PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Office +64 3 345 7100
Web www.pdp.co.nz

solutions for your environment

pdp

memorandum

TO	Tanvir Bhamji	FROM	Oliver Hunt, Mark Bellingham and Alan Pattle
	Watercare Services Ltd	DATE	17 May 2024
RE	Assessment of Potential Effects on Soils and Ecology from Beachlands WWTP Overland Flow System (Memorandum 4)		

1.0 Background

Watercare Services Ltd (**Watercare**) is currently undertaking technical assessments to inform a resource consent application for the discharge of treated wastewater from the Beachlands Wastewater Treatment Plant (**WWTP**). The consent will provide for projected population growth and an increase the capacity of the WWTP to 30,000PE over a proposed term of 35 years. The Best Practicable Option (**BPO**) for the discharge has been identified as the continued use and expansion of the existing overland flow system from the Beachlands WWTP which is used to create a diffuse discharge to the Te Puru Stream.

Pattle Delamore Partners (**PDP**) has previously completed work to assess the overland flow area required for expansion of the WWTP's capacity to 30,000 PE, summarise the current performance data available for the existing system, and to detail the interim results of a sampling regime investigating the specific performance of the existing system (PDP Memorandums 1, 2 and 3).

This memorandum has been prepared to assess the potential adverse effects on soils, groundwater, and ecology of the proposed discharge of wastewater to land within the existing and proposed overland flow areas. This assessment concludes that effects of the proposed discharge are likely to be minimal and can be adequately avoided through suitable design of the expanded overland flow area.

2.0 Description of Overland Flow System

The United States Environmental Protection Agency (**USEPA**) provides the following description of generic overland flow treatment: "the controlled application of wastewater onto grass-covered, uniformly graded, gentle slopes, with relatively impermeable surface soils" (USEPA, 2006). Overland flow systems are designed to provide for biological activity to occur as the wastewater flows over the surface of the land. Typically, wastewater application rates exceed the infiltration capacity of the soils, and it is expected that the majority of wastewater applied to the top of the slope runs off at the bottom and is captured in a controlled manner rather than infiltrating into deep soil layers or any aquifer below the overland flow area.

As noted in Memorandum 1, the existing overland flow area differs from the USEPA guidelines in several aspects. It is anticipated that native vegetation, as is currently present in the existing area, will be retained in the existing area and included in proposed area. However, other changes may form part of the final design which more closely follow the USEPA standards including the improvements to the dispersal systems.

Overall, overland flow areas have been selected as they generally conform to the requirements of the USEPA guidelines including low soil permeability and gentle slope. It is anticipated that losses of wastewater via infiltration will generally be low. Most wastewater applied to the top of the slopes will be discharged into the farm pond in a controlled manner either, as run-off from the existing area, or, will be conveyed to a discharge point on the banks of the farm pond from the proposed areas (Area B2). Losses due to evaporation/evapotranspiration are expected to be negligible.

3.0 Potential Effects on Ecology

The wider Watercare WWTP site at Beachlands includes Significant Ecological Areas (SEAs) identified in the Auckland Unitary Plan (AUP). Within these SEAs, PDP has identified that there are possibly wetlands within the gullies between Areas B1 and B2 and in the riparian margins of the stream downstream of the farm pond (Memorandum 1).

The SEA identified in the AUP includes the constructed farm pond and existing overland flow area, both of which are used for treatment/discharge of wastewater. These areas are part of the Beachlands WWTP and have been part of the WWTP since 2006. These areas are not natural ecosystems, they have been developed to facilitate wastewater treatment and discharge and therefore do not meet the SEA criteria in the AUP or the natural inland wetlands criteria of the NPS-FM.

Two areas have been identified as possible additional wastewater disposal areas. Area A (the western area, refer Figure 1) is mostly within the 100-metre buffer of the wetlands within the downstream riparian margin. Area B (the eastern area) primarily drains or could be modified to drain to the existing farm pond. Some of Area B is within 100m of the downstream riparian SEA/wetlands, however, with the proposed overland flow slope design, the wastewater field will not drain into these downstream riparian wetland areas. The development of Area B, with drainage into the existing farm pond and not into any downstream wetlands is unlikely to have any additional adverse ecological effects on the SEA and wetlands in the Te Puru Stream catchment.

It is anticipated that the existing overland flow area will continue to drain directly into the farm pond.

It is also noted that the proposed overland flow expansion, dependent on the final design, has the potential to increase the area of native flora present at the Watercare site. This may a provide positive effect as a result of the discharge.

4.0 Potential Effects on Soils

The soils at the site are described in PDP (2024) as consisting of 200 – 300mm deep silty topsoil overlying a silty clay subsoil. This report is attached to this memorandum for convenience. The soils are predominantly mottled or gley indicating poor drainage characteristics as evidenced by the slow field infiltration test results in the region of 2.4mm/hr for the topsoil and 0.6mm/hr for the subsoil. The typical soil profile is shown in Figure 1. Further profile photos are included in the attachments to the soils reports including adjacent to the existing area and at the proposed expansion area.

