); and
(i) for grazing stock, excluding sheep.

(b) The consent holder shall inform the Consent Authority in writing if the land application areas are to be used for any other purpose than mown grass, landscaping, and/or grazing stock pursuant to Condition 11 of this consent.

9. The consent holder shall not apply any nitrogen fertilizer on the land application areas besides from the treated effluent.

10. A buffer zone of 20 metres shall be maintained between any surface water body and the boundary of the land application areas, and at least 100 metres between any bore drawing groundwater from an unconfined aquifer and the boundary of the land application areas.

11. The consent holder may graze the land application areas with sheep provided the number of sheep does not exceed 10 stock units per hectare. A record is to be kept of the number of sheep and the periods when grazing occurs and such records shall be submitted to the Consent Authority by 1 June each year.

12. The consent holder shall construct and maintain stormwater cut-off drains up-gradient of the land application areas to stop any stormwater entering the land application areas. Photographs of the stormwater cut off drains shall be provided to the Consent Authority when they are completed.

Performance Monitoring

13. (a) Prior to commissioning each treatment and land application system, the consent holder shall install a flow meter on the outlet pipe from the treatment system to record the volume of effluent discharged to each land application area. The flow meter shall have an accuracy range of +/- 5%.

(b) Once each flow meter is installed, the consent holder shall record the daily volume (based on a no more than weekly average). The flow records for the period 1 May to 30 April inclusive from each flow meter shall be forwarded to the Consent Authority by 1 June each year, and upon request.

14. Following the instalment of each treatment and land application system, the consent holder shall supply the Consent Authority with a Producer Statement or a Certificate of Compliance, certifying that the treatment and land application system has been installed in accordance with Condition 6 of this consent.

15. (a) By 1 September 2021, the Consent Holder must have established a piezometer array as shown in the plan attached as Appendix 2 to this consent (or as otherwise agreed by the Consent Authority) and begin monitoring in accordance with Condition 16(b) of this consent.

(b) The piezometer array must be established in a staged fashion as per the table below, with the stages being contingent upon trigger levels. The trigger levels are:

i. annual (January to December)median increases of 1.5 milligrams per litre of nitrate-nitrogen in either bore P2 or P3 over any continuous two year period from P2 or P3's nitrate-nitrogen median value from the first 12 months of sampling required by Condition 16(c); and

ii. annual (January to December) median increases of 1.5 milligrams per litre of nitrate-nitrogen in either P2 or P3 (downgradient bores) when compared to P4 (upgradient bore), regardless of the initial difference in concentration between these bores.

Threshold for establishment of piezometer	**Piezometer bores to be established**
To be established by 1 September 2021	P4 (upgradient) P2 and P3 (downgradient) If a perched water level is encountered when drilling P2 or P3 then another bore is to be drilled beside the bore to be screened in the perched water bearing layer. Additional perched water level bores are to be monitored in accordance with Condition 16(c).
Trigger exceeded: Bore P2 exceeds one or both of Condition 15(b)(i) and 15(b)(ii)	P2a
Trigger exceeded: Bore P3 exceeds one or both of Condition 15 (b)(i) and 15 (b)(ii)	P1

The Consent Authority must be notified within 10 wording days of P2a and/or P1 being established.

(c) The piezometers shall be installed in accordance with the methods given in New Zealand Standard 4411:2001, "Environmental Standard for Drilling of Soil and Rock". The consent holder shall confirm the exact location of the piezometers with the Consent Authority prior to installation. A bore log shall be forwarded to the Consent Authority for each of the piezometers installed in accordance with Conditions 15(a) and 15(b) of this consent. Each log shall clearly indicate the depth of the bore and the depth to groundwater.

(d) If the Consent Holder is not granted permission to sample from Bore P4 or loses access to the bore at any time during the exercise of this consent, the Consent Holder must:

i. install a new bore as close as practical to the location of Bore P4 as shown on the plan attached as Appendix 2 to this consent.

ii. prior to drilling, provide the proposed location to the Consent Authority and receive approval from the Consent Authority for the bore location.

16. (a) Following the commissioning of each treatment and land application system, the consent holder shall obtain representative samples of the effluent and sample for the following parameters.

Sample location	Parameters	Monitoring Frequency
The final effluent from each of the wastewater treatment plants immediately prior to discharge to land	- Total nitrogen	Monthly (until varied by the condition below)
	- 5-day biochemical oxygen demand (BOD_5) - Total suspended solids - Total phosphorus - *Escherichia coli* - Total nitrogen (as determined by the condition below)	January, April, July, October each year

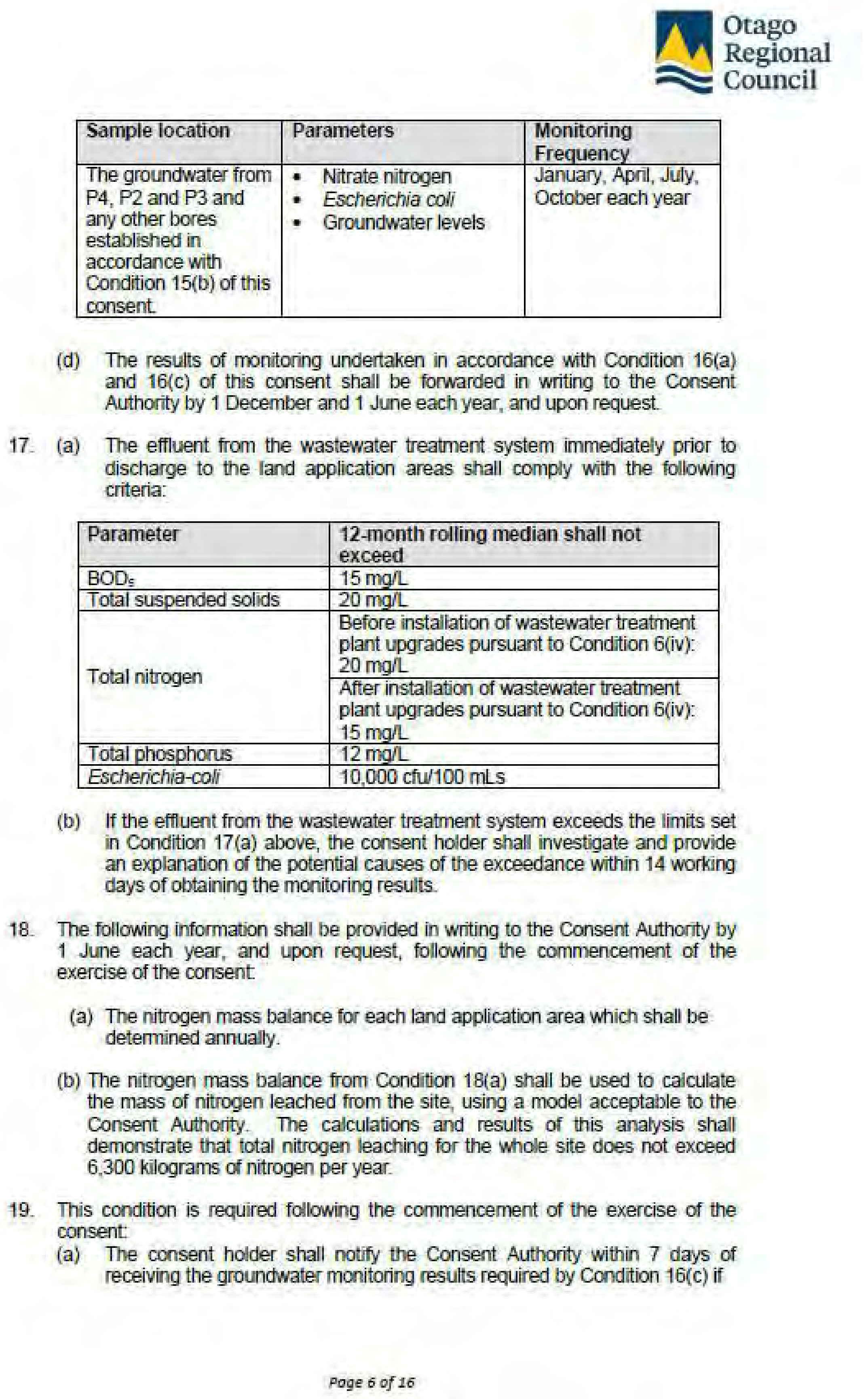
(b) Total nitrogen shall continue to be monitored monthly for a period of two years following commissioning of the final upgraded wastewater treatment plants. The Consent Holder must notify the Consent Authority once the last wastewater treatment plant has been upgraded. At the completion of the two-year period:

(i) If any of the sample results are greater than the consented limits for total nitrogen, as detailed in Condition 17(a) of this consent, the monitoring shall remain monthly until there are two consecutive years with no breaches of the consented limits.

(ii) If all of the samples meet the consented limits, the consent holder shall calculate the annual means for the preceding two 12-month periods. If the sample results from each treatment plant for these two 12-month periods are all within a 20 % variation from their annual means, then the monitoring frequency shall reduce to quarterly, with samples to be taken in January, April, July and October.

(iii) If any of the sample results are outside of the 20% variation from their annual mean, the monitoring shall remain monthly. Quarterly sampling can commence when each monthly sample is within a 20% variation from their annual mean for two consecutive years.

(c) By 1 December 2021, the consent holder must obtain representative samples of the groundwater from the piezometers installed under Condition 15(b) of this consent.



Sample location	Parameters	Monitoring Frequency
The groundwater from P4, P2 and P3 and any other bores established in accordance with Condition 15(b) of this consent.	• Nitrate nitrogen • *Escherichia coli* • Groundwater levels	January, April, July, October each year

(d) The results of monitoring undertaken in accordance with Condition 16(a) and 16(c) of this consent shall be forwarded in writing to the Consent Authority by 1 December and 1 June each year, and upon request.

17. (a) The effluent from the wastewater treatment system immediately prior to discharge to the land application areas shall comply with the following criteria:

Parameter	12-month rolling median shall not exceed
BOD_5	15 mg/L
Total suspended solids	20 mg/L
Total nitrogen	Before installation of wastewater treatment plant upgrades pursuant to Condition 6(iv): 20 mg/L
	After installation of wastewater treatment plant upgrades pursuant to Condition 6(iv): 15 mg/L
Total phosphorus	12 mg/L
Escherichia-coli	10,000 cfu/100 mLs

(b) If the effluent from the wastewater treatment system exceeds the limits set in Condition 17(a) above, the consent holder shall investigate and provide an explanation of the potential causes of the exceedance within 14 working days of obtaining the monitoring results.

18. The following information shall be provided in writing to the Consent Authority by 1 June each year, and upon request, following the commencement of the exercise of the consent:

(a) The nitrogen mass balance for each land application area which shall be determined annually.

(b) The nitrogen mass balance from Condition 18(a) shall be used to calculate the mass of nitrogen leached from the site, using a model acceptable to the Consent Authority. The calculations and results of this analysis shall demonstrate that total nitrogen leaching for the whole site does not exceed 6,300 kilograms of nitrogen per year.

19. This condition is required following the commencement of the exercise of the consent:

(a) The consent holder shall notify the Consent Authority within 7 days of receiving the groundwater monitoring results required by Condition 16(c) if the nitrate-nitrogen concentration within the down-gradient monitoring bores is 3 milligrams per litre or greater than the up-gradient monitoring bore, or if the *Escherichia coli* concentrations are greater than 1 coliform unit per 100 millilitres.

(b) If there is an exceedance of Condition 19(a), the consent holder shall investigate and forward a written report to the Consent Authority within 30 days of receiving notice of the exceedance outlining the likely reasons for the exceedance and methods to reduce the adverse effect (e.g. disinfecting the effluent prior to discharge, increasing the size of the land application areas).

20. (a) Prior to 1 March 2022, the following ecological baseline studies must be undertaken:

   a. A one-off baseline ecological study on Maori Jack Stream at the location shown on the plan attached as Appendix 3 to this consent. The study must be undertaken in the summer period (November to February) by a suitably qualified and experienced freshwater ecologist. The study must include, but is not limited to, benthic macroinvertebrate, periphyton, plant and substrate assessments as well as monthly water quality sampling (November to February inclusive) at two locations, if the stream is flowing. The samples must be analysed for:
      i. *Escherichia coli;*
      ii. Total phosphorus,
      iii. Dissolved reactive phosphorus
      iv. Total nitrogen; and
      v. Dissolved inorganic nitrogen.
   b. A one-off baseline ecological study of the Lake Wakātipu lake margin at the location shown on the plan attached as Appendix 3 to this consent. The study must be undertaken in the summer period (November to February inclusive) and be undertaken by a suitably qualified and experienced freshwater ecologist. The study must include monthly water quality sampling (November to February inclusive) at three locations 5 metres from the lakeshore at 0.5 metres depth. The study must include sampling for:
      i. Chlorophyll-a;
      ii. Water clarity;
      iii. *Escherichia coli;*
      iv. Total phosphorus;
      v. Total nitrogen;
      vi. Calculation of Lake Trophic Level Index (TLI).
   c. A report must be provided to the Consent Authority detailing the results of the baseline sampling and ecological studies with comparison to relevant environmental standards by 1 June 2022. The report must be prepared by a suitably qualified and experienced freshwater ecologist.

(b) Following installation of P1, as triggered by Condition 15(b), if either:

   a. The downgradient Bore P1 shows an annual (January to December) median increase of 1.5 milligrams per litre of nitrate-nitrogen over any two-year period from the median of the first 12 months of sampling required by Condition 16(c); or

b. The downgradient Bore P1 shows an annual (January to December) median increase of 1.5 milligrams per litre of nitrate-nitrogen above the upgradient Bore P4 then the following ecological studies must be undertaken:

   i. An ecological study on Maori Jack Stream during the next summer period after the reported increase at the location shown on the plan attached as Appendix 3 to this consent. The study must be undertaken during the same month as the baseline study in Condition 20(a). The study must be undertaken by a suitably qualified and experienced freshwater ecologist. The study must include monthly water quality sampling (November to February inclusive) at two locations, if the stream is flowing. The samples must be analysed for:
      1. *Escherichia coli*;
      2. Total phosphorus,
      3. Dissolved reactive phosphorus
      4. Total nitrogen; and
      5. Dissolved inorganic nitrogen.

   ii. An ecological study of the Lake Wakātipu lake margin during the next summer period after the reported increase at the location shown on the plan attached as Appendix 3 to this consent. The study must be undertaken during the same month as the baseline study in Condition 20(a). The study must be undertaken by a suitably qualified and experienced freshwater ecologist. The study must include monthly water quality sampling (November to February inclusive) for:
      1. Chlorophyll-a;
      2. Water clarity;
      3. *Escherichia coli*;
      4. Total phosphorus;
      5. Total nitrogen;
      6. Calculation of Lake Trophic Level Index (TLI).

(c) If the monitoring undertaken in accordance with Conditions 20(a) and 20(b) shows that:

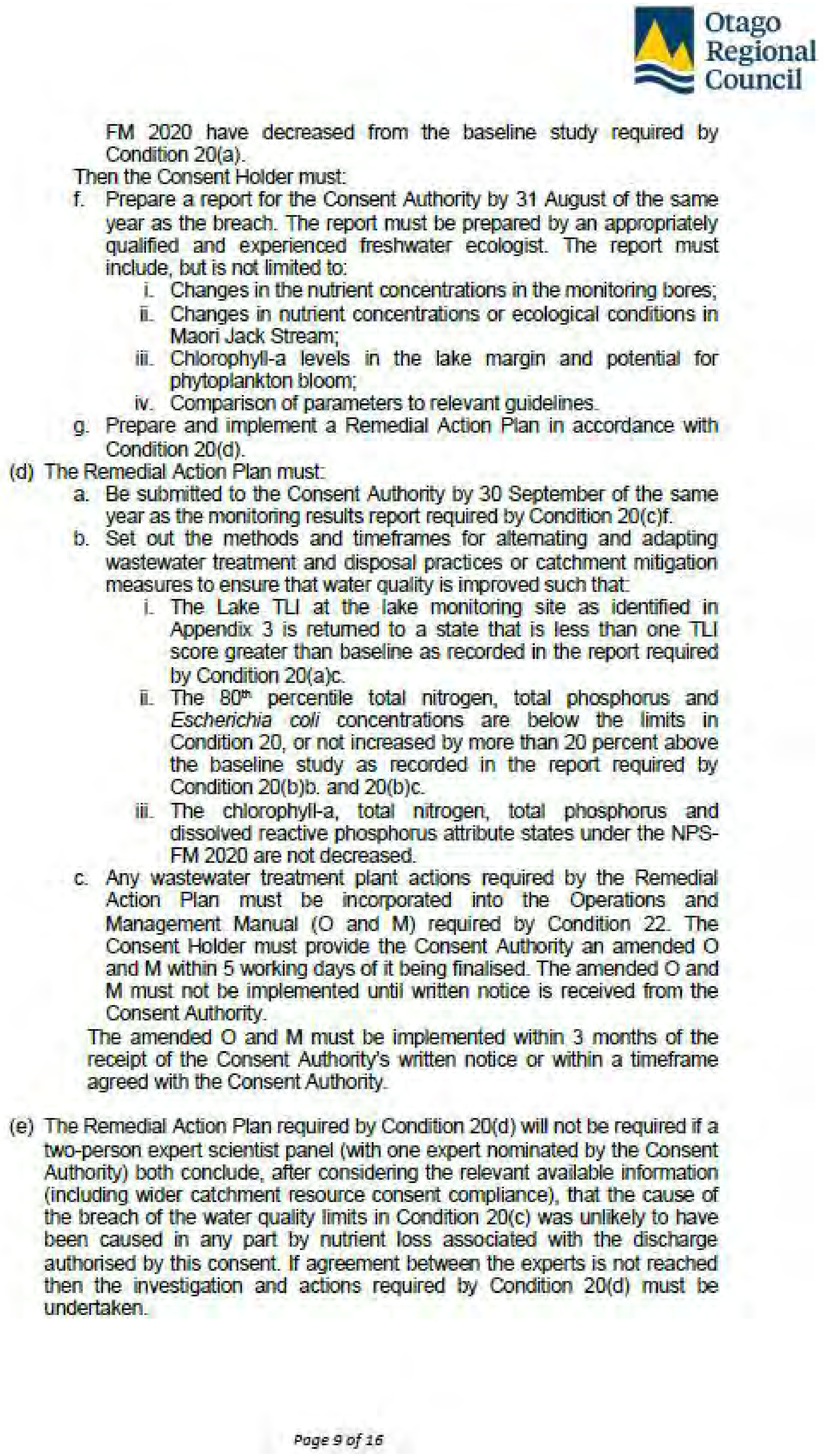
a. The average TLI difference between the baseline period and the most recent monitoring period has increased by one TLI score; or

b. More than 20 percent of the samples at the lake margin exceed the following parameter limits:
   i. Water clarity – 3 nephelometric turbidity units;
   ii. *Escherichia coli* – 10 coliform forming units per 100 millilitres;
   iii. Total phosphorus – 0.005 milligrams per litre;
   iv. Total nitrogen – 0.1 milligrams per litre; or

c. More than 20 percent of the samples in Maori Jack Stream exceed the following parameter limits:
   i *Escherichia coli* - 10 coliform forming units per 100 millilitres;
   ii Total phosphorus - 0.005 milligrams per litre;
   iii Total nitrogen - 0.1 milligrams per litre; and

d. Any of the parameters listed in Condition 20(b)(b.), which were above the limits in Condition 20(c)(b.) or 20(c)(c) in the baseline assessments required by Condition 20(a) have increased by 20 percent or more from the baseline study; or

e. Any of the lake chlorophyll-a, total nitrogen, total phosphorus or dissolved reactive phosphorus attribute states as detailed in the NPS-



FM 2020 have decreased from the baseline study required by Condition 20(a).

Then the Consent Holder must:

f. Prepare a report for the Consent Authority by 31 August of the same year as the breach. The report must be prepared by an appropriately qualified and experienced freshwater ecologist. The report must include, but is not limited to:
   i. Changes in the nutrient concentrations in the monitoring bores;
   ii. Changes in nutrient concentrations or ecological conditions in Maori Jack Stream;
   iii. Chlorophyll-a levels in the lake margin and potential for phytoplankton bloom;
   iv. Comparison of parameters to relevant guidelines.

g. Prepare and implement a Remedial Action Plan in accordance with Condition 20(d).

(d) The Remedial Action Plan must:

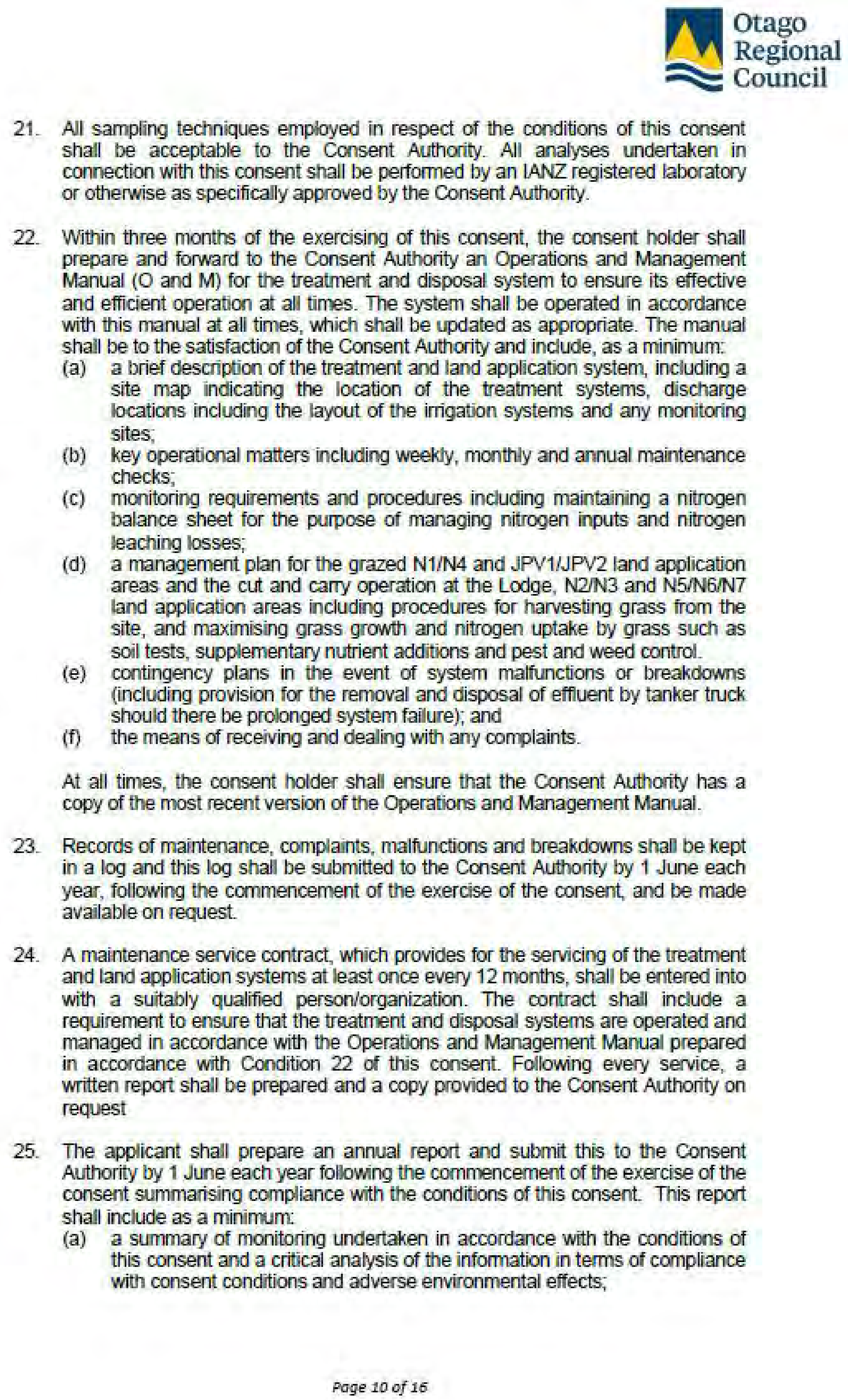
a. Be submitted to the Consent Authority by 30 September of the same year as the monitoring results report required by Condition 20(c)f.

b. Set out the methods and timeframes for alternating and adapting wastewater treatment and disposal practices or catchment mitigation measures to ensure that water quality is improved such that:
   i. The Lake TLI at the lake monitoring site as identified in Appendix 3 is returned to a state that is less than one TLI score greater than baseline as recorded in the report required by Condition 20(a)c.
   ii. The 80th percentile total nitrogen, total phosphorus and *Escherichia coli* concentrations are below the limits in Condition 20, or not increased by more than 20 percent above the baseline study as recorded in the report required by Condition 20(b)b. and 20(b)c.
   iii. The chlorophyll-a, total nitrogen, total phosphorus and dissolved reactive phosphorus attribute states under the NPS-FM 2020 are not decreased.

c. Any wastewater treatment plant actions required by the Remedial Action Plan must be incorporated into the Operations and Management Manual (O and M) required by Condition 22. The Consent Holder must provide the Consent Authority an amended O and M within 5 working days of it being finalised. The amended O and M must not be implemented until written notice is received from the Consent Authority.

The amended O and M must be implemented within 3 months of the receipt of the Consent Authority's written notice or within a timeframe agreed with the Consent Authority.

(e) The Remedial Action Plan required by Condition 20(d) will not be required if a two-person expert scientist panel (with one expert nominated by the Consent Authority) both conclude, after considering the relevant available information (including wider catchment resource consent compliance), that the cause of the breach of the water quality limits in Condition 20(c) was unlikely to have been caused in any part by nutrient loss associated with the discharge authorised by this consent. If agreement between the experts is not reached then the investigation and actions required by Condition 20(d) must be undertaken.



21. All sampling techniques employed in respect of the conditions of this consent shall be acceptable to the Consent Authority. All analyses undertaken in connection with this consent shall be performed by an IANZ registered laboratory or otherwise as specifically approved by the Consent Authority.

22. Within three months of the exercising of this consent, the consent holder shall prepare and forward to the Consent Authority an Operations and Management Manual (O and M) for the treatment and disposal system to ensure its effective and efficient operation at all times. The system shall be operated in accordance with this manual at all times, which shall be updated as appropriate. The manual shall be to the satisfaction of the Consent Authority and include, as a minimum:
    (a) a brief description of the treatment and land application system, including a site map indicating the location of the treatment systems, discharge locations including the layout of the irrigation systems and any monitoring sites;
    (b) key operational matters including weekly, monthly and annual maintenance checks;
    (c) monitoring requirements and procedures including maintaining a nitrogen balance sheet for the purpose of managing nitrogen inputs and nitrogen leaching losses;
    (d) a management plan for the grazed N1/N4 and JPV1/JPV2 land application areas and the cut and carry operation at the Lodge, N2/N3 and N5/N6/N7 land application areas including procedures for harvesting grass from the site, and maximising grass growth and nitrogen uptake by grass such as soil tests, supplementary nutrient additions and pest and weed control.
    (e) contingency plans in the event of system malfunctions or breakdowns (including provision for the removal and disposal of effluent by tanker truck should there be prolonged system failure); and
    (f) the means of receiving and dealing with any complaints.

    At all times, the consent holder shall ensure that the Consent Authority has a copy of the most recent version of the Operations and Management Manual.

23. Records of maintenance, complaints, malfunctions and breakdowns shall be kept in a log and this log shall be submitted to the Consent Authority by 1 June each year, following the commencement of the exercise of the consent, and be made available on request.

24. A maintenance service contract, which provides for the servicing of the treatment and land application systems at least once every 12 months, shall be entered into with a suitably qualified person/organization. The contract shall include a requirement to ensure that the treatment and disposal systems are operated and managed in accordance with the Operations and Management Manual prepared in accordance with Condition 22 of this consent. Following every service, a written report shall be prepared and a copy provided to the Consent Authority on request

25. The applicant shall prepare an annual report and submit this to the Consent Authority by 1 June each year following the commencement of the exercise of the consent summarising compliance with the conditions of this consent. This report shall include as a minimum:
    (a) a summary of monitoring undertaken in accordance with the conditions of this consent and a critical analysis of the information in terms of compliance with consent conditions and adverse environmental effects;

(b) a comparison of the years data with previously collected data in order to identify any emerging trends;

(c) copies of the laboratory analytical results including water quality results; and

(d) details of the cut and carry operation at the Lodge, N2/N3 and N5/N6/N7 land application areas including the number of harvests and nitrogen balance for each site.

(e) details of the number and type of stock and time spent on N1/N4 and JPV1 and JPV2 land application areas.

26. The consent holder shall ensure that there are maintenance contracts in place with a qualified service provider for the maintenance and pump out of every interceptor tank. Records of the pump out of sludge from the interceptor tanks and treatment system shall be provided to the Consent Authority upon request.

General

27. No ponding or surface run-off of effluent shall occur as a result of the exercise of this consent.

28. There shall be no odour emission resulting from the treatment and land application system beyond the boundary of each site that is offensive or objectionable in the opinion of an enforcement officer.

29. This permit does not authorise the discharge of sludge to land or water.

30. If the consent holder:

(a) discovers koiwi tangata (human skeletal remains), waahi taoka (resources of importance including Pounamu/greenstone), waahi tapu (places or features of special significance) or other Maori artefact material, the consent holder shall without delay:

(i) notify the Consent Authority, Tangata whenua and New Zealand Historic Places Trust and in the case of skeletal remains, the New Zealand Police.

(ii) stop work within the immediate vicinity of the discovery to allow a site inspection by the New Zealand Historic Places Trust and the appropriate runanga and their advisors, who shall determine whether the discovery is likely to be extensive, if a thorough site investigation is required, and whether an Archaeological Authority is required.

Any koiwi tangata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate to its removal or preservation.

Site work shall recommence following consultation with the Consent Authority, the New Zealand Historic Places Trust, Tangata whenua, and in the case of skeletal remains, the New Zealand Police, provided that any relevant statutory permissions have been obtained.

(b) discovers any feature or archaeological material that predates 1900, or heritage material, or disturbs a previously unidentified archaeological or heritage site, the consent holder shall without delay:

(i) stop work within the immediate vicinity of the discovery or disturbance and

(ii) advise the Consent Authority, the New Zealand Historic Places Trust, and in the case of Maori features or materials, the Tangata whenua, and if required, shall make an application for an Archaeological Authority pursuant to the Historic Places Act 1993 and

(c) arrange for a suitably qualified archaeologist to undertake a survey of the site.

Site work shall recommence following consultation with the Consent Authority.

31. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent within three months of each anniversary of the commencement of this consent, for the purpose of:
    (a) determining whether the conditions of this consent are adequate to deal with any adverse effect on the environment which may arise from the exercise of the consent and which it is appropriate to deal with at a later stage, or which becomes evident after the date of commencement of the consent; or
    (b) ensuring the conditions of this consent are consistent with any National Environmental Standards; or
    (c) requiring the consent holder to adopt the best practicable option, in order to remove or reduce any adverse effect on the environment arising as a result of the exercise of this consent. Best practicable option includes, but is not limited to, connecting to a reticulated community sewerage scheme, should such an option become available to the consent holder.

Advice Notes:

1. Section 126 of the Resource Management Act 1991 provides that the Consent Authority may cancel this consent by written notice served on the Consent Holder if the consent has been exercised in the past but has not been exercised during the preceding five years.
2. If you require a replacement consent upon the expiry date of this consent, any new application should be lodged at least 6 months prior to the expiry date of this consent. Applying at least 6 months before the expiry date may enable you to continue to exercise this consent under section 124 of the Resource Management Act 1991 until a decision is made on the replacement application (and any appeals are determined).
3. The Consent Holder is responsible for obtaining all other necessary consents, permits, and licences, including those under the Building Act 2004, the Biosecurity Act 1993, the Conservation Act 1987, and the Heritage New Zealand Pouhere Taonga Act 2014. This consent does not remove the need to comply with all other applicable Acts (including the Property Law Act 2007 and the Health and Safety at Work Act 2015), regulations, relevant Bylaws, and rules of law. This consent does not constitute building consent approval. Please check whether a building consent is required under the Building Act 2004.
4. Where information is required to be provided to the Consent Authority in condition/s this is provided in writing to compliance@orc.govt.nz and the email heading is to reference 2009.312.V1 and the condition/s the information relates to.

Issued at Dunedin this 31st day of March 2010
Reissued at Dunedin this 9th day of June 2010 to correct formatting of condition 31

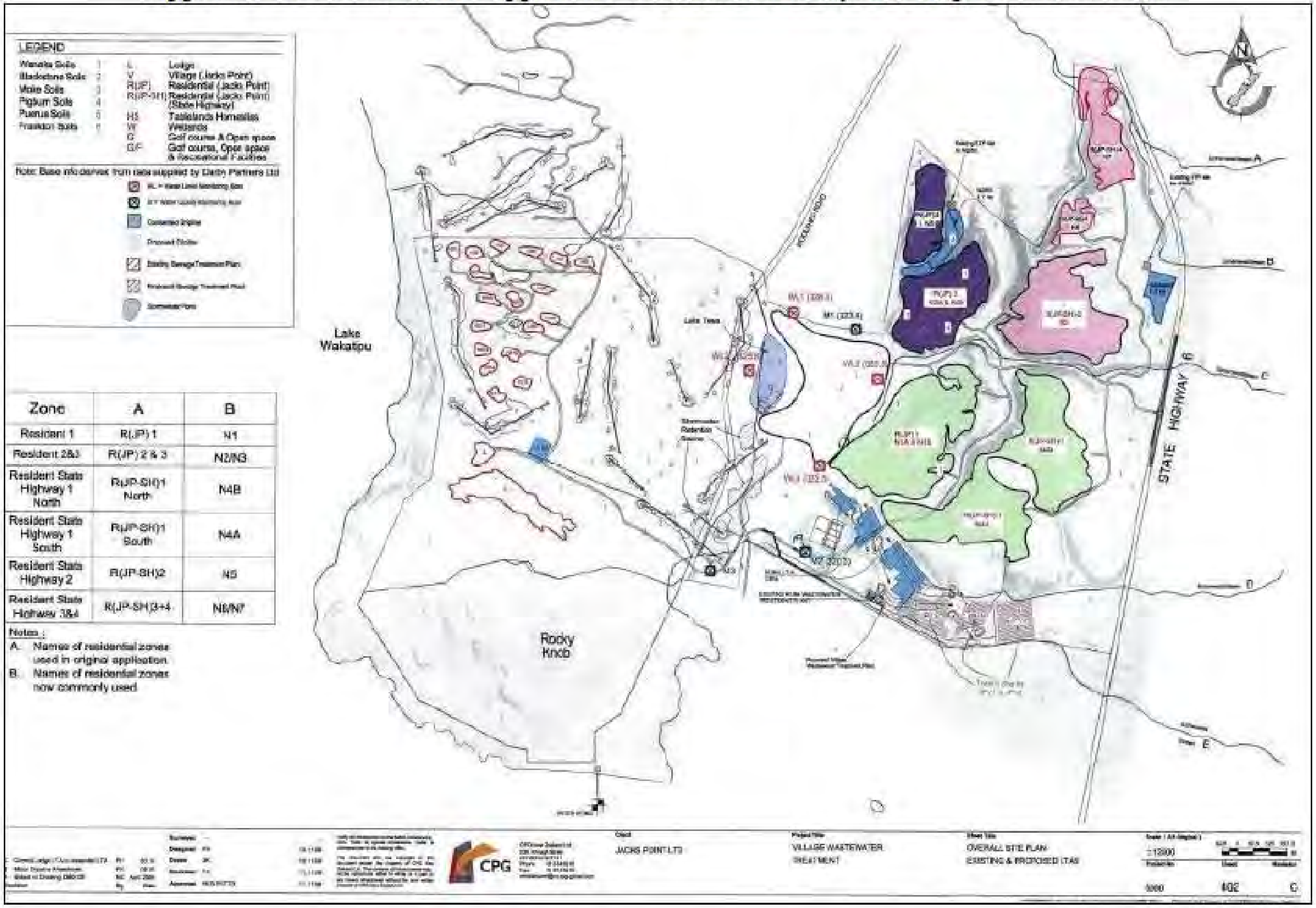
Reissued at Dunedin this 17th day of June 2010 to correct defects in the consent pursuant to Section 133A of the Resource Management Act 1991.
Reissued at Dunedin this 12th day of February 2015 to reflect the transfer of holder from Jacks Point Limited to Jacks Point Residents and Owners Association Incorporated
Reissued at Dunedin this 20th day of May 2021 to reflect changes to Conditions 5, 6, 15, 16(b), 17(a), 18(b),), 20, 22, 25 and to remove Condition 20 and replace it with a new condition and to add Advice Notes 1-4.
Reissued at Dunedin this 4th day of June 2021 to reflect a minor correction pursuant of Section 133a of the Resource Management Act

[redacted]

Joanna Gilroy
Manager Consents

Otago Regional Council

Appendix 1: Location of land application areas authorised by Discharge Permit 2009.312



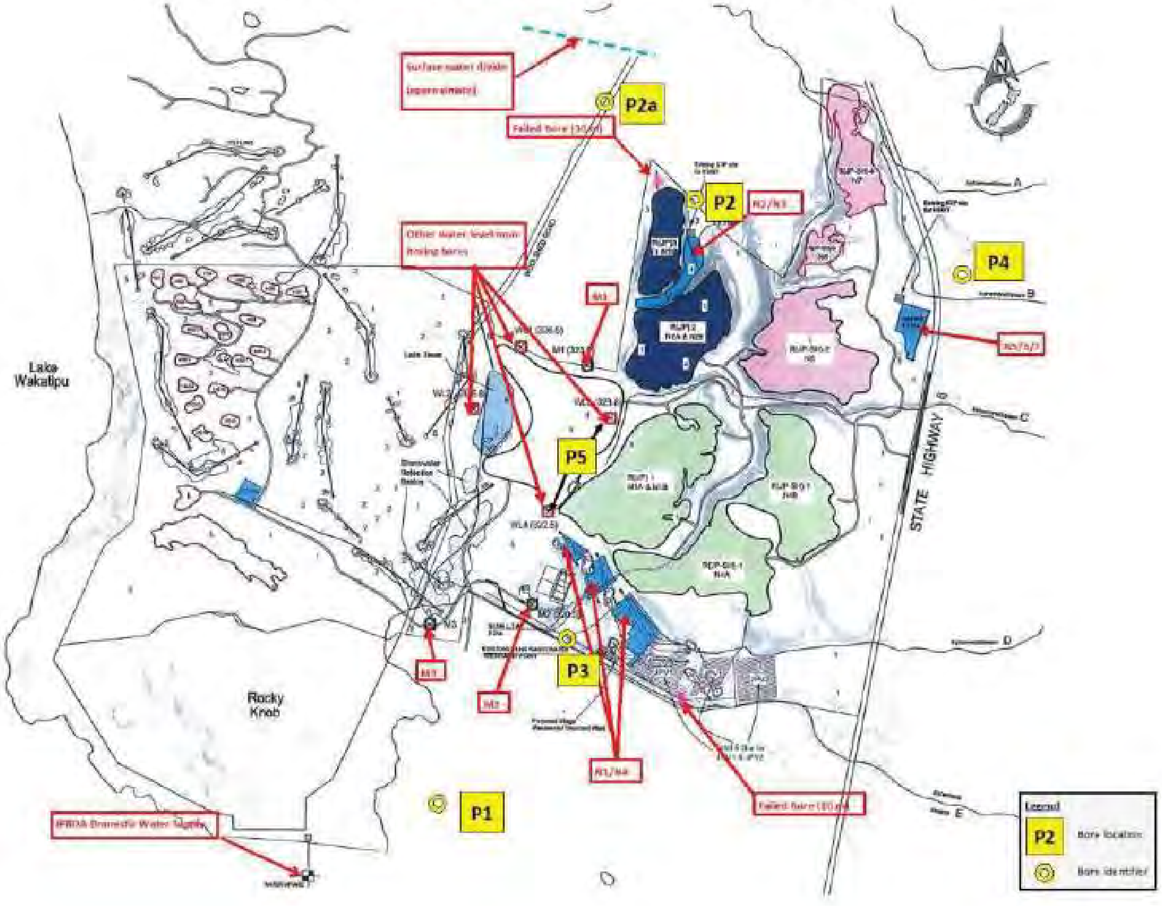
Zone	A	B
Resident 1	R(JP) 1	N1
Resident 2&3	R(JP) 2 & 3	N2/N3
Resident State Highway 1 North	R(JP-SH)1 North	N4B
Resident State Highway 1 South	R(JP-SH)1 South	N4A
Resident State Highway 2	R(JP-SH)2	N5
Resident State Highway 3&4	R(JP-SH)3+4	N6/N7

Notes :

A. Names of residential zones used in original application.

B. Names of residential zones now commonly used

Appendix 2: Piezometer locations authorised by Discharge Permit 2009.312



Otago Regional Council

Appendix 3: Water Quality and Ecology Assessment Locations In Maori Jack Stream and Lake Wakātipu For Discharge Permit 2009.312

Attachment 2: Māori Jack Stream water quality results reproduced from e3S (2022) report Table 4

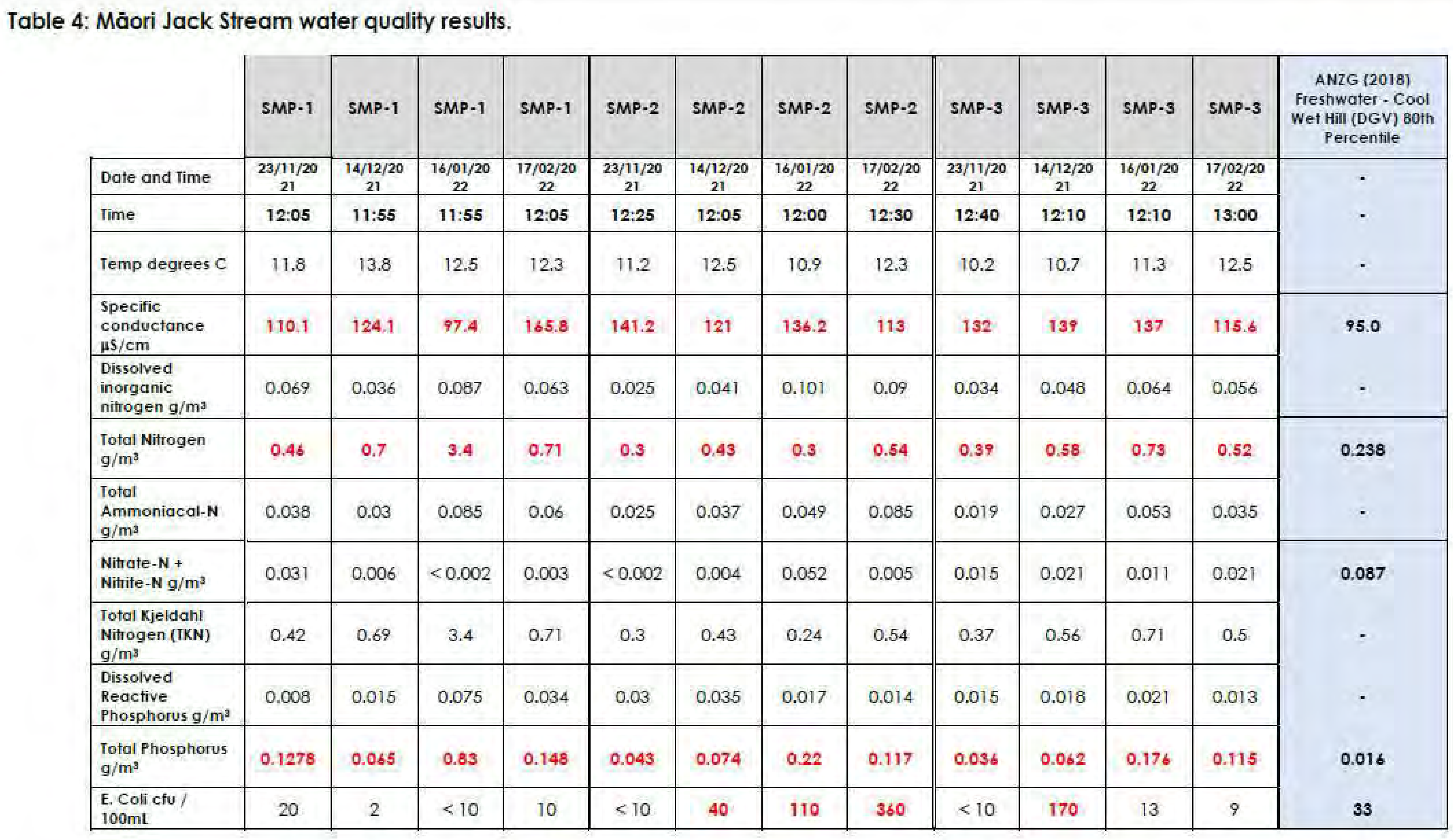


Table 4: Māori Jack Stream water quality results.

	SMP-1	SMP-1	SMP-1	SMP-1	SMP-2	SMP-2	SMP-2	SMP-2	SMP-3	SMP-3	SMP-3	SMP-3	ANZG (2018) Freshwater - Cool Wet Hill (DGV) 80th Percentile
Date and Time	23/11/2021	14/12/2021	16/01/2022	17/02/2022	23/11/2021	14/12/2021	16/01/2022	17/02/2022	23/11/2021	14/12/2021	16/01/2022	17/02/2022	-
Time	12:05	11:55	11:55	12:05	12:25	12:05	12:00	12:30	12:40	12:10	12:10	13:00	-
Temp degrees C	11.8	13.8	12.5	12.3	11.2	12.5	10.9	12.3	10.2	10.7	11.3	12.5	-
Specific conductance µS/cm	**110.1**	**124.1**	**97.4**	**165.8**	**141.2**	**121**	**136.2**	**113**	**132**	**139**	**137**	**115.6**	**95.0**
Dissolved inorganic nitrogen g/m^3	0.069	0.036	0.087	0.063	0.025	0.041	0.101	0.09	0.034	0.048	0.064	0.056	-
Total Nitrogen g/m^3	**0.46**	**0.7**	**3.4**	**0.71**	**0.3**	**0.43**	**0.3**	**0.54**	**0.39**	**0.58**	**0.73**	**0.52**	**0.238**
Total Ammoniacal-N g/m^3	0.038	0.03	0.085	0.06	0.025	0.037	0.049	0.085	0.019	0.027	0.053	0.035	-
Nitrate-N + Nitrite-N g/m^3	0.031	0.006	< 0.002	0.003	< 0.002	0.004	0.052	0.005	0.015	0.021	0.011	0.021	**0.087**
Total Kjeldahl Nitrogen (TKN) g/m^3	0.42	0.69	3.4	0.71	0.3	0.43	0.24	0.54	0.37	0.56	0.71	0.5	-
Dissolved Reactive Phosphorus g/m^3	0.008	0.015	0.075	0.034	0.03	0.035	0.017	0.014	0.015	0.018	0.021	0.013	-
Total Phosphorus g/m^3	**0.1278**	**0.065**	**0.83**	**0.148**	**0.043**	**0.074**	**0.22**	**0.117**	**0.036**	**0.062**	**0.176**	**0.115**	**0.016**
E. Coli cfu / 100mL	20	2	< 10	10	< 10	**40**	**110**	**360**	< 10	**170**	13	9	**33**

Attachment 3: Lake Wakatipu edge water quality results (this page) and sample locations (over page) – both reproduced directly from the e3S (2022) report.

Table 5: Lake Wakatipu water quality results.

	SMP-4	SMP-4	SMP-4	SMP-4	SMP-5	SMP-5	SMP-5	SMP-5	SMP-6	SMP-6	SMP-6	SMP-6	ANZG (2018) Freshwater - Cool Wet Lake (DGV) 80th Percentile
Date	**23/11/ 2021**	**14/12/ 2021**	**16/01/ 2022**	**17/02/ 2022**	**23/11/ 2021**	**14/12/ 2021**	**16/01/ 2022**	**17/02/ 2022**	**23/11/ 2021**	**14/12/ 2021**	**16/01/ 2022**	**17/02/ 2022**	-
Time	**13:00**	**12:20**	**12:25**	**13:50**	**13:15**	**12:40**	**12:35**	**13:25**	**13:30**	**12:50**	**12:45**	**13:40**	-
Temp degrees C	14	14.8	16	17.3	14.5	15.5	16.2	17	14.8	16	15.9	16.5	-
Specific conductance µS/cm	54	55	56	58.8	56	56	54.6	57	56.2	56	53	57.2	102.0
Turbidity NTU	3.1	2.2	1.99	0.38	1.81	0.87	0.67	0.41	0.56	0.46	0.35	0.33	1 - 20
Total Nitrogen g/m^3	0.21	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	0.17	< 0.11	< 0.11	< 0.11	0.104
Nitrate-N + Nitrite-N g/m^3	**0.034**	**0.03**	**0.021**	**0.014**	**0.035**	**0.035**	**0.024**	**0.013**	**0.032**	**0.033**	**0.027**	**0.012**	0.011
Total Kjeldahl Nitrogen (TKN) g/m^3	0.18	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.14	< 0.10	< 0.10	< 0.10	-
Total Phosphorus g/m^3	< 0.002	< 0.002	< 0.002	0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.013
E. Coli cfu / 100mL	3	2	< 1	1	6	1	< 1	1	3	3	< 1	<1	33
Chlorophyl a g/m^3	0.0007	0.0006	0.0006	0.0011	0.0007	0.0006	0.0007	0.0009	0.0004	0.0005	0.0007	<0.0002	0.007
Lake TLI Scores	2.47	2.13	2.10	2.21	2.24	1.82	1.86	1.93	1.88	1.77	1.86	1.33	

Figure 5: Māori Jack Stream sample locations. Note: GPS point locations were taken onshore. Actual sample locations are 5m offshore (perpendicular to the shoreline).

Attachment 4: Analysis of wind data from the mid lake monitoring buoy.

I am grateful to Jason Augspurger and Hugo Borges from ORC and Tadhg Moore from Limnotrack for extracting and supplying the available wind speed data from the mid-lake monitoring buoy out from Homestead Bay ("Open Water 10m" site). I am also grateful to my colleague Caroline Fraser for her manipulation of the dataset and analysis to produce the following outputs for me. Wind speed and direction was recorded every 5 minutes continuously at the buoy for the period 27 April 2023 to 1 January 2025.

Method

Define a minimum time period for low wind "t_{min}" and a wind speed threshold for determining whether low wind (W_T)

For combinations of t_{min}: {6,24} and W_T: {5,10} undertake an event analysis:

1. Take rolling t_{min} mean of windspeed: mean($Wind_{tmin}$)
2. Identify periods where mean($Wind_{tmin}$)<W_T
3. Identify the start of independent events when then the gap between timestamps with mean($Wind_{tmin}$)<W_T is greater 6 hours (this is a bit arbitrary – and it DOES impact on the results)
4. For each event, extract the start date/time, end date/time and the duration of the event.
5. Calculate the time between successive events (start time minus end time)
6. Calculate statistics to describe:
    a. Median time between events (and 5th and 95th percentiles) (days)
    b. Total number of events
    c. Total number of events with duration greater than 1day
    d. Total number of events with duration greater than 2day
    e. Maximum duration
    f. Frequency of events (per year)

Results

- Rolling mean daily (24 hr) windspeed is rarely below 5 knots and rolling maximum daily (24 hr) windspeed is rarely below 10 knots (see top plat in Figure A4-1 below). In other words the lake is very rarely calm and usually hits a daily (24 hr) mean of at least 5 knots and a maximum of at least 10 knots.

- The maximum duration over which mean daily (24 hr) windspeed was less than 5 knots was 2.1 days (Table A4-1).

- From my observations at the lake on 29 January 2025 there are small regular waves lapping the shore at 5 knots and medium waves gently breaking at 10 knots. Rapid mixing appears to be occurring in the shallows (5-15 m from shore) at 5 knots and greater.

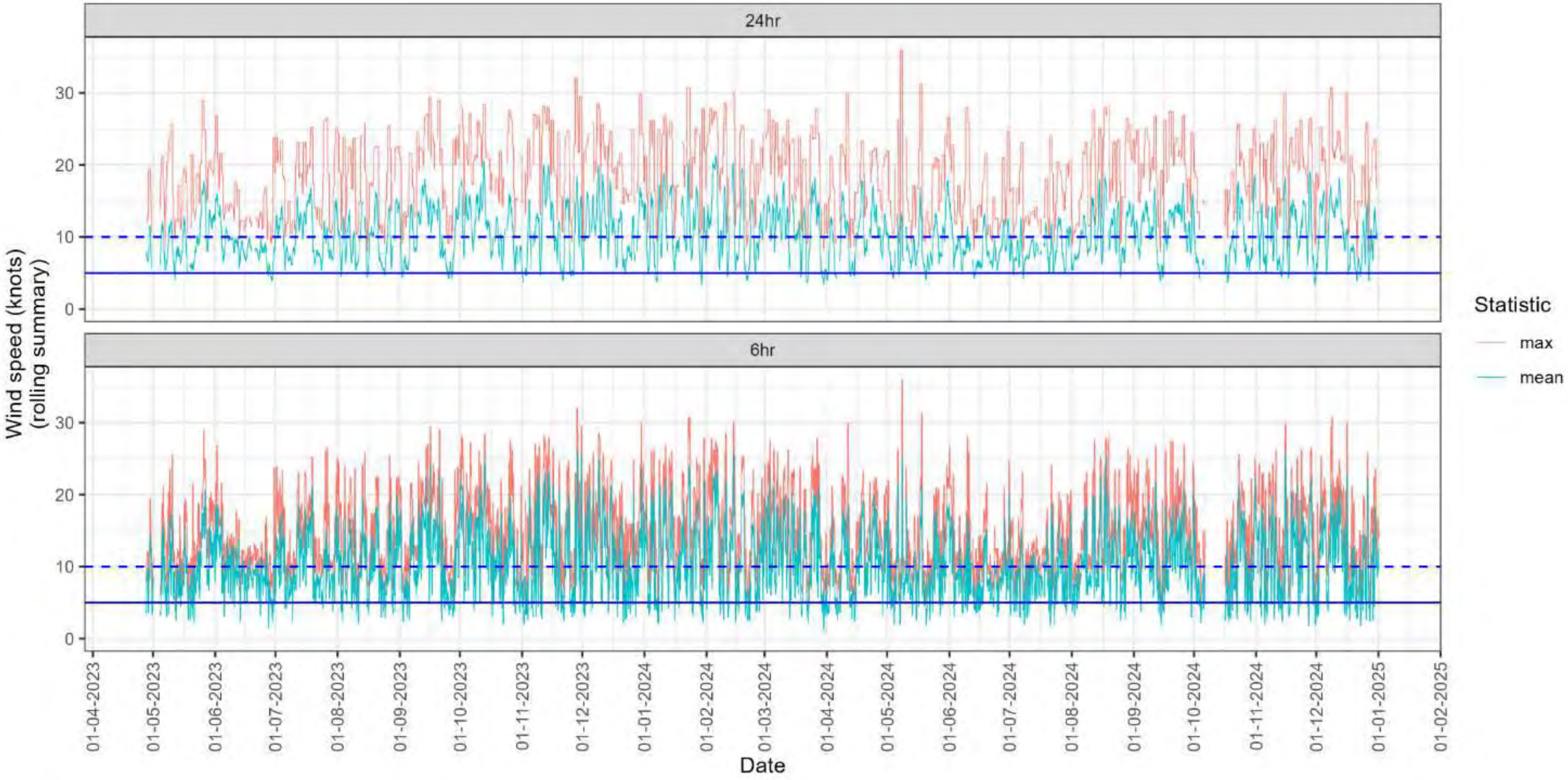


Figure A4-1: Timeseries plot of rolling mean and maximum windspeeds. Rolling means are calculated over 24 hour (top) and 6 hour (bottom) periods

Table A4-1: Frequency and duration of periods where rolling mean wind speed was less than 5 knots or 10 knots

Time period (t_{min})	Wind threshold (knots)	Median time between events (5^{th} – 95^{th} quantiles) (days)	Total number of events	Number of events with duration >1 day	Number of events with duration >2 day	Maximum duration (days)	Annual frequency (events per year)
6	5	2.1 (0.9-8.4)	242	21	0	1.8	143.6
24	5	10 (2.2-33.8)	51	51	5	2.1	30.3
6	10	2.5 (0.9-9.7)	302	128	60	6.8	179.2
24	10	6.1 (2.6-15.9)	144	143	86	13.1	85.5

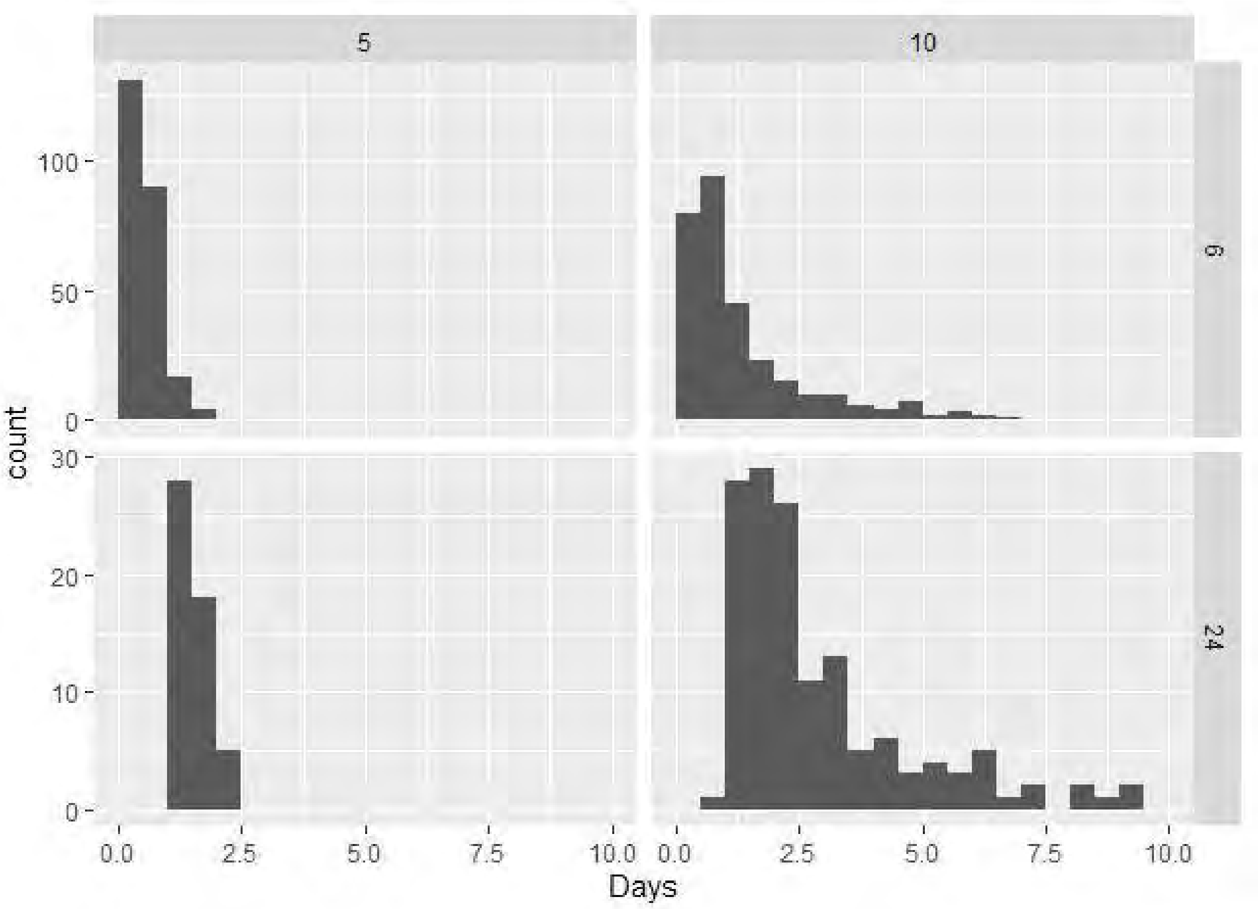
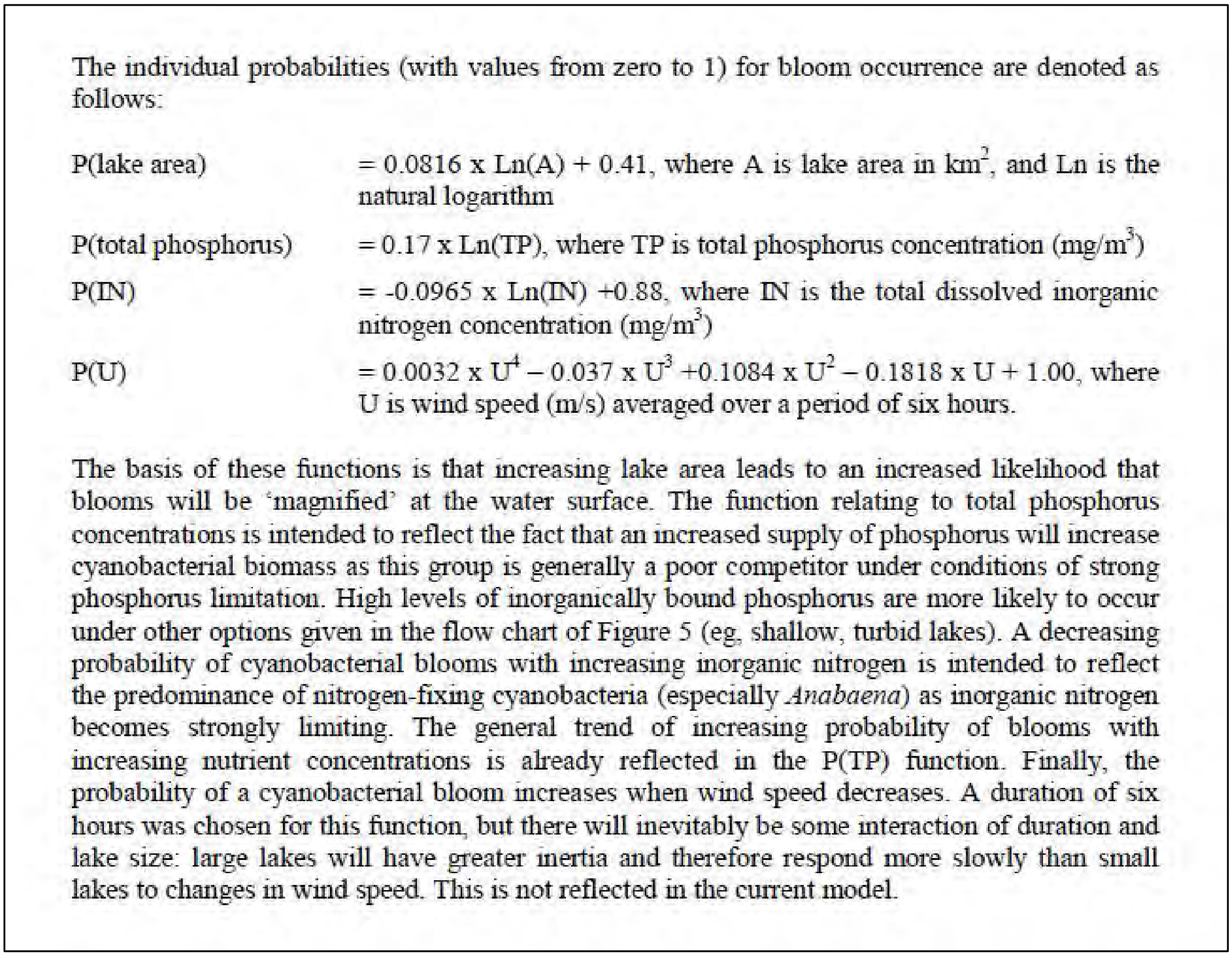


Figure A4-2: Histogram of the distribution of event durations (in days). Labels on top row indicate the wind threshold, and labels on right site indicate the rolling window size (in days)

Attachment 5: Excerpts from New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters (MfE & MoH 2009).

Excerpt from Guidelines page 31



The individual probabilities (with values from zero to 1) for bloom occurrence are denoted as follows:

P(lake area) = 0.0816 x Ln(A) + 0.41, where A is lake area in km^2, and Ln is the natural logarithm

P(total phosphorus) = 0.17 x Ln(TP), where TP is total phosphorus concentration (mg/m^3)

P(IN) = -0.0965 x Ln(IN) +0.88, where IN is the total dissolved inorganic nitrogen concentration (mg/m^3)

P(U) = $0.0032 \times U^4 - 0.037 \times U^3 + 0.1084 \times U^2 - 0.1818 \times U + 1.00$, where U is wind speed (m/s) averaged over a period of six hours.

The basis of these functions is that increasing lake area leads to an increased likelihood that blooms will be 'magnified' at the water surface. The function relating to total phosphorus concentrations is intended to reflect the fact that an increased supply of phosphorus will increase cyanobacterial biomass as this group is generally a poor competitor under conditions of strong phosphorus limitation. High levels of inorganically bound phosphorus are more likely to occur under other options given in the flow chart of Figure 5 (eg, shallow, turbid lakes). A decreasing probability of cyanobacterial blooms with increasing inorganic nitrogen is intended to reflect the predominance of nitrogen-fixing cyanobacteria (especially *Anabaena*) as inorganic nitrogen becomes strongly limiting. The general trend of increasing probability of blooms with increasing nutrient concentrations is already reflected in the P(TP) function. Finally, the probability of a cyanobacterial bloom increases when wind speed decreases. A duration of six hours was chosen for this function, but there will inevitably be some interaction of duration and lake size: large lakes will have greater inertia and therefore respond more slowly than small lakes to changes in wind speed. This is not reflected in the current model.

Excerpt from Guidelines page 32: Orange highlights show pathway through the decision tree as detailed on the next page.

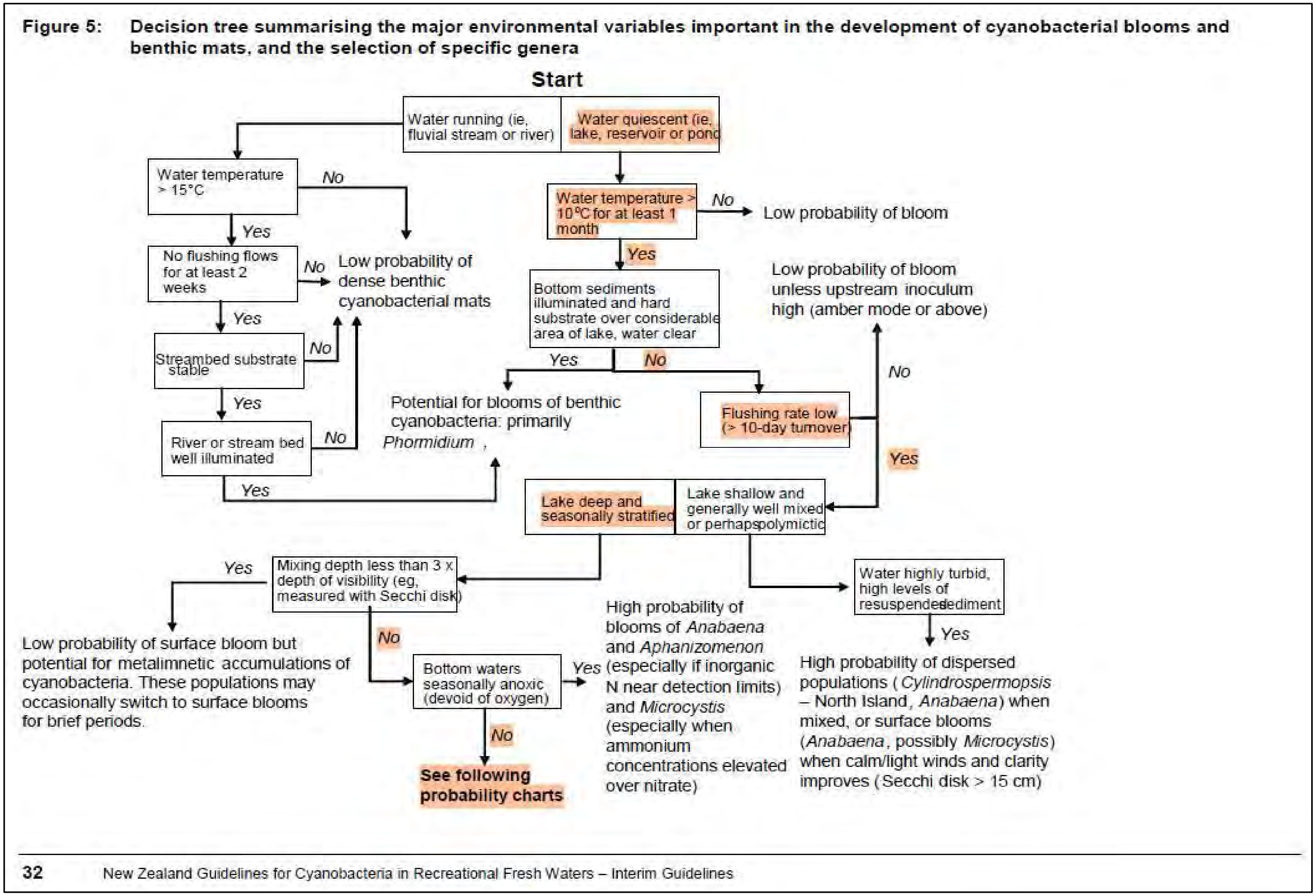


Figure 5: **Decision tree summarising the major environmental variables important in the development of cyanobacterial blooms and benthic mats, and the selection of specific genera**

32 New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines

The orange highlights show the pathway through the decision tree for Homestead Bay, as evidenced by:

i) Is water quiescent (i.e., lake, reservoir or pond) ? – Yes

ii) Is water temperature >10^{o}C for at least 1 month? – Yes (e.g., Borges 2024)

iii) Are bottom sediments illuminated and hard substrate over considerable area of lake, water clear? – Yes for marginal areas only but the risk of benthic blooms near shore in Homestead Bay is considered low due to the frequent wind-driven wave action as evidenced by observation of very clean gravels in that area. The answer is “No” for majority of Homestead Bay area – which in the decision tree leads to assessment of risk for planktonic cyanobacterial blooms in the water column or on the lake surface.

iv) Is the flushing rate low (> 10-day turnover)? – Yes (e.g., mean residence time is 12.6 years; Bayer et al., 2013)

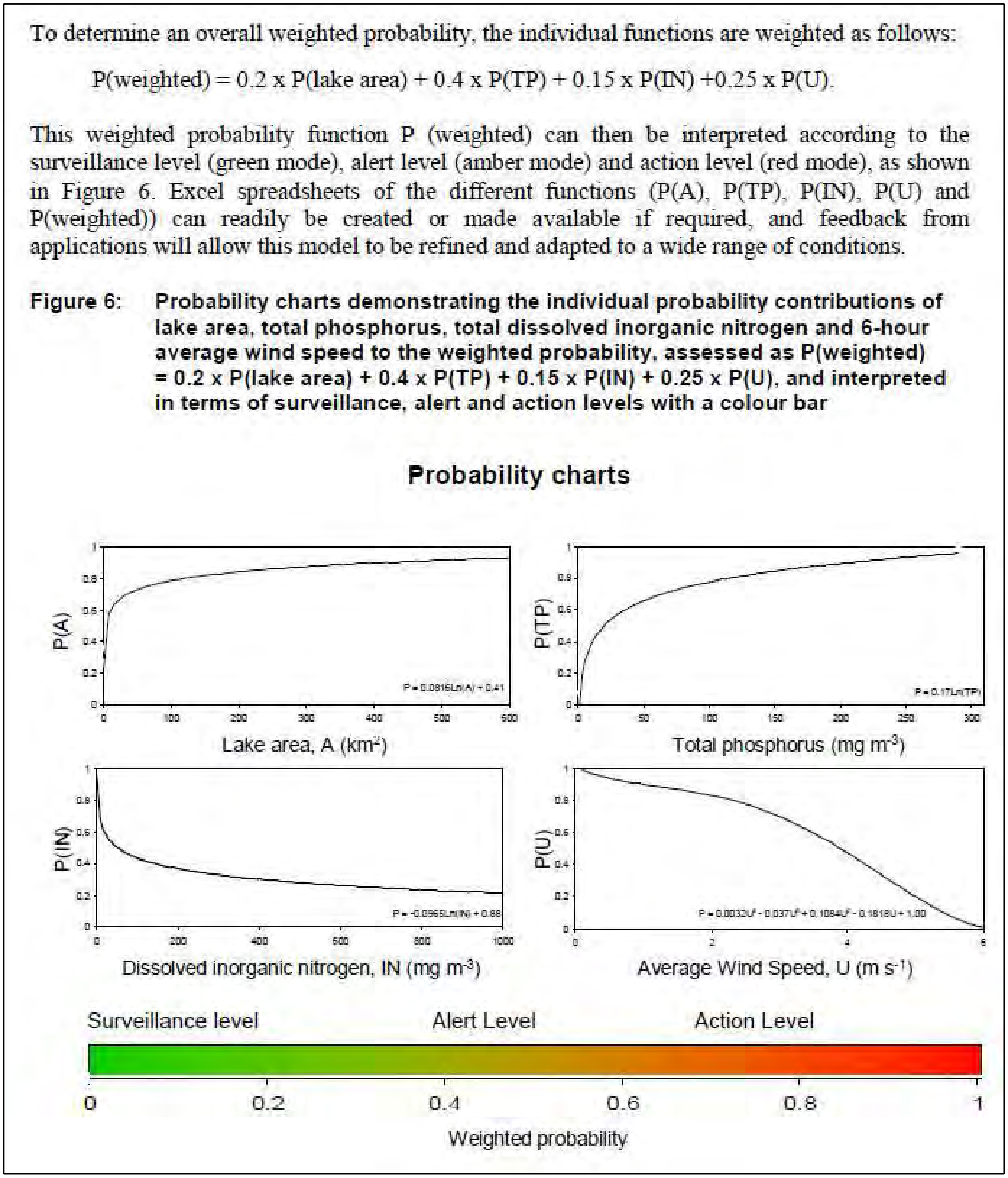
v) Is the lake deep and seasonally stratified? – Yes (e.g., data from monitoring buoy in Borges 2024)

vi) Is the mixing depth less than 3x depth of visibility (e.g., measured with Secchi disc)? – No – see Figure 4 in Borges 4 December 2024 thermocline about 40m deep temporarily (usually greater than 50m) and Secchi depth is usually 10+ m

vii) Are the bottom waters seasonally anoxic (devoid of oxygen)? Likely to be “No” but monitoring buoy currently doesn’t measure to the bottom (e.g., Appendix A of Borges (4 December 2024)) - but “No” for the purposes of the decision tree.

viii) Therefore the decision tree leads to **“See the following probability charts”.**

Excerpt from Guidelines page 33



To determine an overall weighted probability, the individual functions are weighted as follows:

P(weighted) = 0.2 x P(lake area) + 0.4 x P(TP) + 0.15 x P(IN) +0.25 x P(U).

This weighted probability function P (weighted) can then be interpreted according to the surveillance level (green mode), alert level (amber mode) and action level (red mode), as shown in Figure 6. Excel spreadsheets of the different functions (P(A), P(TP), P(IN), P(U) and P(weighted)) can readily be created or made available if required, and feedback from applications will allow this model to be refined and adapted to a wide range of conditions.

Figure 6: **Probability charts demonstrating the individual probability contributions of lake area, total phosphorus, total dissolved inorganic nitrogen and 6-hour average wind speed to the weighted probability, assessed as P(weighted) = 0.2 x P(lake area) + 0.4 x P(TP) + 0.15 x P(IN) + 0.25 x P(U), and interpreted in terms of surveillance, alert and action levels with a colour bar**

APPENDIX D

Aquatic Ecology Assessment Report

Water Ways Consulting

Homestead Bay Aquatic Ecology Assessment

Richard Allibone

Water Ways Consulting

Cover photo: Pond, Homestead Bay

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1. INTRODUCTION

RCL Henley Downs is undertaking investigation for a subdivision development, Homestead Bay development, along the shores of Lake Wakatipu to the south of Jacks Point between State Highway 6 and the shore of the lake. The area is currently pastoral land bisected by some steep side gullies.

This report provides the assessment of water bodies and water courses and their ecological values for the Homestead Bay development.

2. METHODS

The Homestead Bay area was visited on the 15 March 2023. The two water courses and a pond on the property were all visited (Figure 1). The habitat at each site and the permanence of water in the water courses was assessed. For wetted sites the potential for fish residence and fish passage was checked and the likely macroinvertebrate communities determined.

Figure 1: The Homestead Bay aquatic assessment areas.

3. RESULTS

3.1. Pond

The unfenced pond (site HOME1, Figure 1) is situated on a hilltop (altitude 380 m) and has no inflowing tributaries. There is a small hut and oak trees[1] beside the pond (Figure 2), and duck decoys in the pond indicating the pond is used for recreation duck shooting. The pond margin is grazed pasture grass or bare ground.

Figure 2: The pond with small hut and oak trees.

An outflow was present with water flowing out of the pond at a low point along its banks. The outflow does not have permanent flow as the outflow water course was across pasture grass and bare ground (Figure 3). There was also a substantial accumulation of sheep pellets on the bare ground indicating that sheep had been resting in this area when it was dry. The outflow was likely to have commenced flowing after rainfall in the previous two days. A pipe was observed in the pond that was discharging water into the pond and this artificial input was the only water supply for the pond.

With no tributaries and no outflow connection to other water bodies the pond cannot be colonised by fish. Diving beetles, backswimmers and water boatmen were the only macroinvertebrates seen in the pond. For the most part the pond bottom is mud with the occasional stick and rock on the bottom (Figure 4).

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[1] Oak trees are planted to provide acorns for ducks to eat.

Figure 3: The pond outflow on bare ground that is a sheep resting area.

Figure 4: Pond edge and muddy bottom.

3.2. Water Course 1

Water Course 1 is a water course approximately 1 km long that rises downslope from State Highway 6 and extends downstream to Lake Wakatipu. The stream was walked from the lake edge upstream for approximately 550 m. At the lake edge there was no evidence of a stream or stream course flowing across the lake shore and above the gravel lake shore the stream channel is well vegetated with terrestrial shrubbery (Figure 5).

Figure 5: The lakeshore where Water Course 1 discharges into Lake Wakatipu.

Fifty metres upstream from the lake shore the stream emerges from a steep sided valley and pine plantation. At Site Home 2 windfall pines, valley floor vegetation and leaf litter have created a dam and upstream of this a small wet area with well-established weedy terrestrial species (Figure 6).

Figure 6: windfall pine and leaf litter creating a dam and ponded water.

This wetted area of the valley floor extends for less than 75 m between sites HOME2 and HOME3 and the water is very shallow. At Site HOME3 and upstream to site HOME4 and further the water course is dry and vegetated with terrestrial plants, often grazed grasses (Figure 7).

Figure 7: Water Course 1 at (left) top of pine plantation and (right) near site HOME4 with a terrestrial vegetation valley floor.

The rest of pine plantation the valley floor is covered with pine needle and further upstream the valley floor it is vegetated with grass. Neither area has an obvious stream course where vegetation has not established, or leaf litter has been washed away.

3.3. Water Course 2

Water Course 2 rises on the flank of the Remarkables Range, flows under State Highway 6 and down slope to Lake Wakatipu. The outflow to Lake Wakatipu across the lake front has a dry stream channel upstream of the lake shore where wave action creates the lake shore gravel/cobble beach zone (Figure 8). The stream flows out of a canyon like valley with a wide valley floor and steep, often vertical sides (Figure 9).

Upstream of the shoreline the stream has a well-established, 1 m wide incised channel with a dry gravel/cobble/boulder bed. This channel extends upstream for nearly 400 m before terrestrial grasses began to establish in the channel. Within this reach there are small boulder waterfall structures with downstream scour pools. While the channel is deep none of the scour pool retained water (Figure 10). The scour pools do indicate that when the stream flows it has the power to move cobble and gravel material downstream. Between 400 m and 500 m upstream from the lake there are a number of tributary inflows, and the channel become progressively smaller and terrestrial grasses and shrubs begin to grow in the channel. The tributaries include scour channel flowing over the canyon walls (Figure 11). Beyond site HOME8 the channel has intermittently exposed rock but is predominately overgrown with terrestrial vegetation.

Figure 8: The Lake shore and dry channel of Stream Course 2.

Figure 9: Looking upstream in Stream Course 2.

Figure 10: Scour pool in Stream Course 2.

Figure 11: Erosion channel in canyon walls.

4. ECOLOGICAL VALUE OF WATER BODIES

4.1. Pond

The pond appears to be an artificial water body, that is maintained by a water discharge rather than any natural inflows. The lack of any wetted connection to any other water body prevents fish colonisation and has only allowed a few winged insect species to occupy the pond. The presence of a small hut, duck decoys and oak trees indicate that the pond is used for recreational duck shooting, but the pond has very limited aquatic ecological values.

4.2. Stream Course 1

This is an ephemeral water course with little wetted habitat in the stream course. The short wetted section is insufficient to support fish and there is no fish passage between this wet section and Lake Wakatipu to allow fish to migrate upstream. It is likely that the stream only flows during and after heavy rainfall and the majority of the water course dries very quickly. The presence of terrestrial grasses in the mid and upper reaches of the water course shows that when wet there is not enough water-power to scour a channel nor is the duration of any wet period sufficient to eliminate the terrestrial plants. The small section of wetted channel appears to have been created by a channel blockage where windfall pines have fallen in the stream channel. This habitat is unlikely to be permanent as the blockage will fail as the trees decay and flow events flush the accumulated leaf litter downstream.

This ephemeral channel does not support any fish, nor any stream macroinvertebrates. Wet tolerant invertebrates may utilise the wet section, but the longevity of this habitat is limited.

4.3. Stream Course 2

This is an ephemeral stream with no evidence of any permanent water. The stream does have high flow events that have scoured an obvious and often deep channel along the canyon valley floor. The lower 400 m of this channel is sufficiently regularly scoured to prevent terrestrial vegetation establishing in the channel. Upstream as the flow diminishes the terrestrial vegetation has become established in the water course.

This ephemeral channel does not support any fish, nor any stream macroinvertebrates.

5. AQUATIC ECOLOGICAL EFFECTS OF THE DEVELOPMENT

5.1. Stormwater Discharges

The two stream courses are possible stormwater receiving environments. The design of the stormwater infrastructure is yet to be completed so discharge locations and volumes are yet to be determined. Once the design is complete a full assessment of the potential effects of stormwater discharges can be conducted. However, at this stage given the two water courses are ephemeral streams with no aquatic life the any stormwater inflows will not alter this and can only change the duration and size of the infrequent flow events along the water courses.

APPENDIX E

Soil Investigation Memo

LOWE Environmental Impact

MEMORANDUM Job 10934

To: Dan Wells, RCL

From: Millie Taylor and Shamim Al Mamun, Lowe Environmental Impact

Date: 23 September 2024

Subject: Homestead Bay Development Soils Site Investigation

Dear Dan,

The following information outlines the results of the site investigation into the potential of wastewater dispersal at the Homestead Bay and QEII sites, based on LEI staff's visit on June 4th to 7th, 2024.

OVERVIEW

RCL Homestead Bay Limited (RCL) is investigating the Homestead Bay and QEII properties south of Jacks Point on Kingston Road SH6 to discharge community-treated wastewater to multiple land treatment areas (LTA). The sites have been earmarked due to their proximity to the proposed subdivision and available suitable land.

The sites are currently owned separately by RCL and QE11. The RCL site is located on Lot 8 DP 443832 (163.46 ha), while the QEII farming block is located on titles Part Lot 1 DP 26261 (656.94 ha) and Lot 2 DP 26261 (205.98 ha). Part of the RCL lot has been used previously for clean fill, but the rest of the site is low-sloping to rolling pasture with some cattle grazing. The QEII site is generally steeper at the foot of the Remarkables and is pasture with a small area of cropping and deer/cattle grazing. The QEII land is dominated by gravels due to the relative proximity to the mountains, whereas the RCL land has a deeper loess profile. Both sites are consistent with the S-map descriptions and what is expected from the current classification.

DESKTOP SOIL CHARACTERISTICS

Landcare Research Soils Map

An assessment of the area's Landcare Research soil map (S-Map) suggests the soil is classified as Typic Immature Pallic Loam with well-drained rapid permeability, as attached in Appendix B. The S-Map also suggests a very low water logging vulnerability and medium nitrogen leaching vulnerability.

The soil type specific to the site was confirmed in the LEI site investigation (this report).

Jacks Point Soils Investigation

The Homestead Bay residential zoned area occupies sloping topography from the east down to the flats of the central plain area south of the Jacks Point development. In the assessment of the soils from Jacks Point, the land consists of four main soil types.

Table 1: Soil Information

Soil Family	Characteristics (S-Map)	Irrigation Suitability
Wakatipu	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic Soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be dry in summer and wet in winter. It is formed in a blanket deposit of silt sized windblown materials overlying poorly stratified poorly sorted gravel sand and mud deposited from glacial ice or meltwater, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth is 20 - 45 (cm), due to densely packed gravels that mechanically impedes root growth. Generally, the soil is well drained with moderate vulnerability of water logging in non-irrigated conditions and has moderate to low soil water holding capacity. Inherently these soils have a high structural vulnerability and a moderate N leaching potential, which should be accounted for when making land management decisions.	Subsoil infiltration limitation; Year-round irrigation possible
Pigburn	This soil belongs to the Recent soil order of the New Zealand soil classification. Recent Soils are weakly developed, showing limited signs of soil-forming processes although a distinct topsoil is present, a B horizon is either absent or only weakly expressed. It is formed in alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is slightly stony. The subsoil has dominantly loam textures, with very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally, the soil is well drained with very low vulnerability of water logging in non-irrigated conditions and has moderate to high soil water holding capacity. Inherently these soils have a high structural vulnerability and a moderate N leaching potential, which should be accounted for when making land management decisions.	Limited to nil Subsoil infiltration limitation; Year-round irrigation possible
Barrhill	This soil belongs to the Pallic soil order of the New Zealand soil classification. Pallic Soils have pale coloured subsoils, due to low contents of iron oxides, have weak soil structure and high density in subsurface horizons. Pallic Soils tend to be dry in summer and wet in winter. It is formed in a blanket deposit of silt sized windblown materials overlying	Some subsoil infiltration limitation; Year-round irrigation possible

Soil Family	Characteristics (S-Map)	Irrigation Suitability
	alluvial sand silt or gravel deposited by running water, from schist parent material. The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with gravel content of less than 3%. The plant rooting depth extends beyond 1m. Generally, the soil is moderately well drained with very low vulnerability of water logging in non-irrigated conditions and has high soil water holding capacity. Inherently these soils have a high structural vulnerability and a low N leaching potential, which should be accounted for when making land management decisions.	
Tucker	This soil belongs to the Recent soil order of the New Zealand soil classification. Recent Soils are weakly developed, showing limited signs of soil-forming processes although a distinct topsoil is present, a B horizon is either absent or only weakly expressed. It is formed in weathered soil and rock material mantling slopes, from schist parent material. The topsoil typically has sand texture and is moderately stony. The subsoil has dominantly sand textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally, the soil is well drained with very low vulnerability of water logging in non-irrigated conditions and has moderate to low soil water holding capacity. Inherently these soils have a very high structural vulnerability and a high N leaching potential, which should be accounted for when making land management decisions	Potential for year-round irrigation at low application rates

At Jacks Point, the dominant soils have been classified as AS/NZS1547 Category 3.

These soils generally aligned with those seen at Homestead Bay across both the RCL and QEII sites, and contain the following soil types:

- Wakatipu soils – cover the greatest area and are typically flat to gently sloping soils, which are formed in glacial deposits;
- Barrhill soils – are soils located in the central valley and also east of Jacks Point on the QEII property; and
- Pigburn soils – occupy a large area of the QEII property and are typically characterised as being a recent soil which is weakly developed.

The Tucker soils were not found at the Homestead Bay area.

Homestead Bay Soil Investigations

A comprehensive soil investigation was undertaken by LEI at these two sites on behalf of RCL between 4 to 7 June 2024. It comprised of the machine excavation of 17 test pits, nine of which also included hydraulic testing, as shown in Figure 1. These test pits were excavated down to a depth of approximately 2 m, with hydraulic testing completed at a depth of 0.2 m.

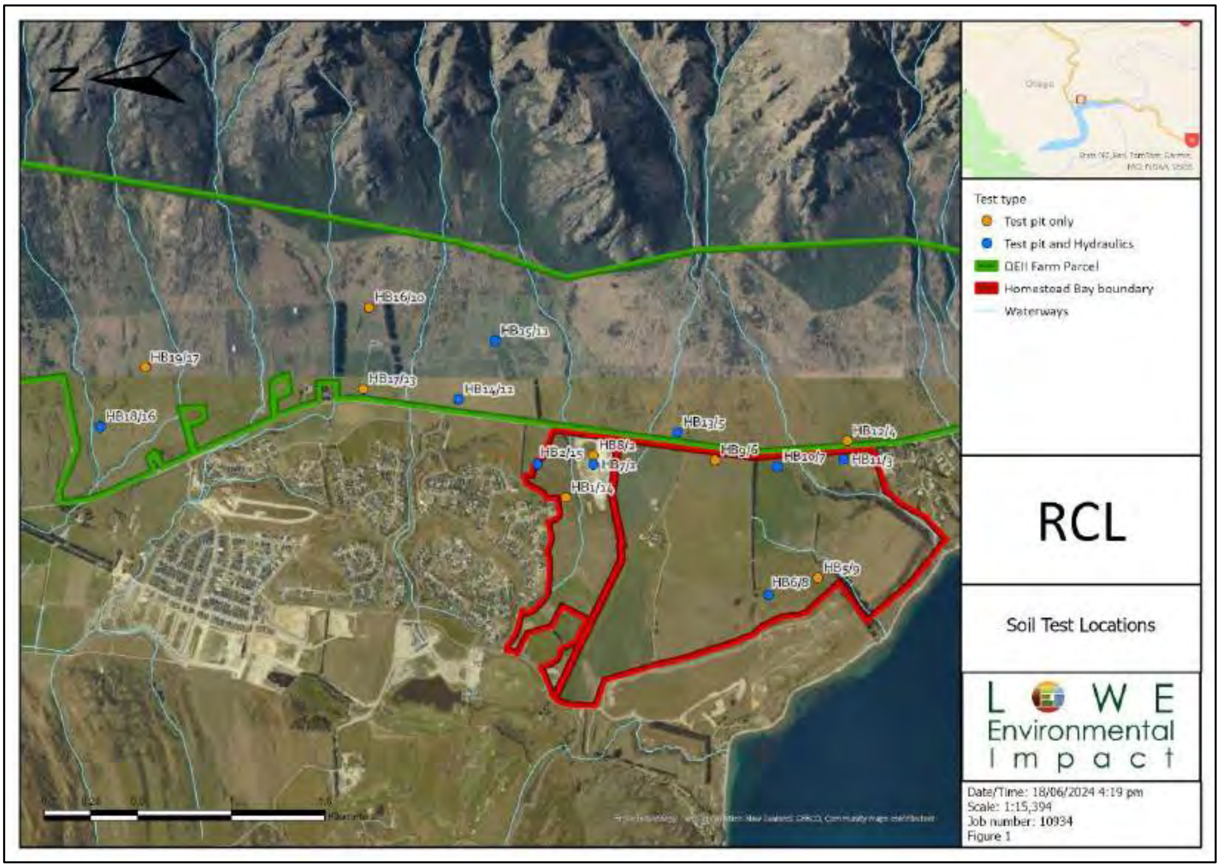

Figure 1: Location of Soil Test Sites

The RCL and QEII sites both contain a mixture of all three soil types, Barrhill, Pigburn, and Wakatipu, as noted in Error! Reference source not found.. The area of sites HB7/1 and HB8/2 is the clean fill site of the nearby Jacks Point subdivision, so it is classed differently due to this human interfered soil profile. The area of HB17/13 is also classed differently due to the note from the farmer of the presence of groundwater springs during wet periods, as well as the appearance of mottling in the profile, despite the Barrhill classification.

The soil profile at each site was photographed and logged with these individual profiles included as an attachment to this report. The summary of average soil profiles for each soil type is supplied in Table 2. The soil profiles typically comprised of 0.35 m of weathered topsoil (organic silt) with roots throughout, underlain by a silt subsoil down to alluvial or colluvial gravels at depth.

These soil logs show a consistent silt loam down to 0.9 m, with ranging stratification of gravels below this. Soil Categories 2 and 3 within AS/NZS 1547:2012 are representative of sands and loams.

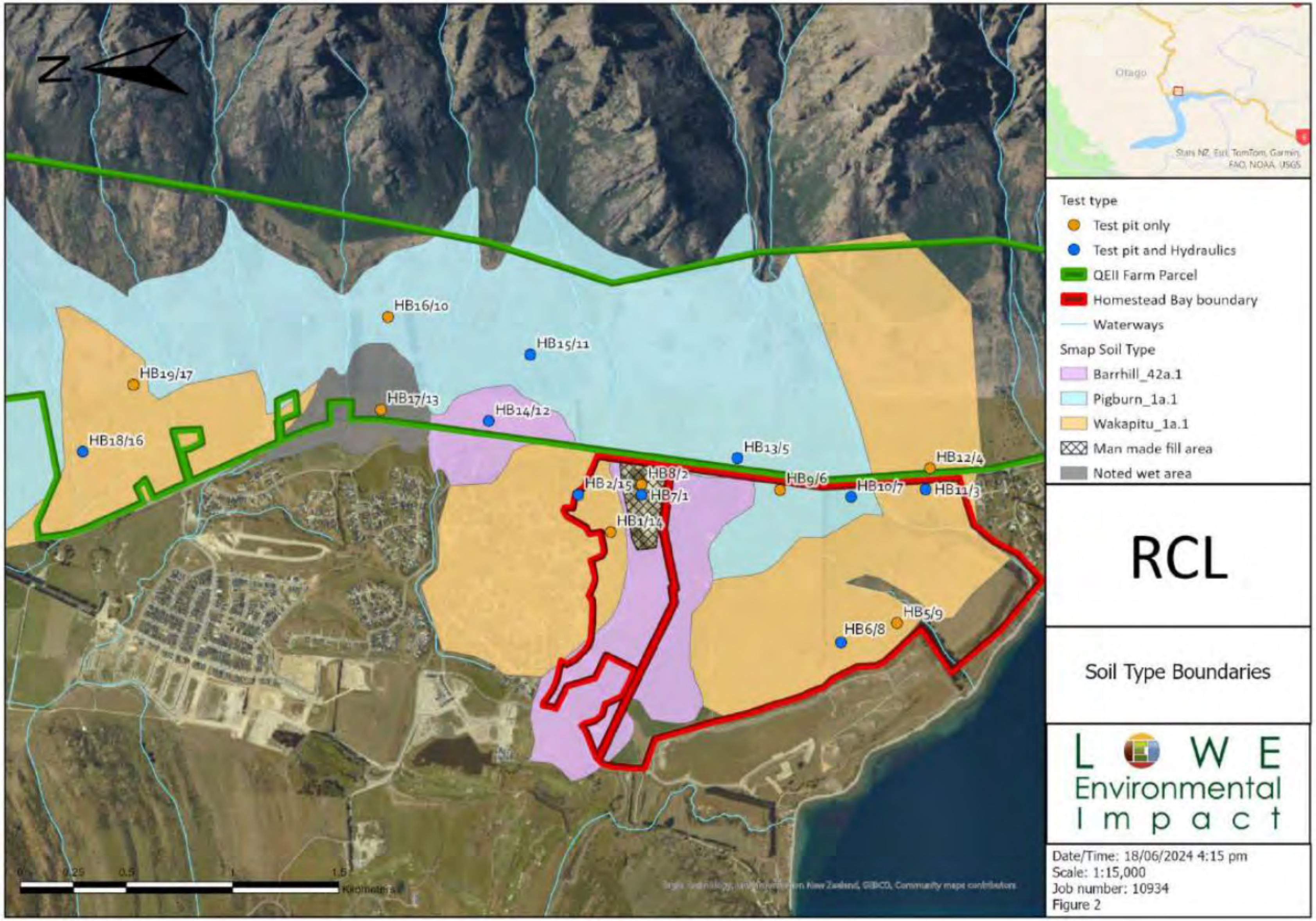

Figure 2: Soil Type Boundaries

Table 2: Averaged LEI Test Pit Logs by Soil Family

Below ground level (m)	Pigburn	Below ground level (m)	Wakatipu	Below ground level (m)	Barrhill
S-Map class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0 - 0.3	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is weak and friable. Common fine roots. Boundary is abrupt and smooth.	0-0.35	Moist, 10YR 3/2 (very dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Common fine roots. Boundary is distinct and occluded.	0-0.40	Moist, 10YR 4/2 (dark greyish brown) coloured soil. No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy. Soil strength is slightly firm, aggregate strength is slightly firm and friable. Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.
0.3-0.9	Moist, 10YR 6/2 (light brownish grey) coloured soil. **No gravels**. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth. Some occlusions.	0.35-0.6	Moist, 10YR 5/8 (yellowish brown) coloured soil. **Slightly gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. Few fine roots. Boundary is sharp and smooth.	0.4-0.9	Moist, 10YR 5/4 (yellowish brown) coloured soil. **Very slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is firm, aggregate strength is weak and brittle. Few fine roots. Boundary is sharp and smooth. Oxide staining layers throughout the b horizon.
		0.6-1.8+			

Below ground level (m)	**Pigburn**	**Below ground level (m)**	**Wakatipu**	**Below ground level (m)**	**Barrhill**
S-Map class	Weathered Fluvial Recent Soils		Typic Immature Pallic Soils (PIT)		Typic Immature Pallic Soils (PIT)
0.9-1.1	Moist, 10YR 6/3 (pale brown) coloured soil. **Very gravelly**, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and very friable. Few fine roots. Boundary is sharp and smooth.		Slightly moist, 10YR 7/3 (very pale brown) coloured soil. **Extremely gravelly**, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain. Soil strength is firm, aggregate strength is slightly firm and brittle. No roots. Concreted texture but water soaks away.	0.9-1	Slightly moist, 10YR 5/4 (yellowish brown) coloured soil. **Extremely gravelly**, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. No roots. Boundary is sharp and smooth.
1.1-1.45	Moist, 10YR 6/1 (grey) coloured soil. **Slightly gravelly**, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. Few fine roots. Boundary is sharp and smooth.			1-1.4	Moist, 10YR 6/3 (pale brown) coloured soil. **No gravels**. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive. Soil strength is slightly firm, aggregate strength is weak and brittle. Organic staining from roots. Boundary is sharp and smooth.
1.45-1.8+	Moist, 10YR 6/1 (grey) coloured soil. **Very gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is very weak, aggregate strength is very weak and very friable. Few fine roots. Mixture of size class gravels.			1.4-1.7+	Moist, 10YR 6/3 (pale brown). **Extremely gravelly**, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain. Soil strength is weak, aggregate strength is weak and friable. No roots. Mixed size of gravels and sand.

LEI SOILS TESTING RESULTS

Hydraulic Conductivity Tests

Saturated and unsaturated hydraulic conductivity tests were undertaken at nine sites (Figure 1) at a depth of 0.2 m using a combination of double-ring infiltrometers and unsaturated plate permeameters. This depth was assessed as the drippers would be laid due to this depth. Table 3 presents the saturated hydraulic conductivity (total flow through the soil, including macropores, such as root and wormholes) for the sites.

Saturated hydraulic conductivity describes the ease with which water moves through soil when all its pores are completely filled with water. In this fully saturated state, water movement is driven primarily by gravity and the pressure gradient, as there are no air-filled pores to impede the flow. The larger pores, or macropores, such as those created by root channels, cracks, and spaces between soil aggregates, dominate water flow under saturated conditions. Water flows through these macropores quickly due to the low resistance and the direct path they provide. Soil texture, structure, and the presence of organic matter significantly influence the rate of water movement, with sandy soils generally exhibiting higher saturated conductivity than clayey soils due to their larger pore spaces. The conductivity is also influenced by the degree of soil compaction and the connectivity of the pore network. In undisturbed, well-structured soils and in soils where a lot of sands and gravels are present, the rate of water percolation is higher, while in compacted or poorly structured soils, it is lower due to the reduction in macropore space.

The saturated tests are likely to provide a more representative result of the gravity drainage through the larger macropores. The faster draining soils in the saturated tests are the Wakatipu soils, which all displayed an extremely gravelly, concreted type soil beyond around 0.6 m depth. This natural concreted type layer, quickly percolate water when applied, supporting this high infiltration rate.

The testing at site HB 13/5 was unsuccessful because the soil was too gravelly to install the double rings properly, preventing LEI from obtaining an additional reading. The manmade clean fill site had the lowest saturated conductivity, likely due to the anthropic nature of the site experiencing artificial compaction with heavy machinery. Pigburn and Barrhill gave similar saturated hydraulic conductivity readings.

Table 3: Soil Saturated Hydraulic Conductivity (K_{sat})

Serial no.	Site	Soil Type	Topsoil Average K_{sat} (mm/day)
1	Site HB2/15	Wakatipu	1,440
2	Site HB6/8	Wakatipu	3,960
3	Site HB7/1	Manmade	150
4	Site HB10/7	Pigburn	720
5	Site HB11/3	Wakatipu	1,044
6	Site HB13/5	Pigburn	*Too gravelly to conduct testing
7	Site HB14/12	Barrhill	720
8	Site HB15/11	Pigburn	920
9	Site HB18/16	Wakatipu	720

Table 4 presents the unsaturated hydraulic conductivity (represents the flow through meso and micropores, i.e. full matrix flow through the soil) for the nine sites. Field tests using the plate permeameters ($K_{-40\ mm}$) found that the rate moving through the soil indicated a strongly unified soil texture which showed only small increments of change across the different pressures. The unsaturated tests are well grouped between the soil types, with the faster draining soils being the Pigburn, compared with the slower draining Wakatipu and Barrhill.

Unsaturated hydraulic conductivity, which describes how water moves through soil when the soil is not fully saturated, primarily occurs through the soil's micro and mesopores. Micropores are the small pores in the soil, often found within soil aggregates or between tightly packed soil particles. They play a significant role in retaining water against gravity due to capillary forces, and they control water movement when the soil is at lower moisture levels.

Mesopores are slightly larger pores than micropores, and they facilitate water movement when the soil is at moderate moisture levels. In unsaturated conditions, mesopores allow water to flow through the soil more readily than micropores, but they still retain water that plants can access.

Together, the micro and mesopores regulate the unsaturated conductivity in soils, with the rate of water movement depending on the pore size distribution and soil moisture content. At lower soil moisture levels, water primarily moves through micropores, while at higher unsaturated conditions, mesopores become more active in conducting water.

Table 4: Soil Unsaturated Hydraulic Conductivity ($K_{-40\ mm}$)

Serial no.	Site sample number	Soil Type	Field investigation of topsoil average unsaturated hydraulic conductivity, K_{-40} (mm/day)	Landcare Research laboratory result unsaturated hydraulic conductivity, K_{-40} (mm/day)
1	Site HB2-15	Wakatipu	22	360
2	Site HB6-8	Wakatipu	30	768
3	Site HB11-3	Wakatipu	11	336
4	Site HB18-16	Wakatipu	25	624
5	Site HB7-1	Manmade	53.5	96
6	Site HB10-7	Pigburn	123	312
7	Site HB13-5	Pigburn	73	336
8	Site HB15-11	Pigburn	110	480
9	Site HB14-12	Barrhill	37	72

The value of unsaturated hydraulic conductivity in the topsoil of the sites ranged from 11 to123 mm/day. The unsaturated hydraulic conductivity of the sample cores of the sites those were sent to Landcare Research ranged from 72 to 768 mm/day. The variation between field observation and laboratory tests are expected as the plate permeameter (field observation) method usually are conducted by using one to four replications which considers variability of unsaturated hydraulic conductivity in 2-4 spots and the average results are considered whereas in laboratory studies only one sample has been considered. The variability in the properties of soils in field conditions is also common.

The hydraulic results based on soil distribution are shown below in Error! Reference source not found.. The distribution of these rates supports the proposal to irrigate based on soil type.

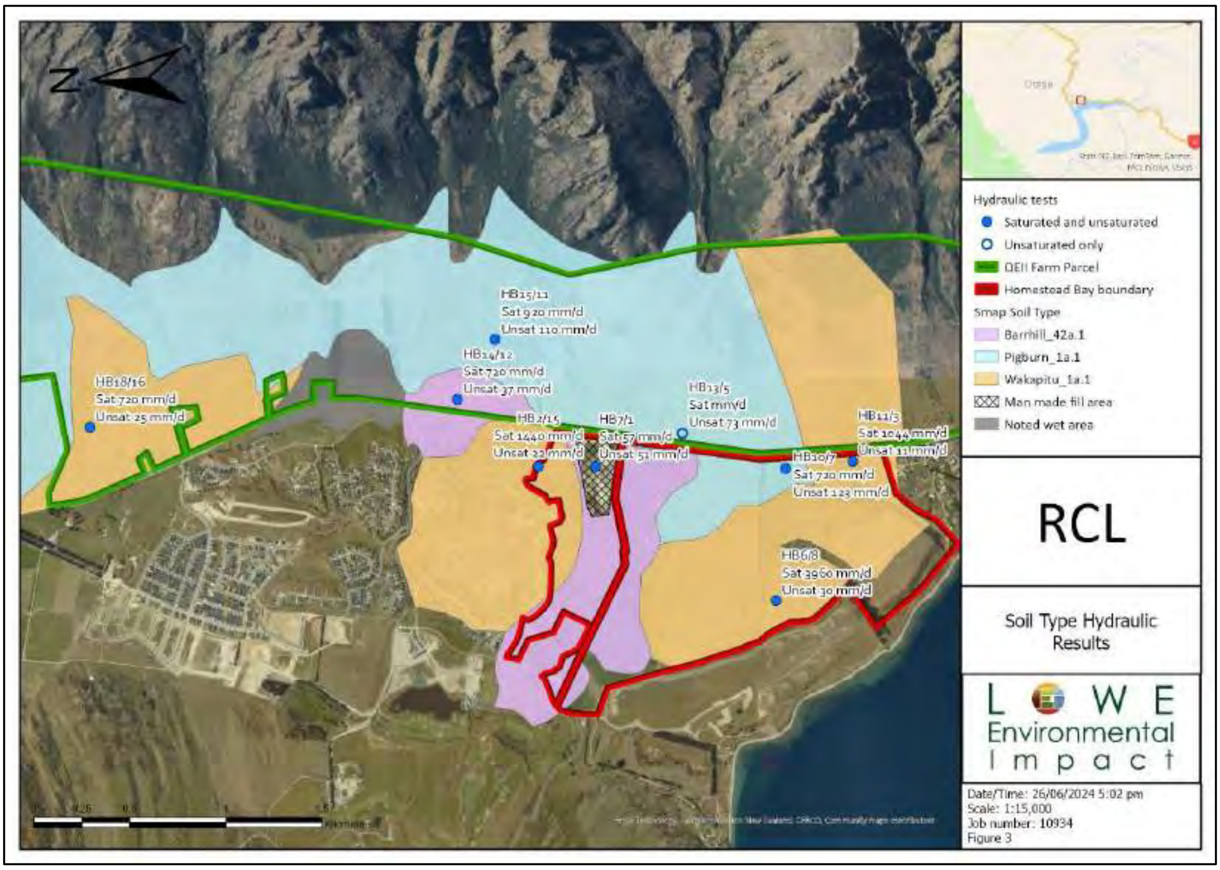

Figure 3: Soil Hydraulic Distribution

Field measurements typically only observe clean water effects, but the impact of wastewater constituents must also be considered. Organic material, solids and nutrients in the wastewater can allow the development of microbial growth, commonly referred to as biofilm, which in turn can result in a 'clogging' effect of the soil pores, particularly near the irrigation line outlets. This can reduce the soil's infiltration capacity. In addition, the salt concentration will influence the soil wetting by altering the water tension.

Crites and Tchobanoglous (1998) recommend a value of 10 - 30% of the K_{sat} to provide a Design Irrigation Rate (DIR). LEI has conservatively adopted a value of 10% of the K_{sat} and 30% of the K_{unsat} to provide a DIR.

Due to the previously mentioned consistent grouping by soil type, the design application rates have been prepared separately for Barrhill, Pigburn, and Wakatipu soil types. These are shown below in Table 5, Table 6, and Table 7.

DIR DEPENDING ON SOIL TYPES

Barrhill Soils

The Barrhill soil DIR is calculated from on-site measurements and from past investigations on the neighbouring Jacks Point development.

Table 5: Barrhill Design Irrigation Rate

Items	**Saturated hydraulic conductivity (K_{sat})**	**Unsaturated hydraulic conductivity (K_{-40})**
Field Measurement low permeability subsoil (mm/day)	720 ± 0	37
Adjustment (%)	10	30
DIR (mm/day)	72 ± 0	11.0

DIR recommended by the investigation is up to 11 mm/day.

Pigburn Soils

The Pigburn soils dominate the higher elevations of the QEII site and part of the RCL site. These soils show a high saturated infiltration rate and unsaturated hydraulic conductivity.

Table 6: Pigburn Design Irrigation Rate

	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	820 ± 173	137 ± 61
Adjustment (%)	10	30
DIR (mm/day)	82 ± 17	41 ± 18

The DIR recommended from the investigation is up to 41 mm/day.

Wakatipu Soils

The Wakatipu soils experience higher saturated infiltration rates due to the rapid infiltration at around 0.6 m depth. The lower unsaturated infiltration rate is similar to that of the Barrhill soils, which are also pallic soils.

Table 7: Wakatipu Design Irrigation Rate

	Saturated (K_{sat})	Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	1,791 ± 1,300	24.2 ± 10.7
Adjustment (%)	10	30
DIR (mm/day)	179 ± 130	7.3 ± 3.2

The DIR recommended from the investigation is up to 7 mm/day.

Manmade Soils

The manmade soils are imported as clean fill of unsuitable construction foundation material from the nearby developments. This area has been identified for the location of the WWTP but could also be used for an LTA.

Table 8: Manmade Design Irrigation Rate

	Saturated (K_{sat})	Mean Unsaturated (K_{-40mm})
Field Measurement low permeability subsoil (mm/day)	150 ± 52	53.5 ± 15.5
Adjustment (%)	10	30
Maximum DIR (mm/day)	15 ± 5.2	16.1 ± 4.7

The DIR recommended from the investigation is up to 15 mm/day (Table 9). However, due to the nature of the parent material and the mechanical/landfilling compaction that has been undertaken, a lower infiltration rate of 5 mm/day is recommended as a conservative approach.

Proposed Design Irrigation Rate

The soil investigation has indicated that all of the site's soils have a high hydraulic capacity to assimilate the wastewater. Based on this information, LEI concludes that DIR should be further informed based on land treatment area, nitrogen leaching and catchment nitrogen effects. Proposed DIRs for this community system need to consider the land area available, land use and catchment sensitivities. Table 9 presents recommended rates for the basis of the scheme design and nutrient modelling.

Table 9: Proposed Design Application Rate

	Proposed DIR (mm/day)
Barrhill Soils	7
Pigburn Soils	7
Wakatipu Soils	7
Manmade Soils	5

Depending on the LTA area, final selected DIR will be recommended in the Conceptual Design report.

Soil's Physical properties in relation to hydraulic conductivity

The Table 10 provides a detailed overview of the soil physical properties across various sites, including particle density, dry bulk density, total porosity, macro-porosity, and micro-porosity. These parameters are essential in understanding the soil's ability to retain water, support plant growth, and allow for air and water movement through the soil profile (Brady et al., 2008; McLaren and Cameroon, 1996).

Table 10: Soil physical properties

Site no.	Particle Density (g/cm³)	Dry Bulk (g/cm³)	Total porosity (%)	Macro-porosity (%)	Micro-porosity (%)
HB 7/1	2.72	1.60	41	13	28
HB 8/2	2.72	1.28	53	16	37
HB 11/3	2.79	1.49	47	13	34
HB 12/4	2.75	1.43	48	11	37
HB 13/5	2.80	1.34	52	10	43
HB 9/6	2.82	1.33	53	8	45
HB 10/7	2.78	1.44	48	10	38
HB 6/8	2.67	1.43	47	15	31
HB 5/9	2.68	1.32	51	15	36
HB 16/10	2.76	1.33	52	15	37
HB 15/11	2.80	1.36	52	13	39
HB 14/12	2.82	1.45	49	9	40
HB 17/13	2.77	1.27	54	12	43
HB 1/14	2.65	1.30	51	11	40
HB 2/15	2.69	1.34	50	14	36
HB 18/16	2.77	1.33	52	14	38
HB 19/17	2.79	1.41	50	13	37

Particle Density and Dry Bulk Density:

Particle density is a measure of the mass of soil particles per unit volume, typically excluding pore spaces. In this dataset, the particle density ranges from 2.65 g/cm³ to 2.82 g/cm³, indicating slight variations in the mineral composition of the soils across the sites. Soils with higher particle density, such as Site HB 9/6 and HB 14/12 (2.82 g/cm³), may contain heavier minerals, possibly contributing to different soil behaviour compared to those with lower particle density, such as Site HB 1/14 (2.65 g/cm³).

Bulk density is a measure of soil compaction, expressed as the mass of soil per unit volume. Dry bulk density, on the other hand, measures the mass of soil, including pore spaces, and it is a key indicator of soil compaction. Lower bulk density values generally indicate better soil structure with more pore spaces, which are crucial for root penetration and water infiltration. Dry bulk density ranges from 1.27 g/cm³ at Site HB 17/13 to 1.60 g/cm³ at Site HB 7/1. Soils with higher bulk density, such as Site HB 7/1, may be more compacted, reducing porosity and potentially limiting water movement and root growth. For pasture soils, the target bulk density typically falls within the range of 0.7 to 1.4 g/cm³ (Sparling et al., 2008). At these levels, soil is considered to have an adequate balance between compactness and porosity, allowing for sufficient root growth and water infiltration.

A bulk density below 0.7 g/cm³ indicates that the soil is too loose, which can lead to issues such as erosion or insufficient support for plants. On the other hand, a bulk density above 1.4 g/cm³ suggests that the soil is becoming too compacted, potentially restricting root penetration, reducing water infiltration, and impairing overall soil health. Managing bulk density within this target range helps maintain soil structure conducive to healthy pasture growth. In the investigated site the in soils ranged from 1.27 to 1.60 g/cm³. Th bulk density in site HB 17/13 was the lowest (1.27 g/cm³) whereas the bulk density in site HB 7/1 was the highest (1.60 g/cm³). Site HB 19/17, HB 12/4, HB 6/8, HB 10/7, HB 14/12, HB 11/3 and HB 7/1 had higher bulk density than the prescribed level (Sparling et al., 2008). This high bulk density needs to be decreased for better plant growth and environmental wellbeing.

Total Porosity

Total porosity, which represents the proportion of soil volume occupied by pores, is inversely related to bulk density. Higher porosity values suggest a greater ability of the soil to store water and air, which is essential for healthy plant growth and water infiltration. The sites show a range of total porosity from 41% at Site HB 7/1 to 54% at Site HB 17/13. Higher porosity, as seen in Site HB 17/13, indicates that the soil has more spaces available for air and water, which could enhance plant growth and water percolation.

Macro-porosity and Micro-porosity

Macro-porosity refers to the larger pores in the soil that allow for rapid drainage and air exchange, whereas micro-porosity includes smaller pores that retain water for plant use. In this dataset, macro-porosity ranges from 8% at Site HB 9/6 to 16% at Site HB 8/2, while micro-porosity varies between 28% and 45%. Sites with higher macro-porosity, such as HB 8/2, are likely to have better drainage but may also be more prone to drying out, especially in periods of low rainfall. Conversely, higher micro-porosity, as seen in Site HB 9/6 (45%), suggests a greater capacity to hold water, which can be crucial during dry periods but may also slow down drainage, potentially leading to waterlogging under higher rates of water application.

Macroporosity are essential for water drainage, air exchange, and root growth. For pasture soils, the target range for macroporosity is 6 to 30% (Sparling et al., 2008), with 30% considered high and ideal for most agricultural purposes. Adequate macroporosity (within the 6-30% range) ensures that the soil has enough large pores to allow for efficient water movement and root development, critical for sustaining pasture productivity. A macroporosity below 6% is considered low, indicating that the soil may be too compacted, leading to poor drainage and limited oxygen availability to plant roots, which can stifle growth and reduce pasture yield.

In the tested sites, all the sites macroporosity was more than 6% which implies that sites macroporosity is in reasonable condition. The lowest macro porosity was observed in site HB 9/6 (8%) and highest was observed in site HB 8/2 (16%).

Implications for Soil Management

Understanding these physical properties is critical for effective soil management. Soils with lower bulk density and higher porosity, like those at Site HB 17/13, are generally more favourable for root growth and water infiltration, making them suitable for a wide range of crops. However, these soils might require more frequent irrigation due to their higher drainage capacity. On the other hand, soils with higher bulk density and lower porosity, such as those at Site HB 7/1, may need management practices that improve structure, such as adding organic matter or reducing compaction through appropriate tillage practices.

Water holding capacity

Field Capacity (FC)

FC is crucial when applying treated wastewater to soils because it represents the maximum amount of water the soil can hold after excess water has drained away. Applying wastewater up to the FC level ensures that the soil is sufficiently moist without causing waterlogging, which could lead to runoff, leaching of nutrients, and potential contamination of groundwater.

Available Water Capacity (AWC)

AWC indicates the range of water available for plant use between field capacity and the wilting point. In treated wastewater applications, knowing the AWC helps in determining the appropriate amount and frequency of wastewater irrigation, ensuring that plants receive enough moisture without over-irrigation, which could cause nutrient imbalances or pollution.

Gravimetric Water Content

This measure provides insights into the actual water content in the soil as a percentage of its dry weight. It is useful in assessing how much treated wastewater has been retained by the soil after application. Monitoring gravimetric water content helps in optimizing water use efficiency and preventing excessive buildup of moisture that could lead to anaerobic conditions or soil degradation.

Volumetric Water Content

Volumetric water content, expressed as a percentage of the soil's total volume, is key to understanding how much water is present in the soil at various moisture levels. It is particularly important in the context of treated wastewater application, as it helps in tracking how the soil's moisture profile changes with irrigation, ensuring that the soil maintains adequate moisture for plant growth without reaching saturation levels that could result in surface runoff or nutrient leaching.

Table 11 presents, Field Capacity (%), which provides insight into the water-holding capacity of the soil after excess water has drained away and the soil has reached a point where it holds water against gravity. The values range from 27% to 41%, indicating significant variability among the samples field capacity. The highest field capacity was observed in sample HB 9/6 (41%) whereas the lowest field capacity was observed in sample HB 7/1 with 27%.

Available Water Capacity (AWC % v/v), represents the volume of water available for plant uptake, calculated as the difference between the water content at Field Capacity and the Permanent Wilting Point. AWC values in these samples range from 15% to 37%, reflecting the soil's ability to supply water to plants. Higher AWC values, such as 37% in sample HB 9/6, indicate that a significant portion of the retained water is accessible to plants, making this soil highly suitable for agricultural purposes. Conversely, lower AWC values, like the 15% observed in sample HB 7/1, suggest that even though the soil may hold water, less of it is available for plants to absorb, potentially leading to stress during dry spells.

The gravimetric water content (GWC) of the soils across the different sites shows considerable variability, reflecting their differing capacities to retain water under various conditions. At saturation, the GWC at saturation ranges from a low of 26% at Site HB 7/1 to a high of 43% at Site HB 17/13, indicating that some soils, like HB 17/13, can hold significantly more water when fully saturated compared to others.

Table 11: Gravimetric Water Content

Plot	Field Capacity (%)	AWC (% v/v) (-10 to -1500 kPa)	Gravimetric Water Content (%w/w)				
			At field condition	At saturation	@ -5 kPa	@ -10 kPa	@ -1500kPa
			(%w/w)	(%w/w)	(%w/w)	(%w/w)	(%w/w)
HB 7/1	27	15	12	26	18	17	7
HB 8/2	33	26	18	41	29	26	5
HB 11/3	30	21	11	31	23	20	6
HB 12/4	34	29	16	34	26	24	4
HB 13/5	37	27	12	39	32	27	7
HB 9/6	41	37	12	40	34	30	2
HB 10/7	35	31	13	33	26	24	3
HB 6/8	29	24	17	33	22	20	4
HB 5/9	33	24	16	39	27	25	7
HB 16/10	34	26	19	39	28	25	6
HB 15/11	36	31	17	38	28	26	4
HB 14/12	38	26	20	33	28	26	8
HB 17/13	40	29	28	43	34	32	9
HB 1/14	35	24	19	39	31	27	8
HB 2/15	31	23	17	38	27	23	7
HB 18/16	35	23	20	39	28	26	8
HB 19/17	34	24	18	35	26	24	8

As the soil begins to drain and reaches -5 kPa, the GWC decreases, with values ranging from 18% at Site HB 7/1 to 34% at Site HB 17/13, again highlighting the superior water retention ability of Site HB 17/13.

At -10 kPa, which is closer to the soil's field capacity, the GWC further decreases, with the lowest value at 17% for Site HB 7/1 and the highest at 32% for Site HB 17/13.

Finally, at -1500 kPa, which represents the wilting point where water is no longer available to plants, the GWC ranges from 2% at Site HB 9/6 to 9% at Site HB 17/13.

This data indicates that soils like those at HB 17/13 consistently exhibit higher water retention across all moisture levels, making them more resilient during dry periods. In contrast, soils at HB 7/1, with consistently lower GWC values, are likely to dry out faster and may require more frequent irrigation to sustain plant growth, highlighting the need for tailored water management practices based on the specific characteristics of each site.

It is also important to note here that the gravimetric water content in site HB 7/1 was only 52 to 60% of the gravimetric water content in site 17/13 at saturation to field capacity (saturation to -10kPa)

A similar result was observed when the volumetric water content was considered. That is site HB 17/13 had the highest water retention capability which implies that volumetric water content and gravimetric water content are actually showing the similar result.

Table 12: Volumetric Water Content

Sites	Volumetric Water Content (% v/v)				
	At field moisture	At saturation	@ -5 kPa	@ -10 kPa	@ -1500kPa
HB 7/1	20	41	28	27	12
HB 8/2	24	53	37	33	7
HB 11/3	17	47	34	30	9
HB 12/4	23	48	37	34	5
HB 13/5	16	52	43	37	10
HB 9/6	16	53	45	41	3
HB 10/7	19	48	38	35	4
HB 6/8	24	47	31	29	6
HB 5/9	22	51	36	33	9
HB 16/10	26	52	37	34	8
HB 15/11	23	52	39	36	5
HB 14/12	29	49	40	38	12
HB 17/13	36	54	43	40	11
HB 1/14	24	51	40	35	10
HB 2/15	22	50	36	31	9
HB 18/16	26	52	38	35	11
HB 19/17	26	50	37	34	11

The Table 12 provides a detailed overview of the Volumetric Water Content (% v/v) across various sites, measured at different soil moisture conditions: field moisture, saturation, and specific matric potentials (-5 kPa, -10 kPa, and -1500 kPa). The data shows significant variation in water content across the sites, with field moisture values ranging from 16% to 36%, indicating differences in the soil's ability to retain water under natural conditions. The saturation values, which range from 41% to 54%, highlight the maximum water content the soils can hold, reflecting the soil's porosity.

At the matric potentials of -5 kPa and -10 kPa, the water content decreases as the soil dries, with notable declines in water retention. The water content at -1500 kPa, representing the permanent wilting point ranges between 3% and 12%.

This variation across the sites suggests differences in soil texture, structure, and organic matter content, influencing the soil's water retention and availability to plants. The site HB 7/1 has the lowest available water content but the highest water percentage at wilting point implying that to manage water application in this site will need special care so that no ponding or waster logging happens that might affect the management of wastewater and plant growth negatively.

PHOSPHORUS

Maximum Phosphorus (P) sorption capacity of soils calculated from Landcare Research tests data

At different concentration of Phosphorus (P) in solution, there is a corresponding P sorption by the soil. The P sorption capability in soils is a key indicator of how effectively a soil can absorb and hold phosphorus, a critical nutrient for plant growth. This percentage represents the proportion of added phosphorus that is adsorbed by the soil, preventing it from being lost through leaching or runoff. High phosphorus adsorption is particularly important in preventing environmental issues such as eutrophication. Several factors influence phosphorus retention in soils, including soil texture, pH, organic matter content, and mineral composition. Soils with a high clay content generally have higher phosphorus sorption due to the greater surface area and charge of clay particles, which provide more binding sites for phosphorus. The pH of the soil also plays a significant role, with high and low pH impacting availability and leaching; in acidic soils (low pH <5.8), phosphorus tends to bind with iron and aluminium oxides, increasing sorption, whereas, at high pH >7, P tends to react with Ca and becomes unavailable.

Organic matter usually increases phosphorus sorption depending on the specific organic compounds present and their interactions with soil minerals. Soils rich in iron and aluminium oxides typically exhibit high phosphorus retention. Understanding phosphorus retention percentages is crucial for effective nutrient management in agriculture. In soils with high retention, more phosphorus may need to be applied to meet crop needs, while in soils with low retention, careful management is required to prevent phosphorus loss. By optimizing phosphorus retention through the soil and wastewater management practices, it is possible to improve crop yields while protecting the environment.

Phosphorus (P) sorption in soils (Error! Reference source not found.) is a critical factor in determining the availability of this essential nutrient for plant uptake and its potential impact on the environment. Phosphorus plays a crucial role in plant growth, contributing to processes like energy transfer, photosynthesis, and the synthesis of nucleic acids. However, phosphorus is often a limiting nutrient in soils due to its strong tendency to bind to soil particles, making it less available to plants. Understanding phosphorus sorption dynamics is vital for effective soil management, optimizing fertilization practices, and preventing environmental issues like eutrophication.

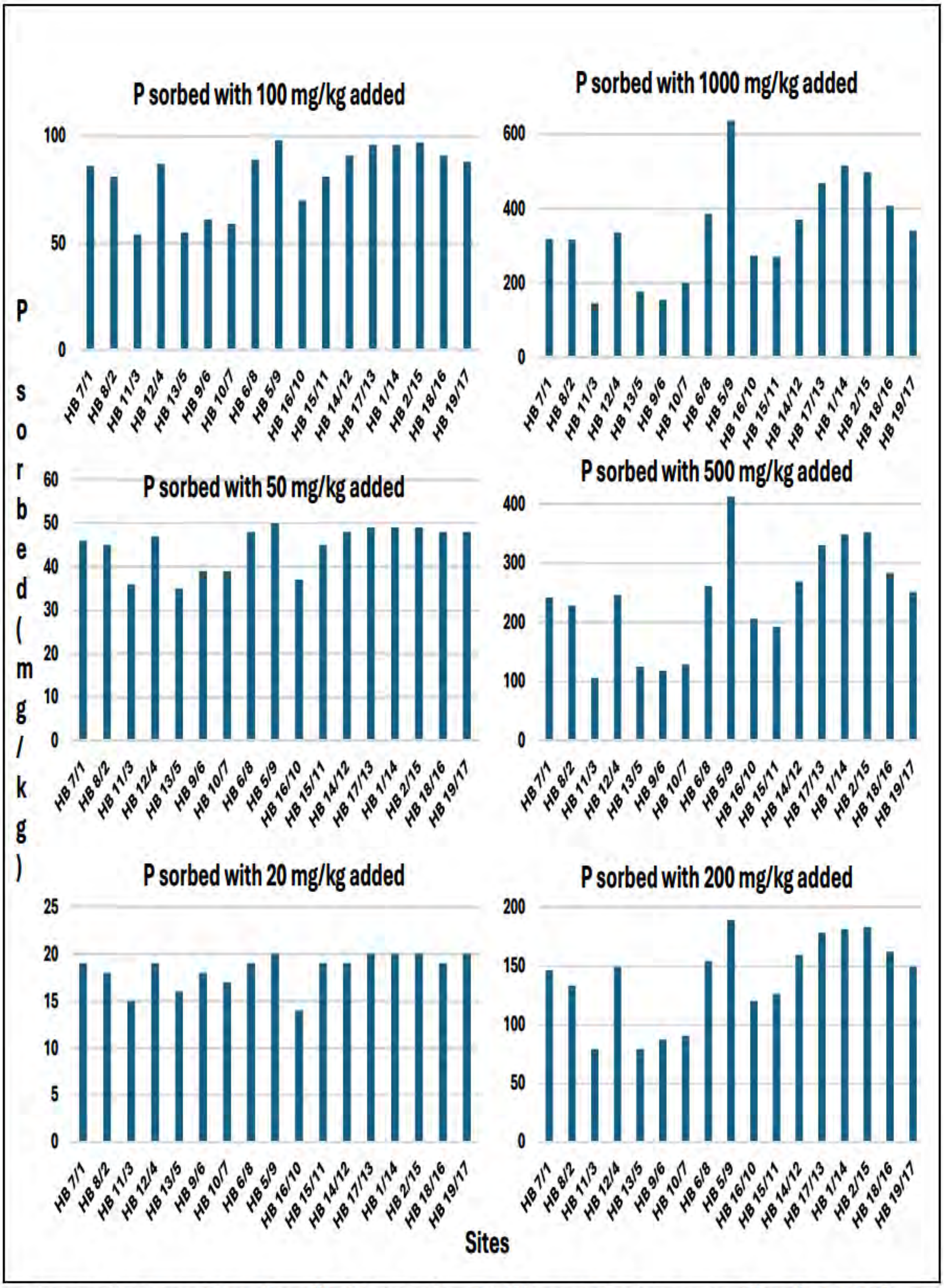

Figure 4: P sorption (mg/kg) by Soils at Different P Concentration in Solution (mg/kg)

The low sorption values of some sites suggest that the soils at these sites are less effective at retaining phosphorus, making it more susceptible to phosphorus leaching. This can lead to nutrient loss and increased environmental risks, particularly in areas where phosphorus runoff might contribute to water pollution. Soils with low phosphorus could be amendeded with biochar as biochar has been reported to increase phosphorus retention in soils and supply of P to plants when plants need it (Glaser & Lehr, 2019).

The Maximum Phosphorus Sorption Capacity (MPSC) (mg/kg) in soil samples ranged from 1,887-8,507 mg/kg soil (Table 13) which has been calculated by using the data from Landcare Research.

The highest MPSC was observed at Site HB 5/9, with a value of 8,507 mg/kg, suggesting a superior ability to adsorb phosphorus, which could be attributed to factors such as high clay content, organic matter, or the presence of minerals like iron and aluminum oxides known for high phosphorus sorption. In contrast, the lowest capacity was recorded at Site HB 11/3, with an MPSC of 1,887 mg/kg, indicating a lower potential to retain phosphorus, possibly due to lower reactive surface area or different mineralogical composition.

Several other sites exhibited relatively high phosphorus sorption capacities, such as HB 1/14 (6,575 mg/kg) and HB 17/13 (5,881 mg/kg), which are likely influenced by similar soil properties that enhance phosphorus retention. On the other hand, sites like HB 9/6 (1,958 mg/kg) and HB 13/5 (2,534 mg/kg) had lower capacities, highlighting variability in soil characteristics across the locations.

The significant variability in MPSC among the sites emphasizes the need for site-specific soil management practices to optimize phosphorus use efficiency. Understanding these variations can help in designing appropriate soil amendments and management strategies that enhance phosphorus sorption, reduce leaching, and mitigate environmental impacts associated with phosphorus runoff.

The significant difference between these sites highlights the variability in phosphorus sorption across different soil types. Managing these differences is crucial for optimizing fertilization practices and minimizing environmental impact.

Table 13: Maximum Phosphorus Sorption Capacity (mg/kg) of Soils in different Sites

Site number	Maximum Phosphorus Sorption Capacity (mg/kg)
HB 7/1	4,175
HB 8/2	4,429
HB 11/3	1,887
HB 12/4	4,380
HB 13/5	2,534
HB 9/6	1,958
HB 10/7	2,769
HB 6/8	5,097
HB 5/9	8,507
HB 16/10	4,035
HB 15/11	3,499
HB 14/12	4,764
HB 17/13	5,881
HB 1/14	6,575
HB 2/15	6,248
HB 18/16	5,324
HB 19/17	4,464

Implications for Soil Management

The significant variation in phosphorus sorption between different sites underscores the importance of understanding and managing soil-specific phosphorus dynamics. Soils with high sorption capacities, like those at HB 5/9, are effective at retaining applied phosphorus, which is beneficial for long-term nutrient availability and environmental protection. However, these soils may require higher phosphorus inputs to meet crop needs, as a substantial portion of the applied phosphorus is immobilized within the soil matrix and is not immediately available to plants.

On the other hand, soils with low phosphorus sorption capacities, such as those at HB 11/3, pose a different set of challenges. These soils are more susceptible to phosphorus loss through leaching, which can lead to reduced phosphorus availability for crops and increased risk of environmental pollution. Effective management strategies for these soils might include the use of phosphorus sorption enhancing amendments eg. Biochar (Glaser & Lehr, 2019; Jindo, et al. 2020), more frequent but smaller phosphorus applications, or the implementation of buffer zones to prevent runoff.

Summary:

The summary given below that has been derived from the discussion of the report.

- The DIR (Design Irrigation Rates) has been recommended as 7 mm/day for all sites except HB 7/1 (manmade site) where the DIR has been recommended as 5 mm/day.
- For increasing the sites water holding capacity, P retention and P sorption capability, the soils are recommended to use a biochar (if necessary) to increase the discharge rates especially where the infiltration rate was seen slow eg. HB 11/3, HB 9/6 and HB 7/1.

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Appendices

Appendix A	Field Investigation Soil Profile Descriptions
Appendix B	Landcare Research Soil Reports

APPENDIX A

Field Investigation Soil Profile Descriptions

LEI Soil Profile Description

June 6, 2024 3:46 PM	*HB1/14*	
Millie	*Elevated rolling hills*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 903

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.08185743, 168.75313995

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Pasture	
A	0 - 30 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels.* No *mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is distinct and occluded.*	
B1	30 - 50 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive.* Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is diffuse and convolute. B horizon merging into bw.*	

B2	50 - 80 cm	*Moist, 10YR 8/4 (very pale brown)* coloured soil. *Very gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal massive*. Soil strength is firm, aggregate strength is weak and friable. *Few fine roots. Boundary is abrupt and wavy*. *Mixed zone of b and bw horizon. Compacted sand with mixed-in gravels.*	
C	80 - 180 cm	*Moist, 10YR 8/2 (very pale brown)* coloured soil. *Extremely gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots. Cemented type texture but water drains away fine*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description

June 6, 2024 4:28 PM	*HB2/15*	
Millie	*Elevated rolling hills closest to highway*	
overcast, calm	*Much the same as HB1/14 but bigger boulders in b horizon*	
Soil Core # (if collected)	Top soil:	Sub soil: 832

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.08058172, 168.75546644

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Pasture/browntop	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and occluded.*	
B1	25 - 50 cm	*Moist, 10YR 3/6 (dark yellowish brown)* coloured soil. *Moderately gravelly, sub-rounded, boulders. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is weak, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and convolute. Some boulders amongst smaller gravels in this layer.*	

B2	50 - 90 cm	*Slightly moist, 10YR 7/3 (very pale brown)* coloured soil. *Extremely gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is distinct and wavy*. *Patches of above layer interspersed into this intermediate layer. The layer is concreted in hardness and texture, but water still soaks away when profile is wetted.*	
C	90 - 180 cm	*Slightly moist, 10YR 7/3 (very pale brown)* coloured soil. *Extremely gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, loamy sand. Apedal single grain*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots. Concreted texture but water soaks away.*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 4:49 PM	*HB5/9*	
Millie	*Flat mound*	
overcast, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 691

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.09377604, 168.74686383

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Pasture	
A	0 - 25 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. No *gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and occluded.*	
B	25 - 55 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. No mottles, non-sticky, slightly plastic, sandy clay loam. Apedal massive.* Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth.*	

C	55 - 150 cm	*Dry, 10YR 6/1 (grey)* coloured soil. *Very gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal massive*. Soil strength is hard, aggregate strength is hard and brittle. *No roots. Cemented type later same as site 6.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 3:49 PM	*HB6/8*	
Millie	*Rolling hills closest to lake*	
overcast, calm	*Wanaka soil*	
Soil Core # (if collected)	Top soil:	Sub soil: 693

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.09138058, 168.74586377

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	20 cm	Groundcover: Pasture	
A	0 - 20 cm	*Moist, 10YR 3/3 (dark brown)* coloured soil. *No gravels*. No *mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Many fine roots. Boundary is sharp and irregular.*	
B	20 - 60 cm	*Moist, 10YR 5/8 (yellowish brown)* coloured soil. *Moderately gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, slightly plastic, sandy clay loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Abundant roots. Boundary is sharp and smooth.*	

C	60 - 170 cm	*Dry, 10YR 6/1 (grey)* coloured soil. *Extremely gravelly, sub-rounded, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is hard, aggregate strength is very firm and brittle. *Common fine roots. Concreted texture but water soaks away on it. Consolidated sand and gravels. Roots down to around 70cm.*	


HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 12:22 PM	*HB7/1*	
Millie	*Flat fill site*	
fine, calm	*Anthropic soil, clay starting at 50cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 738

Soil	Anthropic Soil on top of Pigburn 1a.1
NZSC	Anthropic Soil / Weathered Fluvial Recent Soils (RFW)
Drainage	Clay starting at 50 cm, Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08324649, 168.75527559

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	50 cm	Groundcover: Poor pasture and bare soil	
A	0 - 50 cm	*Moderately moist, 10YR 4/3 (brown)* coloured soil. *Moderately gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, silty clay. Apedal cloddy*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B	50 - 85 cm	*Moderately moist, 10YR 5/2 (greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. Few fine 10YR 5/8 mottles, slightly sticky, slightly plastic, clay. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Soil colour 5/10Y greenish gray gley chart 1*	
C	85 - 180 cm	*Slightly moist, 10YR 5/2 (greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravels. Common medium 10YR 5/8 mottles*, *slightly sticky, slightly plastic, loamy clay. Apedal cloddy*. Soil strength is firm, aggregate strength is slightly firm and brittle. *No roots.*	


HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 2:26 PM	*HB8/2*	
Millie	*Flat backfill closest to alps*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 829

Soil	Anthropic Soil on top of Pigburn 1a.1
NZSC	Anthropic Soil / Weathered Fluvial Recent Soils (RFW)
Drainage	Clay starting at 50 cm, Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08327028, 168.75587617

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	40 cm	Groundcover: Poor pasture	
A	0 - 40 cm	*Moist, 10YR 4/3 (brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and smooth.*	
B	40 - 90 cm	*Moist, 2.5y6/3 light yellowish brown coloured soil. Moderately gravelly, angular, coarse gravel. Few fine 10YR 5/8 mottles, slightly sticky, slightly plastic, clay. Apedal massive*. Soil strength is firm, aggregate strength is firm and semi-deformable. *Few fine roots. Boundary is sharp and smooth.*	

C	90 - 180 cm	*Moist, 2.5y6/3 light yellowish brown coloured soil*. Moderately *gravelly, angular, coarse gravel. Few coarse 10YR 5/8 mottles, slightly sticky, slightly plastic, loamy clay. Apedal massive*. Soil strength is firm, aggregate strength firm and semi-deformable. *No roots.*	

HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 11:15 AM	*HB9/6*	
Millie	*Pasture beside airfield*	
overcast, calm	*Generally homogeneous profile*	
Soil Core # (if collected)	Top soil:	Sub soil: 697

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.08911557, 168.75516592

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Pasture	
A	0 - 30 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is sharp and smooth.*	
B1	30 - 80 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels*. No *mottles, non-sticky, slightly plastic, silty clay. Apedal massive*. Soil strength is weak, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B2	80 - 90 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *gravels, moderately gravelly, angular, fine gravel no mottles, non-sticky, non-plastic, clay loam. apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B3	90 - 130 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels*. No *mottles, non-sticky, slightly plastic, silty clay. Apedal massive*. Soil strength is weak, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*.	
B4	130 - 140 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *Very gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth. Coloured stones.*	

B5	140 - 150 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B6	150 - 160 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *Moderately gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *No roots. Boundary is sharp and smooth*.	
B7	160 - 180 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth*.	

C	180 cm +	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Mixture of size class gravels.*	


HB7/1
HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 5, 2024 1:42 PM	*HB10/7*	
Millie	*Flats closest to stream*	
overcast, calm	*Possible rabbit burrow at 70cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 714

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09209636, 168.75452343

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	20 cm	Groundcover: Mixed pasture	
A	0 - 20 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and smooth.*	
B1	20 - 45 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, sandy clay loam. Apedal massive.* Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

B2	45 - 90 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. No mottles, non-sticky, slightly plastic, silty clay. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*.	
B3	90 - 105 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Very gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
B4	105 - 145 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels*. No *mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Much the same as 3rd horizon.*	

C	145 cm +	*Moist, 10YR 6/3 (pale brown)* coloured soil. *Very gravelly, angular, coarse gravel.*	


HB13/5
HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 4:00 PM	*HB11/3*	
Millie	*Farmland*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 688

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09526211, 168.75478687

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	35 cm	Groundcover: Pasture	
A	0 - 35 cm	*Slightly moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and occluded.*	
B	35 - 85 cm	*Slightly moist, 10YR 5/6 (yellowish brown)* coloured soil. *Moderately gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive.* Soil strength is firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth.*	

C	85 - 180 cm	*Moderately moist, 10YR 7/2 (light grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is hard, aggregate strength is slightly firm and brittle. *No roots. Quite concreted from 85cm and large rocks.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 4, 2024 4:46 PM	*HB12/4*	
Millie	*Base of alluvial fan*	
fine, calm	*Likely landslide material from 70cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 680

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.09549271, 168.75602208

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Browntop and ryegrass	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is sharp and occluded. Earthworms observed*	

B	25 - 50 cm	*Moist, 10YR 5/6 (yellowish brown)* coloured soil. *Very gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Many fine roots. Boundary is sharp and smooth*.	
C	50 - 90 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Moderately gravelly, angular, boulders. No mottles, non-sticky, non-plastic, loamy clay. Apedal massive*. Soil strength is firm, aggregate strength is slightly firm and brittle. *Few fine roots. Very large boulders 30cm wide. Hard to dig down with digger.*	


HB9/6
HB6/8
HB10/7
HB5/9
HB11/3
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 5, 2024 10:08 AM	*HB13/5*	
Millie	*Lower fan*	
overcast, calm	*At hydraulic sites, the was a ranging amount of gravels. Several holes were dug to find non gravelly soils to do unsats. Unable to conduct saturated tests*	
Soil Core # (if collected)	Top soil:	Sub soil: 850

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.0873764, 168.75717342

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Pasture	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is sharp and smooth.*	

B1	25 - 45 cm	*Moist, 10YR 6/2 (light brownish grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is weak, aggregate strength is weak and very friable. *Few fine roots. Boundary is sharp and smooth*. *Some occlusions.*	
B2	45 - 60 cm	*Moist, 10YR 5/2 (greyish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth*.	
B3	60 - 75 cm	*Moist, 10YR 7/1 (light grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	

B4	75 - 90 cm	*Moist, 10YR 4/1 (dark grey)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and smooth*.	
B5	90 - 105 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, medium sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
B6	105 - 145 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, fine sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable.*Few fine roots. Boundary is sharp and smooth. A layer of fine gravels through the middle, uncompacted.*	

C	145 - 180 cm	*Moist, 10YR 6/1 (grey)* coloured soil. *Very gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Mixture of size class gravels.*	


HB2/15
HB1/14
HB7/1
HB13/5
HB9/6
HB6/8
HB10/7
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 6, 2024 12:23 PM	*HB14/12*	
Millie	*Lower flats beside Jacks Point entrance driveway*	
overcast, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 730

Soil	Barrhill 42a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Moderately Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.07694565, 168.7601236

Horizon	Depth (cm)	Description	Image
Topsoil	25 cm	Groundcover: Pasture/browntop	
A	0 - 25 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is sharp and occluded.*	

B1	25 - 90 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth*. *Oxide staining layers throughout the b horizon.*	
C	90 - 100 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth*.	
B2	100 - 180 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *No roots. Iron oxide staining layers at 110-125cm.*	


HB17/13
HB16/10
HB14/12
HB15/11
HB2/15
HB1/14
Eagle Technology, LINZ
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LEI Soil Profile Description

June 6, 2024 10:36 AM	*HB15/11*	
Millie	*Flat alluvial fan*	
fine, calm	*Gravels beyond 180cm*	
Soil Core # (if collected)	Top soil:	Sub soil: 689

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.07883283, 168.76397055

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	25 cm	Groundcover: Poor pasture	
A	0 - 25 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy.* Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and smooth.*	
B1	25 - 50 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive.* Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Some occlusions*	

B2	50 - 70 cm	*Dry, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Many fine roots. Boundary is sharp and smooth*.	
B3	70 - 110 cm	*Dry, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *Few fine roots. Boundary is sharp and smooth*.	
C1	110 - 145 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	

C2	145 - 160 cm	*Slightly moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. apedal single grain*. Soil strength is very weak, aggregate strength is very weak and very friable. *No roots. Boundary is sharp and smooth*. *Mixed size gravels and sand.*	
C3	160 - 180 cm	*Moderately moist, 10YR 5/4 (yellowish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots.*	


HB17/13
HB16/10
HB14/12
HB15/11
HB2/15
HB1/14
HB7/1
Eagle Technology, LINZ
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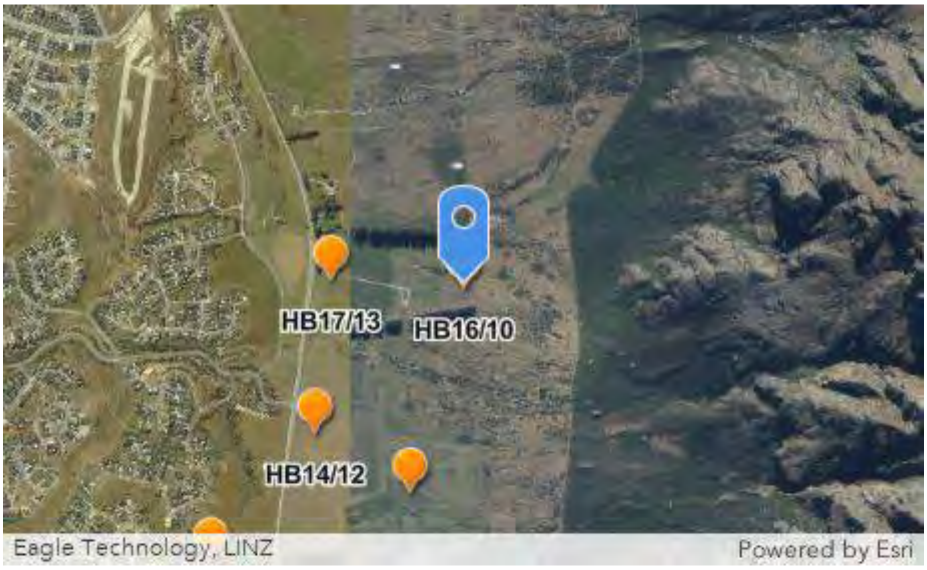
LEI Soil Profile Description		
June 6, 2024 8:53 AM	*HB16/10*	
Millie	*Alluvial fan in deer paddock*	
overcast, calm	*Topsoil core at 80mm due to gravels*	
Soil Core # (if collected)	Top soil: 672	Sub soil: 687

Soil	Pigburn 1a.1
NZSC	Weathered Fluvial Recent Soils (RFW)
Drainage	Well Drained below (Fundamental Soil Layer)
Location (NZGD2000)	-45.07288304, 168.76664941

Horizon	Depth (cm)	Description	Image
Topsoil	20 cm	Groundcover: Poor pasture	
A	0 - 20 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Many fine roots. Boundary is indistinct and smooth.*	
B	20 - 170 cm	*Moist, 10YR 5/4 (yellowish brown)* coloured soil. *Extremely gravelly, sub-angular, boulders. No mottles, non-sticky, non-plastic, sandy loam. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Common fine roots. Roots down to 70cm. Very mixed grades of gravels not well stratified. Site is at base of mountains on possible fan.*	


HB17/13
HB16/10
HB14/12
Eagle Technology, LINZ
Powered by Esri

LEI Soil Profile Description		
June 6, 2024 2:21 PM	*HB17/13*	
Millie	*Turnip paddock*	
overcast, calm	*Farmer mentioned that this paddock experiences overflow drainage and springs can pop up in winter. this is confirmed with the presence of mottles*	
Soil Core # (if collected)	Top soil:	Sub soil: 739

Soil	Barrhill 42a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Moderately Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.07240964, 168.76113465

Horizon	Depth (cm)	Description	Image
Topsoil	40 cm	Groundcover: Turnips	
A	0 - 40 cm	*Moist, 10YR 4/2 (dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Few fine roots. Boundary is sharp and occluded. Many worms and bioturbation into subsoil.*	

B1	40 - 90 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Thin layer of small gravels at 55-60cm. Mottling throughout b horizon.*	
B2	90 - 100 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Extremely gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal single grain*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Boundary is sharp and smooth*.	
B3	100 - 140 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. Common fine 10YR 5/8 mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Organic staining from roots. Boundary is sharp and smooth*.	

C	140 - 170 cm	*Moist, 10YR 6/3 (pale brown). Extremely gravelly, angular, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *No roots. Mixed size of gravels and sand.*	


HB17/13
HB16/10
HB14/12
Eagle Technology, LINZ
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LEI Soil Profile Description

June 7, 2024 9:57 AM	*HB18/16*	
Millie	*Flats closest to farm house*	
overcast		
Soil Core # (if collected)	Top soil:	Sub soil: 707

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.05969167, 168.7594749

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Browntop	
A	0 - 30 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *Very slightly gravelly, angular, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is weak and friable. *Common fine roots. Boundary is abrupt and occluded.*	
B1	30 - 65 cm	*Moist, 10YR 6/4 (light yellowish brown)* coloured soil. *Very slightly gravelly, angular, fine gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is indistinct and occluded.*	

B2	65 - 95 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. No *gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is weak and brittle. *Few fine roots. Boundary is sharp and smooth. Some occlusions from above.*	
C	95 - 185 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. *Extremely gravelly, sub-rounded, very coarse gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is firm, aggregate strength is weak and friable. *No roots. Ranging sizes of gravels up to boulders. Seam of iron coating at 120-130cm but same material. Water drains away easily.*	


HB18/16
HB19/17
Eagle Technology, LINZ
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LEI Soil Profile Description		
June 7, 2024 11:16 AM	*HB19/17*	
Millie	*Elevated flats*	
fine, calm		
Soil Core # (if collected)	Top soil:	Sub soil: 898

Soil	Wakapitu 1a.1
NZSC	Typic Immature Pallic Soils (PIT)
Drainage	Well Drained (Fundamental Soil Layer)
Location (NZGD2000)	-45.06198426, 168.76333246

Horizon	**Depth (cm)**	**Description**	**Image**
Topsoil	30 cm	Groundcover: Browntop	
A	0 - 30 cm	*Moist, 10YR 3/2 (very dark greyish brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal earthy*. Soil strength is slightly firm, aggregate strength is slightly firm and friable. *Common fine roots. Boundary is distinct and occluded.*	
B1	30 - 75 cm	*Moist, 10YR 6/6 (brownish yellow)* coloured soil. *Slightly gravelly, sub-rounded, medium gravel. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *Few fine roots. Boundary is sharp and smooth. Patches of gravels at around 45-55cm. Topsoil occlusions down to 70cm.*	

B2	75 - 93 cm	*Moist, 10YR 7/2 (light grey)* coloured soil. *Extremely gravelly, sub-angular, medium gravel. No mottles, non-sticky, non-plastic, coarse sand. Apedal single grain*. Soil strength is weak, aggregate strength is weak and friable. *Few fine roots. Boundary is sharp and smooth. Potential slip material.*	
C	93 - 190 cm	*Moist, 10YR 6/3 (pale brown)* coloured soil. *No gravels. No mottles, non-sticky, non-plastic, silt loam. Apedal massive*. Soil strength is slightly firm, aggregate strength is slightly firm and brittle. *No roots. Seams of iron coatings throughout the horizon as well as a darker orange seam at 128cm but not a hard pan. No gravels struck at 190cm.*	


HB18/16
HB19/17
Eagle Technology, LINZ
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APPENDIX B

Landcare Research Soil Reports

Environmental Chemistry Laboratory
Analytical Report – Soils

Manaaki Whenua – Landcare Research
Riddet Rd, Massey University Campus, Private Bag 11052, Palmerston North 4442
Phone: +64 6 353 4800

Job number: LJ24009

Date received: 15 July 2024

Customer: Henry van der Vossen, Lowe Environmental Impact
PO Box 4667, Palmerston North 4442

Date reported: 14 August 2024

Notes: Samples were dried and ground by the MW-LR Physics Laboratory in Palmerston North.

Analysis was carried out between the 17th and 26th of July 2024.

Client ID	Sample No.	Air dry soil water content (calculation)* (%)	Phosphate retention (method 132) (%)
738 HB 7/1	M24/0598	1.1	22
829 HB 8/2	M24/0599	1.4	17
688 HB 11/3	M24/0600	0.8	12
680 HB 12/4	M24/0601	1.4	8
850 HB 13/5	M24/0602	0.7	6
697 HB 9/6	M24/0603	0.8	12
714 HB 10/7	M24/0604	0.9	0
693 HB 6/8	M24/0605	1.3	16
691 HB 5/9	M24/0606	1.8	33
687 HB 16/10-2	M24/0607	1.2	21
689 HB 15/11	M24/0608	0.8	17
730 HB 14/12	M24/0609	1.4	22
739 HB 17/13	M24/0610	1.4	25
903 HB 1/14	M24/0611	1.7	29
832 HB 2/15	M24/0612	1.3	29
707 HB 18/16	M24/0613	1.5	25
898 HB 19/17	M24/0614	1.2	18

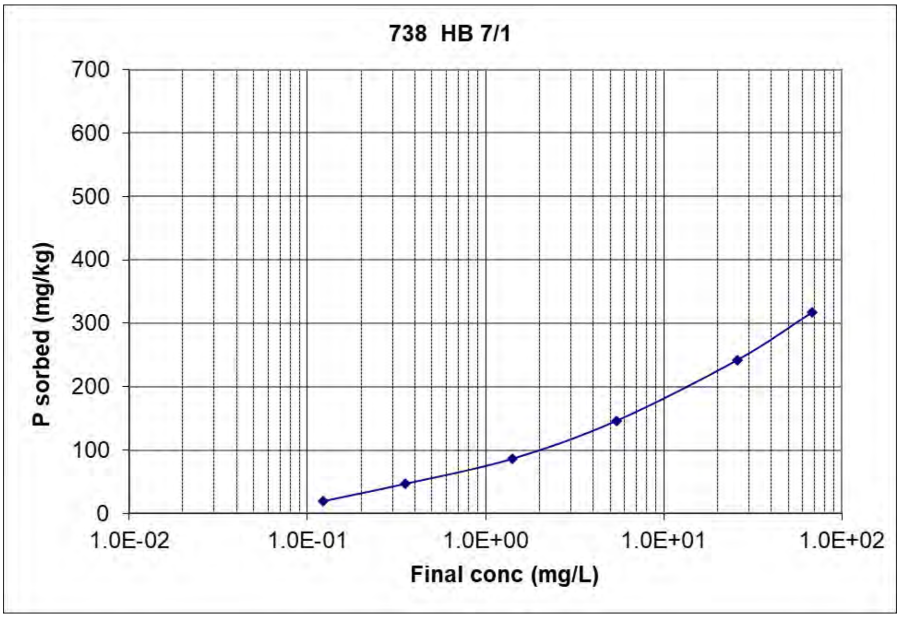
[redacted]

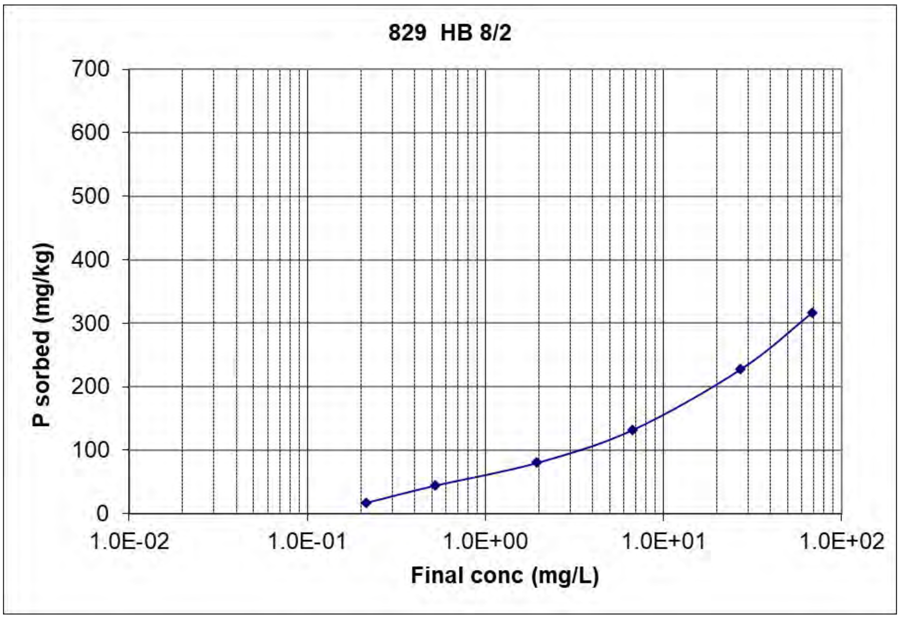
Ngaire Foster, Lab Manager

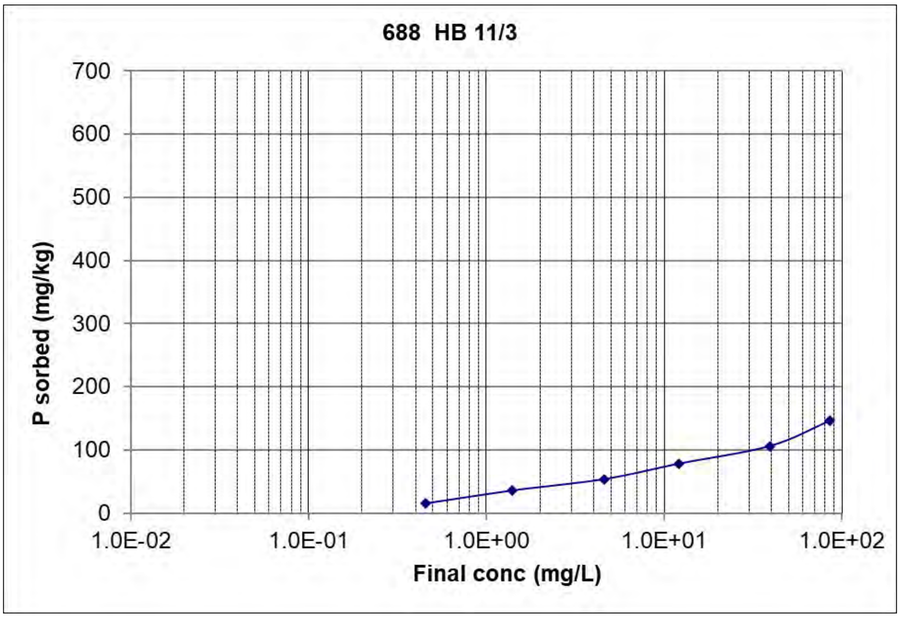
Results apply to the samples as received and are expressed on an oven-dry (105°C) basis. Details of method codes are available online at https://www.landcareresearch.co.nz/partner-with-us/laboratories-and-diagnostics/environmental-chemistry-laboratory/soil-testing. This report may not be reproduced, except in full, without the consent of the signatory.

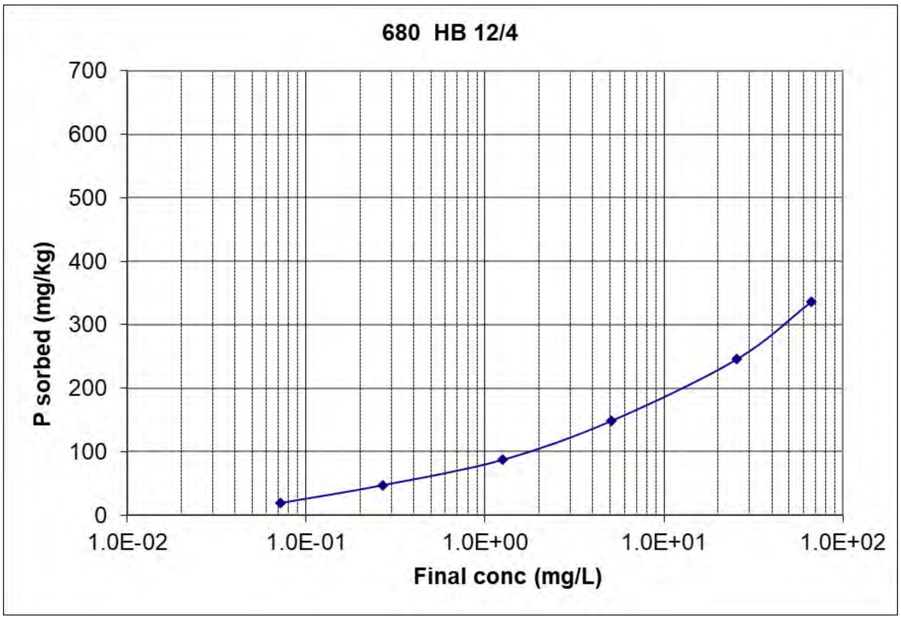
Client ID	Sample No.	Final conc with 2 mg/L added (method 134) mg/L	Final conc with 5 mg/L added (method 134) mg/L	Final conc with 10 mg/L added (method 134) mg/L	Final conc with 20 mg/L added (method 134) mg/L	Final conc with 50 mg/L added (method 134) mg/L	Final conc with 100 mg/L added (method 134) mg/L
738 HB 7/1	M24/0598	0.12	0.36	1.41	5.42	25.8	68.2
829 HB 8/2	M24/0599	0.22	0.52	1.94	6.74	27.2	68.3
688 HB 11/3	M24/0600	0.45	1.40	4.60	12.1	39.4	85.4
680 HB 12/4	M24/0601	0.07	0.27	1.26	5.10	25.4	66.4
850 HB 13/5	M24/0602	0.42	1.53	4.51	12.1	37.5	82.3
697 HB 9/6	M24/0603	0.23	1.13	3.90	11.3	38.2	84.5
714 HB 10/7	M24/0604	0.28	1.13	4.10	11.0	37.1	80.0
693 HB 6/8	M24/0605	0.08	0.23	1.06	4.57	23.9	61.4
691 HB 5/9	M24/0606	0.02	0.05	0.23	1.07	8.78	36.4
687 HB 16/10-2	M24/0607	0.61	1.28	2.99	8.04	29.4	72.6
689 HB 15/11	M24/0608	0.11	0.47	1.94	7.41	30.8	72.9
730 HB 14/12	M24/0609	0.05	0.23	0.93	4.14	23.1	63.0
739 HB 17/13	M24/0610	0.01	0.10	0.42	2.15	17.0	53.2
903 HB 1/14	M24/0611	0.01	0.12	0.38	1.90	15.2	48.4
832 HB 2/15	M24/0612	0.03	0.10	0.34	1.72	14.8	50.2
707 HB 18/16	M24/0613	0.06	0.23	0.90	3.79	21.7	59.3
898 HB 19/17	M24/0614	0.02	0.24	1.16	5.07	24.9	65.9

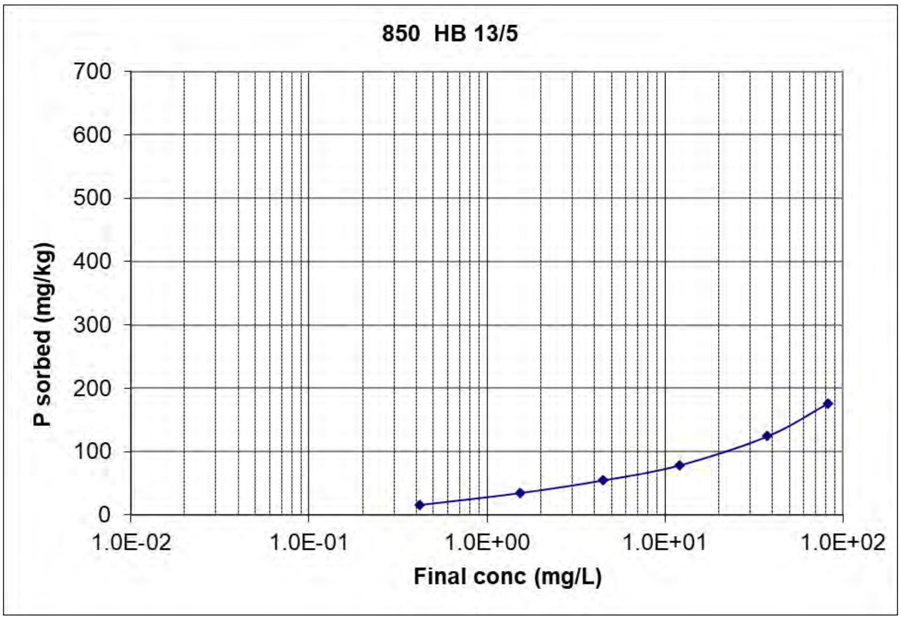
Client ID	Sample No.	P sorbed with 20 mg/kg added (method 134) (mg/kg)	P sorbed with 50 mg/kg added (method 134) (mg/kg)	P sorbed with 100 mg/kg added (method 134) (mg/kg)	P sorbed with 200 mg/kg added (method 134) (mg/kg)	P sorbed with 500 mg/kg added (method 134) (mg/kg)	P sorbed with 1000 mg/kg added (method 134) (mg/kg)
738 HB 7/1	M24/0598	19	46	86	146	242	318
829 HB 8/2	M24/0599	18	45	81	133	228	317
688 HB 11/3	M24/0600	15	36	54	79	106	146
680 HB 12/4	M24/0601	19	47	87	149	246	336
850 HB 13/5	M24/0602	16	35	55	79	125	177
697 HB 9/6	M24/0603	18	39	61	87	118	155
714 HB 10/7	M24/0604	17	39	59	90	129	200
693 HB 6/8	M24/0605	19	48	89	154	261	386
691 HB 5/9	M24/0606	20	50	98	189	412	636
687 HB 16/10-2	M24/0607	14	37	70	120	206	274
689 HB 15/11	M24/0608	19	45	81	126	192	271
730 HB 14/12	M24/0609	19	48	91	159	269	370
739 HB 17/13	M24/0610	20	49	96	178	330	468
903 HB 1/14	M24/0611	20	49	96	181	348	516
832 HB 2/15	M24/0612	20	49	97	183	352	498
707 HB 18/16	M24/0613	19	48	91	162	283	407
898 HB 19/17	M24/0614	20	48	88	149	251	341


738 HB 7/1
P sorbed (mg/kg)
0
100
200
300
400
500
600
700
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


829 HB 8/2
P sorbed (mg/kg)
0
100
200
300
400
500
600
700
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


688 HB 11/3
P sorbed (mg/kg)
0
100
200
300
400
500
600
700
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Final conc (mg/L)


680 HB 12/4
P sorbed (mg/kg)
0
100
200
300
400
500
600
700
Final conc (mg/L)
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02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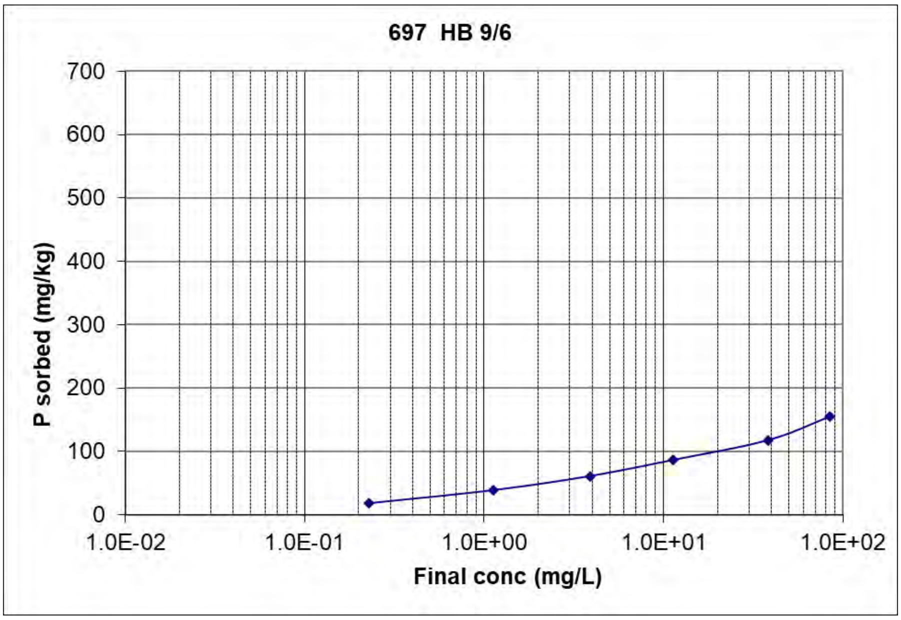
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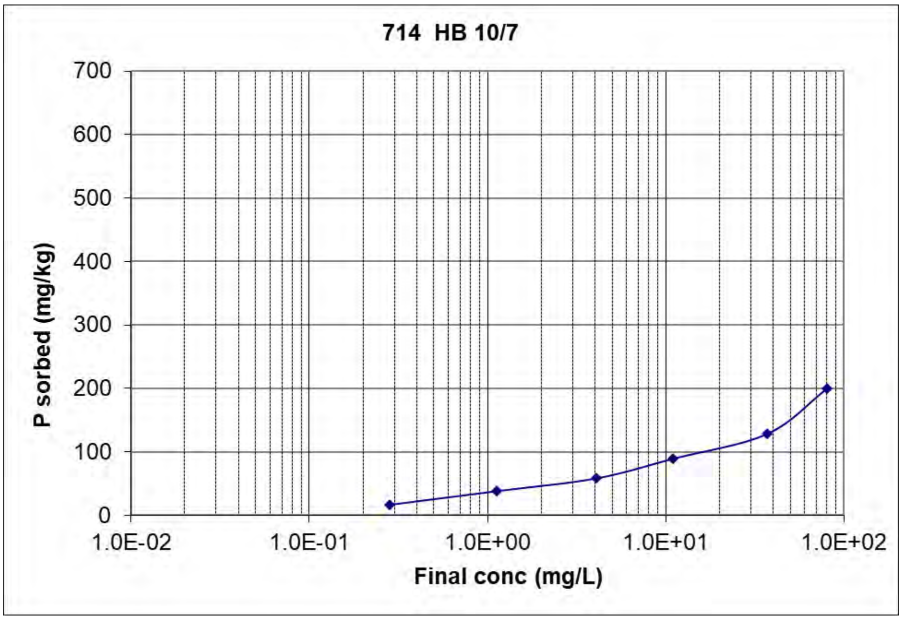
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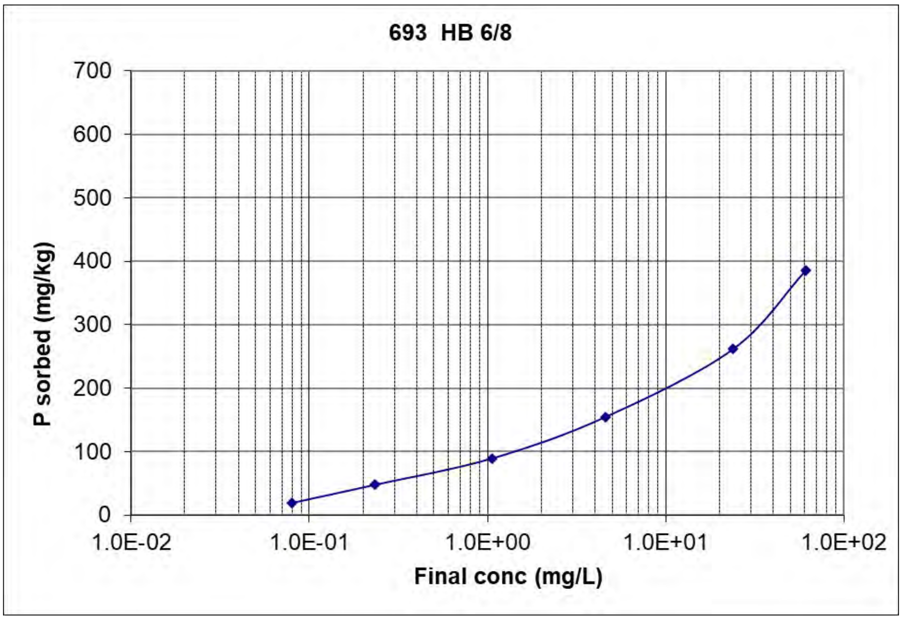
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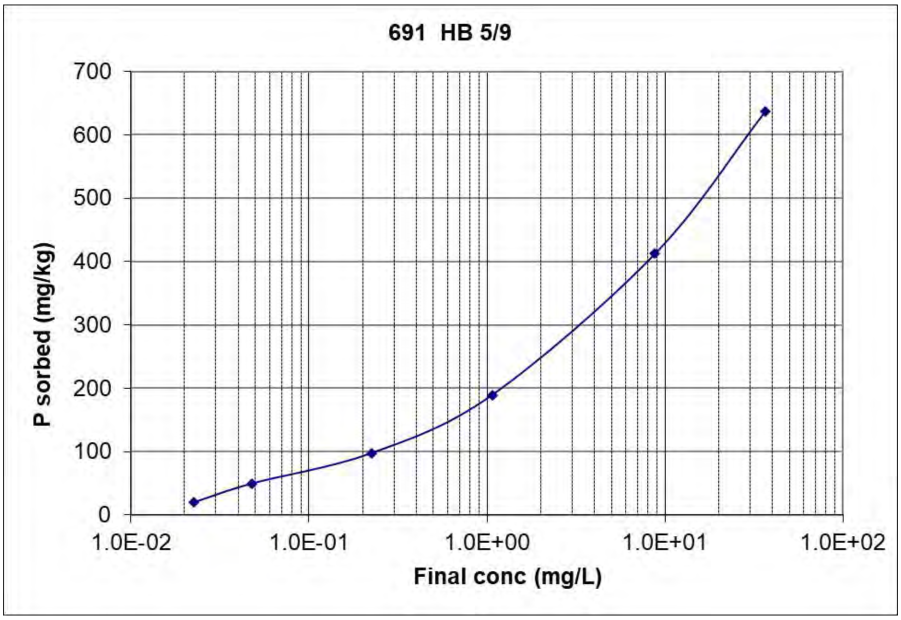
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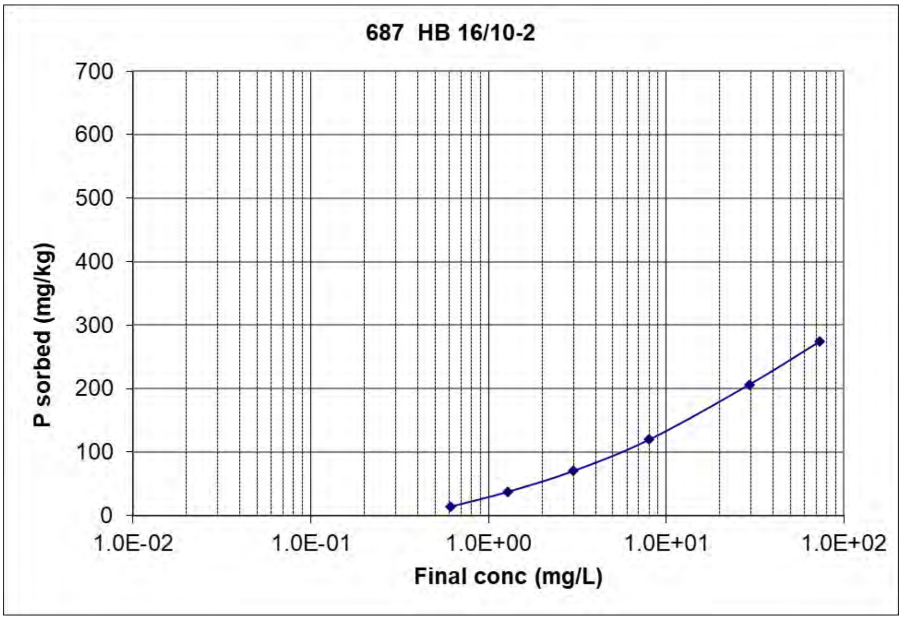
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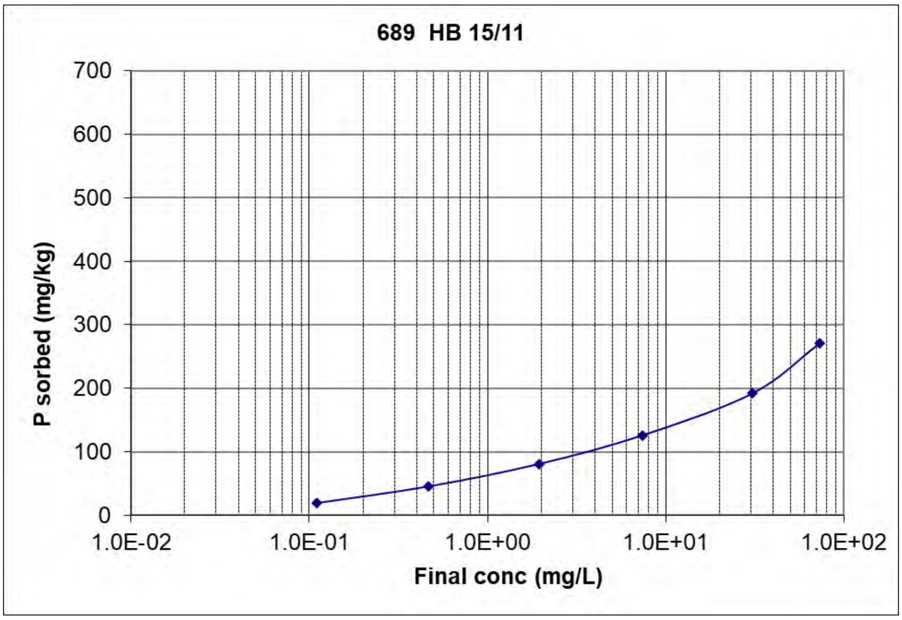
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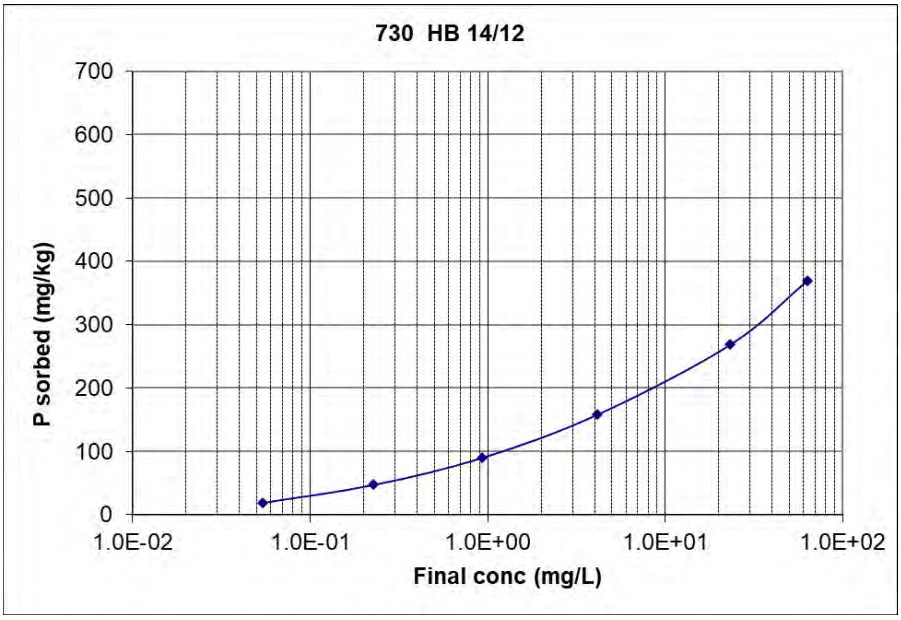
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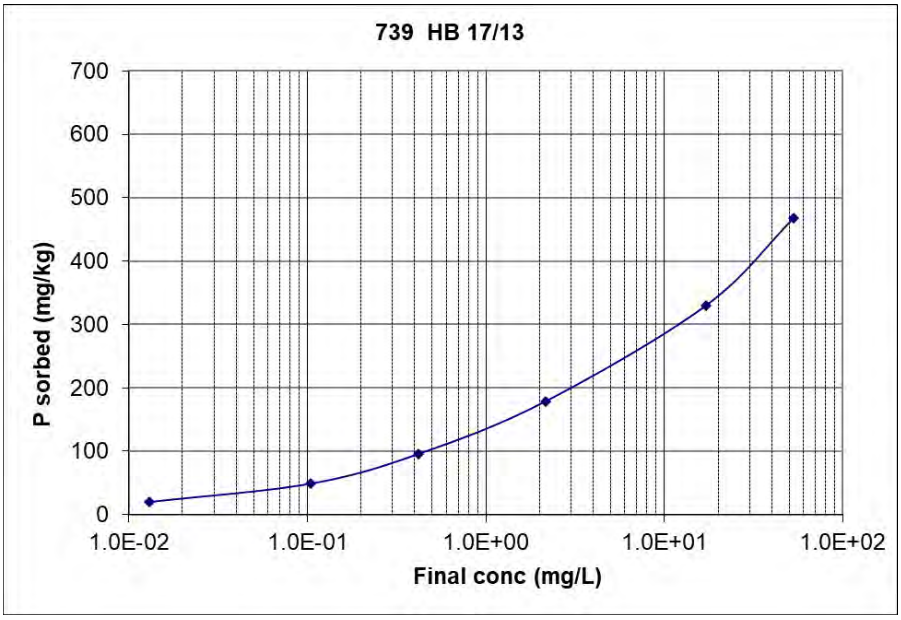
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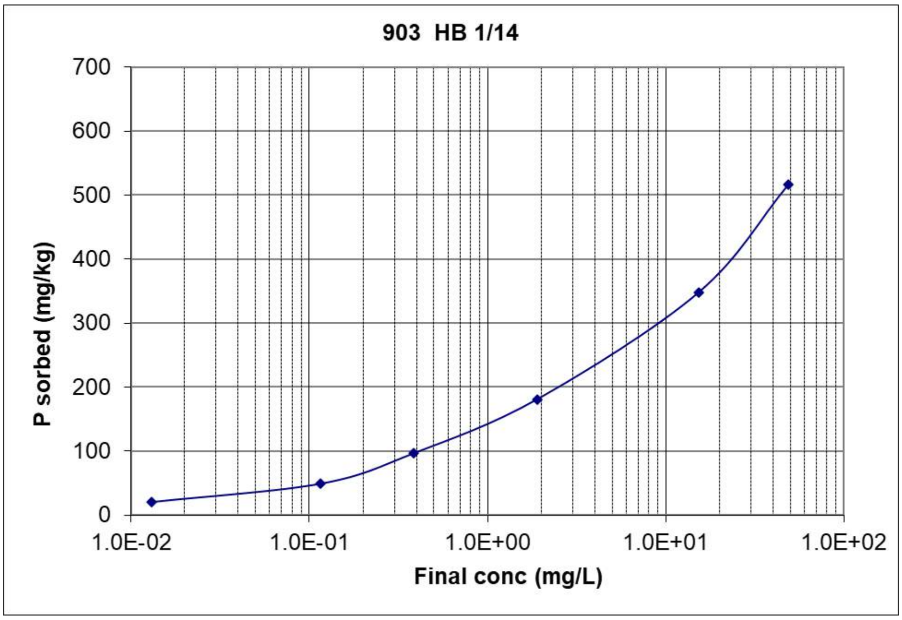
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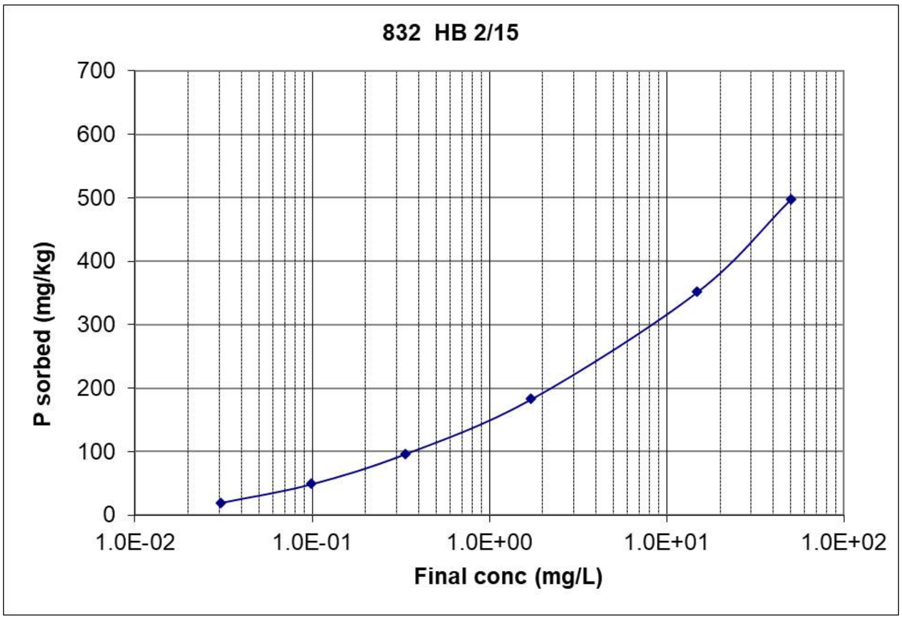
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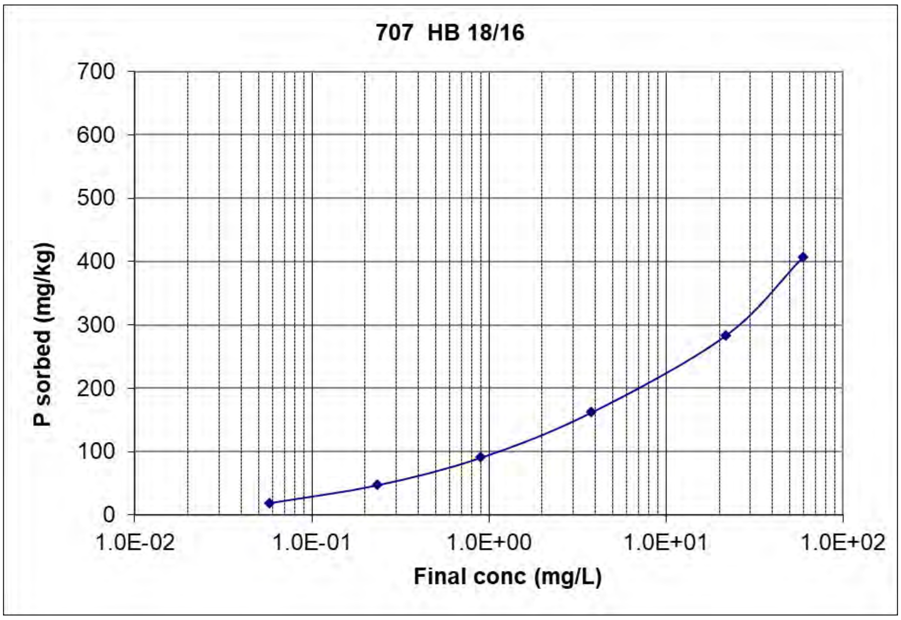
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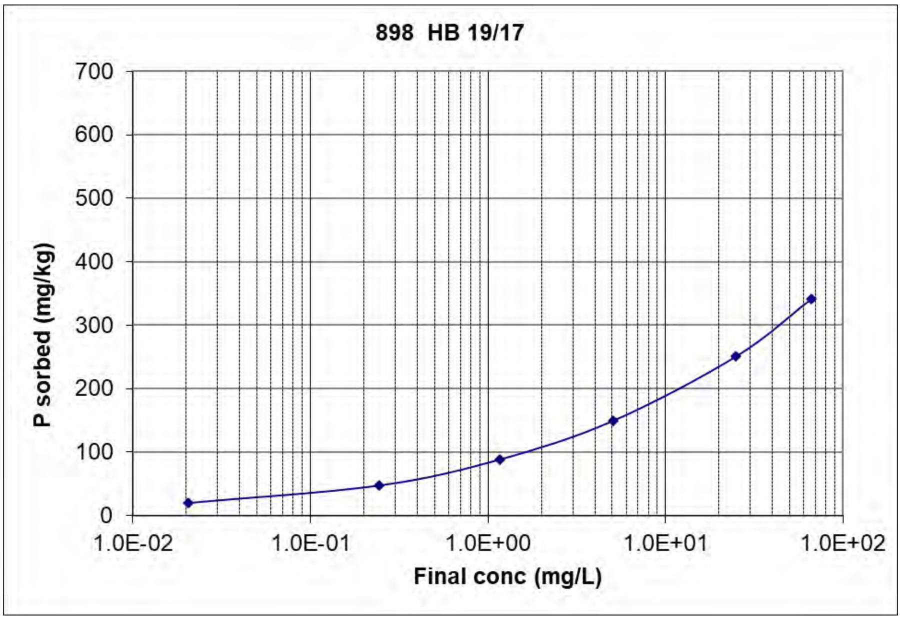
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Final conc (mg/L)

Soil Physics Laboratory
Analytical Report

Manaaki Whenua – Landcare Research
Riddet Rd, Massey University Campus,
Private Bag 11052, Palmerston North 4442
Phone: +64 6 353 4800

Job number: PJ23052

Customer: Lowe Environmental Impact
Millie Taylor

Date received: 10 June 2024

Date Analysed: 8 July 2024 to 29 July 2024

Date reported: 13 August 2024

Homestead Bay

Sample name	Core number	ID number	Remarks	Particle density (g/cm^3)	Dry bulk density (g/cm^3)	Porosity (%)	Macro-Porosity (-5 kPa) (%)	Air Capacity (-10 kPa) (%)	Field capacity (%)	AWC (%)	K-40 (mm/hr)
HB 7/1	738	PP23-1730	1	2.72	1.60	41	13	15	27	15	4
HB 8/2	829	PP23-1731		2.72	1.28	53	16	20	33	26	-
HB 11/3	688	PP23-1732		2.79	1.49	47	13	16	30	21	14
HB 12/4	680	PP23-1733		2.75	1.43	48	11	14	34	29	-
HB 13/5	850	PP23-1734		2.80	1.34	52	10	16	37	27	14
HB 9/6	697	PP23-1735		2.82	1.33	53	8	12	41	37	-
HB 10/7	714	PP23-1736		2.78	1.44	48	10	13	35	31	13
HB 6/8	693	PP23-1737		2.67	1.43	47	15	17	29	24	32
HB 5/9	691	PP23-1738		2.68	1.32	51	15	18	33	24	-
HB 16/10-2	687	PP23-1740		2.76	1.33	52	15	18	34	26	-
HB 15/11	689	PP23-1741		2.80	1.36	52	13	16	36	31	20
HB 14/12	730	PP23-1742		2.82	1.45	49	9	10	38	26	3
HB 17/13	739	PP23-1743		2.77	1.27	54	12	14	40	29	-
HB 1/14	903	PP23-1744		2.65	1.30	51	11	16	35	24	-
HB 2/15	832	PP23-1745		2.69	1.34	50	14	19	31	23	15
HB 18/16	707	PP23-1746		2.77	1.33	52	14	17	35	23	26
HB 19/17	898	PP23-1747		2.79	1.41	50	13	15	34	24	-

Remarks: 1) Large stones removed from lower surface and backfilled

Sample name	**Gravimetric water content (%w/w)**					**Volumetric water content (%w/w)**				
	As received moisture	Saturation (calc.)	5 kPa	10 kPa	1500 kPa	As received moisture	Saturation (calc.)	5 kPa	10 kPa	1500 kPa
HB 7/1	12	26	18	17	7	20	41	28	27	12
HB 8/2	18	41	29	26	5	24	53	37	33	7
HB 11/3	11	31	23	20	6	17	47	34	30	9
HB 12/4	16	34	26	24	4	23	48	37	34	5
HB 13/5	12	39	32	27	7	16	52	43	37	10
HB 9/6	12	40	34	30	2	16	53	45	41	3
HB 10/7	13	33	26	24	3	19	48	38	35	4
HB 6/8	17	33	22	20	4	24	47	31	29	6
HB 5/9	16	39	27	25	7	22	51	36	33	9
HB 16/10-2	19	39	28	25	6	26	52	37	34	8
HB 15/11	17	38	28	26	4	23	52	39	36	5
HB 14/12	20	33	28	26	8	29	49	40	38	12
HB 17/13	28	43	34	32	9	36	54	43	40	11
HB 1/14	19	39	31	27	8	24	51	40	35	10
HB 2/15	17	38	27	23	7	22	50	36	31	9
HB 18/16	20	39	28	26	8	26	52	38	35	11
HB 19/17	18	35	26	24	8	26	50	37	34	11

Macro-porosity cited here is determined between total porosity and tension of -5 kPa, for consistency with the National Soils Database of New Zealand (NSD).
Air Capacity cited here is determined between total porosity and tension of -10 kPa. This may be referred to as Macro-porosity for specifications requiring this characteristic to be measured at -10 kPa. It is important to be aware what tension has been used, particularly with historical or NSD

References:
Gradwell, M.W. 1972: Methods for physical analysis of soils. *Scientific Report 10C.* Lower Hutt, N.Z. Soil Bureau.
Cook FJ, Lilley GP, Nunns RA 1993. Unsaturated hydraulic conductivity and sorptivity: Laboratory measurement. In: Carter MR ed. Soil sampling and methods of analysis. Boca Raton, FL, Lewis Publishers. Pp. 615–624.

[redacted]

Shane Cox
Laboratory Manager – Soil Physics

APPENDIX F

Overseer Modelling Memo

LOWE
Environmental
Impact

MEMORANDUM **Job** **10934**

To: Brian Ellwood

From: Jimena Rodriguez

Date: 17 December 2024

Subject: **OVERSEER Nutrient Modelling for Homestead Bay**

This memo summarises the OverseerFM nutrient modelling outcomes for the baseline (current farm system) and two scenarios that modelled the discharge of wastewater from a 'residential and commercial development' at RCL's Homestead Bay.

The baseline data was provided by Matt Little, who is the farm manager for both properties. Attachment A is the farm map provided by Matt indicating the boundary of the farm. The properties are operated together and have been modelled as a single operating unit.

BASELINE NUTRIENT LOSS RATES

The baseline Overseer input Data used in the nutrient modelling is provided in the following tables.

Table 1: Overseer Blocks and Area

Block	Property	Area (ha)
Dryland flats	QEII	135
Hill	QEII	400
Irrigation	QEII	80
Lot 8	RCL	134
Lot 12	RCL	36
Lucerne	RCL	13.4
Young grass	QEII	18
Barley	RCL	16.7
Bush	QEII	25.5
Trees	QEII	43.4

Table 2: Baseline Fertiliser Inputs

Blocks	Area (ha)	Fertiliser and Application Rate
Young grass	18	- Cropzeal: 250 kg/ha in Spring - Lime: 1-3 tonnes in Spring - DAP sulphur super: 125 kg/ha in spring - Urea- rate assumed 55 kg N/ha in April
Swedes	10	- Cropzeal: 250 kg/ha in Spring - DAP sulphur super: 125 kg/ha in spring
Dryland flats	125	- DAP sulphur super: 125 kg/ha in spring Urea- rate assumed 55 kg N/ha in October and March
Hill	400	- Super 10: 125 kg/ha in late winter - Lime: 1-3 tonnes in Spring
Irrigation	80	- DAP sulphur super: 125 kg/ha in spring
Airstrip -Barely	16.7	- Cropzeal and some urea Rate assumed to 80 kg N/ha in September and November

Table 3: Baseline Stock

	Sheep			Beef					Deer
Month	Ewes	Hoggets	Lambs	Cows	Steer	Heifers	Rep Heifers	Bulls	Hinds
July	1,800	520		110	65	65	25	4	840
Aug	1,800	520		110	65	65	25	4	840
Sep	1,780	520	2,520	110	65	65	25	4	840
Oct	1,770	520	2,520	110	65	65	25	4	840
Nov	1,670	520	2200	110	65	65	25	4	840
Dec	1,650	520	1,800	110	65	65	25	4	840
Jan	1,500	520	1,500	110	65	65	25	4	840
Feb	1,375	450	1,100	110	65	65	25	4	840
Mar	1,350	-	400	110	65	65	25	4	840
Apr	1,800	520	150	110	65	65	25	4	840
May	1,800	520		110	65	65	25	4	840
Jun	1,800	520		110	65	65	25	4	840

Table 4: Baseline Supplements and Crops

Crop Type	Harvest Block		Destination	Amount Made (T)	Animals Fed
Barley	Airstrip		Most Blocks	120	Deer
Baleage	Irrigation		Most Blocks	650 bales	Most
Swedes	Cattle yards			110	Weaners

- Irrigation block:
  - 80 ha
  - Application depth 52 mm
  - Irrigation from November to March

SCENARIOS

1. RCL:
   - In this scenario, the Wastewater from the residential development is discharged to A1, A2, A3 and A4 at RCL property (see map in Appendix B for the identification and location of each area).
   - The number of animals is reduced proportional to the reduction in the total area available for grazing, keeping the stock unit per ha similar to the baseline. In this Scenario, Lot 8 (165 ha) is a house block (residential development); the rest of Lot 8 and 12 (8 ha) will be landscaped lawns mowed at least twice a year, with the grass will be collected.
   - The area (ha) and average annual discharge depth (mm/day) where the WW is discharged is summarised in Table 5 below:

Table 5: Areas of Discharge and Discharge Depth

Overseer Block Groups	Land Treatment Area's	Area (ha)	Average Discharge Depth (mm/d)	Design Flow Rate (m3/day)	Annual Flow Rate (m3/year)
Area 1	C3, C4, C5 and JP buffer-grazed	4.5	5.4	250	89,089
Area 2	C1, C2, A, D, E, F, G	11.6	7.1	820	299,554
Area 3	H,I,J,K,L	7.2	7.1	515	187,716
Area 4	JP Village	5.2	8.0	420	152,005
Total		**28.5**	**7.0**	**2,005**	**728,364**

   - Table 6 summarises the N and P loading (kg/ha) per month that is discharged in Areas groups 1 to 4. The nutrient loading and discharge depth are the same for the four areas. Therefore, it is summarised as A1 to A4. The nitrogen is provided in the model as organic fertiliser.

Table 6: Total N and P Applied (kg/ha) in Irrigation Wastewater

Area 1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	167	151	167	162	167	162	167	167	162	167	162	167	1,971
Nitrogen Loading kg	57	51	57	55	57	55	57	57	55	57	55	57	668
N Loading kg/ ha	12.6	11.3	12.6	12.2	12.6	12.2	12.6	12.6	12.2	12.6	12.2	12.6	148
P Loading kg	19	17	19	18	19	18	19	19	18	19	18	19	223
P Loading kg/ ha	4	4	4	4	4	4	4	4	4	4	4	4	49

Area 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	220	199	220	213	220	213	220	220	213	220	213	220	2,592
Nitrogen Loading kg	191	172	191	185	191	185	191	191	185	191	185	191	2,247
N Loading kg/ ha	16.5	14.9	16.5	16.0	16.5	16.0	16.5	16.5	16.0	16.5	16.0	16.5	194
P Loading kg	64	57	64	62	64	62	64	64	62	64	62	64	749
P Loading kg/ ha	6	5	6	5	6	5	6	6	5	6	5	6	65

Area 3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	220	199	220	213	220	213	220	220	213	220	213	220	2,592
Nitrogen Loading kg	120	108	120	116	120	116	120	120	116	120	116	120	1,408
N Loading kg/ ha	16.5	14.9	16.5	16.0	16.5	16.0	16.5	16.5	16.0	16.5	16.0	16.5	194
P Loading kg	40	36	40	39	40	39	40	40	39	40	39	40	469
P Loading kg/ ha	6	5	6	5	6	5	6	6	5	6	5	6	65

Area 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/year
Application depth ADW (mm/ha)	248	224	248	240	248	240	248	248	240	248	240	248	2,920
Nitrogen Loading kg	97	87	97	94	97	94	97	97	94	97	94	97	1,140
N Loading kg/ ha	18.6	16.8	18.6	18.0	18.6	18.0	18.6	18.6	18.0	18.6	18.0	18.6	219
P Loading kg	32	29	32	31	32	31	32	32	31	32	31	32	380
P Loading kg/ ha	6	6	6	6	6	6	6	6	6	6	6	6	73

- Supplements:

  The management for the Area 1 group is grazed by sheep or planted in native forestry, while Area 2, 3 and 4 are operated as cut & carried; baleage will be harvested four times per year, removing approximately 10 t DM/ha/yr.

OVERSEER OUTCOMES

The nutrient loss for the baseline farmed area total, the RCL blocks of the current system and the proposed RCL total subdivision and Land treatment areas are presented in Table 7.

Table 7: Total Losses for Baseline and the Scenario

	Total losses				
Analyses	**N (kg/y)**	**N (kg/ha/y)**	**P(kg/y)**	**P (kg/ha)**	**GHG (t)**
Year 2023-2024 (Baseline)	8,039	9.0	128	0.1	3,121.7
RCL- baseline*	1,839	9.1			
RCL LTA	2,052	10.2	62	0.3	91.9

* refers to the total N losses/y from those located at RCL (Lot 8, lucerne, barley and Lot 12)

Table 8 illustrates the nutrient loss rates for the individual blocks, which comprise the RCL area during the current farming period as a baseline and the proposed housing development.

Table 8: Nitrogen Losses Per Block for the Baseline and RCL-LTA

	Blocks	**Blocks area (ha)**	**Total N loss (kg/y)**	**N leaching (kg/ha/y)**	**Total P Loss (kg/y)**	**P Loss (kg/ha/yr)**
Year 2023-2024 Baseline	Lot 8	134	1,188	9	4	0.1
	Lucerne	13.4	148	10.8	0	0.1
	Barley	16.7	284	16.9	1	0.1
	Lot 12	36	219	6.5	2	0.1
	N losses from lucerne, barley lot 8 and lot 12		*1,839*	9.1	7	0.1
RCL LTA	Area 1- C3, C4, C5, JP Buffer - grazed	4.5	411	91.6	16	3.4
	Area 2- C1, C2, A, D, E, F, G	11.6	582	50.1	14	1.2
	Area 3 - i, H, J, K, L	7.2	352	48.5	9	1.2
	Area 4 - JP Village	5.2	311	60	6	1.3
	Lot 8 and 12 other areas	8	24	3	0	
	Lot 8 housing	165	371	2	16	0.1
	N losses		2,052	10.2	61	0.3

COMMENTS

Year 2023-2024- Baseline (original farm system)

- In the baseline, there are 10 blocks: Dryland flat, Hill, Irrigation, Lot 8, Lot 12, Lucerne, Young grass, Barley, Swedes, Bush and Scrub.
- The N losses per ha for the baseline equals to 9.0 kg N/ha.
- The total N losses from the baseline is **8,039 kg N/y**.
- Total N losses from RCL-specific Blocks, Lot 8, Lot 12, Lucerne, and Barley blocks equal **1,839 kg N /y**. These blocks are the only blocks kept in the Scenario below (RCL- LTA) with WW applied.

RCL- LTA

- WW volume discharged per year equals to 728,364 m^3/yr or averaging 1,996 m^3/day.
- In the RCL development scenario, WW is discharged to four areas (A1 to A4) which are located in Lot 8 and 12.
- The N loss per ha for the full development area equals 10.2 kg N/ha.
- The total N losses for this scenario equals to **2,052 kg N/y** (212 kg N/yr higher than the RCL baseline model), where WW will be discharged.
- A RCL housing development block was added to the model, which is the block where the houses will be built. N losses from this block are equal to 371 kg N/yr.

With WW applied to Areas 1, 2, 3 and 4, the total N losses increased by 212 kg N/yr (1,839 kg N/yr compared to 2,052 kg N/yr).

Table 9 compares the N losses permitted by the ORC Water Plan (RWP)[1] and the N losses obtained from OverseerFM. The N losses predicted by Overseer is 2,052 kg N/y, which is 986 kg N/y lower than the amount permitted without consent by the RWP (3,038 kg N/y).

Table 9: Permitted N Losses by the RWP and N losses Modelled by OverseerFM

Block	Property	Area (ha)	Permitted N Loss (15 kg N/ha/y)	Modelled loss (kg N/y)
Lot 8 and Lot 12	RCL	8	120	24
Lot 8 housing	RCL	165	2,475	371
A1 to A4	RCL	28.5	428	1,656
Total		200.1	**3,038**	**2,052**

*This is the total amount lost from A1, A2, A3, A4 and area from lot 12 modelled by Overseer

---

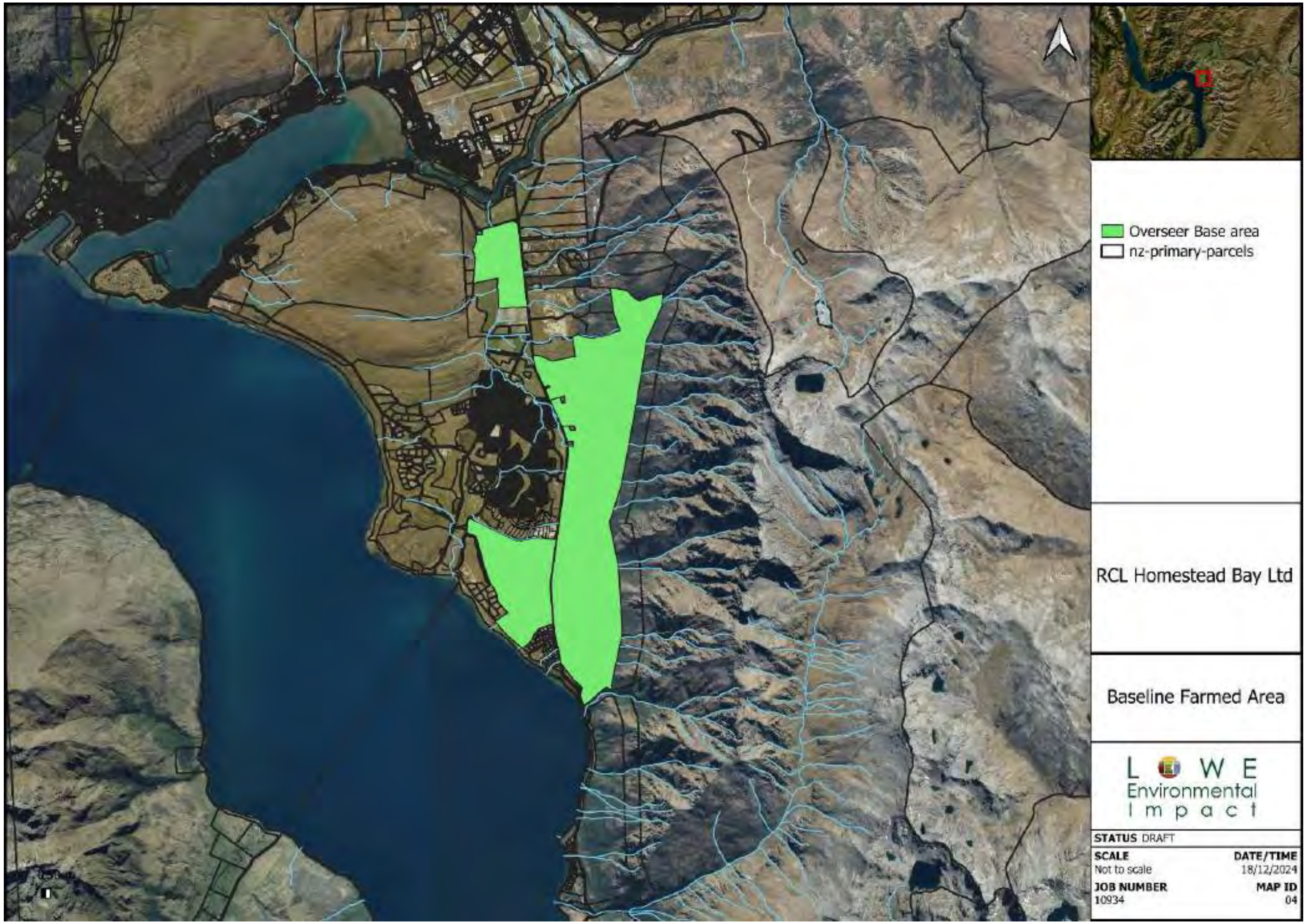
[1] ORC Regional Plan: Water for Otago (RPW) Plan

APPENDICES

Appendix A	Farm Map
Appendix B	Identification and Location of the LTA at RCL Property

APPENDIX A

Farmed Area Maps

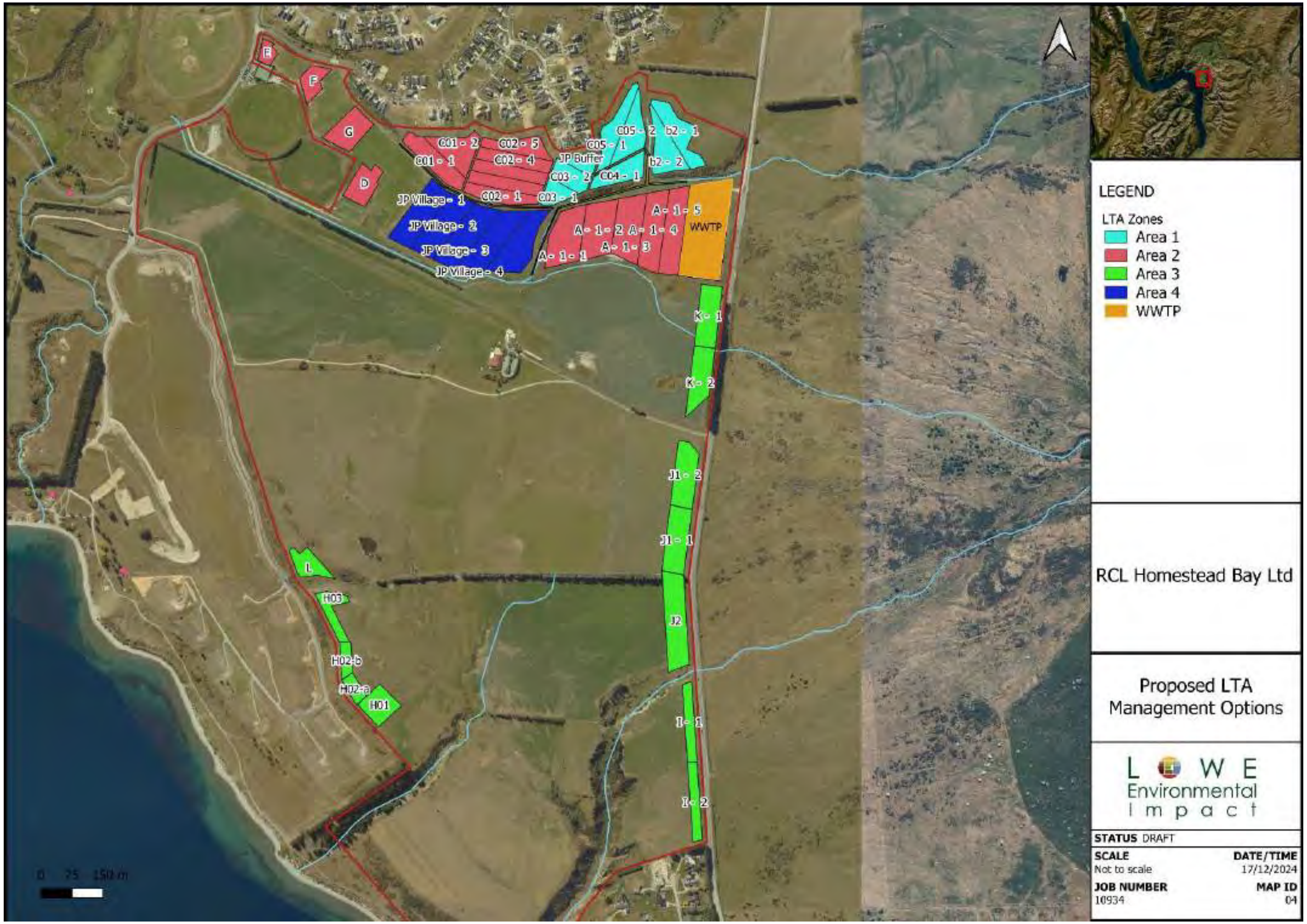


Appendix A: Baseline Farmed Area

Appendix A: Paddock Map

APPENDIX B

Identification and Location of the LTA at RCL



Appendix B: Proposed Land Treatment Areas

APPENDIX G

Surface and Groundwater Monitoring Location Plan

MEMORANDUM Job 10934

To: Dan Wells, RCL Ltd

From: Brian Ellwood, LEI

Date: 17 September 2025, 3rd version

Subject: HOMESTEAD BAY DEVELOPMENT
GROUNDWATER AND SURFACE WATER QUALITY MONITORING PLAN

This memo outlines the proposed groundwater and surface water quality monitoring plan.

INTRODUCTION

This Groundwater and Surface Water Quality Monitoring Plan (Water Quality Monitoring Plan) has been developed for RCL Limited for the RCL Homestead Bay development Site. This groundwater and surface water quality monitoring plan is a part of the Assessment of Environmental Effects (AEE) report that has been prepared for the consent application. The plan has been updated to reflect the agreed changes following the ORC review of the application.

Purpose and Scope

The Water Quality Monitoring Plan has been developed to monitor for changes in groundwater and surface water quality as a result of the land application of wastewater in the designated LTAs in the RCL Homestead Bay development site.

The Water Quality Monitoring Plan includes baseline data and ongoing operational data collection and analysis. A monitoring program related to monitoring water quality in the groundwater and surface water level has been developed separately as a component of the Assessment of the Environmental Effects (AEE) of the RCL Homestead Bay development site. The purpose of the Water Quality Monitoring Plan is to demonstrate compliance of the land application of the treated wastewater with that assessed.

Moreover, the monitoring program is proposed to ensure that the proposed activities are conducted in a manner that protects and maintains the current level of water quality necessary to sustain existing water uses.

These uses include groundwater for drinking water supplies and the adjacent surface waters that support both aquatic life/biological diversity and recreational opportunities.

Surrounding Surface Waters

There are three ephemeral water courses crossing the site, namely Water Course 1, Water Course 2 and Māori Jacks stream Tributary. The surface water courses inside the site are ephemeral.

The below-ground applied wastewater will drain vertically and is not expected to enter any surface waterways within the development area. The sensitive surface water bodies identified with the application and AEE are the lower reaches of Māori Jack Stream and Lake Wakatipu.

To select the locations for the surface water and groundwater monitoring, the Figure 1 and Figure 2 were considered. The locations of sampling have been given in Figure 3 (surface water and groundwater).

Monitoring Locations for Surface Water

Monitoring of surface water and groundwater quality will be carried out at designated locations across the site. Surface water quality will be assessed within Lake Wakatipu at SMP-4, SMP-5, and SMP-6 (Figure 3) through the observation of relevant parameters. These sites are the same as those associated with Jack's Point wastewater discharge consent.

Monitoring is proposed within Māori Jack Stream at two locations within the Mid and Lower reaches. The following detailed conditions provide for these sampling locations:

Prior to commencing construction, the following surface water quality monitoring programme shall commence in Māori Jack Stream and Lake Wakatipu:

a. Monthly sampling of Māori Jack Stream at the two locations shown on the plan Figure 3. The "Lower" site is for attainment of water quality criteria defined in conditions.

   The "Mid" site is to provide a dataset that may assist with understanding nutrient transport and transformation processes occurring in the anaerobic wetland mid-section of Māori Jack Stream, hence potentially assisting future interpretation of results and reporting when acting in accordance with conditions requiring an Assessment Report and a Remedial Action Plan

   Sampling of the "Lower" site need only occur if, at the time of each monthly field visit, there is continuous connected surface water flowing in the lower-most 100 m of Māori Jack Stream down to the landward edge of the gravel beach barrier, but not necessarily through the barrier to Lake Wakatipu.

   Sampling of the "Mid" site need only occur if, at the time of each monthly field visit, there is surface water present at the site.

   The samples must be analysed for:
   - *i. Escherichia coli;*
   - ii. Total phosphorus,
   - iii. Dissolved reactive phosphorus
   - iv. Total nitrogen;
   - v. Nitrate-nitrogen;

vi. Ammoniacal nitrogen;
vii. Total Kjeldahl nitrogen;
viii. Dissolved inorganic nitrogen
ix. Dissolved metals (copper, lead, zinc) at the lower site only
x. pH; and
xi. Conductivity

c. Monthly sampling of the Lake Wakātipu lake margin at three locations 5 metres from the lakeshore at 0.5 metres depth, at the locations SMP-4, SMP-5, SMP-6 shown on the plan attached Figure 3. The samples must be analysed for:
   i. Chlorophyll-a;
   ii. Water clarity;
   iii. Escherichia coli;
   iv. Total phosphorus;
   v. Total nitrogen;
   vi. Nitrate-nitrogen;
   vii. Ammoniacal nitrogen;
   viii. Total Kjeldahl nitrogen;
   ix. Calculation of Lake Trophic Level Index (TLI).
   x. Dissolved metals (copper, lead, zinc) – at the one central site only (SMP5) on Homestead Bay waterfront;
   xi. pH and;
   xii. Conductivity.

d. For each monthly monitoring visit the following conditions must be recorded as a minimum:
   i. Date and time samples taken;
   ii. Weather conditions including wind speed at time each sample is taken, as recorded at near real time on Otago Regional Council's website for the mid-lake Wakatipu monitoring buoy "Open Water 10 m" site;
   iii. Preceding general weather conditions over the week prior to sampling including general description of rainfall in that week;
   iv. Description and photograph of each sampling site and the state of the gravel beach barrier at the mouth of Māori Jack Stream to Lake Wakatipu.

Monitoring Locations for Groundwater

The groundwater monitoring network will include samples from dedicated monitoring bores.

Groundwater monitoring will occur at locations' P1, P5, P6, P7, and P8 (P= Piezometer) as shown in Figure 3. This sampling location will be established prior to construction commencing. Bore P1 is associated with the Jacks Point consents and is required to be drilled and monitored by Jacks Point if the concentration of nitrogen in P3 is 1.5 mg/l greater than the upgradient monitoring bore (P4).

Within three months of the exercising of this consent, the consent holder shall obtain representative samples of the groundwater from the piezometers installed under Condition 3 (f) and 5 (d) of this consent.

Sampling of groundwater at the site in January, April, July, October each year only needs to occur if the bores are not dry.

Sample location	Parameters	Monitoring Frequency
The groundwater from bores P1, P3, P4, P5, P6, P7 and P8 and bores added under condition 5(d)	(a) Nitrate nitrogen *(b) Escherichia coli* (c) Groundwater level	January, April, July and October each year

The results of these samples shall be reported to the Otago Regional Council annually. If the Consent Holder is not granted permission to establish or sample from the bores P3, or P4, P14 or loses access to the site/s at any time during the exercise of this consent, the Consent Holder is not required to collect a sample. An alternative sampling location may be proposed and agreed by the Otago Regional Council.

Sampling locations may be progressively established as site development progresses.

REPORTING

All collected samples will be submitted to accredited laboratories using approved sampling methods, and results will be assessed against the consented parameter limits to ensure compliance.

Note: If monitoring results are below consented levels, no mitigation is necessary.

Follow the commissioning of the wastewater treatment plant, the Consent Holder shall forward an annual report in writing to the Consent Authority by 1 September each year. The annual report will cover the preceding calendar year 1 July to 30 June and report on compliance with the consent conditions.

As a minimum, the report shall include:
a) A copy of all analytical results for the year;
b) A summary of the year's monitoring results, in context of the previous years' results;
c) Comments on compliance with the conditions of this discharge permit;
d) Details of the cut and carry operation including the number of harvests, mass harvested, N concentration of herbage;
e) A summary of complaints received, the validity of each complaint and the corrective action taken;
f) A summary of any malfunctions or breakdowns and the corrective action taken; and
g) Any other issues considered relevant by the consent holder.

If there are exceedances of water quality triggers, a remedial action plan and reports are required. The following details are required.

i. Prepare a report for the Consent Authority by 31 August of the same year as the breach. The report must be prepared by an appropriately qualified and experienced freshwater ecologist.
   The report must include, but is not limited to:
   a. Changes in the nutrient concentrations in any groundwater monitoring bores;
   b. Changes in nutrient concentrations or ecological conditions in Māori Jack Stream;
   c. Changes in nutrient concentrations or ecological conditions in the near-shore (5 metre) margins of Lake Wakatipu within the 1.8 km stretch of shoreline between Māori Jack Stream and the jetty at the end of Lakeshore Drive in Drift Bay;
   d. Chlorophyll-a levels in the lake margin and potential for phytoplankton blooms;
   e. Comparison of parameters to relevant regional plan criteria and guidelines where relevant.
ii. Relationship of any changes observed as listed above with monitoring over the same time period of Homestead Bay wastewater treatment plant effluent quality and the application rate of effluent to land treatment areas.

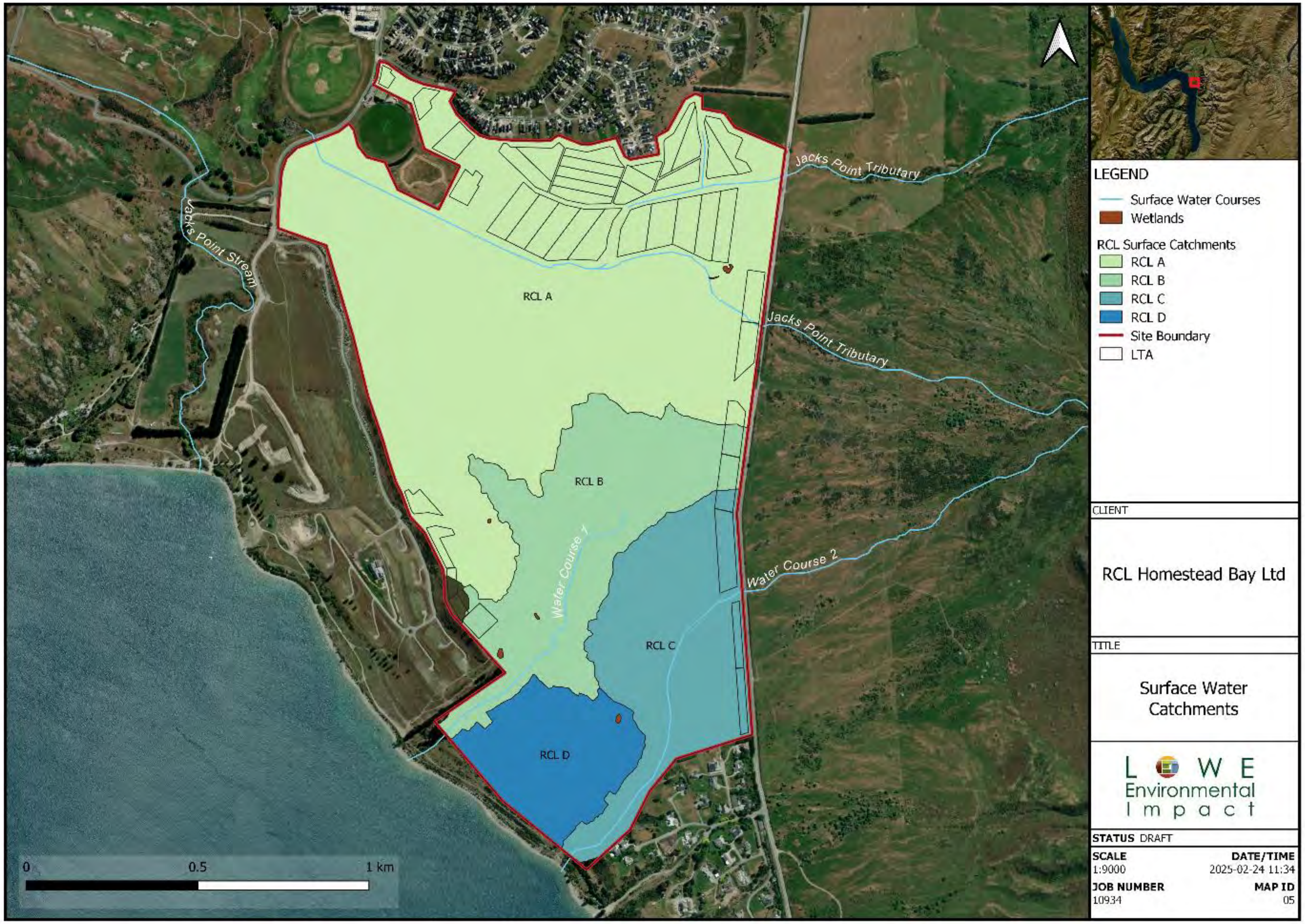


Figure 1: Surface Water Features

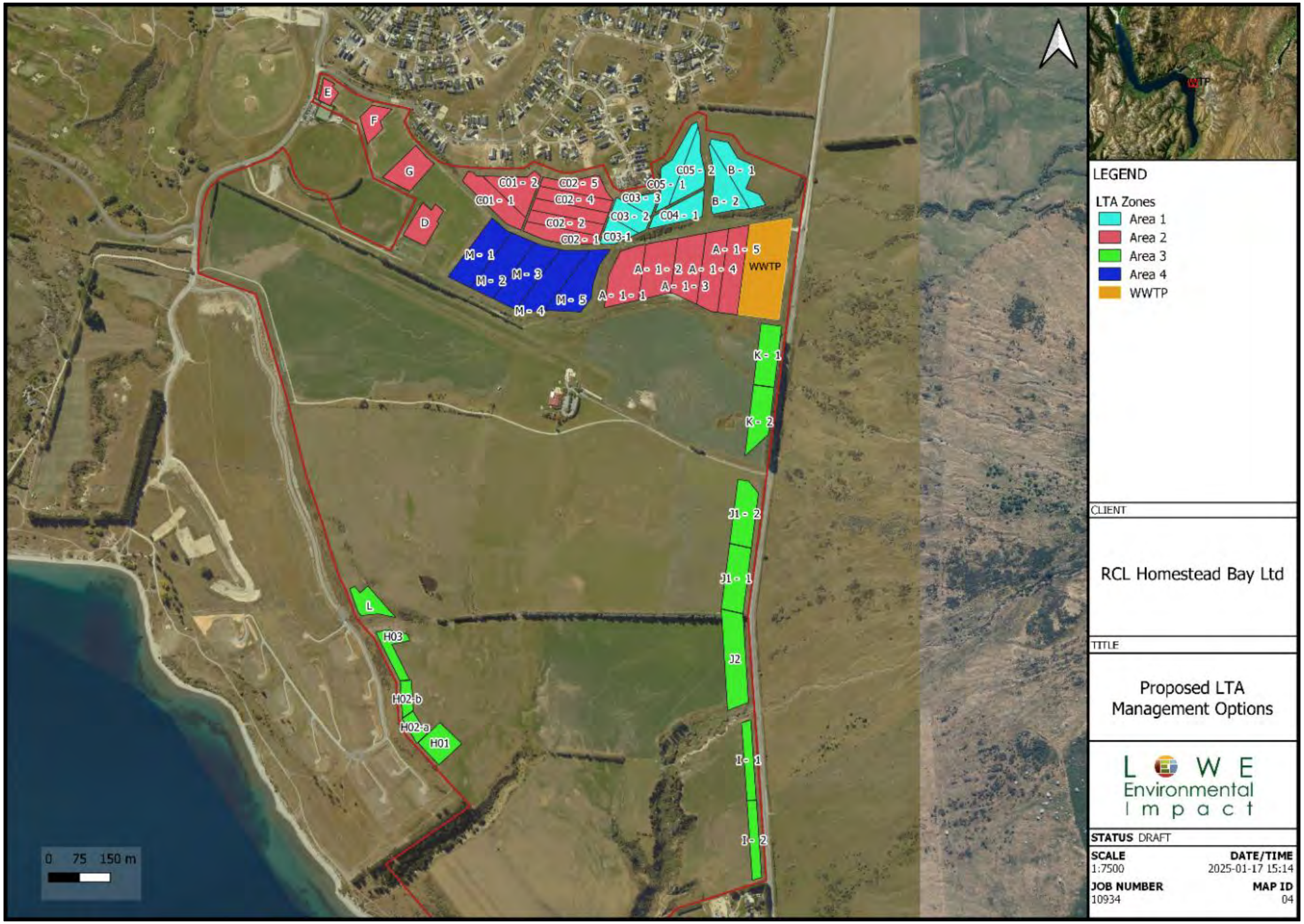


Figure 2: LTA of the RCL Homestead Bay development

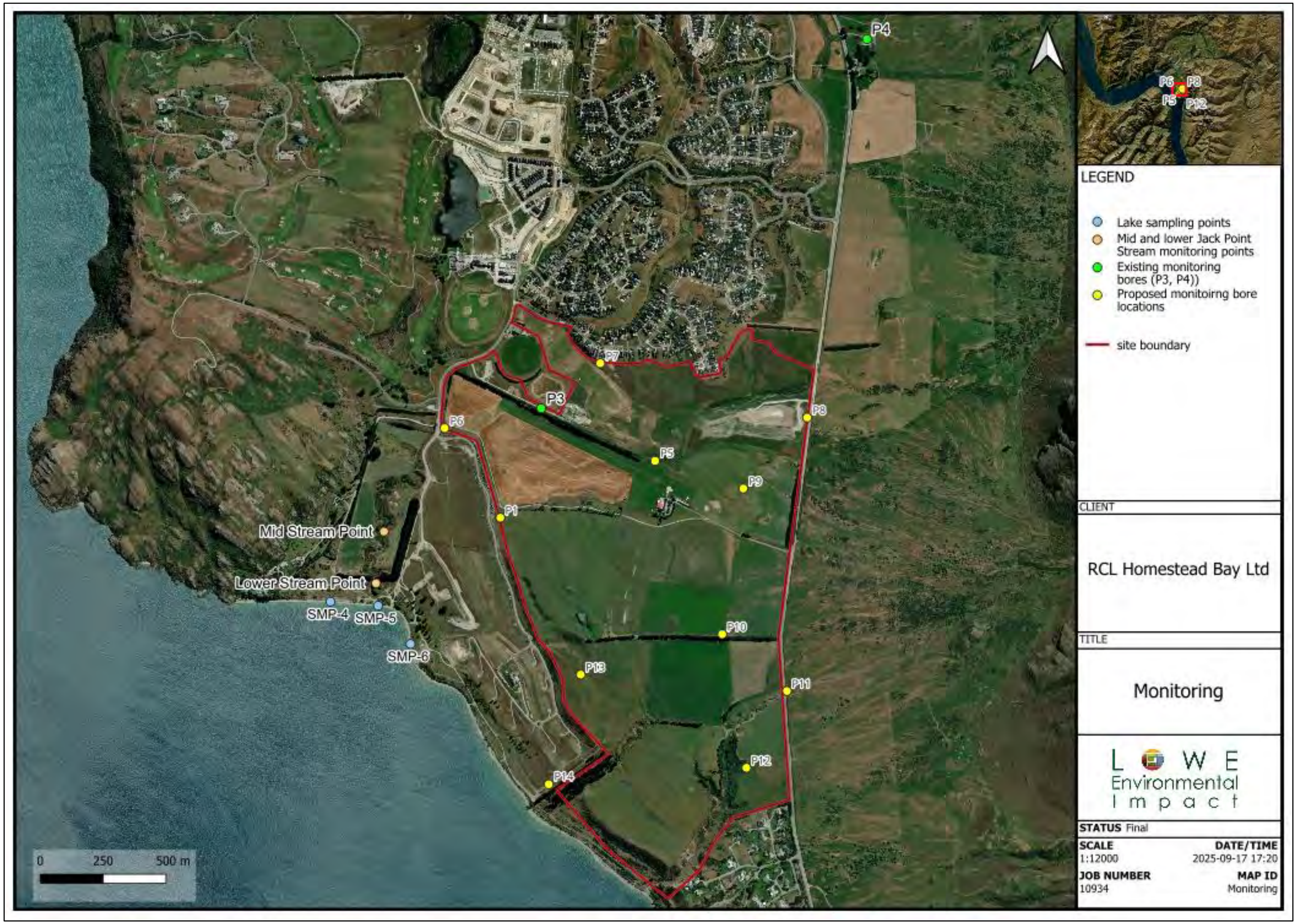


Figure 3: Proposed Location of Sampling Sites for Surface Water and Groundwater Monitoring

APPENDIX H

Wildland Consultants Ltd
Wetland Assessment

Wetland Assessment at Homestead Bay, Queenstown

Contract Report No. 7483a

Providing outstanding ecological services to sustain and improve our environments

Wildlands

Wetland Assessment at Homestead Bay, Queenstown

Contract Report No. 7483a

February 2025

Project Team:

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Kelvin Lloyd - Report review

Prepared for:

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Reviewed and approved for release by:

[redacted]

Kelvin Lloyd
Senior Principal Ecologist
Wildland Consultants Ltd
14/02/2025

Cite this report as follows:

Wildland Consultants (2025). *Wetland Assessment at Homestead Bay, Queenstown.* Wildland Consultants Contract Report No. 7483a. Prepared for RCL Homestead Bay Limited. 54pp.

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NET ZERO CARBON Organisation ekos

1.0 Introduction

Remarkable Planning, on behalf of RCL Henry Downs Limited, is preparing a Fast Track resource consent application for a residential subdivision on approximately 41 hectares of rural land at Homestead Bay, just south of Jacks Point in Queenstown, Otago (Figure 1). The gently sloping site has been farmed for many decades and is largely vegetated in exotic pasture, but also contains small areas of tūmatakuru/matagouri (*Discaria toumatou*) shrublands, gullies with ephemeral streams, and possibly small natural inland wetlands. Previous aquatic and terrestrial ecology assessments have been undertaken for the site, but further assessments of natural inland wetlands are now also required.

RCL Homestead Bay Limited has commissioned Wildland Consultants Ltd (Wildlands) to identify any wetlands present and determine whether these would be exempt from the definition of a natural inland wetland under Clause 3.21(e) of the National Policy Statement for Freshwater Management (Ministry for the Environment 2020b).

2.0 Project Scope

The scope of this project includes:

- Identification of any wetlands within the proposed development.
- Determine if any wetlands present meet the definition of a natural inland wetland under Clause 3.21 of the National Policy Statement for Freshwater Management (NPS-FM; October 2024 amendments).

3.0 Relevant Legalisation

3.1 Wetland definitions

Wetlands have been defined in the Resource Management Act (RMA, ‘the Act’), as outlined below.

Wetland – permanently or intermittently wet areas, shallow water, and land/water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions, including within the coastal marine area.

The National Policy Statement for Freshwater Management (NPS-FW) defines ‘natural inland wetlands’ as outlined below.

Natural inland wetland means a wetland (as defined in the Act) that is not:

> *(a) in the coastal marine area; or*
>
> *(b) a deliberately constructed wetland, other than a wetland constructed to offset impacts on, or to restore, an existing or former natural inland wetland; or*
>
> *(c) a wetland that has developed in or around a deliberately constructed water body, since the construction of the water body; or*
>
> *(d) a geothermal wetland; or*

Figure 1. Potential wetland areas at a proposed sub-division development at a property Homestead Bay, Otago

0 200 400 m

N

Data Acknowledgment

Contains data sourced from the LINZ Data Service licensed for reuse under CC BY 4.0

Report: 7483a
Ref: 11903
Client: RCL Henry Downs Limited
Name: Figure_PotentialWetlands.aprx
Path: E:\gis\HomesteadBayQT\mxd\

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Wildlands
www.wildlands.co.nz, 0508 WILDNZ

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Date:	17/02/2025
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> *(e) a wetland that:*
>
> > *(i) is within an area of pasture used for grazing; and*
> >
> > *(ii) has vegetation cover comprising more than 50% exotic pasture species (as identified in the National List of Exotic Pasture Species using the Pasture Exclusion Assessment Methodology (see clause 1.8)); unless*
> >
> > *(iii) the wetland is a location of a habitat of a threatened species identified under clause 3.8 of this National Policy Statement, in which case the exclusion in (e) does not apply.*

According to this definition, the pre-requisite for an area to be classified as a natural inland wetland is for the area to meet the wetland definition under the RMA, which requires both suitable hydrological conditions and presence of plants that are adapted to wet conditions, but which must not meet any of the exceptions listed above.

4.0 Methods

4.1 Desktop analysis and considerations

An initial search was undertaken on Google Earth to identify potential wetland areas to survey.

The hydrological guidance for accurate wetland delineation recommends that site inspections should be undertaken under 'normal' hydrological conditions and within the growing season for plants in the relevant region. Normal hydrological conditions require 'normal' expected rainfall for the two to three months prior to the site inspection, and for the site inspection to not be undertaken following a period of heavy rain.

The growing season for the lower areas around Queenstown starts in September and ends in May (Ministry for the Environment 2021). This survey was undertaken within the appropriate local growing season (January and February 2025).

Rainfall for January 2025 (26.8 millimetres) was significantly lower than historical average (58.1 millimetres). Rainfall for December 2024 was higher (69.8 millimetres) than the historical average of 56.1 millimetres. Rainfall for November 2024 (57.8 millimetres) was very slightly higher than the historical average of 56.5 millimetres) (Appendix 2, Metservice 2025). The dryer than normal conditions of January 2025 were taken into consideration when assessing all potential wetlands.

The soil temperature was not measured during this assessment. Soil temperature is taken to enable the determination of the growing season. However, the growing season was determined by using the guidelines in the Wetland Hydrology Tool (Ministry for the Environment 2021).

4.2 Field survey

Site investigations were undertaken on 30 January, 3 and 4 February 2025 to assess potential wetlands. Wetland vegetation types were classified and described following the structural classes outlined in Atkinson (1985). Wetland types were classified and described following the classification outlined in Johnson and Gerbeaux (2004).

4.3 Wetland assessment

Part 1: Assess wetland status under the RMA

To define whether a wetland meets the RMA definition of a wetland, the Part 1 assessment within the defining ‘natural wetlands’ and ‘natural inland wetlands’ guidance document needs to be undertaken (Ministry for the Environment 2021). This assessment can also help define the extent of any wetland present.

The New Zealand vegetation tool for wetland delineation (Clarkson 2013) has become the standard methodology to assess the presence of plants adapted to wet conditions. This methodology classifies all plant species recorded in wetlands into five categories.

- OBL: Obligate. Almost always is a hydrophyte, rarely in uplands (estimated probability >99% occurrence in wetlands).
- FACW: Facultative Wetland. Usually is a hydrophyte but occasionally found in uplands (estimated probability 67-99% occurrence in wetlands).
- FAC: Facultative. Commonly occurs as either a hydrophyte or non-hydrophyte (estimate probability 34-66% occurrence in wetlands).
- FACU: Facultative Upland. Occasionally is a hydrophyte but usually occurs in uplands (estimated probability 1-33% occurrence in wetlands).
- UPL: Obligate Upland. Rarely is a hydrophyte, almost always in uplands (estimated probability <1% occurrence in wetlands).

Species that are classed as OBL, FACW, or FAC are considered hydrophytic and generally indicative of wetland habitat. The relative dominance of each species and corresponding classification can therefore determine whether an area should be defined as a wetland.

In accordance with the methods described in the wetland delineation protocols (Clarkson 2021, Ministry for the Environment 2020, Ministry for the Environment 2021, Ministry for the Environment 2022 and Fraser *et al.* 2013), in areas of potential wetland, the following methods were applied:

- Firstly, the Rapid wetland test was completed. For this test to confirm the area as a wetland, all dominant species must be either OBL or FACW species. If the Rapid Wetland test failed, additional hydrophytic vegetation tests are required.
- Two tests are required for the hydrophytic vegetation determination (Dominance test and Prevalence index). Representative plots (2 metre × 2 metre for herb strata, 5 metre radius circular plot for shrub strata and 10 metre circular plot for tree/forest strata) where established in different vegetation types and geomorphic positions across the site. In each plot, the species in each stratum were identified and percent cover estimated (i.e. tree, sapling/shrub, herb). Species hydrophytic categories were taken from Manaaki Whenua (2021) and the dominant species were noted. For the Dominance test to confirm the area as a wetland, >50% of the dominant species must be OBL, FACW or FAC and all/most dominant species must not be FAC.
  - For the Prevalence Index (PI) test, a plot-based algorithm derived from the unique combination of OBL–UPL plants and their cover is calculated. The vegetation is hydrophytic (wetland) if PI ≤ 3.0, but values around 3.0 can also be considered wetlands when other wetland indicators indicate wetland presence.
  - If the Dominance, and Prevalence tests failed to identify the area as a wetland, then indicators of hydric soils and wetland hydrology were taken to determine if there was wetland hydrology

present. If one of the hydrophytic vegetation tests passed and the other failed or if the result was uncertain (PI = 3.0 or Dominance test = 50%), further assessment is required.

- Methods for the soil assessment to determine hydric soils were taken from Fraser *et al.* (2013). The simple flow key (Figure 19) was followed to determine hydric soil features or other soil (or uncertain soil).

- Methods for the hydrology assessment were taken from Ministry for the Environment (2021). Wetland hydrology is determined by the presence or absence of hydrological indicators. Wetland hydrology indicators are assembled into four groups: 1) observation of flooding or groundwater; 2) evidence of flooding or ponding; 3) soil saturation; 4) landscape, vegetation and soil observations. Group 1 are primary indicators and Groups 2 to 4 have a mix of primary and secondary indicators. The presence of one primary indicator, or two secondary indicators, confirms the presence of a wetland.

- If the hydric soils and wetland hydrology tests are passed, then the definition of a wetland is met for the site under the Resource Management Act (RMA), but may not pass under the National Policy Statement for Freshwater Management (NPS-FM). If the hydric soils fail and the wetland hydrology pass, then this is also defined as a wetland. If the hydric soils pass and the wetland hydrology fail, then the area is a drained wetland or atypical environmental conditions are present. A site assessment is needed to determine the status in the latter case.

Part 2: Assessing whether a wetland is a ‘natural wetland’ or ‘natural inland wetland’ under the NPS-FM

Once a wetland has been defined under the RMA, further assessment is needed to define whether a ‘wetland’ is a ‘natural wetland’ or a ‘natural inland wetland’. The Part 2 assessment was followed within the defining ‘natural wetlands’ and ‘natural inland wetlands’ guidance document (Ministry for the Environment 2021). Exotic pasture species are noted from the National list of exotic pasture species document by Cosgrove *et al.* 2022.

5.0 Potential wetland areas

5.1 Overview

RCL Homestead Bay Limited and Remarkable Planning identified two areas of potential wetlands (Wet Area 1 and 2). An initial and brief google earth analysis was undertaken at the proposal phase of this project and another possible five wetlands were identified (Wet Areas 3-5). Three of these potential wetlands are likely to be ephemeral wetlands due to their shape and geographic position which can be seen aerially on google earth. During the field survey, another area was also suspected to be a wetland (Wet Area 6). A total of eight areas were assessed for potential wetlands (Figure 1 and Table 1). Plant species recorded within the Wet Areas are listed in Appendix 1.

All potential wetland areas identified are currently within grazed pasture (improved pasture). The clause in the NPS-FM that concludes that a wetland that ‘is within an area of pasture used for grazing’ is not a natural inland wetland does not apply to these potential wetland areas as it is being proposed for residential development.

Table 1 – Wetland delineation results summary for potential wet areas identified at Homestead Bay, Otago.

Wet Area Number	Plot Number	Hydrophytic Vegetation Test				Hydric Soils	Hydrology	RMA Wetland	Is it Dominated by (>50%) Exotic Pasture Species?	NPS-FM Natural Inland Wetland
		Rapid Test	Dominance Test	Prevalence Index	Hydric Vegetation					
Wet Area 1	Plot 1	Fail	Pass (67%)	Pass (2.70)	Yes	Yes	Yes	Yes	Yes (59%)	Yes
	Plot 2	Fail	Uncertain (50%)	Fail (3.68)	No	Not assessed	Not assessed	No	-	No
	Plot 3	Fail	Pass (100%)	Pass (2.20)	Yes	Not assessed	Not assessed	Yes	No (37%)	Yes
Wet Area 2	Plot 4	Pass	Pass (100%)	Pass (2.0)	Yes	Not assessed	Not assessed	Yes	No (0%)	Yes
	Plot 5	Fail	Fail (33%)	Fail (3.13)	No	Yes	No	No	-	No
	Plot 6	Fail	Uncertain (50%)	Fail (3.36)	No	Not assessed	Not assessed	No	-	No
	Plot 7	Fail	Fail (33%)	Fail (3.07)	Uncertain	Uncertain	No	No	-	No
Wet Area 3	Plot 8	Fail	Fail (0%)	Fail (3.97)	No	Not assessed	Not assessed	No	-	No
	Plot 9	Fail	Uncertain (50%)	Fail (3.05)	Uncertain	Yes	Yes	Yes	No (3%)	Yes
Wet Area 4	Plot 10	Fail	Uncertain (50%)	Pass (2.18)	Yes	Uncertain	Yes	Yes	No (32%)	Yes
	Plot 11	Fail	Fail (0%)	Fail (3.97)	No	Not assessed	Not assessed	No	-	No
	Plot 12	Fail	Fail (0%)	Fail (4.0)	No	Not assessed	Not assessed	No	-	No
Wet Area 5	Plot 13	Fail	Fail (0%)	Fail (3.77)	No	No	No	No	-	No
Wet Area 6	Plot 14	Fail	Not assessed (no vegetation present)	Not assessed (no vegetation present)	No	Uncertain	Yes	Yes	Not assessed (no vegetation present	Yes
	Plot 15	Fail	Fail (0%)	Fail (4.0)	No	Not assessed	Not assessed	No	-	No
Wet Area 7	No plot assessment	Pass	-	-	Not assessed	Not assessed	Not assessed	Yes	-	No
Wet Area 8	No plot assessment	-	-	-	Not assessed	Not assessed	Not assessed	No	-	No

5.2 Wet Area 1

Wet Area 1 is at the northern end of the property and consists of mainly exotic pasture grassland and features a pond, a very small gully, rushlands and an area of pugged bare soils.

Plot 1

The rapid test included Yorkshire fog (*Holcus lanatus*; FAC), browntop (*Agrostis capillaris*; FACU), soft rush (*Juncus effusus*; FACW) and sharp spike sedge (*Eleocharis acuta*; OBL) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. Plot 1 was placed within the soft rush and sharp spike sedge rushland (Plate A3-1). The vegetation assessment within this plot, resulted in hydrophytic vegetation being present (Dominance Test = 67%; Prevalence Index = 2.70). Both hydrophytic vegetation tests passed and technically no further wetland tests such as soils and hydrology are necessary. As this, was the first wetland assessment on the property soils and hydrology tests were performed to gain a better understanding of the soils in the area. As expected, these assessments recorded hydric soils and wetland hydrology features being present.

This plot is within a soft rushland that occurs on a slight slope above a pond (Plate A3-16). It is unknown if the pond has been artificially made. It may have historically been a wetland but after many years of farming is now consistently a pond. The pond is just visible in a Retolens image on the 22 April 1964 (SN1641). The pond is consistently inundated, visible in Google Earth from 1 August 2006 to present day. If the pond has been artificially made then the rushland is not a 'natural inland wetland' as it has developed around a deliberately constructed water body (Clause 'c'. within the RMA definition of a natural inland wetland). However, there is no found evidence that this pond has been artificially made and the pond was likely to have been a wetland historically. Therefore, this rush is a natural inland wetland.

Plot 2

The rapid test included Yorkshire fog (FAC), Californian thistle (*Cirsium arvense*; FACU), shepherds purse (*Capsella bursa-pastoralis*; no wetland status) and sweet vernal (*Anthoxanthum odoratum;* FACU) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This area contained two small areas of concave, mostly unvegetated soil that had some pugging within it (Plate A3-2). The vegetation assessment for this plot resulted in the Dominance Test (50%) and Prevalence Test (3.68) failing. No further testing was done. This area is not a wetland.

Plot 3

The rapid test included Yorkshire fog (FAC), soft rush (FACW), and floating sweetgrass (*Glyceria fluitans*; OBL) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This plot was placed in a wet channel containing mostly soft rush, Yorkshire fog (*Holcus lanatus*) and floating sweetgrass (*Glyceria declinata*) (Plate A3-3). The vegetation assessment for this plot passed the vegetation test (Dominance Test = 100%; Prevalence Index = 2.20), and contains hydrophytic vegetation. No further testing was necessary and this area is considered a natural inland wetland.

5.3 Wet Area 2

Wet Area 2 is near the southern end of the property and lays just above one of the gullies. This area consists of exotic pasture grassland, rushlands and a concave oval hollow.

Plot 4

The rapid test included kneed foxtail (*Alopercurus geniculatus*; FACW) and *Lobelia perpusilla* (FACW) as the dominant species and resulted in a ‘passed’ result. According to the Wetland Delineation Protocols, no more assessments are required and this area can be considered as a natural inland wetland. However, more hydrophytic vegetation tests were undertaken to ensure a thorough assessment was performed. Plot 4 was placed in a concave oval hollow with abundant kneed foxtail and patches of *Lobelia perpusilla* (Plate A3-4). This plot resulted in a hydrophytic vegetation being present by passing both vegetation tests (Dominance Test = 100%, Prevalence Index = 2.0), therefore this area is a wetland. No further soil and hydrology assessments were required for this plot. This wet area is a natural inland wetland.

Plot 5

South of the concave hollow, is a leafless/wīwī rush (*Juncus australis*) rushland. The rapid test included wī/leafless rush (*Juncus australis*; FACW), browntop (FACU), and ryegrass (*Lolium perenne*; FACU) as the dominant species and resulted in a ‘failed’ result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. Plot 5 was placed within the rushland (Plate A3-5). Vegetation assessments resulted in a fail (Dominance Test = 33%, Prevalence Test = 3.13). However, because the prevalence test was marginal, a soil and hydrology assessment were also undertaken. The soil assessment resulted in hydric soils and the hydrology assessment failed. According to the Wetland Delineation Protocols (Ministry for the Environment 2022), this would mean that this is a drained wetland or atypical environment and further analysis is required. After re-reviewing Google Earth historic imagery and marginal assessment outcomes, it is concluded that this area is not a natural inland wetland.

Plot 6

North of the concave oval hollow, is a very small soft rushland on a slope (Plate A3-6). Within the rushland is a shallow drain. The rapid test included soft rush (FACW), white clover (*Trifolium repens*; FACU) and browntop (FACU) as the dominant species and resulted in a ‘failed’ result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This plot failed both of the vegetation tests (Dominance Test = 50%, Prevalence Index = 3.36), and is therefore not a wetland.

Plot 7

Another plot was undertaken within the same vegetation area of Plot 5 to try and give more clarity to this area (Plate A2-7). The rapid test included wīwī/leafless rush (FACW), white clover (FACU) and browntop (FACU) as the dominant species and resulted in a ‘failed’ result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. The vegetation assessments results were similar to Plot 5 and resulted in a marginal fail for the Prevalence Index (Dominance Test = 33%, Prevalence Index = 3.07). The soil assessment resulted in uncertain hydric soils and the hydrology assessment failed. It is concluded that this area is not a wetland.

5.4 Wet Area 3

Wet Area 3 is north east of Wet Area 2 and covers an area of exotic pasture grassland and minor undulating land.

Plot 8

The rapid test included ryegrass (FACU) and white clover (FACU) as the dominant species and resulted in a ‘failed’ result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. Plot 8 was placed in a flat area in a slight depression that is covered in exotic herbs and grasses (Plate A3-8). The vegetation tests both failed for this plot (Dominance Test = 0%, Prevalence Index = 3.97). No further assessments were done for this plot and is concluded that it is a dryland habitat and not within a wetland.

Plot 9

A deeper oval depression is present just northeast of the above area (Plate A3-2). The rapid test included swamp plantain (*Plantago australis*; FAC), nettle (*Urtica urens*; no wetland status) and fathan (*Chenopodium album*; no wetland status) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. The vegetation assessment for this plot resulted in uncertain results, with a Dominance Test of 50% and a Prevalence Index of 3.05. More tests (soil and hydrology) were undertaken to further investigate the wetland assessment. The soil profile presented several signs of hydric soil characteristics. The hydrology assessment also contained several indicators such as being sparsely vegetated concave surface (2H; primary indicator), saturation in aerial imagery (3F; secondary indicator) and geomorphic position (4B; secondary indicator). Plot 9 is within a wetland and can be also classed as a natural inland wetland.

5.5 Wet Area 4

Wet Area 4 is at the southern end of the property and occurs just above one of the larger gullies. This area consists of exotic pasture grassland, rushlands, a concave oval hollow and undulating land.

Plot 10

Another deep oval depression is present at the southern end of the property (Plate A3-10). The rapid test included floating sweetgrass (OBL), browntop (FACU) and clammy goosefoot (*Dysphamia pumilio*; no wetland status) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. The vegetation assessment resulted in uncertain results, with a Dominance Test of 50% (fail) and a Prevalence Index of 2.18 (pass). More tests (soil and hydrology) were undertaken to further investigate the wetland assessment. The soil profile presented several signs of hydric soil characteristics. The hydrology assessment had similar results as Plot 9 and also contained several indicators to confirm wetland hydrology being present. Plot 10 is within a wetland and can be classed as a natural inland wetland.

Plot 11

Adjacent to the oval depression above is a small flat area with minimal vegetation (Plate A2-11). The rapid test included Scotch thistle (*Cirsium vulgare*; FACU), ryegrass (FACU), and annual poa (*Poa annua*; FACU) and fathen (no wetland status) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This plot failed both of the vegetation tests (Dominance Test = 0%, Prevalence Index = 3.97) and is a dryland area and not a natural inland wetland.

Plot 12

This plot is within a small undulation to the north of the large deep oval depression (Plot 10) (Plate A2-12). The rapid test included Californian thistle (FACU) and ryegrass (FACU) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This plot failed both vegetation tests (Dominance Test = 0%, Prevalence Index = 4.0) and is a dryland area and not a wetland.

5.6 Wet Area 5

Wet Area 5 is a small area that is within the start of the small gully. The area consists of exotic pasture grassland and sweet briar (*Rosa rubiginosa*).

Plot 13

This plot is at the bottom of a small mostly unvegetated gully (Plate A3-13). The rapid test included shepherd's purse (no wetland status), nettle (no wetland status) and ryegrass (FACU) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. This plot failed both of the vegetation tests (Dominance Test = 0%, Prevalence Index = 3.77) and is a dryland area and not a natural inland wetland.

5.7 Wet Area 6

This potential wetland is a flat to shallow mostly unvegetated oval depression. Only a small area had pugging and surface soils cracks nearby the fenceline. The rest of the area had compacted soils and sparse exotic herbs and grasses around the edges. Unvegetated areas within paddocks can also be caused from having more intense congregation from stock. However, since the area was in a depression and showed some hydrological indicator signs, the area was assessed.

Plot 14

The rapid test included fathen (no wetland status), dwarf mallow (*Malva neglecta*; no wetland status), white clover (FACU) and ryegrass (FACU) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. Plot 14 was placed within the small pugged area of the lowest part of the mild depression (Plate A3-14). This area was a difficult assessment as no plant species were within the plot, meaning that the vegetation assessment could not be undertaken. The soil profile contains some low chroma colours and iron concretions that are suggestive of potential hydric soils. The topsoil chroma is 3/2, and any topsoils 3 or less are not good indicators of hydric soils as many topsoils have this colour range (Fraser *et al*. 2018). This soil profile has an outcome of 'uncertain' soils. The hydrology assessment contained indicators such as being sparsely vegetated concave surface (2H; primary indicator), saturation in aerial imagery (3F; secondary indicator) and geomorphic position (4B; secondary indicator). According to the Wetland Delineation Protocols (Ministry for the Environment), if the soil assessment fails (uncertain here), and the hydrology passes (this area contains one primary indicator and also two secondary hydrology indicators), then this area is a wetland. This area is likely to be a very recent natural inland wetland.

Plot 15

The rapid test included fathen (no wetland status), dwarf mallow (no wetland status), white clover (FACU) and ryegrass (FACU) as the dominant species and resulted in a 'failed' result. Due to the failed result of the rapid test more hydrophytic vegetation assessments were required. A plot was placed on the upper edge of the depression where the soil was compacted and contained a few sparse exotic herbs and shrubs (Plate A3-15). Both vegetation assessments failed for this plot (Dominance Test = 0%, Prevalence Index = 4.0). This area is not a natural inland wetland.

5.8 Wet Area 7

Wet Area 7 is a large area that has possibly been dug out and contains an island in the middle (Plate A3-17 and A3-18). This area may have historically been a wetland but was modified by the landowner.

Google Earth images from 1 August 2006, suggests that the modification may have occurred around this date.

The large hole has steep sides with exotic pasture species. The bottom on the hole contains a herbfield of marsh bedstraw (*Galium palustre* subsp. *palustre;* OBL), sharp spike sedge (OBL), kneed foxtail (FACW), waoriki (*Ranunculus glabrifolius;* OBL) and Shepard's purse (no wetland status). The dominate species present (marsh bedstraw, sharp spike sedge, kneed foxtail and waoriki) all have a wetland status of either FACW and OBL. This area passes the rapid test and is considered a wetland under the RMA. This wetland is excluded from the 'natural wetland' definition because it has been formed in a constructed excavation and was likely intended to be a pond (currently dry).

5.9 Wet Area 8

This area covers undulating land covered in exotic pasture grassland and a terrace. One area at a low point within the undulating land looked to may have contained water-logging in the initial and brief look at historic Google Earth images. This area contains consistent, well-covered exotic pasture species that are mostly Facultative Upland or Upland species (dryland species).

The other area considered to be worth checking out after the initial and brief look at historic Google Earth images was a low-lying area at the bottom of the shrubland terrace. This area contained species that are all Facultative Upland species such as porcupine shrub (*Melicytus alpinus*), barley grass (*Hordeum murinum* subsp. *murinum*), cocksfoot (*Dactylus glomerata*) and Scotch thistle (*Cirsium vulgare*). The other species present such as burdock (*Arctium lappa*), dovesfoot cranesbill (*Geranium molle*), nettle and dwarf mallow do not have a wetland status but all are likely to be Facultative Upland or Upland species (dryland species). The dominance of dryland vegetation species and the lack of any hydrology features leads to the conclusion that this area is a dryland.

6.0 Natural inland wetlands

6.1 Overview

Six natural inland wetlands have been identified at the Homestead Bay property proposed for development (Figure 2). The natural inland wetlands are small in size and are predominantly dominated by exotic plant species. Three classes of natural inland wetlands (marsh, swamp and ephemeral) are present at the Homestead Bay property. Despite, the exotic plant dominance the wetlands are still valuable in their ability to be a carbon sink and providing habitat for indigenous bird and invertebrates species, in particular wading birds such as pūkeko (*Porphyrio melanotus;* Not Threatened).

Four of natural inland wetlands present are ephemeral wetlands. Ephemeral wetlands are typically in closed depressions and contain low statue plant species that are often arranged in a zonation pattern. This type of wetland has unique hydrology characteristics by being intermittently inundated throughout the year. Typical hydrology of an ephemeral wetland is usually ponded during winter/spring, with the water level gradually lowering in summer (Johnson and Rogers 2003). Ephemeral wetlands are ecologically valuable as they can contain a diverse range of plant species, host a high proportion of uncommon and threatened plants (Johnson and Rogers 2003) and provide habitat for wading indigenous birds. Ephemeral wetlands threatened by many factors including human-induced modifications, sedimentation, nutrient enrichment, pollutants, trampling impacts from mammals, weed invasions and introduced fish (Johnson and Rogers 20030. Ephemeral wetlands are a critically endangered naturally uncommon ecosystem in New Zealand (Holdaway *et al*. 2012)

1. Soft rush-browntop-sharp spike sedge rushland marsh (0.0419 hectares)

Clusters of soft rush are spread throughout a mosaic of browntop, sharp spike sedge and Yorkshire fog (Plate 1). Other species occasionally present include white clover, wīwī/leafless rush and jointed rush (*Juncus articulatus*). A sedge species is also present in very low abundance. The sedge did not have an inflorescence to confirm identification but is likely Sinclair's sedge (*Carex sinclairii*), due to its leaf characteristics[1] and habitat match.

Plate 1 – Rushland marsh wetland above the pond in Wet Area 1 at Homestead Bay. 30 January 2025.

2. Soft rush-floating sweet grass-Yorkshire fog grassland swamp (0.0087 hectares)

This swamp wetland lays in a channel that sits below the pond in Wet Area 1 (Plate 2). The swamp wetland contains a mosaic of soft rush, Yorkshire fog, floating sweetgrass, curled dock (Rumex crispus) and jointed rush. The wetland contains the occasional clusters of water fern (*Azolla rubra*) sitting on the water surface.

3. Kneed foxtail-*Lobelia perpusilla* grassland ephemeral wetland (0.0372 hectares)

This ephemeral wetland is located in the middle of the Wet Area 2 and is a concave hollow that is lined with soft rush on the northern end and leafless/wīwī rush on the southern end (Plate 3). The ephemeral wetland contains abundant kneed foxtail with common patches of the indigenous herb *Lobelia perpusilla*.

---

[1] Double folded leaf, leaf width of 4-4.5 millimetres, leaf length of *c.* 40 centimetres and light yellow-green leaf colouration.

Data Acknowledgment
Contains data sourced from the LINZ Data Service licensed for reuse under CC BY 4.0

Report: 7483a
Ref: 11903
Client: RCL Henry Downs Limited
Name: Figure_NaturalInlandWetlands.aprx
Path: E:\gis\HomesteadBayQT\mxd\

Figure 2. Natural inland wetlands at a proposed sub-division development at a property Homestead Bay, Otago

© 2025
Wildlands
www.wildlands.co.nz, 0508 WILDNZ
Scale: 1:4,500
Date: 20/02/2025
Cartographer: LW
Format: A3

Plate 2 – Rushland swamp wetland below the pond in Wet Area 1 at Homestead Bay. Plot 3 can be seen within the wetland. 30 January 2025.

Plate 3 – Ephemeral wetland surrounded by rushlands in the middle of Wet Area 2 at Homestead Bay. 30 January 2025.

4. [Swamp plantain] herbfield ephemeral wetland (0.0130 hectares)

Another ephemeral wetland is located in Wet Area 3. This wetland is within an oval depression and is mostly unvegetated (Plate 4). A few exotic species are scarce and scattered near the edges and include: marsh plantain, ryegrass, nettle and clammy goosefoot.

Plate 4 – Ephemeral wetland within the exotic pasture grassland within Wet Area 3 at Homestead Bay. 30 January 2025.

5. [Floating sweetgrass-kneed foxtail-clammy goosefoot] grassland ephemeral wetland (0.0289 hectares)

This ephemeral wetland is also within a mostly unvegetated oval depression (Plate 5). Scarce and scattered exotic species located near the edges of the wetland include floating sweetgrass, browntop, clammy goosefoot, white clover, and black nightshade (*Solanum nigrum*).

6. Mudflat ephemeral wetland (0.0105 hectares)

This unvegetated ephemeral wetland is lies in a small depression and is very small in size. This area is likely a recently developed wetland, as suggested by the 'uncertain' soil result in the guidelines (Fraser *et al.* 2018). The first evidence of water pooling in this wetland on Google Earth can only be seen from 10 February 2010. The ephemeral wetland is at the lowest point (paler soil) of a compacted open soil patch (Plate 6).

Plate 5 – Ephemeral wetland within the exotic pasture grassland within Wet Area 4 at Homestead Bay. 3 February 2025.

Plate 6 – Ephemeral wetland within the exotic pasture grassland within Wet Area 6 at Homestead Bay. 4 February 2025.

7.0 Summary

Eight areas were investigated for the possibility of wetlands being present. A total of six natural inland wetlands were identified within the property at Homestead Bay proposed for a sub-division development. The marsh and swamp wetlands are dominated by exotic species, with soft rush being the most common species present. The ephemeral wetlands are mostly dominated by exotic plant species, nonetheless still contain typical characteristics of their ecosystem type. These natural inland wetlands will likely provide habitat to indigenous bird and invertebrate species. The ephemeral wetlands are particularly ecologically valuable due their potential to host diverse plant species as well as uncommon and threatened plant species. Ephemeral wetlands are a unique and uncommon habitat and has been listed as a critically endangered ecosystem. All wetland present are important on a national scale as New Zealand has lost 90% of its pre-human wetland extent, making wetlands the most nationally threatened ecosystem type (Aussiel *et al.* 2008).

The residential development could consider avoiding these wetlands and incorporating them into their reserve areas. All wetlands would benefit from enhancement actions such as indigenous plantings (around the wetland margin for the ephemeral wetlands), weed control and cattle exclusion. Light grazing from sheep can be beneficial for ephemeral wetlands as they discourage woody weed species and encourage low-statue turf communities that are typical for this type of wetland ecosystem.

Acknowledgments

Amanda Leith (Planner/Director of Remarkables Planning) is thanked for providing useful information and site access. Farm Managers Dave Atkin and Matt Little are thanked for allowing access to the active farm areas.

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Appendix 1

Plant species recorded and their wetland indicator status

Species	Common Name	Threat Status[2]	Status	Wetland Indicator Status
Achillea millefolium	Yarrow	-	Exotic	FACU
Agrostis capillaris	Browntop	-	Exotic	FACU
Alopecurus geniculatus	Kneed foxtail	-	Exotic	FACW
Anthoxanthum odoratum	Sweet vernal	-	Exotic	FACU
Arctium lappa	Burdock	-	Exotic	None
Azolla rubra	Pacific azolla, azolla, red azolla	Not Threatened	Indigenous Non-Endemic	None
Capsella bursa-pastoris	Shepherds purse		Exotic	None
Carex sp.[3]	Sedge	Not Threatened	Indigenous Non-Endemic	None
Carex sp.	Sedge	-	Indigenous Non-Endemic	None
Cerastium glomeratum	Chickweed	-	Exotic	FACU
Chenopodium album	Fathen	-	Exotic	None
Cirsium arvense	Californian thistle	-	Exotic	FACU
Cirsium vulgare	Scotch thistle	-	Exotic	FACU
Cynosurus cristatus	Crested dogstail	-	Exotic	UPL
Dactylis glomerata	Cocksfoot	-	Exotic	FACU
Dysphania pumilio	Clammy goosefoot	-	Exotic	None
Eleocharis acuta	Spike sedge	Not Threatened	Indigenous Non-Endemic	OBL
Erodium cicutarium	Storksbill	-	Exotic	None
Galium palustre	Marsh bedstraw	-	Exotic	OBL
Geranium molle	Dovesfoot cranesbill	-	Exotic	None
Glyceria fluitans	Floating sweetgrass	-	Exotic	OBL
Holcus lanatus	Yorkshire fog	-	Exotic	FAC
Hordeum murinum	Barley grass	-	Exotic	FACU
Hypericum humifusum	Trailing Saint John's wort	-	Exotic	FAC
Hypochaeris radicata	Catsear	-	Exotic	FACU
Juncus articulatus	Jointed rush	-	Exotic	FACW
Juncus australis	Wīwī, wī, leafless rush	Not Threatened	Indigenous Non-Endemic	FACW
Juncus effusus	Soft rush	-	Exotic	FACW
Juncus tenuis subsp. dichotomus		-	Exotic	FACW
Leontodon saxatilis	Hawkbit	-	Exotic	FAC
Lobelia perpusilla		Not Threatened	Indigenous Endemic	FACW
Lolium perenne	Ryegrass	-	Exotic	FACU

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[2] de Lange *et al*. 2024

[3] Likely *Carex sinclairii*

Species	Common Name	Threat Status[2]	Status	Wetland Indicator Status
Malva neglecta	Dwarf mallow	-	Exotic	None
Melicytus alpinus	Porcupine shrub	Not Threatened	Indigenous Endemic	FACU
Plantago australis	Swamp plantain	-	Exotic	FAC
Poa annua	Annual poa	-	Exotic	FACU
Ranunculus glabrifolius	Waoriki	Not Threatened	Indigenous Non-Endemic	OBL
Rumex crispus	Curled dock	-	Exotic	FAC
Rumex obtusifolius	Broad-leaved dock	-	Exotic	FAC
Sagina procumbens	Pearlwort	-	Exotic	FACU
Solanum nigrum	Black nightshade	-	Exotic	FACU
Sonchus asper	Prickly puha	-	Exotic	FACU
Spergula arvensis	Spurrey	-	Exotic	None
Taraxacum officinale	Dandelion	-	Exotic	FACU
Trifolium repens	White clover	-	Exotic	FACU
Urtica urens	Nettle	-	Exotic	None
Verbascum thapsus	Woolly mullein	-	Exotic	None
Verbascum virgatum	Moth mullein	-	Exotic	None

Appendix 2

Monthly rainfall data for 2024, 2025 and historical averages

Past Weather for Queenstown

● Feb 2024 - Jan 2025 ● Feb 2023 - Jan 2024 ● Historical average

High (°C)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
25.9°	26.9°	20.8°	19.1°	19.5°	15.9°	16.5°	18.6°	21.5°	24.2°	29.0°	28.6°
28.9°	25.5°	20.5°	23.0°	14.9°	15.1°	14.8°	22.8°	20.7°	23.6°	25.6°	27.0°
27.8°	24.9°	21.1°	17.9°	14.5°	13.7°	15.4°	19.0°	21.5°	24.2°	26.5°	28.2°

Low (°C)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
4.8°	1.2°	-0.4°	-3.3°	-3.0°	-4.9°	-4.2°	-1.1°	-0.4°	-0.7°	2.5°	4.2°
4.6°	-0.6°	-0.8°	0.2°	-4.0°	-4.3°	-3.8°	-1.0°	-1.7°	0.6°	3.1°	2.8°
3.2°	1.6°	-1.1°	-2.9°	-5.0°	-6.0°	-4.3°	-2.7°	-1.5°	0.1°	2.7°	3.9°

Rain (mm)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
40.4mm	85.6mm	75.6mm	21.8mm	26.0mm	62.2mm	53.0mm	203.0mm	139,4mm	57.8mm	69.8mm	26.8mm
62.0mm	102.0mm	65.2mm	172.6mm	51.0mm	29.0mm	52.6mm	134.4mm	63.4mm	34.8mm	60.8mm	65.2mm
48.4mm	38.9mm	50.1mm	64.5mm	51.1mm	44.1mm	43.2mm	57.4mm	58.1mm	52.6mm	56.5mm	58.1mm

The shade of the bar indicates the year or historical average.

Temperature The historical data is the extreme maximum air temperature for the month averaged over a historical period (e.g. 10 years) and the extreme minimum air temperature for the month averaged over a historical period. The data for the previous two years is the highest maximum and lowest minimum recorded for the month.

Rainfall The total rainfall that fell during the month

Observations recorded at Queenstown Airport (AWS-93831)

Appendix 3

Site photographs

Plate A3-1 – Vegetation Plot 1 within Wet Area 1 at Homestead Bay. 30 January 2025.

Plate A3-2 – Vegetation Plot 2 within Wet Area 1 at Homestead Bay. 30 January 2025.

Plate A3-3 – Vegetation Plot 3 within Wet Area 1 at Homestead Bay. 30 January 2025.

Plate A3-4 – Vegetation Plot 4 within Wet Area 2 at Homestead Bay. 30 January 2025.

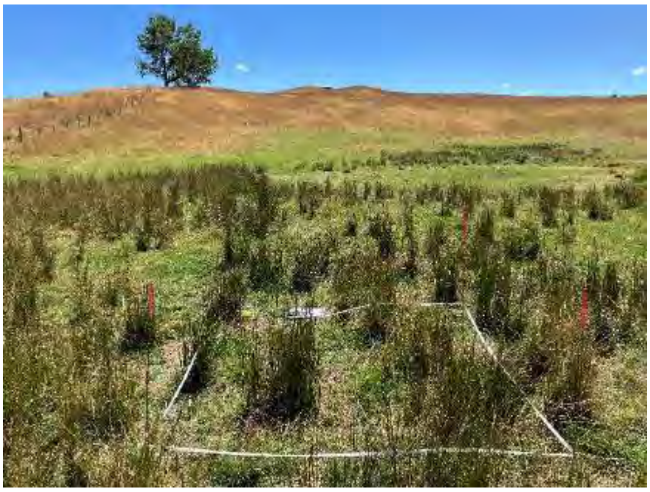


Plate A3-5 – Vegetation Plot 5 within Wet Area 2 at Homestead Bay. 30 January 2025.

Plate A3-6 –Vegetation Plot 6 within Wet Area 2 at Homestead Bay. 30 January 2025.

Plate A3-7 – Vegetation Plot 7 within Wet Area 3 at Homestead Bay. 3 February 2025.

Plate A3-8 – Vegetation Plot 8 within Wet Area 3 at Homestead Bay. 3 February 2025.

Plate A3-9 – Vegetation Plot 9 within Wet Area 3 at Homestead Bay. 3 February 2025.

Plate A3-10 – Vegetation Plot 10 within Wet Area 4 at Homestead Bay. 3 February 2025.

Plate A3-11 – Vegetation Plot 11 within Wet Area 4 at Homestead Bay. 3 February 2025.

Plate A3-12 –Vegetation Plot 12 within Wet Area 4 at Homestead Bay. 3 February 2025.

Plate A3-13 – Vegetation Plot 13 within Wet Area 5 at Homestead Bay. 4 February 2025.

Plate A3-14 – Vegetation Plot 14 within Wet Area 6 at Homestead Bay. 4 February 2025.

Plate A3-15 – Vegetation Plot 15 within Wet Area 6 at Homestead Bay. 4 February 2025.

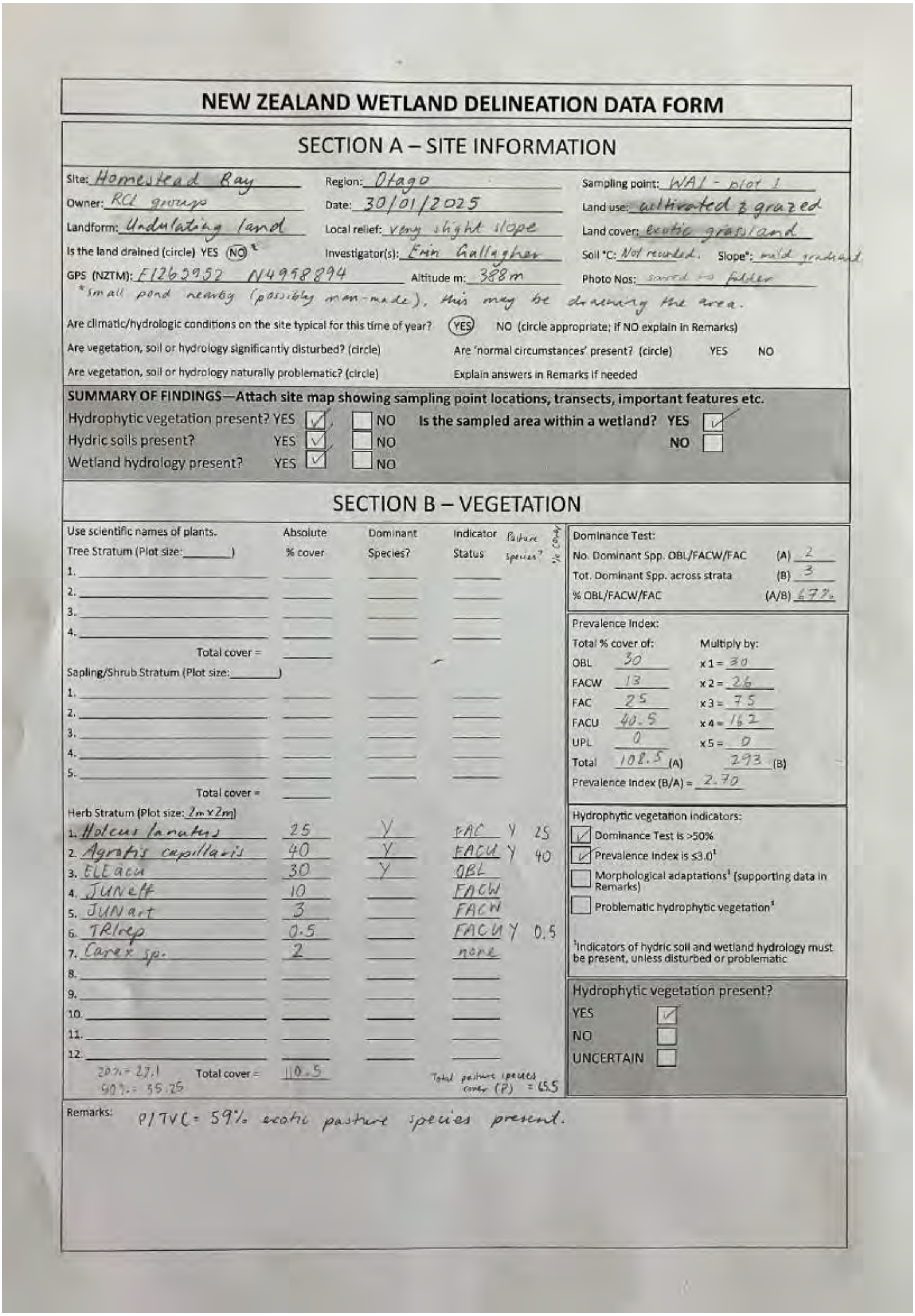
Plate A3-16 – Pond in Wet Area 1 at Homestead Bay. 30 January 2025.

Plate A3-17 – Drain on the upper edge of the large excavation area within Wet Area 7 at Homestead Bay. 30 January 2025.

Plate A3-18 – The large excavation area within Wet Area 7 at Homestead Bay. 30 January 2025.

Appendix 4

Wetland delineation plot sheets



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA1 - plot 1
Owner: RCL groups
Date: 30/01/2025
Land use: cultivated & grazed
Landform: Undulating land
Local relief: very slight slope
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]*
Investigator(s): Erin Gallagher
Soil °C: Not recorded.
Slope°: mild gradient
GPS (NZTM): E1263952 N4958894
Altitude m: 388m
Photo Nos: saved to folder

*small pond nearby (possibly man-made), this may be draining the area.

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)

Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) YES NO

Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☑ ☐ NO
Hydric soils present? YES ☑ ☐ NO
Wetland hydrology present? YES ☑ ☐ NO

Is the sampled area within a wetland? YES ☑ NO ☐

SECTION B – VEGETATION

Use scientific names of plants.

Tree Stratum (Plot size:)	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% Cover
1.					
2.					
3.					
4.					
Total cover =					

Sapling/Shrub Stratum (Plot size:)	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% Cover
1.					
2.					
3.					
4.					
5.					
Total cover =					

Herb Stratum (Plot size: 2m x 2m)	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% Cover
1. Holcus lanatus	25	Y	FAC	Y	25
2. Agrostis capillaris	40	Y	FACU	Y	40
3. ELEacu	30	Y	OBL		
4. JUNeff	10		FACW		
5. JUNart	3		FACW		
6. TRIrep	0.5		FACU	Y	0.5
7. Carex sp.	2		none		
8.					
9.					
10.					
11.					
12.					
20% = 27.1 50% = 55.25 Total cover =	110.5		Total pasture species cover (P)		= 65.5

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 2
Tot. Dominant Spp. across strata (B) 3
% OBL/FACW/FAC (A/B) 67%

Prevalence Index:

Total % cover of:		Multiply by:
OBL	30	x 1 = 30
FACW	13	x 2 = 26
FAC	25	x 3 = 75
FACU	40.5	x 4 = 162
UPL	0	x 5 = 0
Total	108.5 (A)	293 (B)

Prevalence Index (B/A) = 2.70

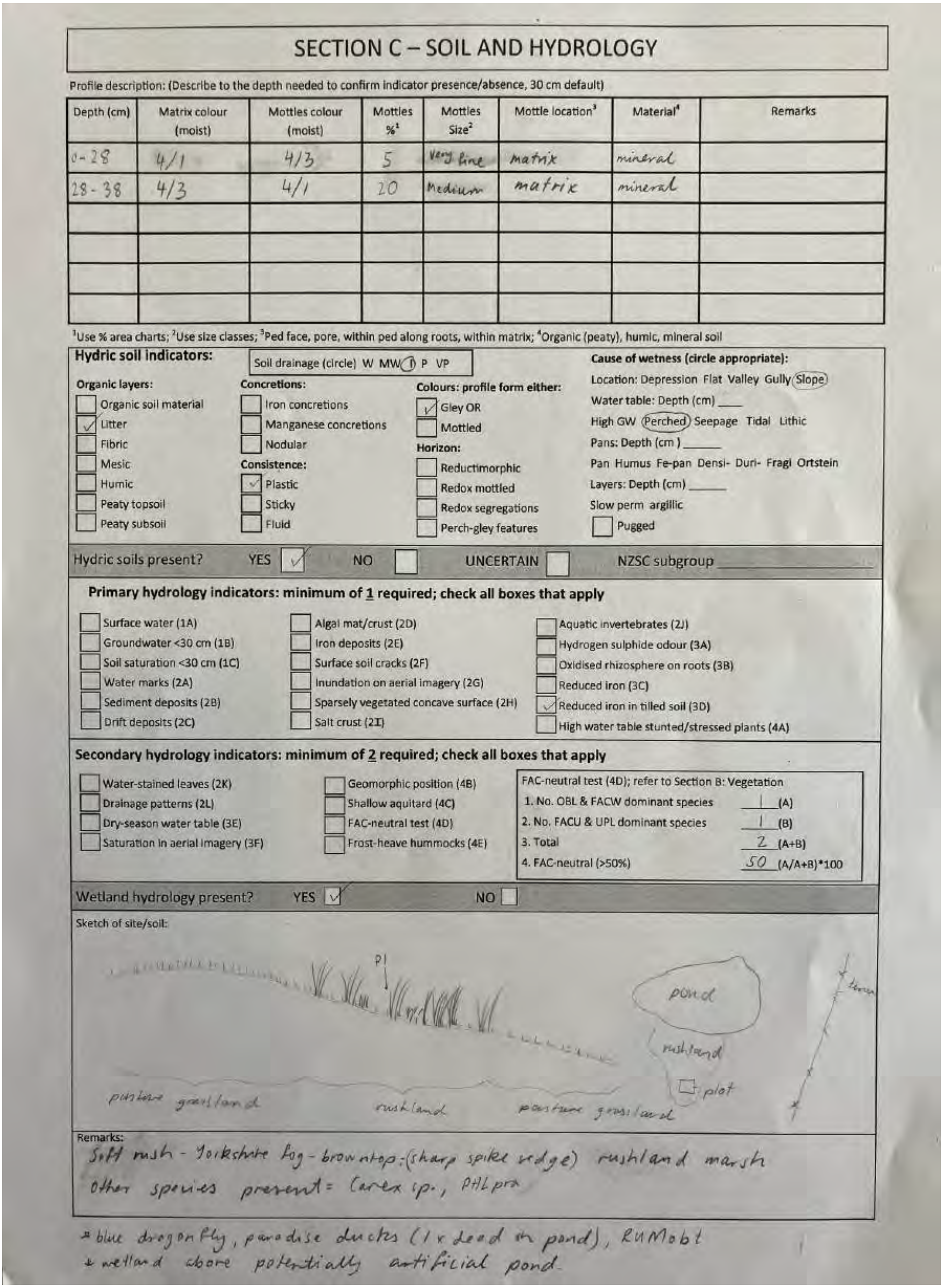
Hydrophytic vegetation indicators:

☑ Dominance Test is >50%
☑ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☑
NO ☐
UNCERTAIN ☐

Remarks: P/TVC = 59% exotic pasture species present.



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
0-28	4/1	4/3	5	Very fine	matrix	mineral	
28-38	4/3	4/1	20	Medium	matrix	mineral	

[1] Use % area charts; [2] Use size classes; [3] Ped face, pore, within ped along roots, within matrix; [4] Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW [✓ I] P VP

Organic layers:
- ☐ Organic soil material
- ☑ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☐ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☑ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☑ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: Depression Flat Valley Gully [✓ Slope]

Water table: Depth (cm) ____

High GW [✓ Perched] Seepage Tidal Lithic

Pans: Depth (cm) ______

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ______

Slow perm argillic

☐ Pugged

Hydric soils present? YES ☑ NO ☐ UNCERTAIN ☐ NZSC subgroup ____________

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☐ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☐ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☑ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☐ Saturation in aerial imagery (3F)
- ☐ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

FAC-neutral test (4D); refer to Section B: Vegetation
1. No. OBL & FACW dominant species 1 (A)
2. No. FACU & UPL dominant species 1 (B)
3. Total 2 (A+B)
4. FAC-neutral (>50%) 50 (A/A+B)*100

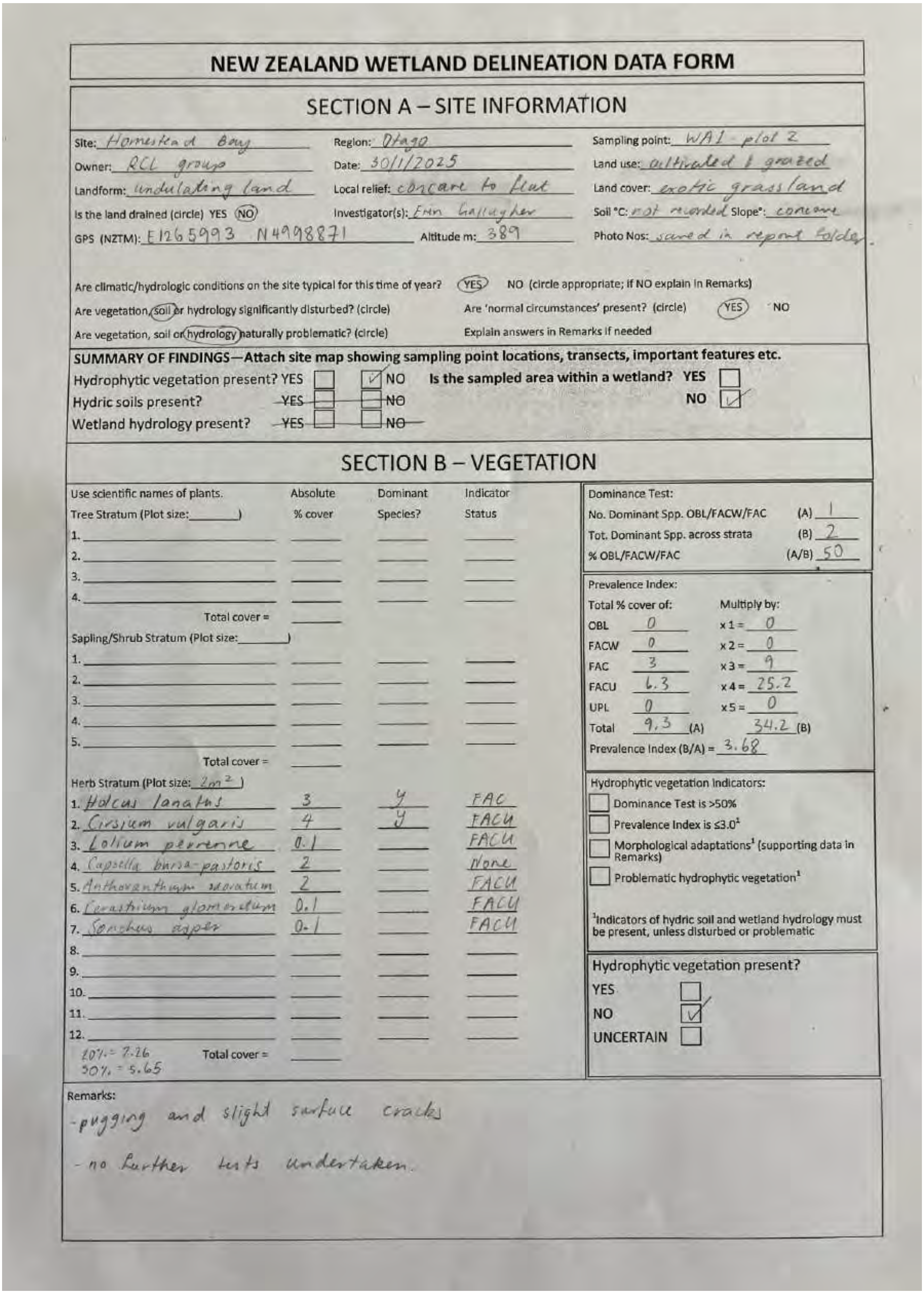
Wetland hydrology present? YES ☑ NO ☐

Sketch of site/soil:

Remarks:

Soft rush - Yorkshire fog - browntop:(sharp spike sedge) rushland marsh
Other species present = Carex sp., PHLpra

* blue dragonfly, paradise ducks (1x dead in pond), RUMobt
* wetland above potentially artificial pond.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA1 - plot 2
Owner: RCL group
Date: 30/1/2025
Land use: cultivated & grazed
Landform: undulating land
Local relief: concave to flat
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: concave
GPS (NZTM): E1265993 N4998871
Altitude m: 389
Photo Nos: saved in report folder.

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, [✓ soil] or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or [✓ hydrology] naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
Hydric soils present? ~~YES ☐ ☐ NO~~
Wetland hydrology present? ~~YES ☐ ☐ NO~~
Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Holcus lanatus	3	y	FAC
2. Cirsium vulgaris	4	y	FACU
3. Lolium perenne	0.1		FACU
4. Capsella bursa-pastoris	2		None
5. Anthoxanthum odoratum	2		FACU
6. Cerastium glomeratum	0.1		FACU
7. Sonchus asper	0.1		FACU
8.			
9.			
10.			
11.			
12.			
20% = 7.26 50% = 5.65 Total cover =			

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 1
Tot. Dominant Spp. across strata (B) 2
% OBL/FACW/FAC (A/B) 50

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	3	x 3 = 9
FACU	6.3	x 4 = 25.2
UPL	0	x 5 = 0
Total	9.3 (A)	34.2 (B)

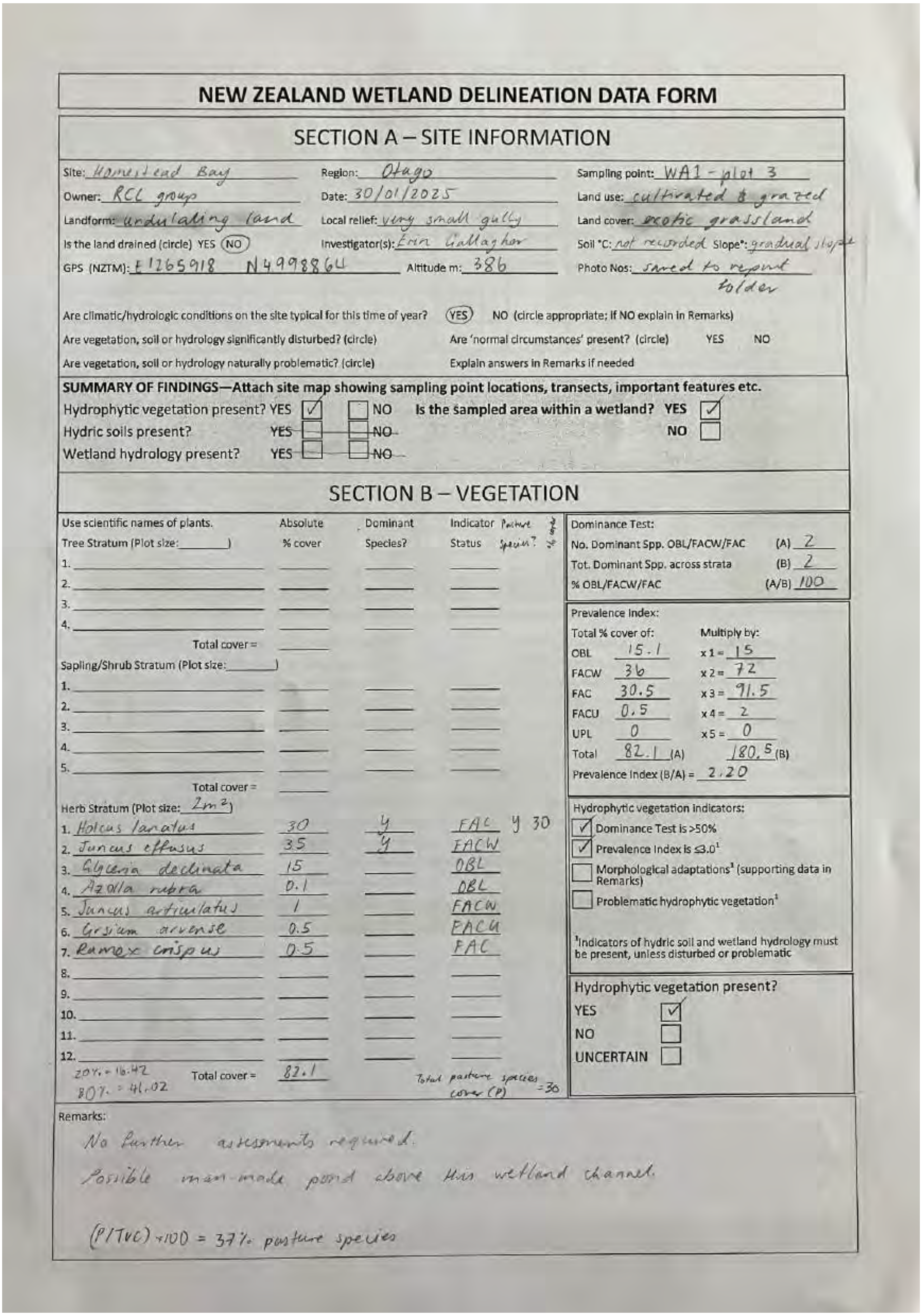
Prevalence Index (B/A) = 3.68

Hydrophytic vegetation indicators:
- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
- pugging and slight surface cracks
- no further tests undertaken.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA1 - plot 3
Owner: RCL group
Date: 30/01/2025
Land use: cultivated & grazed
Landform: undulating land
Local relief: very small gully
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: gradual slope
GPS (NZTM): E 1265918 N 4998864
Altitude m: 386
Photo Nos: saved to report folder

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; If NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) YES NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☑ ☐ NO
Hydric soils present? ~~YES ☐ ☐ NO~~
Wetland hydrology present? ~~YES ☐ ☐ NO~~

Is the sampled area within a wetland? **YES** ☑ **NO** ☐

SECTION B – VEGETATION

Use scientific names of plants.

Tree Stratum (Plot size:)

	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% cover
1.					
2.					
3.					
4.					
Total cover =					

Sapling/Shrub Stratum (Plot size:)

	Absolute % cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
Total cover =			

Herb Stratum (Plot size: 2m²)

	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% cover
1. Holcus lanatus	30	y	FAC	y	30
2. Juncus effusus	35	y	FACW		
3. Glyceria declinata	15		OBL		
4. Azolla rubra	0.1		OBL		
5. Juncus articulatus	1		FACW		
6. Cirsium arvense	0.5		FACU		
7. Rumex crispus	0.5		FAC		
8.					
9.					
10.					
11.					
12.					
Total cover =	82.1				

20% = 16.42
80% = 41.02

Total pasture species cover (P) = 30

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 2
Tot. Dominant Spp. across strata (B) 2
% OBL/FACW/FAC (A/B) 100

Prevalence Index:

Total % cover of:		Multiply by:
OBL	15.1	x 1 = 15
FACW	36	x 2 = 72
FAC	30.5	x 3 = 91.5
FACU	0.5	x 4 = 2
UPL	0	x 5 = 0
Total	82.1 (A)	180.5 (B)

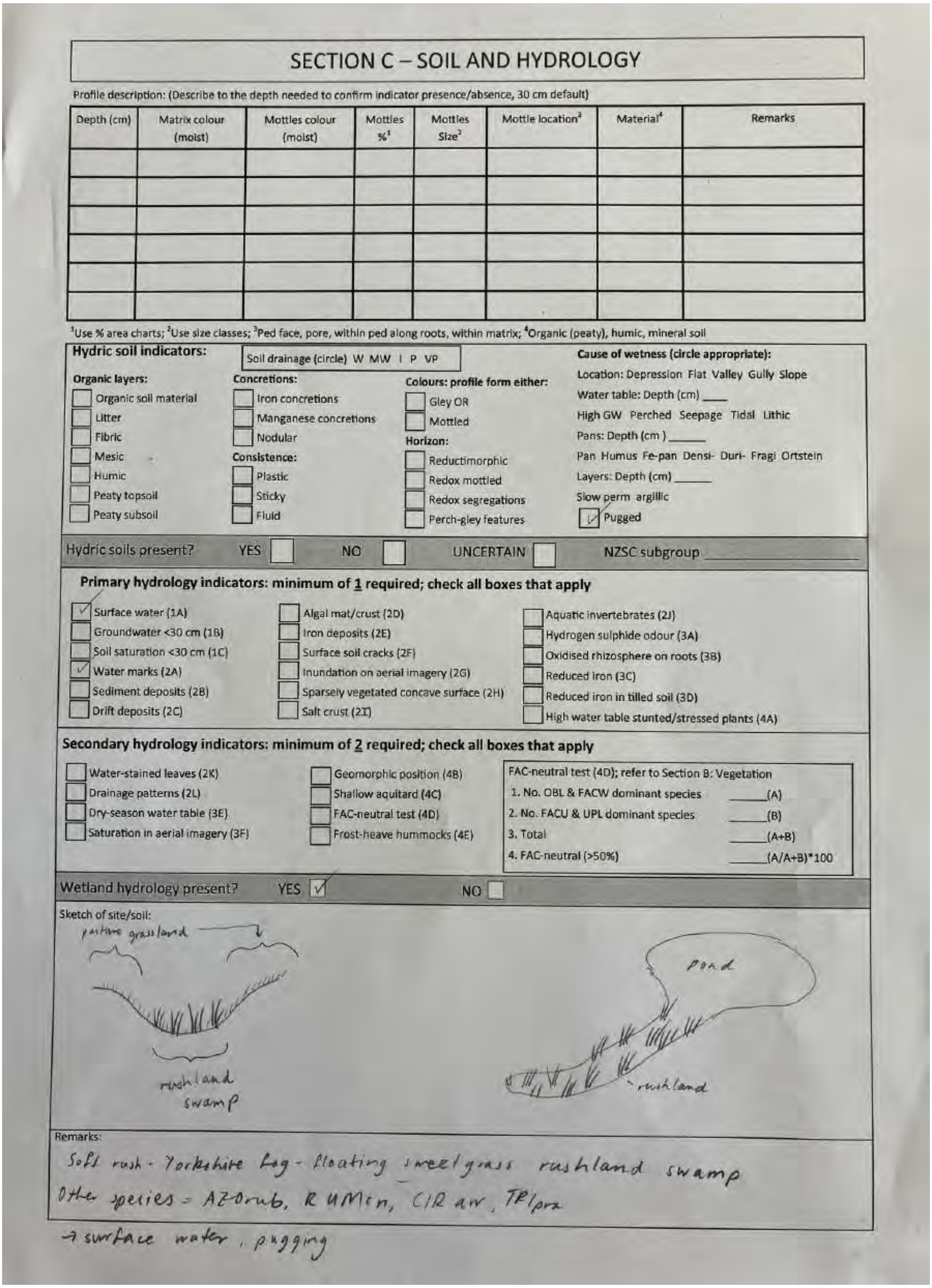
Prevalence Index (B/A) = 2.20

Hydrophytic vegetation indicators:
- ☑ Dominance Test is >50%
- ☑ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☑
NO ☐
UNCERTAIN ☐

Remarks:
No further assessments required.
Possible man-made pond above this wetland channel.
(P/TVC) ×100 = 37% pasture species



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks

[1] Use % area charts; [2] Use size classes; [3] Ped face, pore, within ped along roots, within matrix; [4] Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I P VP

Organic layers:
- ☐ Organic soil material
- ☐ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☐ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☐ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☐ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: Depression Flat Valley Gully Slope

Water table: Depth (cm) ____

High GW Perched Seepage Tidal Lithic

Pans: Depth (cm) ______

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ______

Slow perm argillic

☑ Pugged

Hydric soils present? YES ☐ NO ☐ UNCERTAIN ☐ NZSC subgroup ____________________

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☑ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☑ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☐ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☐ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☐ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☐ Saturation in aerial imagery (3F)
- ☐ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

FAC-neutral test (4D); refer to Section B: Vegetation

1. No. OBL & FACW dominant species _____(A)
2. No. FACU & UPL dominant species _____(B)
3. Total _____(A+B)
4. FAC-neutral (>50%) _____(A/A+B)*100

Wetland hydrology present? YES ☑ NO ☐

Sketch of site/soil:

pasture grassland

rushland swamp

pond

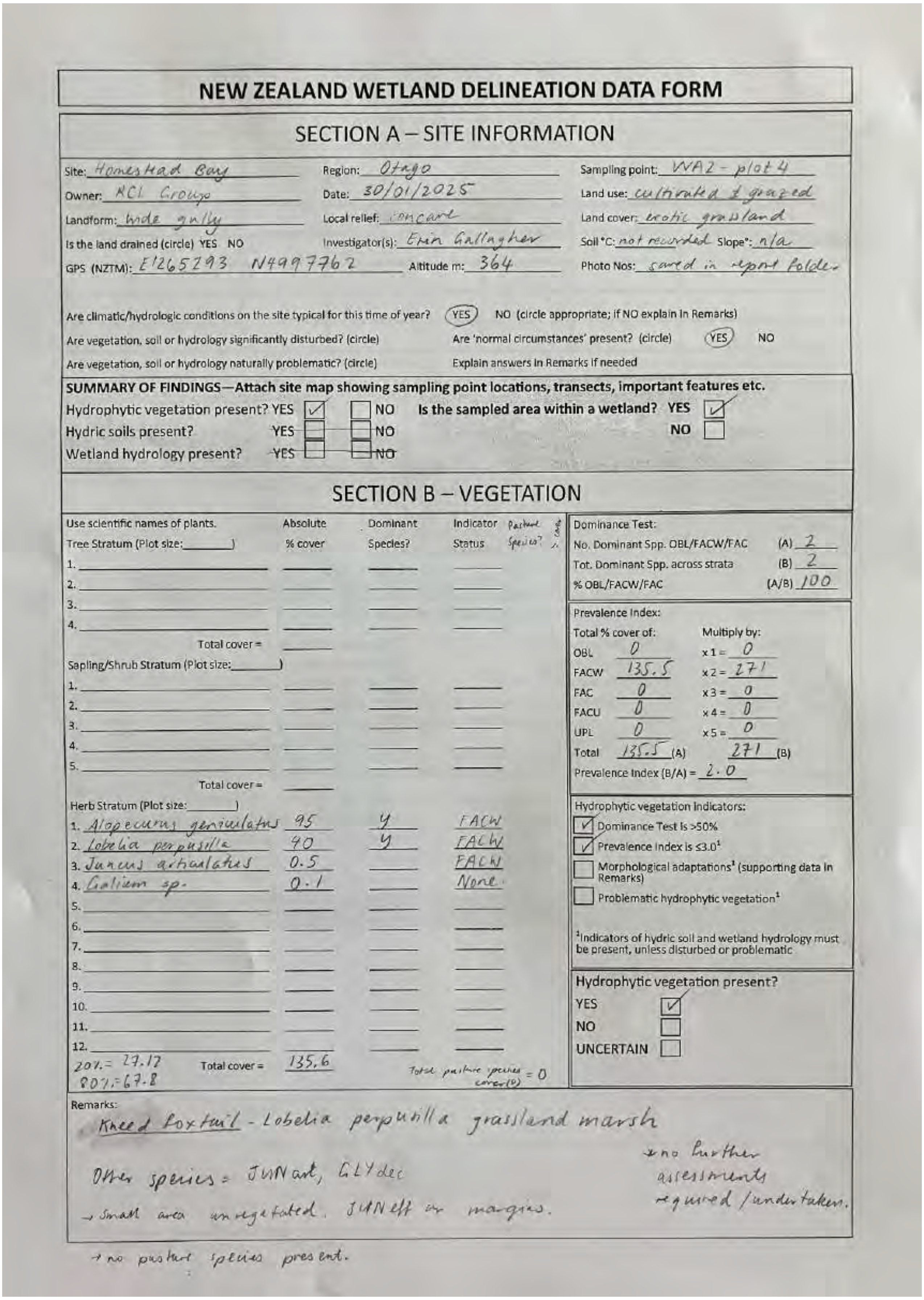
rushland

Remarks:

Soft rush - Yorkshire fog - floating sweetgrass rushland swamp

Other species = AZOrub, RUMcn, CIR arv, TRIpra

→ surface water, pugging



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA2 - plot 4
Owner: RCL Group
Date: 30/01/2025
Land use: cultivated & grazed
Landform: wide gully
Local relief: concave
Land cover: exotic grassland
Is the land drained (circle) YES NO
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: n/a
GPS (NZTM): E1265293 N4997762
Altitude m: 364
Photo Nos: saved in report folder

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☑ ☐ NO
~~Hydric soils present? YES ☐ ☐ NO~~
~~Wetland hydrology present? YES ☐ ☐ NO~~
Is the sampled area within a wetland? YES ☑
NO ☐

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?
Tree Stratum (Plot size:____)				
1.				
2.				
3.				
4.				
Total cover =				
Sapling/Shrub Stratum (Plot size:____)				
1.				
2.				
3.				
4.				
5.				
Total cover =				
Herb Stratum (Plot size:____)				
1. Alopecurus geniculatus	95	y	FACW	
2. Lobelia perpusilla	40	y	FACW	
3. Juncus articulatus	0.5		FACW	
4. Galium sp.	0.1		None	
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
Total cover =	135.6			

20% = 27.12
80% = 67.8

Total pasture species cover (%) = 0

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 2
Tot. Dominant Spp. across strata (B) 2
% OBL/FACW/FAC (A/B) 100

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	135.5	x 2 = 271
FAC	0	x 3 = 0
FACU	0	x 4 = 0
UPL	0	x 5 = 0
Total	135.5 (A)	271 (B)

Prevalence Index (B/A) = 2.0

Hydrophytic vegetation indicators:
- ☑ Dominance Test is >50%
- ☑ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☑
NO ☐
UNCERTAIN ☐

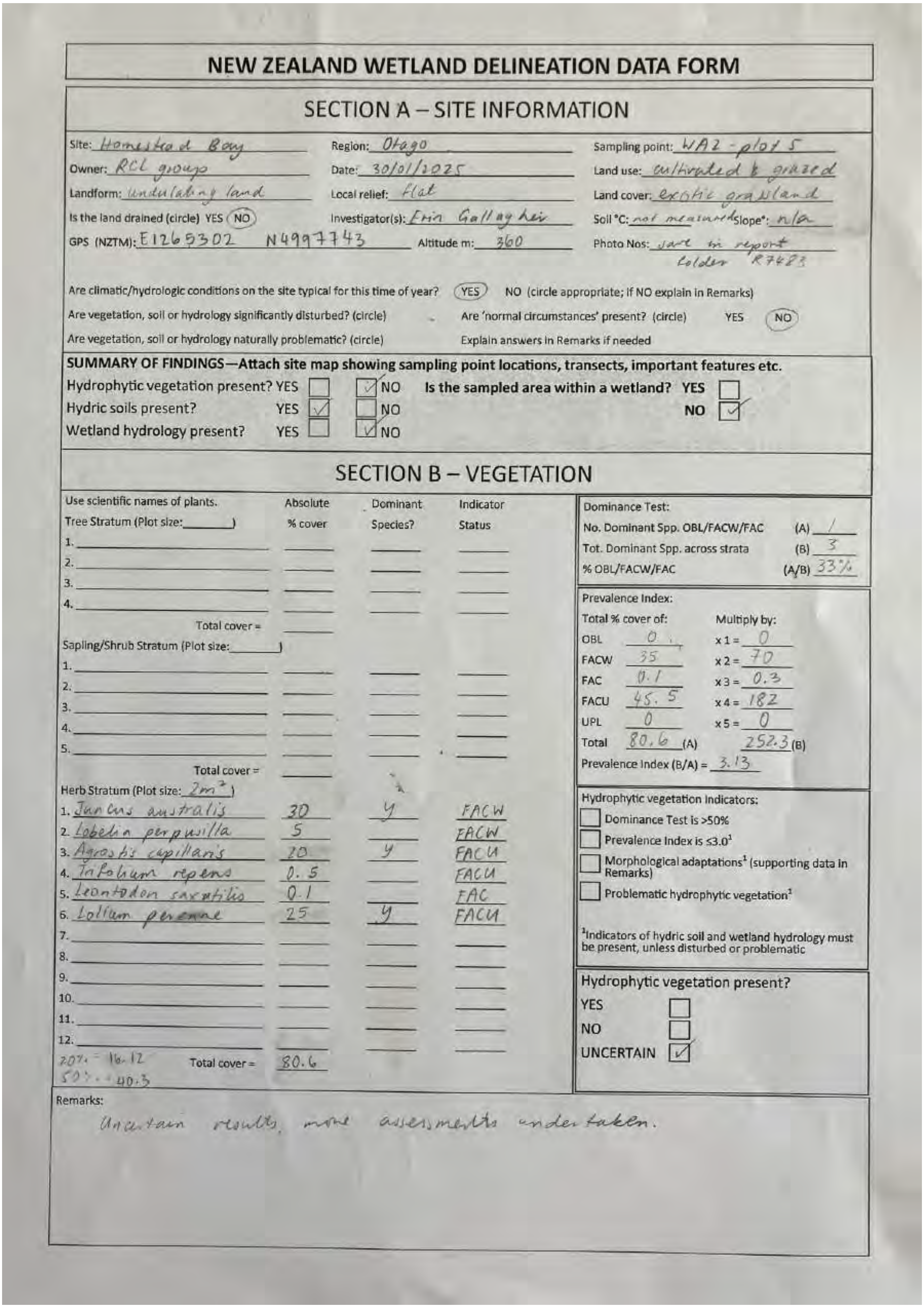
Remarks:
Kneed foxtail - Lobelia perpusilla grassland marsh

Other species = JUNart, GLYdec

→ small area unvegetated. JUNeff on margins.

→ no further assessments required / undertaken.

→ no pasture species present.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay	Region: Otago	Sampling point: WA2 - plot 5
Owner: RCL group	Date: 30/01/2025	Land use: cultivated & grazed
Landform: undulating land	Local relief: flat	Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]	Investigator(s): Erin Gallagher	Soil °C: not measured Slope°: n/a
GPS (NZTM): E1265302 N4997743	Altitude m: 360	Photo Nos: saved in report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)

Are vegetation, soil or hydrology significantly disturbed? (circle) Are 'normal circumstances' present? (circle) YES [✓ NO]

Are vegetation, soil or hydrology naturally problematic? (circle) Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO

Hydric soils present? YES ☑ ☐ NO

Wetland hydrology present? YES ☐ ☑ NO

Is the sampled area within a wetland? YES ☐ **NO** ☑

SECTION B – VEGETATION

Use scientific names of plants.

	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Juncus australis	30	y	FACW
2. Lobelia perpusilla	5		FACW
3. Agrostis capillaris	20	y	FACU
4. Trifolium repens	0.5		FACU
5. Leontodon saxatilis	0.1		FAC
6. Lolium perenne	25	y	FACU
7.			
8.			
9.			
10.			
11.			
12.			
20% = 16.12 50% = 40.3 Total cover =	80.6		

Dominance Test:

No. Dominant Spp. OBL/FACW/FAC	(A)	1
Tot. Dominant Spp. across strata	(B)	3
% OBL/FACW/FAC	(A/B)	33%

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	35	x 2 = 70
FAC	0.1	x 3 = 0.3
FACU	45.5	x 4 = 182
UPL	0	x 5 = 0
Total	80.6 (A)	252.3 (B)

Prevalence Index (B/A) = 3.13

Hydrophytic vegetation Indicators:

- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?

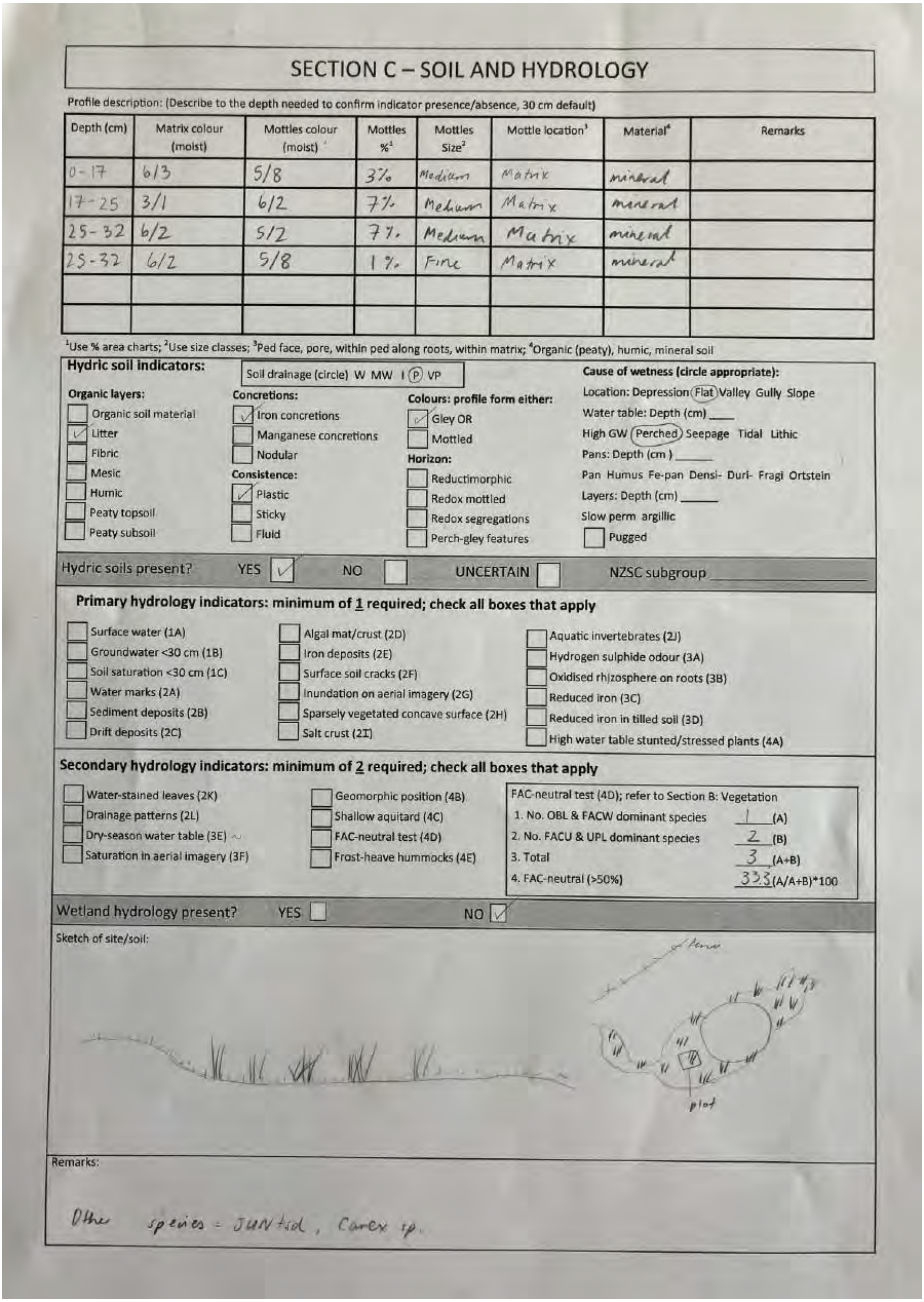
YES ☐

NO ☐

UNCERTAIN ☑

Remarks:

Uncertain results, more assessments undertaken.



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
0-17	6/3	5/8	3%	Medium	Matrix	mineral	
17-25	3/1	6/2	7%	Medium	Matrix	mineral	
25-32	6/2	5/2	7%	Medium	Matrix	mineral	
25-32	6/2	5/8	1%	Fine	Matrix	mineral	

[1]Use % area charts; [2]Use size classes; [3]Ped face, pore, within ped along roots, within matrix; [4]Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I [✓ P] VP

Organic layers:
- ☐ Organic soil material
- ☑ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☑ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☑ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☑ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: Depression [✓ Flat] Valley Gully Slope

Water table: Depth (cm) ____

High GW [✓ Perched] Seepage Tidal Lithic

Pans: Depth (cm) ______

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ______

Slow perm argillic

☐ Pugged

Hydric soils present? YES ☑ NO ☐ UNCERTAIN ☐ NZSC subgroup ______________

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☐ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☐ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☐ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☐ Saturation in aerial imagery (3F)
- ☐ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

FAC-neutral test (4D); refer to Section B: Vegetation

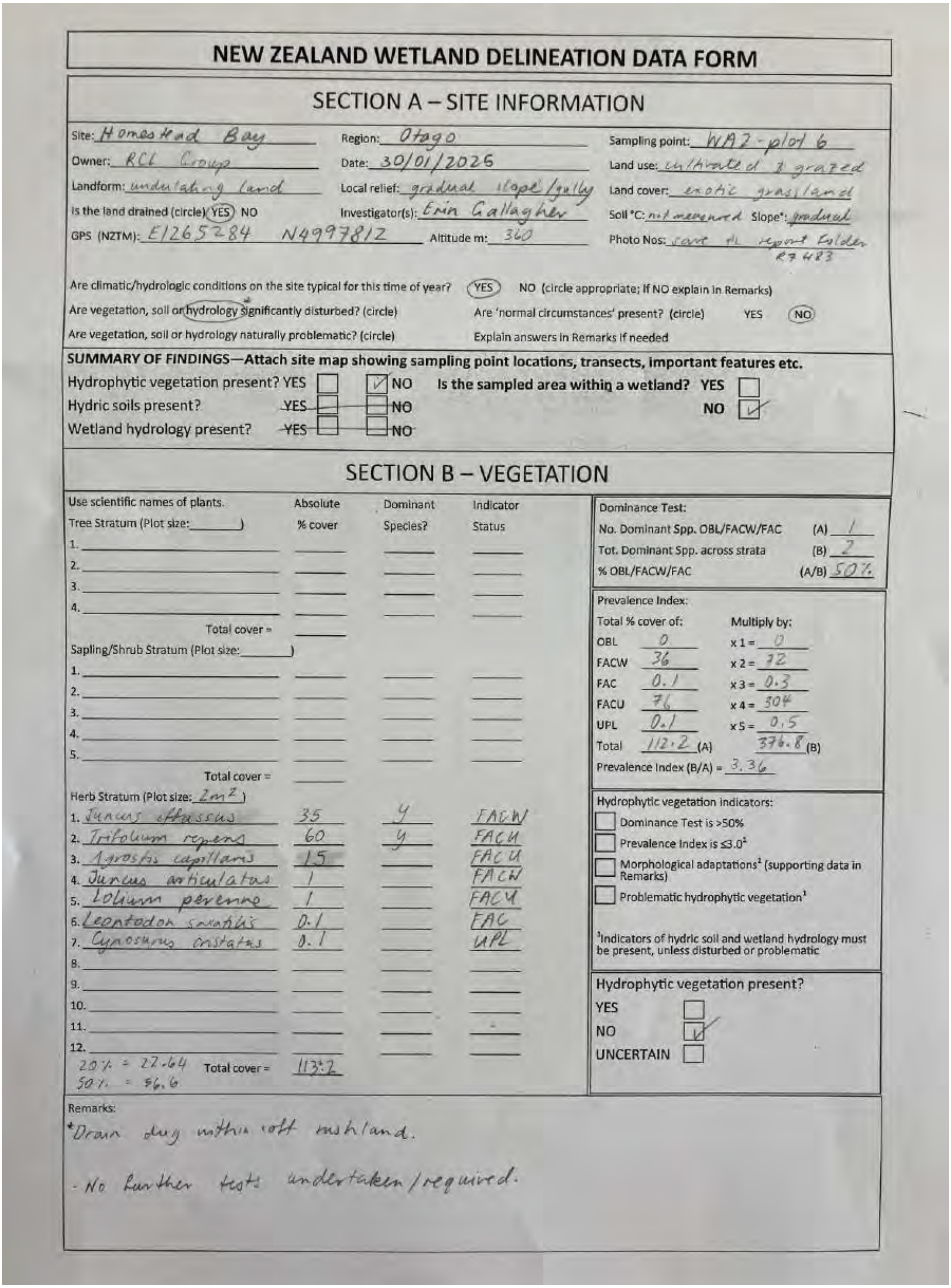
1. No. OBL & FACW dominant species	1	(A)
2. No. FACU & UPL dominant species	2	(B)
3. Total	3	(A+B)
4. FAC-neutral (>50%)	33.3	(A/A+B)*100

Wetland hydrology present? YES ☐ NO ☑

Sketch of site/soil:

Remarks:

Other species = Jun tsd, Carex sp.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA2-plot 6
Owner: RCL Group
Date: 30/01/2025
Land use: cultivated & grazed
Landform: undulating land
Local relief: gradual slope/gully
Land cover: exotic grassland
Is the land drained (circle) [✓ YES] NO
Investigator(s): Erin Gallagher
Soil °C: not measured Slope°: gradual
GPS (NZTM): E1265284 N4997812
Altitude m: 360
Photo Nos: save to report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or [✓ hydrology] *significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) YES [✓ NO]
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
Hydric soils present? ~~YES ☐ ☐ NO~~
Wetland hydrology present? ~~YES ☐ ☐ NO~~
Is the sampled area within a wetland? YES ☐
NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Juncus effussus	35	y	FACW
2. Trifolium repens	60	y	FACU
3. Agrostis capillaris	15		FACU
4. Juncus articulatus	1		FACW
5. Lolium perenne	1		FACU
6. Leontodon saxatilis	0.1		FAC
7. Cynosurus cristatus	0.1		UPL
8.			
9.			
10.			
11.			
12.			
Total cover =	113.2		

20% = 22.64
50% = 56.6

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 1
Tot. Dominant Spp. across strata (B) 2
% OBL/FACW/FAC (A/B) 50%

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	36	x 2 = 72
FAC	0.1	x 3 = 0.3
FACU	76	x 4 = 304
UPL	0.1	x 5 = 0.5
Total	112.2 (A)	376.8 (B)

Prevalence Index (B/A) = 3.36

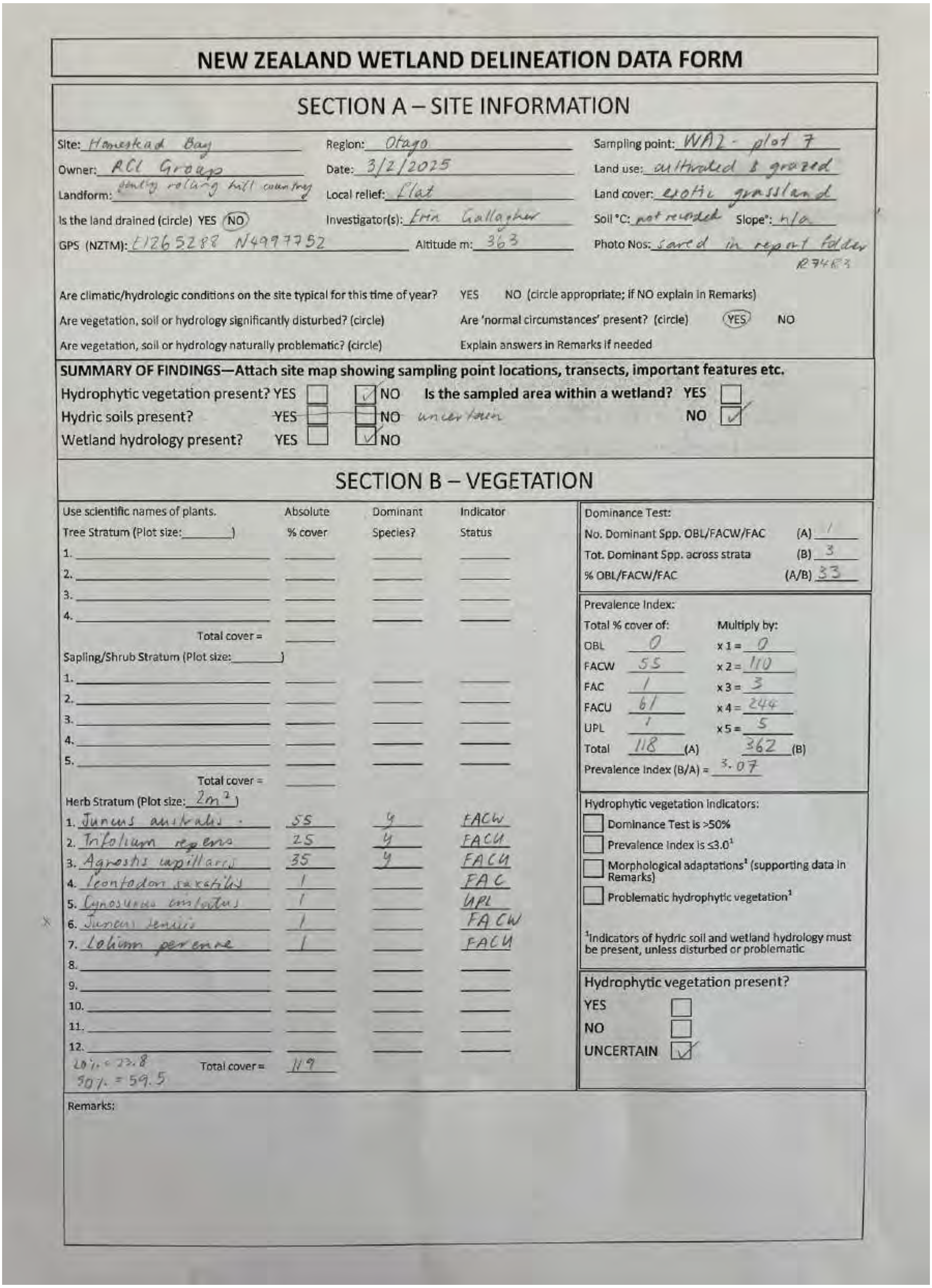
Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
*Drain dug within soft rushland.

- No further tests undertaken/required.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA2 - plot 7
Owner: RCL Group
Date: 3/2/2025
Land use: cultivated & grazed
Landform: gently rolling hill country
Local relief: flat
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded
Slope°: n/a
GPS (NZTM): E1265288 N4997752
Altitude m: 363
Photo Nos: saved in report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? YES NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
Hydric soils present? ~~YES ☐ ☐ NO~~ uncertain
Wetland hydrology present? YES ☐ ☑ NO

Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Juncus australis	55	y	FACW
2. Trifolium repens	25	y	FACU
3. Agrostis capillaris	35	y	FACU
4. Leontodon saxatilis	1		FAC
5. Cynosurus cristatus	1		UPL
* 6. Juncus tenuis	1		FACW
7. Lolium perenne	1		FACU
8.			
9.			
10.			
11.			
12.			
20% = 23.8 50% = 59.5 Total cover =	119		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 1
Tot. Dominant Spp. across strata (B) 3
% OBL/FACW/FAC (A/B) 33

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	55	x 2 = 110
FAC	1	x 3 = 3
FACU	61	x 4 = 244
UPL	1	x 5 = 5
Total	118 (A)	362 (B)

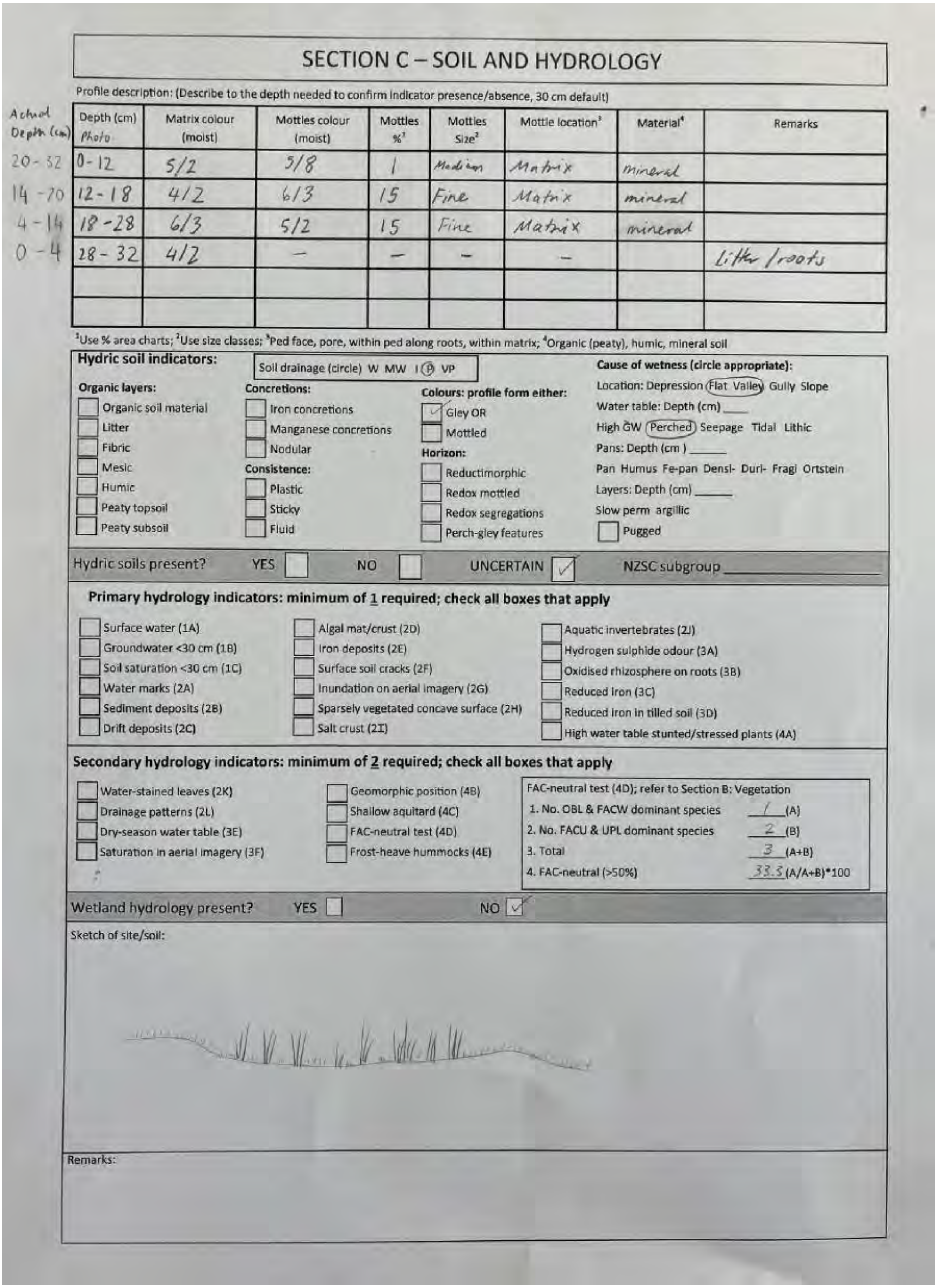
Prevalence Index (B/A) = 3.07

Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☐
UNCERTAIN ☑

Remarks:



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Actual Depth (cm)	Depth (cm) Photo	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
20-32	0-12	5/2	5/8	1	Medium	Matrix	mineral	
14-20	12-18	4/2	6/3	15	Fine	Matrix	mineral	
4-14	18-28	6/3	5/2	15	Fine	Matrix	mineral	
0-4	28-32	4/2	–	–	–	–		Litter/roots

[1]Use % area charts; [2]Use size classes; [3]Ped face, pore, within ped along roots, within matrix; [4]Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I [✓ P] VP

Organic layers:
- ☐ Organic soil material
- ☐ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☐ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☐ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☑ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: Depression [✓ Flat Valley] Gully Slope

Water table: Depth (cm) ____

High GW [✓ Perched] Seepage Tidal Lithic

Pans: Depth (cm) ______

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ______

Slow perm argillic

☐ Pugged

Hydric soils present? YES ☐ NO ☐ UNCERTAIN ☑ NZSC subgroup ____________

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☐ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☐ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☐ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☐ Saturation in aerial imagery (3F)
- ☐ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

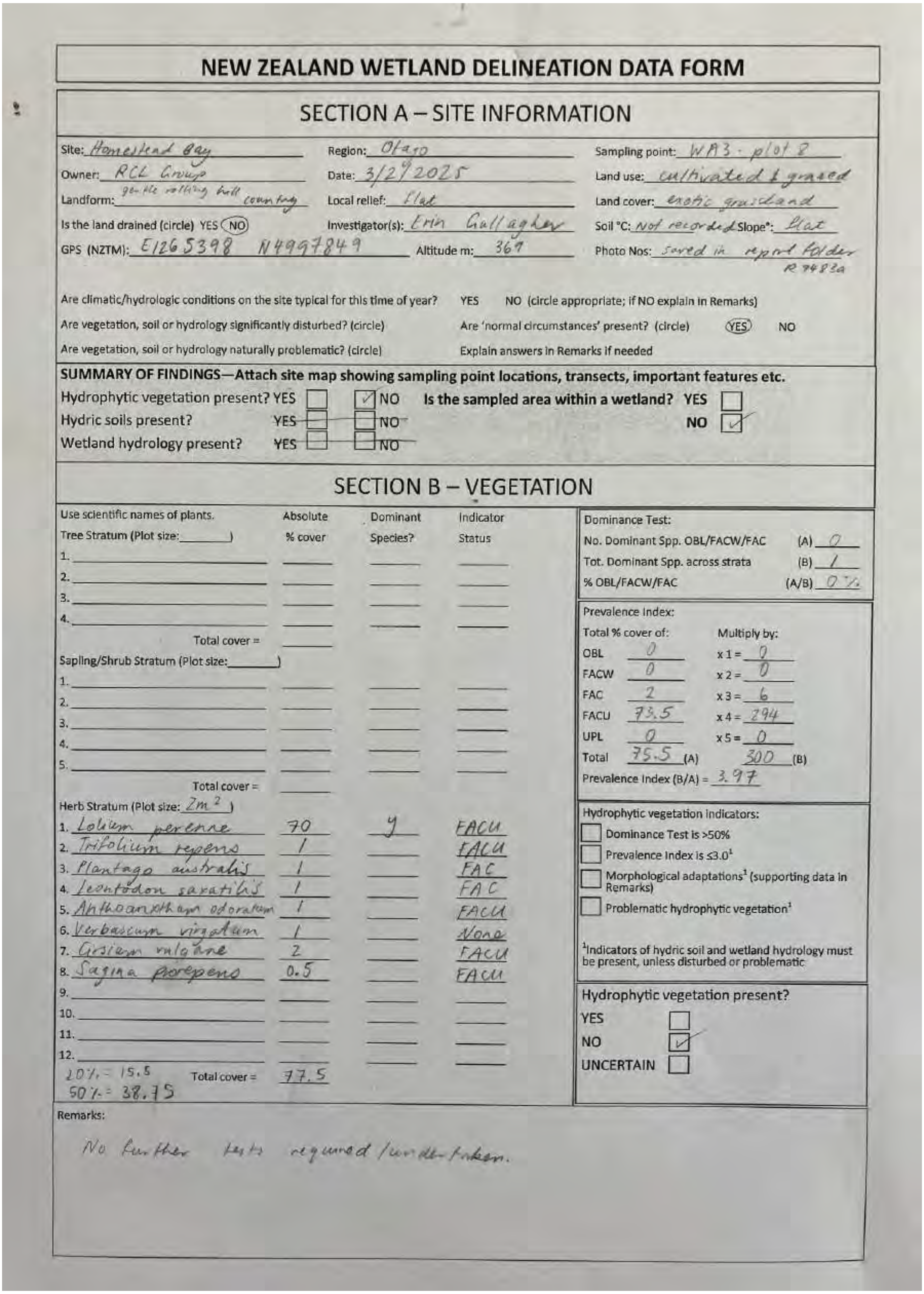
FAC-neutral test (4D); refer to Section B: Vegetation

1. No. OBL & FACW dominant species	1	(A)
2. No. FACU & UPL dominant species	2	(B)
3. Total	3	(A+B)
4. FAC-neutral (>50%)	33.3	(A/A+B)*100

Wetland hydrology present? YES ☐ NO ☑

Sketch of site/soil:

Remarks:



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA3 - plot 8
Owner: RCL Group
Date: 3/2/2025
Land use: cultivated & grazed
Landform: gentle rolling hill country
Local relief: flat
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: Not recorded Slope°: flat
GPS (NZTM): E1265398 N4997849
Altitude m: 367
Photo Nos: saved in report folder R 7483a

Are climatic/hydrologic conditions on the site typical for this time of year? YES NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
~~Hydric soils present? YES ☐ ☐ NO~~
~~Wetland hydrology present? YES ☐ ☐ NO~~

Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m^2)			
1. Lolium perenne	70	y	FACU
2. Trifolium repens	1		FACU
3. Plantago australis	1		FAC
4. Leontodon saxatilis	1		FAC
5. Anthoxanthum odoratum	1		FACU
6. Verbascum virgatum	1		None
7. Cirsium vulgare	2		FACU
8. Sagina procumbens	0.5		FACU
9.			
10.			
11.			
12.			
20% = 15.5 50% = 38.75 Total cover =	77.5		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 1
% OBL/FACW/FAC (A/B) 0 %

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	2	x 3 = 6
FACU	73.5	x 4 = 294
UPL	0	x 5 = 0
Total	75.5 (A)	300 (B)

Prevalence Index (B/A) = 3.97

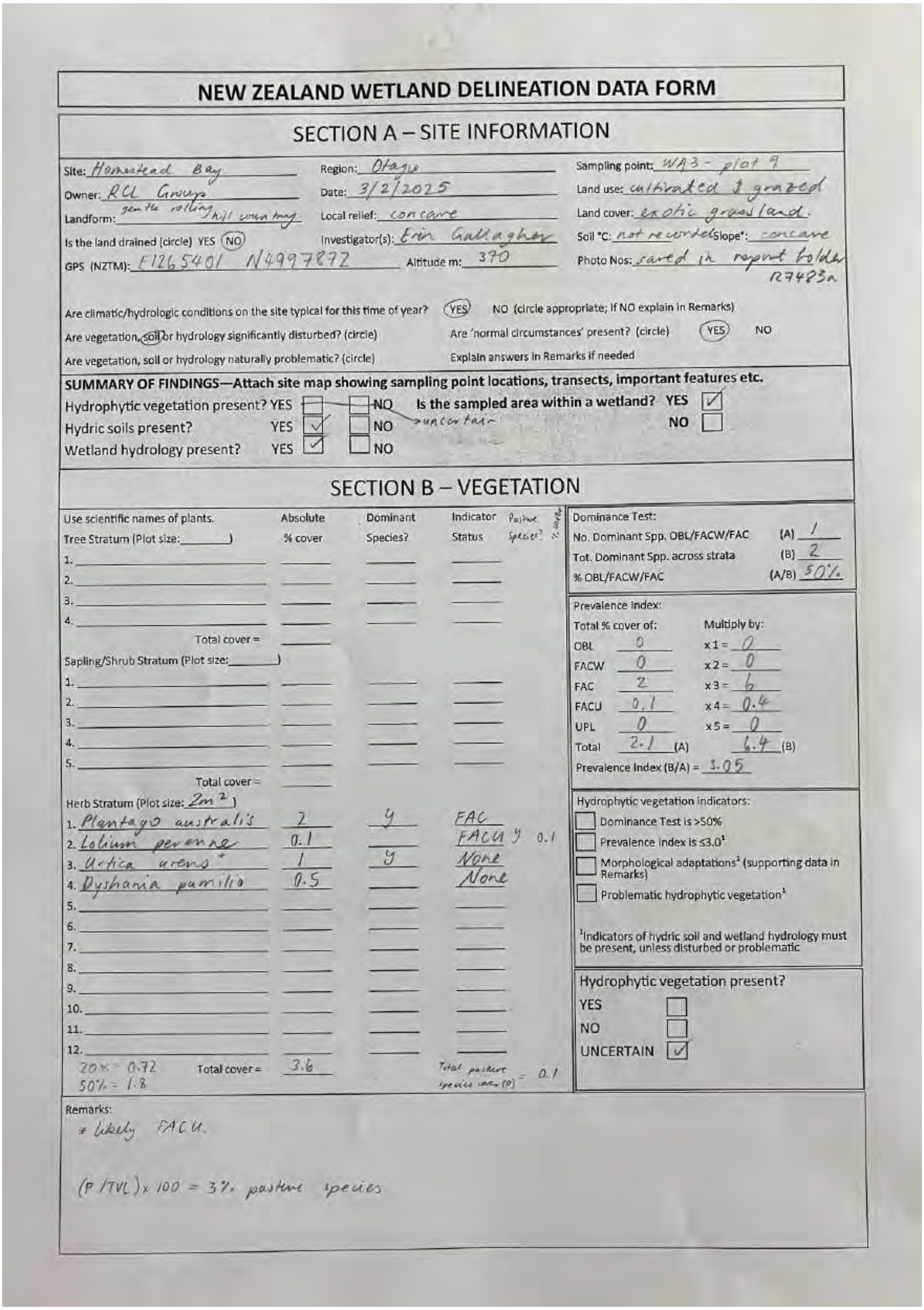
Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:

No further tests required/undertaken.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA3 - plot 9
Owner: RCL Group
Date: 3/2/2025
Land use: cultivated & grazed
Landform: gentle rolling hill country
Local relief: concave
Land cover: exotic grassland.
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: concave
GPS (NZTM): E1265401 N4997872
Altitude m: 370
Photo Nos: saved in report folder R7483a

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)

Are vegetation, [✓ soil] or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO

Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☐ NO uncertain
Hydric soils present? YES ☑ ☐ NO
Wetland hydrology present? YES ☑ ☐ NO

Is the sampled area within a wetland? YES ☑ NO ☐

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status	Pasture Species?	% cover
Tree Stratum (Plot size:)					
1.					
2.					
3.					
4.					
Total cover =					
Sapling/Shrub Stratum (Plot size:)					
1.					
2.					
3.					
4.					
5.					
Total cover =					
Herb Stratum (Plot size: 2m²)					
1. Plantago australis	2	y	FAC		
2. Lolium perenne	0.1		FACU	y	0.1
3. Urtica urens *	1	y	None		
4. Dyshania pumilio	0.5		None		
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
Total cover =	3.6		Total pasture species cover (P) =		0.1

20% = 0.72
50% = 1.8

Dominance Test:

No. Dominant Spp. OBL/FACW/FAC	(A)	1
Tot. Dominant Spp. across strata	(B)	2
% OBL/FACW/FAC	(A/B)	50%

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	2	x 3 = 6
FACU	0.1	x 4 = 0.4
UPL	0	x 5 = 0
Total	2.1 (A)	6.4 (B)

Prevalence Index (B/A) = 3.05

Hydrophytic vegetation indicators:

- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

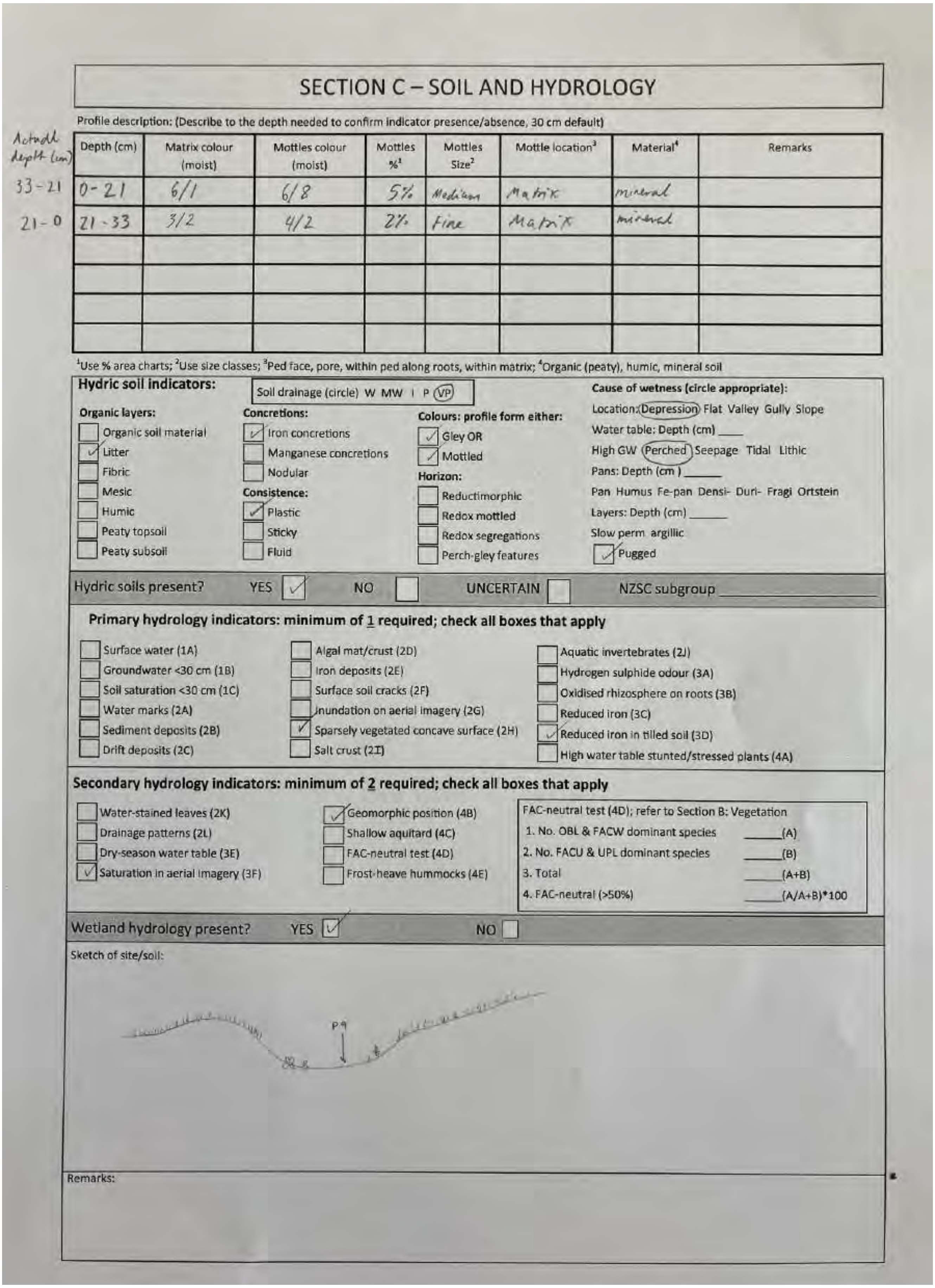
Hydrophytic vegetation present?

YES ☐
NO ☐
UNCERTAIN ☑

Remarks:

* likely FACU.

(P / TVC) x 100 = 3% pasture species



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Actual depth (cm)	Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
33-21	0-21	6/1	6/8	5%	Medium	Matrix	mineral	
21-0	21-33	3/2	4/2	2%	Fine	Matrix	mineral	

[1]Use % area charts; [2]Use size classes; [3]Ped face, pore, within ped along roots, within matrix; [4]Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I P [✓ VP]

Organic layers:
- ☐ Organic soil material
- ☑ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☑ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☑ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☑ Gley OR
- ☑ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: [✓ Depression] Flat Valley Gully Slope

Water table: Depth (cm) ____

High GW [✓ Perched] Seepage Tidal Lithic

Pans: Depth (cm) ______

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ______

Slow perm argillic

☑ Pugged

Hydric soils present? YES ☑ NO ☐ UNCERTAIN ☐ NZSC subgroup ____________

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☐ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☑ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☑ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☑ Saturation in aerial imagery (3F)
- ☑ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

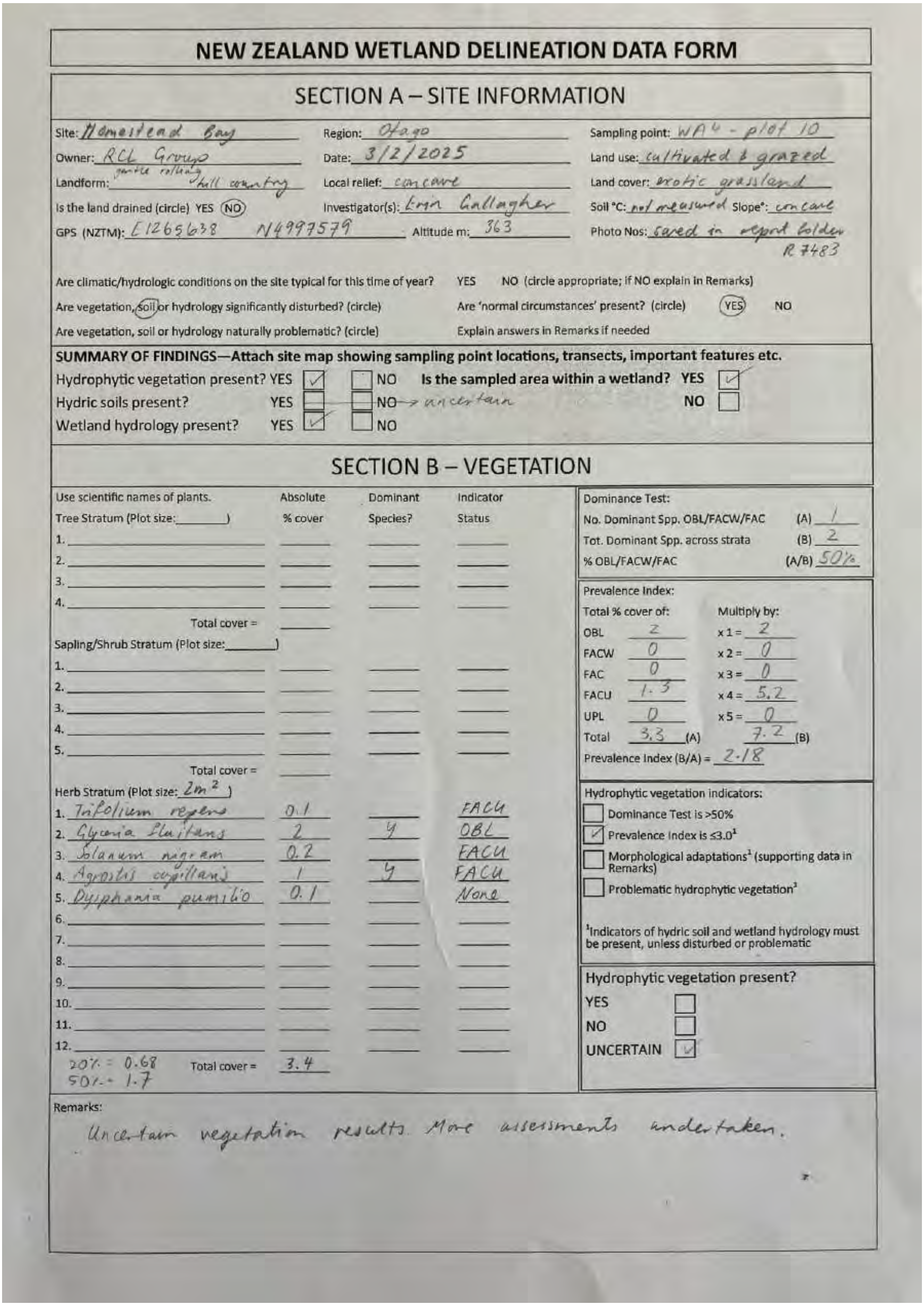
FAC-neutral test (4D); refer to Section B: Vegetation

1. No. OBL & FACW dominant species _____(A)
2. No. FACU & UPL dominant species _____(B)
3. Total _____(A+B)
4. FAC-neutral (>50%) _____(A/A+B)*100

Wetland hydrology present? YES ☑ NO ☐

Sketch of site/soil:

Remarks:



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA4 - plot 10
Owner: RCL Group
Date: 3/2/2025
Land use: cultivated & grazed
Landform: gentle rolling hill country
Local relief: concave
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not measured
Slope°: concave
GPS (NZTM): E1265638 N4997579
Altitude m: 363
Photo Nos: saved in report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? YES NO (circle appropriate; if NO explain in Remarks)

Are vegetation, [✓ soil] or hydrology significantly disturbed? (circle)

Are 'normal circumstances' present? (circle) [✓ YES] NO

Are vegetation, soil or hydrology naturally problematic? (circle)

Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☑ ☐ NO
Hydric soils present? YES ☐ ☐ NO → uncertain
Wetland hydrology present? YES ☑ ☐ NO

Is the sampled area within a wetland? YES ☑ NO ☐

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Trifolium repens	0.1		FACU
2. Glyceria fluitans	2	y	OBL
3. Solanum nigrum	0.2		FACU
4. Agrostis capillaris	1	y	FACU
5. Dysphania pumilio	0.1		None
6.			
7.			
8.			
9.			
10.			
11.			
12.			
Total cover =	3.4		

20% = 0.68
50% = 1.7

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 1
Tot. Dominant Spp. across strata (B) 2
% OBL/FACW/FAC (A/B) 50%

Prevalence Index:

Total % cover of:		Multiply by:
OBL	2	x 1 = 2
FACW	0	x 2 = 0
FAC	0	x 3 = 0
FACU	1.3	x 4 = 5.2
UPL	0	x 5 = 0
Total	3.3 (A)	7.2 (B)

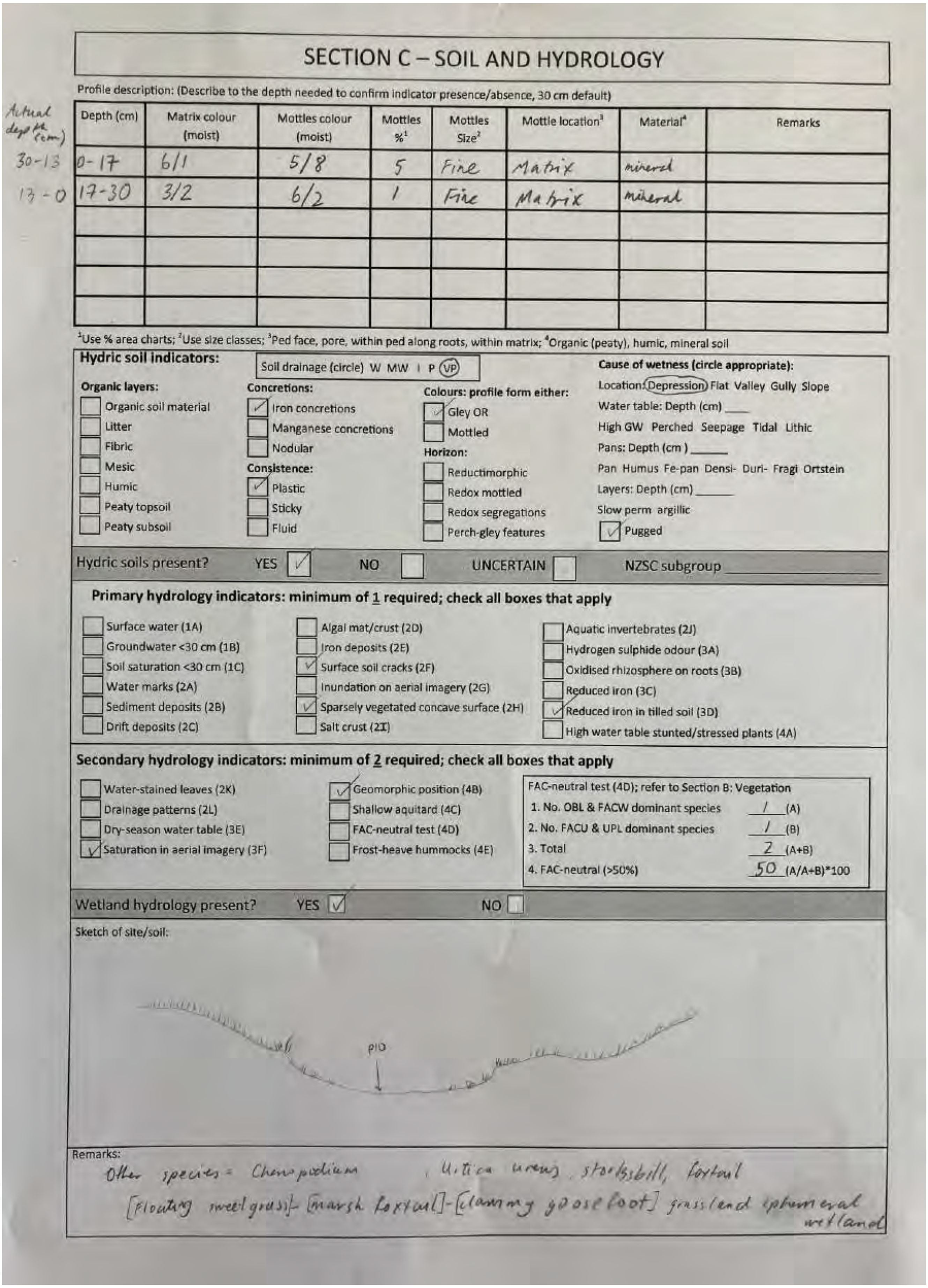
Prevalence Index (B/A) = 2.18

Hydrophytic vegetation indicators:
- ☐ Dominance Test is >50%
- ☑ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☐
UNCERTAIN ☑

Remarks:
Uncertain vegetation results. More assessments undertaken.



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Actual depth (cm)	Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
30-13	0-17	6/1	5/8	5	Fine	Matrix	mineral	
13-0	17-30	3/2	6/2	1	Fine	Matrix	mineral	

[1] Use % area charts; [2] Use size classes; [3] Ped face, pore, within ped along roots, within matrix; [4] Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I P [✓ VP]

Organic layers:
- ☐ Organic soil material
- ☐ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☑ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☑ Plastic
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☑ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: [✓ Depression] Flat Valley Gully Slope

Water table: Depth (cm) ____

High GW Perched Seepage Tidal Lithic

Pans: Depth (cm) ____

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ____

Slow perm argillic

☑ Pugged

Hydric soils present? YES ☑ NO ☐ UNCERTAIN ☐ NZSC subgroup ____

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☑ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☑ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☑ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☑ Saturation in aerial imagery (3F)
- ☑ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

FAC-neutral test (4D); refer to Section B: Vegetation

1. No. OBL & FACW dominant species	1	(A)
2. No. FACU & UPL dominant species	1	(B)
3. Total	2	(A+B)
4. FAC-neutral (>50%)	50	(A/A+B)*100

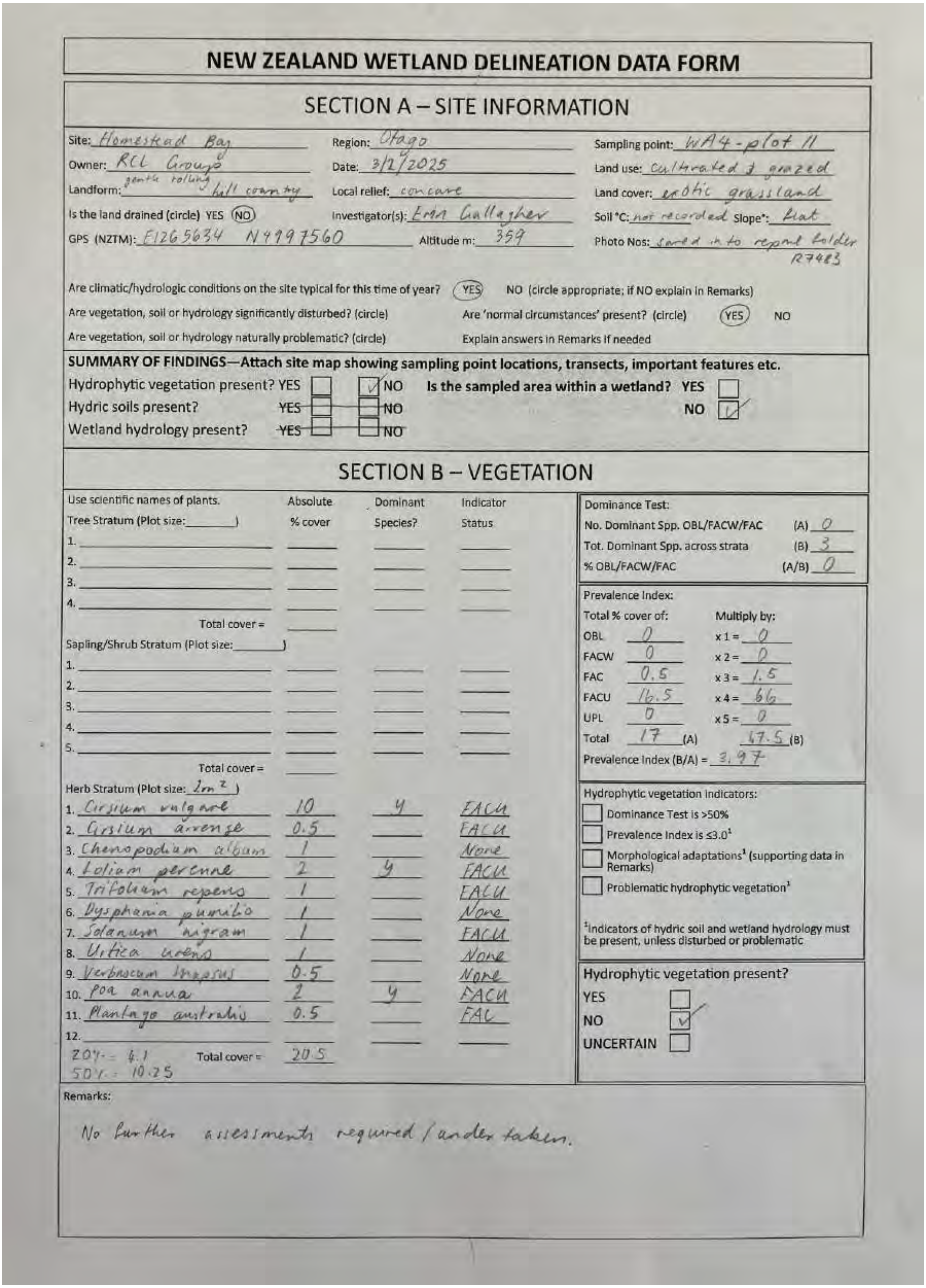
Wetland hydrology present? YES ☑ NO ☐

Sketch of site/soil:

Remarks:

Other species = Chenopodium , Urtica urens , storksbill, foxtail

[Floating sweetgrass]-[marsh foxtail]-[clammy goosefoot] grassland ephemeral wetland



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA4-plot 11
Owner: RCL Group
Date: 3/2/2025
Land use: Cultivated & grazed
Landform: gentle rolling hill country
Local relief: concave
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: flat
GPS (NZTM): E1265634 N4997560
Altitude m: 359
Photo Nos: saved in to report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
~~Hydric soils present? YES ☐ ☐ NO~~
~~Wetland hydrology present? YES ☐ ☐ NO~~

Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Cirsium vulgare	10	y	FACU
2. Cirsium arvense	0.5		FACU
3. Chenopodium album	1		None
4. Lolium perenne	2	y	FACU
5. Trifolium repens	1		FACU
6. Dysphania pumilio	1		None
7. Solanum nigram	1		FACU
8. Urtica urens	1		None
9. Verbascum thapsus	0.5		None
10. Poa annua	2	y	FACU
11. Plantago australis	0.5		FAC
12.			
20% = 4.1 50% = 10.25 Total cover =	20.5		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 3
% OBL/FACW/FAC (A/B) 0

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	0.5	x 3 = 1.5
FACU	16.5	x 4 = 66
UPL	0	x 5 = 0
Total	17 (A)	67.5 (B)

Prevalence Index (B/A) = 3.97

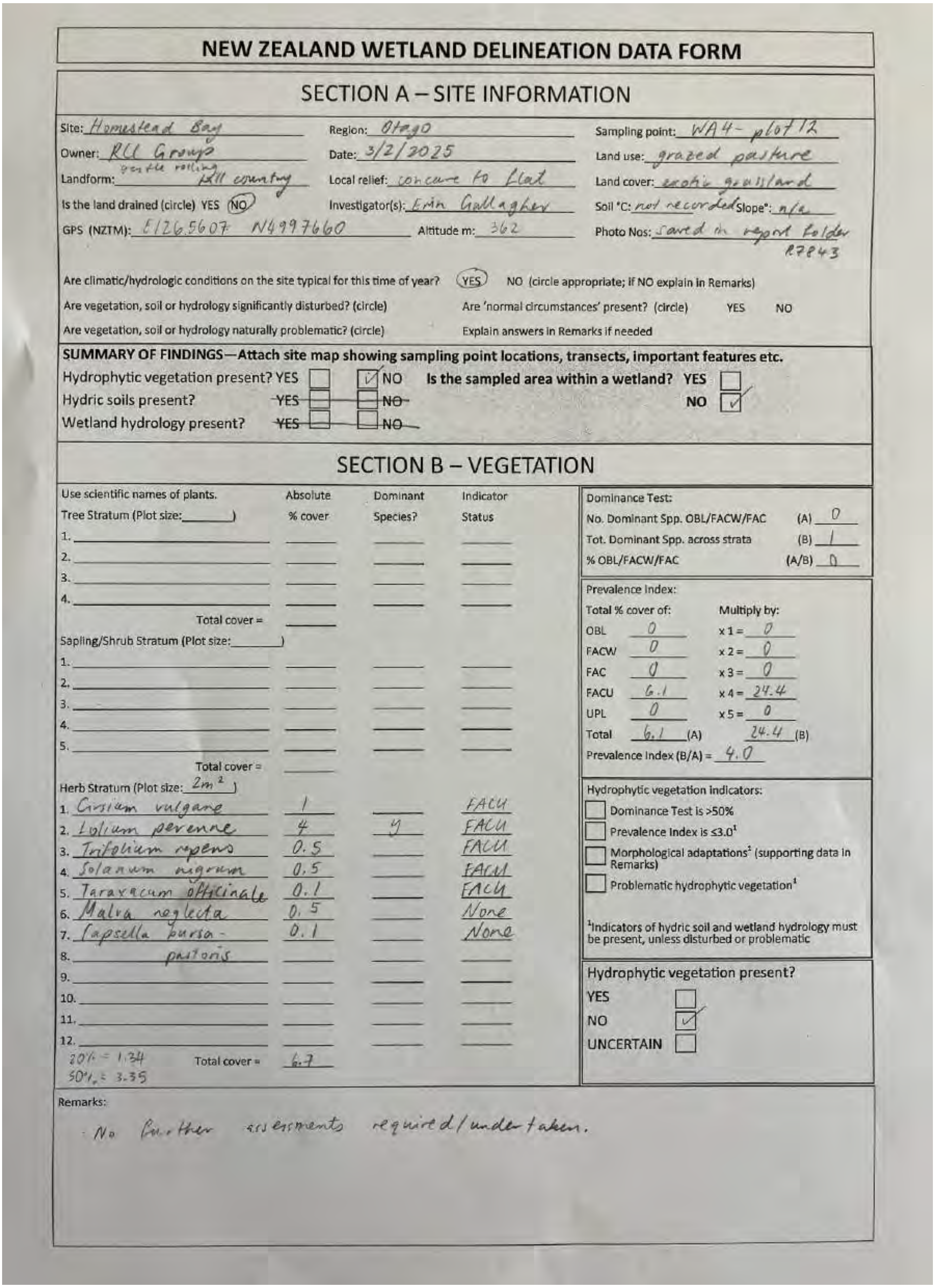
Hydrophytic vegetation indicators:
- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:

No further assessments required / under taken.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA4- plot 12
Owner: RCL Group
Date: 3/2/2025
Land use: grazed pasture
Landform: gentle rolling hill country
Local relief: concave to flat
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: n/a
GPS (NZTM): E1265607 N4997660
Altitude m: 362
Photo Nos: saved in report folder R7843

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) YES NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
~~Hydric soils present? YES ☐ ☐ NO~~
~~Wetland hydrology present? YES ☐ ☐ NO~~

Is the sampled area within a wetland? **YES** ☐ **NO** ☑

SECTION B – VEGETATION

Use scientific names of plants.

	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Cirsium vulgare	1		FACU
2. Lolium perenne	4	y	FACU
3. Trifolium repens	0.5		FACU
4. Solanum nigrum	0.5		FACU
5. Taraxacum officinale	0.1		FACU
6. Malva neglecta	0.5		None
7. Capsella bursa-	0.1		None
8. pastoris			
9.			
10.			
11.			
12.			
20% = 1.34 50% = 3.35 Total cover =	6.7		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 1
% OBL/FACW/FAC (A/B) 0

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	0	x 3 = 0
FACU	6.1	x 4 = 24.4
UPL	0	x 5 = 0
Total	6.1 (A)	24.4 (B)

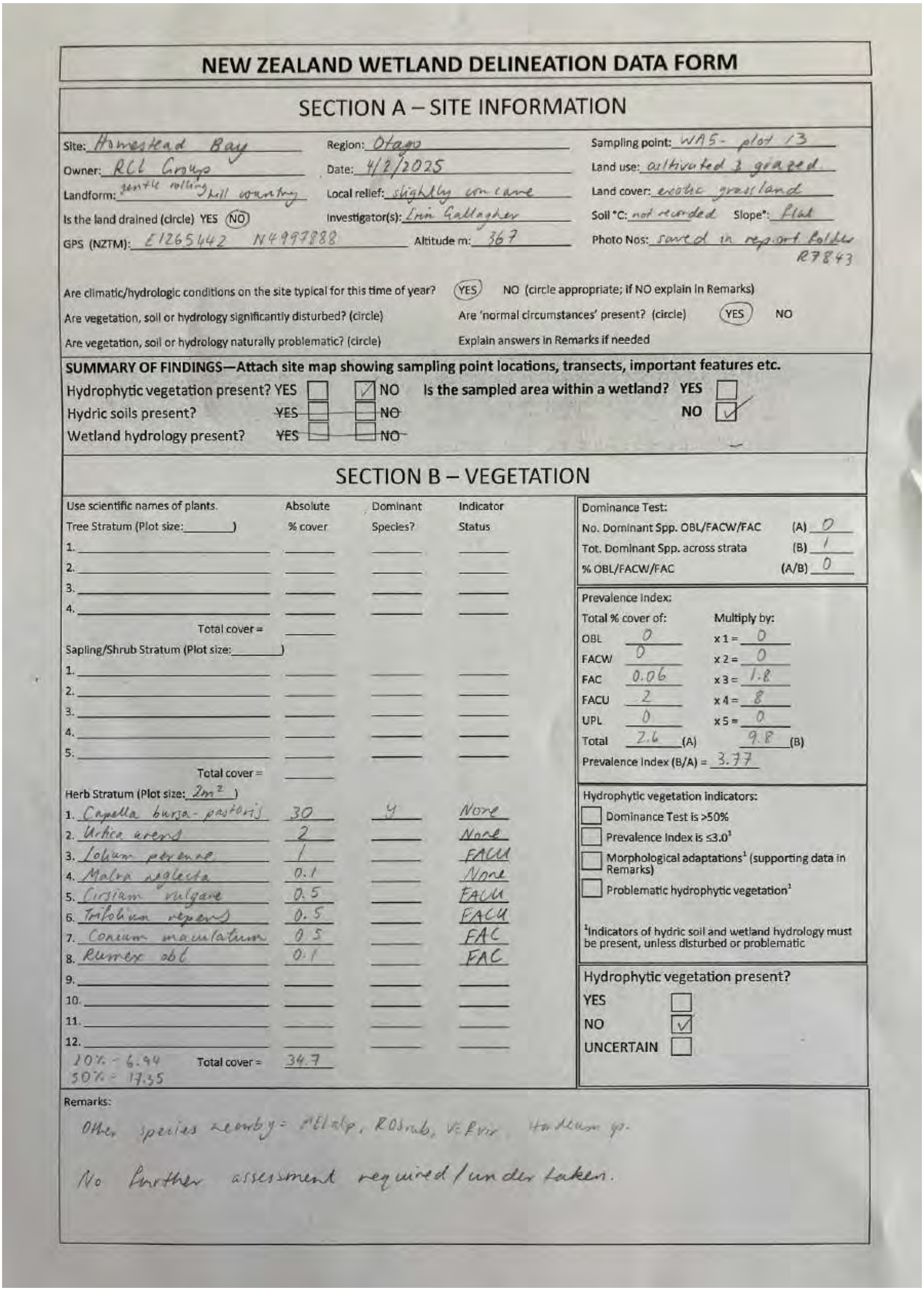
Prevalence Index (B/A) = 4.0

Hydrophytic vegetation indicators:
- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological adaptations[1] (supporting data in Remarks)
- ☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
No further assessments required/undertaken.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA5- plot 13
Owner: RCL Group
Date: 4/2/2025
Land use: cultivated & grazed.
Landform: gentle rolling hill country
Local relief: slightly concave
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded
Slope°: flat
GPS (NZTM): E1265442 N4997888
Altitude m: 367
Photo Nos: saved in report folder R7843

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
~~Hydric soils present? YES ☐ ☐ NO~~
~~Wetland hydrology present? YES ☐ ☐ NO~~
Is the sampled area within a wetland? **YES** ☐ **NO** ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Capella bursa-pastoris	30	Y	None
2. Urtica arens	2		None
3. Lolium perenne	1		FACU
4. Malva neglecta	0.1		None
5. Cirsium vulgare	0.5		FACU
6. Trifolium repens	0.5		FACU
7. Conium maculatum	0.5		FAC
8. Rumex obt	0.1		FAC
9.			
10.			
11.			
12.			
20% - 6.94 50% = 17.35 Total cover =	34.7		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 1
% OBL/FACW/FAC (A/B) 0

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	0.06	x 3 = 1.8
FACU	2	x 4 = 8
UPL	0	x 5 = 0
Total	2.6 (A)	9.8 (B)

Prevalence Index (B/A) = 3.77

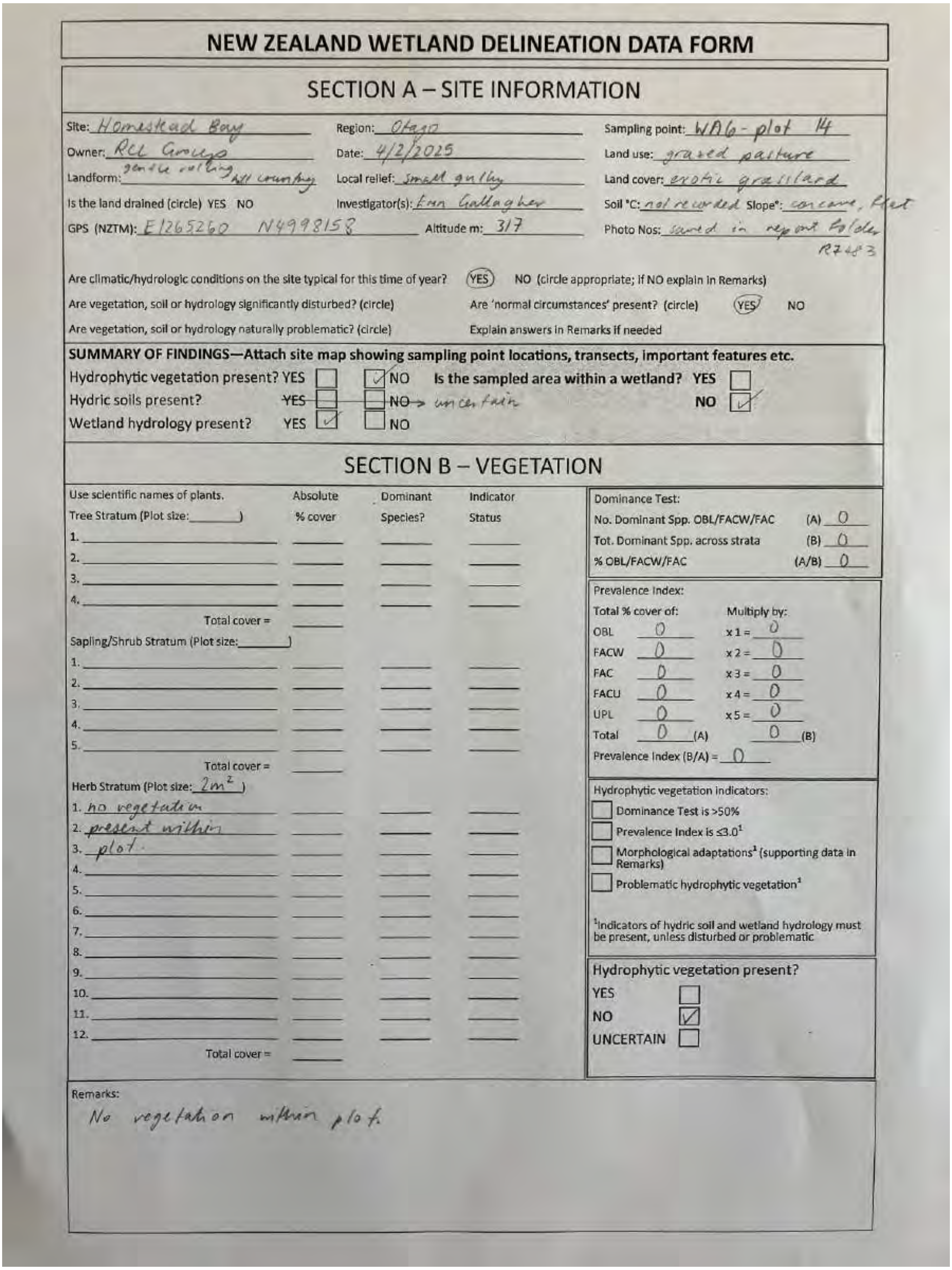
Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
Other species nearby = MElalp, ROSrub, VERvir, Hordeum sp.

No further assessment required/under taken.



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA6 - plot 14
Owner: RCL Groups
Date: 4/2/2025
Land use: grazed pasture
Landform: gentle rolling hill country
Local relief: small gully
Land cover: exotic grassland
Is the land drained (circle) YES NO
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: concave, flat
GPS (NZTM): E1265260 N4998158
Altitude m: 317
Photo Nos: saved in report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? [✓ YES] NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) [✓ YES] NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
Hydric soils present? ~~YES~~ ☐ ☐ ~~NO~~ → uncertain
Wetland hydrology present? YES ☑ ☐ NO
Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.

Tree Stratum (Plot size:____)	Absolute % cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total cover =			

Sapling/Shrub Stratum (Plot size:____)	Absolute % cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
Total cover =			

Herb Stratum (Plot size: $2m^2$)	Absolute % cover	Dominant Species?	Indicator Status
1. no vegetation			
2. present within			
3. plot.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
Total cover =			

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 0
% OBL/FACW/FAC (A/B) 0

Prevalence Index:

Total % cover of:		Multiply by:	
OBL	0	x 1 =	0
FACW	0	x 2 =	0
FAC	0	x 3 =	0
FACU	0	x 4 =	0
UPL	0	x 5 =	0
Total	0 (A)		0 (B)

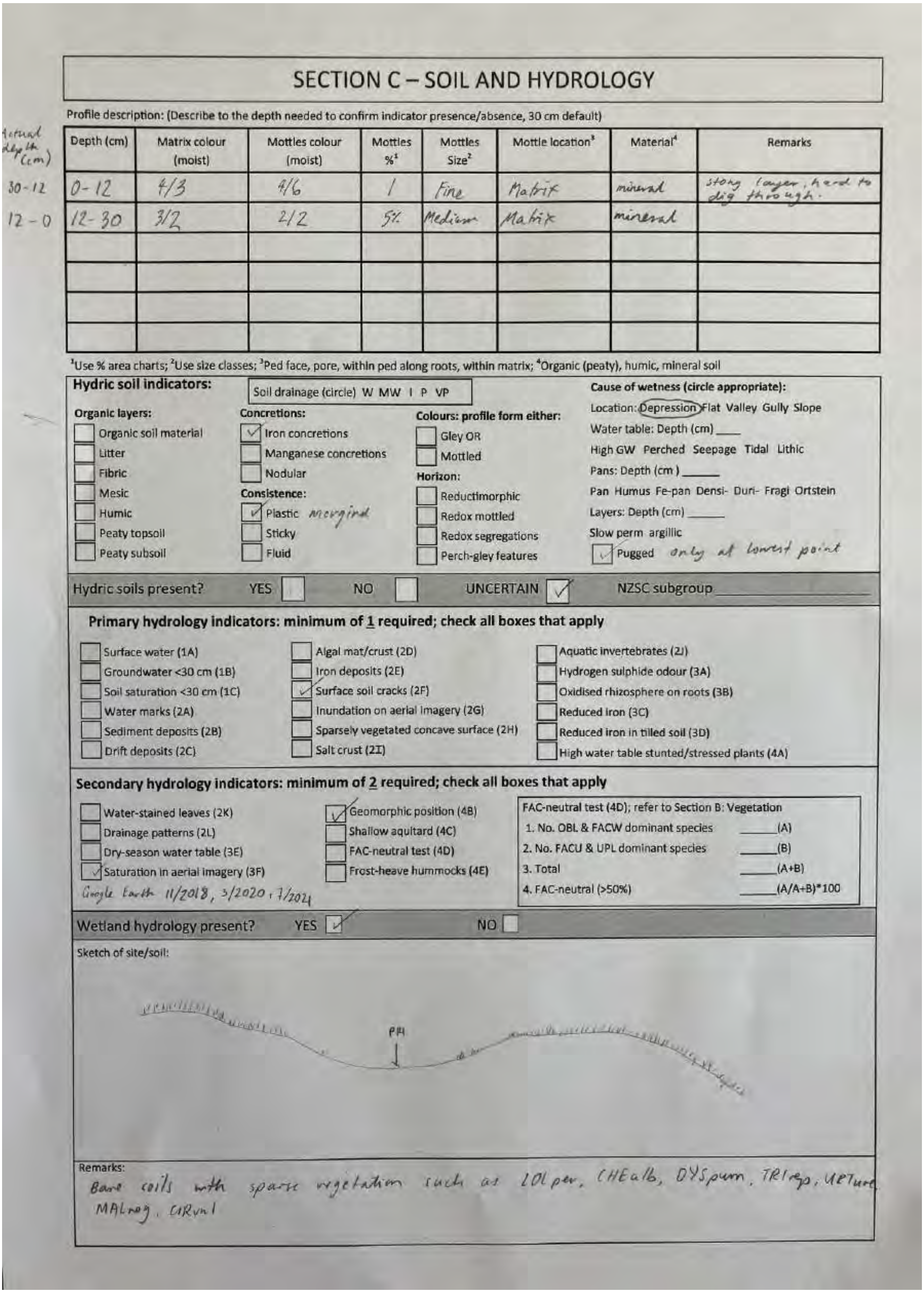
Prevalence Index (B/A) = 0

Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1] Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
No vegetation within plot.



SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Actual depth (cm)	Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
30-12	0-12	4/3	4/6	/	Fine	Matrix	mineral	stony layer, hard to dig through.
12-0	12-30	3/2	2/2	5%	Medium	Matrix	mineral	

[1]Use % area charts; [2]Use size classes; [3]Ped face, pore, within ped along roots, within matrix; [4]Organic (peaty), humic, mineral soil

Hydric soil indicators:

Soil drainage (circle) W MW I P VP

Organic layers:
- ☐ Organic soil material
- ☐ Litter
- ☐ Fibric
- ☐ Mesic
- ☐ Humic
- ☐ Peaty topsoil
- ☐ Peaty subsoil

Concretions:
- ☑ Iron concretions
- ☐ Manganese concretions
- ☐ Nodular

Consistence:
- ☑ Plastic marginal
- ☐ Sticky
- ☐ Fluid

Colours: profile form either:
- ☐ Gley OR
- ☐ Mottled

Horizon:
- ☐ Reductimorphic
- ☐ Redox mottled
- ☐ Redox segregations
- ☐ Perch-gley features

Cause of wetness (circle appropriate):

Location: [✓ Depression] Flat Valley Gully Slope

Water table: Depth (cm) ____

High GW Perched Seepage Tidal Lithic

Pans: Depth (cm) ____

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ____

Slow perm argillic

☑ Pugged only at lowest point

Hydric soils present? YES ☐ NO ☐ UNCERTAIN ☑ NZSC subgroup ____

Primary hydrology indicators: minimum of 1 required; check all boxes that apply

- ☐ Surface water (1A)
- ☐ Groundwater <30 cm (1B)
- ☐ Soil saturation <30 cm (1C)
- ☐ Water marks (2A)
- ☐ Sediment deposits (2B)
- ☐ Drift deposits (2C)
- ☐ Algal mat/crust (2D)
- ☐ Iron deposits (2E)
- ☑ Surface soil cracks (2F)
- ☐ Inundation on aerial imagery (2G)
- ☐ Sparsely vegetated concave surface (2H)
- ☐ Salt crust (2I)
- ☐ Aquatic invertebrates (2J)
- ☐ Hydrogen sulphide odour (3A)
- ☐ Oxidised rhizosphere on roots (3B)
- ☐ Reduced iron (3C)
- ☐ Reduced iron in tilled soil (3D)
- ☐ High water table stunted/stressed plants (4A)

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- ☐ Water-stained leaves (2K)
- ☐ Drainage patterns (2L)
- ☐ Dry-season water table (3E)
- ☑ Saturation in aerial imagery (3F)

Google Earth 11/2018, 3/2020, 7/2021

- ☑ Geomorphic position (4B)
- ☐ Shallow aquitard (4C)
- ☐ FAC-neutral test (4D)
- ☐ Frost-heave hummocks (4E)

FAC-neutral test (4D); refer to Section B: Vegetation

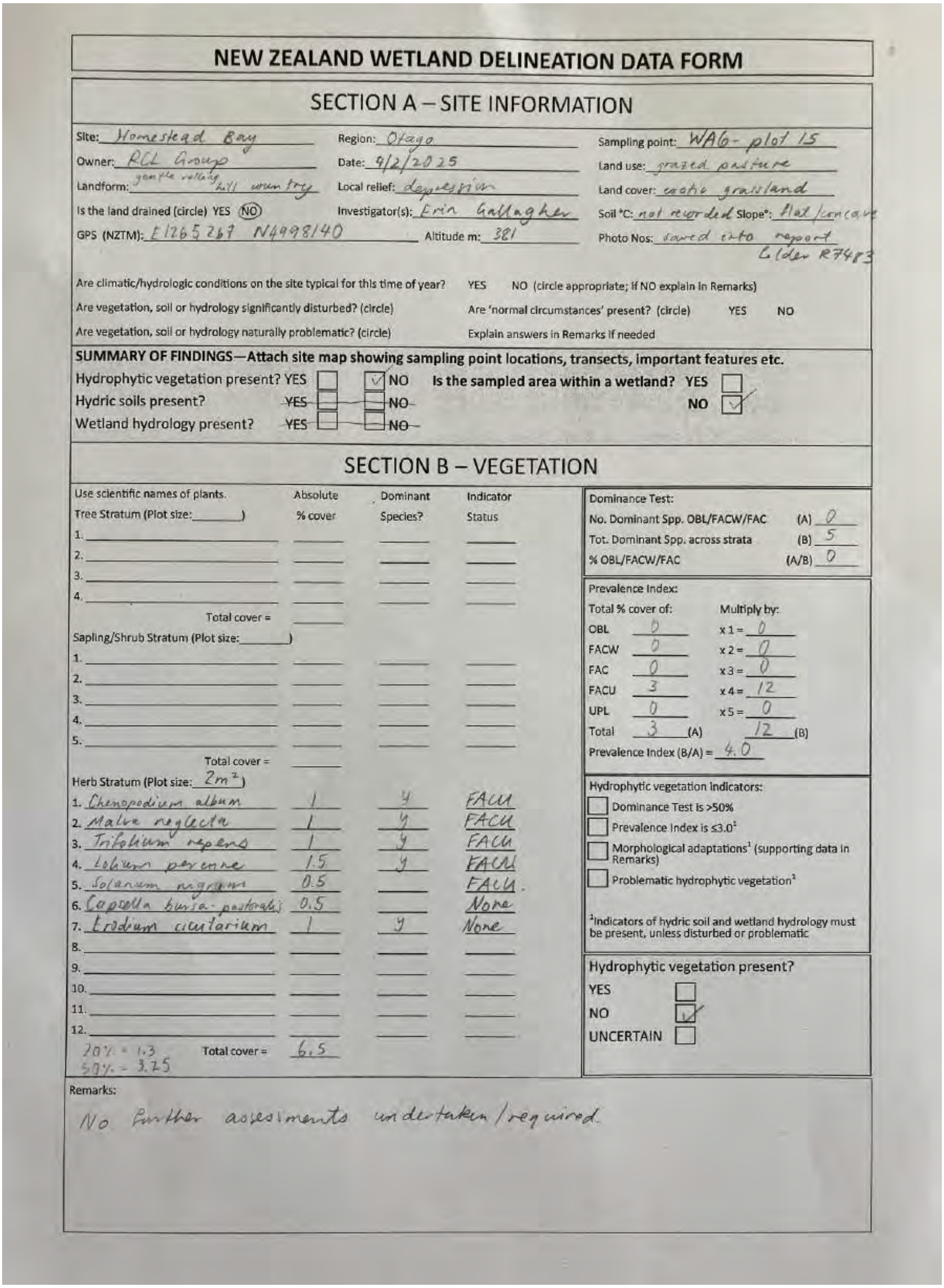
1. No. OBL & FACW dominant species ____(A)
2. No. FACU & UPL dominant species ____(B)
3. Total ____(A+B)
4. FAC-neutral (>50%) ____(A/A+B)*100

Wetland hydrology present? YES ☑ NO ☐

Sketch of site/soil:

Remarks:

Bare soils with sparse vegetation such as LOLper, CHEalb, DYSpum, TRIrep, URTure, MALneg, CIRvul



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Homestead Bay
Region: Otago
Sampling point: WA6- plot 15
Owner: RCL Group
Date: 4/2/2025
Land use: grazed pasture
Landform: gentle rolling hill country
Local relief: depression
Land cover: exotic grassland
Is the land drained (circle) YES [✓ NO]
Investigator(s): Erin Gallagher
Soil °C: not recorded Slope°: flat/concave
GPS (NZTM): E1265267 N4998140
Altitude m: 381
Photo Nos: saved into report folder R7483

Are climatic/hydrologic conditions on the site typical for this time of year? YES NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) YES NO
Are vegetation, soil or hydrology naturally problematic? (circle)
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present? YES ☐ ☑ NO
Hydric soils present? ~~YES ☐ ☐ NO~~
Wetland hydrology present? ~~YES ☐ ☐ NO~~

Is the sampled area within a wetland? YES ☐ NO ☑

SECTION B – VEGETATION

Use scientific names of plants.	Absolute % cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size:)			
1.			
2.			
3.			
4.			
Total cover =			
Sapling/Shrub Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
Total cover =			
Herb Stratum (Plot size: 2m²)			
1. Chenopodium album	1	y	FACU
2. Malva neglecta	1	y	FACU
3. Trifolium repens	1	y	FACU
4. Lolium perenne	1.5	y	FACU
5. Solanum nigrum	0.5		FACU.
6. Capsella bursa-pastoralis	0.5		None
7. Erodium cicutarium	1	y	None
8.			
9.			
10.			
11.			
12.			
20% = 1.3 50% = 3.25 Total cover =	6.5		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 0
Tot. Dominant Spp. across strata (B) 5
% OBL/FACW/FAC (A/B) 0

Prevalence Index:

Total % cover of:		Multiply by:
OBL	0	x 1 = 0
FACW	0	x 2 = 0
FAC	0	x 3 = 0
FACU	3	x 4 = 12
UPL	0	x 5 = 0
Total	3 (A)	12 (B)

Prevalence Index (B/A) = 4.0

Hydrophytic vegetation indicators:
☐ Dominance Test is >50%
☐ Prevalence Index is ≤3.0¹
☐ Morphological adaptations¹ (supporting data in Remarks)
☐ Problematic hydrophytic vegetation¹

¹Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☐
NO ☑
UNCERTAIN ☐

Remarks:
No further assessments undertaken/required.

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