Figure 1: Soil Profile observed within the proposed overland flow expansion area

The soil chemical characteristics (Table 3, PDP, 2024) indicate conditions favourable for the retention of solutes from migration off site. Both cation and anion exchange capacity are at the high end of the typical range for soils which is conducive to adsorption of soluble residues from the wastewater. In addition, the natural phosphorus content of the soil (Olsen P) is low providing capacity for further uptake of phosphorous in the wastewater.

While development of the OLF system may involve earthworks to recontour parts of the site this is unlikely to expose soils characteristics that are different from those existing. The existing profile as exemplified in Figure 1 shows a low permeability regolith profile several meters deep. Topsoil would be reinstated to provide a growing medium in any earthworks areas.

Given the deep soils, low hydraulic conductivity, and high adsorptive capacity of the soils, downwards migration of soluble residues below the overland flow system is expected to be strongly retarded and limited. This provides a baseline for the groundwater effects assessment discussed in Section 5 below.

5.0 Potential Effects on Groundwater

The existing and proposed overland flow areas (Area B2) are located over variable geology consisting of the East Coast Bays Formation (**ECBF**) of the Waitemata Group, the Basal Waitemata Beds and Waipapa Group greywacke. The boundary between the main geological units as taken from NZ Geological map series (Sheet no. 3, IGNS, 2001) is shown in Figure 3 (PDP, 2010) attached to this memorandum. In the area of the site the contact between the ECBF and the greywacke daylights along a sinuous line formed by erosion of the two units. In this area the beds of the ECBF dip moderately (10º to 15º) to the west. The thickness of regolith over unweathered bedrock has been recorded in bore 23094 which is the production bore for the Pine Harbour water supply located in a similar geological setting on a ridge to the overland flow site at the end of Tui Brae Road. The regolith thickness is 7m in that bore which is considered a reasonable estimate for the thickness of regolith at the OFS site.

The groundwater level in the ECBF is inferred to be at RL40m about 1.3km to the west of the overland flow site (Figure 2). However, the reliability of this measurement is low as it is based on an assumed wellhead level for the bore and is likely to underestimate the depth to groundwater. Based on the general groundwater level trend shown in the Figure 2, the groundwater level beneath the site is expected to be no higher than 10 m to 15 m below ground under the high plateau area of the overland flow site and at stream level along the tributaries. Groundwater beneath the site is expected to move along flow paths that discharge to the tributary of Te Puru Stream within the immediate downstream reaches.

The recharge area that feeds groundwater flowing under the overland flow site is expected to comprise not only the local ECBF outcrop but also the underlying greywacke unit that will discharge either directly to the streams or up into the ECBF in this area. This recharge area consists of the hills to the east of the WWTP site and is estimated to be 4 to 6 times the area of the overland flow site. Hence, groundwater flow beneath the site will likely comprise a similar ratio of local to upgradient recharge.

Any potential contaminants from the overland flow site that migrate downwards through the regolith into the groundwater are therefore expected to have flow path lengths no longer than hundreds of metres to the nearest stream discharge zone. This is a conservative (i.e., overrated) assessment and sets a limited envelope of potential effects from the overland flow site. No existing bores or other groundwater takes occur within this area.

As discussed in Section 4.0, the quantum of residues that infiltrate to groundwater beneath the overland flow site is expected to be minor due to the low permeability of the regolith. Further, any residues that reach groundwater over time will mix with the upgradient throughflow reducing the net potential effect on the water quality in the groundwater and the surface water discharge zone. In comparison to the discharge of the treated wastewater from the overland flow system runoff itself this input to the tributary of Te Puru Stream is expected to be undetectable.

6.0 Summary

The proposed use of the existing overland flow areas and expanded overland flow areas (Area B) is expected to have minimal effects on the soils, groundwater, and ecology of these areas due to:

- Appropriate design of overland flow system to minimise drainage through surface soils and to safely capture slope run-off.
- Existing soil characteristics indicate low potential for drainage to groundwater and a high capacity for contaminant retention within the soil profile.
- The final design of the overland flow areas can allow for controlled discharge of wastewater into the farm pond and therefore can any potential effects on the SEA (excluding that area which is already used for wastewater treatment/discharge) or any wetlands.

There may also be the potential for positive effects on terrestrial ecology if, subject to the final design, the overland flow areas are planted with native flora.

7.0 References

PDP. (2010). *Groundwater Supply AEE – Pine Harbour Marina Development.* Auckland.

PDP. (2024). *Beachlands Maraetai WWTP Options Assesment: Soil Sampling LA site – Factual Report.* Auckland.

USEPA. (2006). *Process Design Manual Land Treatment of Municipal Wastewater Effluents.* Cincinnati: U.S. Environmental Protection Agency.

8.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Watercare Services Ltd and others (not directly contracted by PDP for the work). PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This memorandum has been prepared by PDP on the specific instructions of Watercare Services Ltd for the limited purposes described in the memorandum. PDP accepts no liability if the memorandum is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Prepared by

Oliver Hunt

Senior Environmental Engineer

Prepared by

Mark Bellingham

Technical Director - Ecology

Reviewed and Approved by

Alan Pattle

Technical Director - Water and Geotechnics

pdp

FIGURE 1: SUITABLE LAND AREA FOR AN EXPANSION OF THE BEACHLANDS WWTP OVERLAND FLOW SYSTEM

WATERCARE BEACHLANDS MARAETAI WWTP

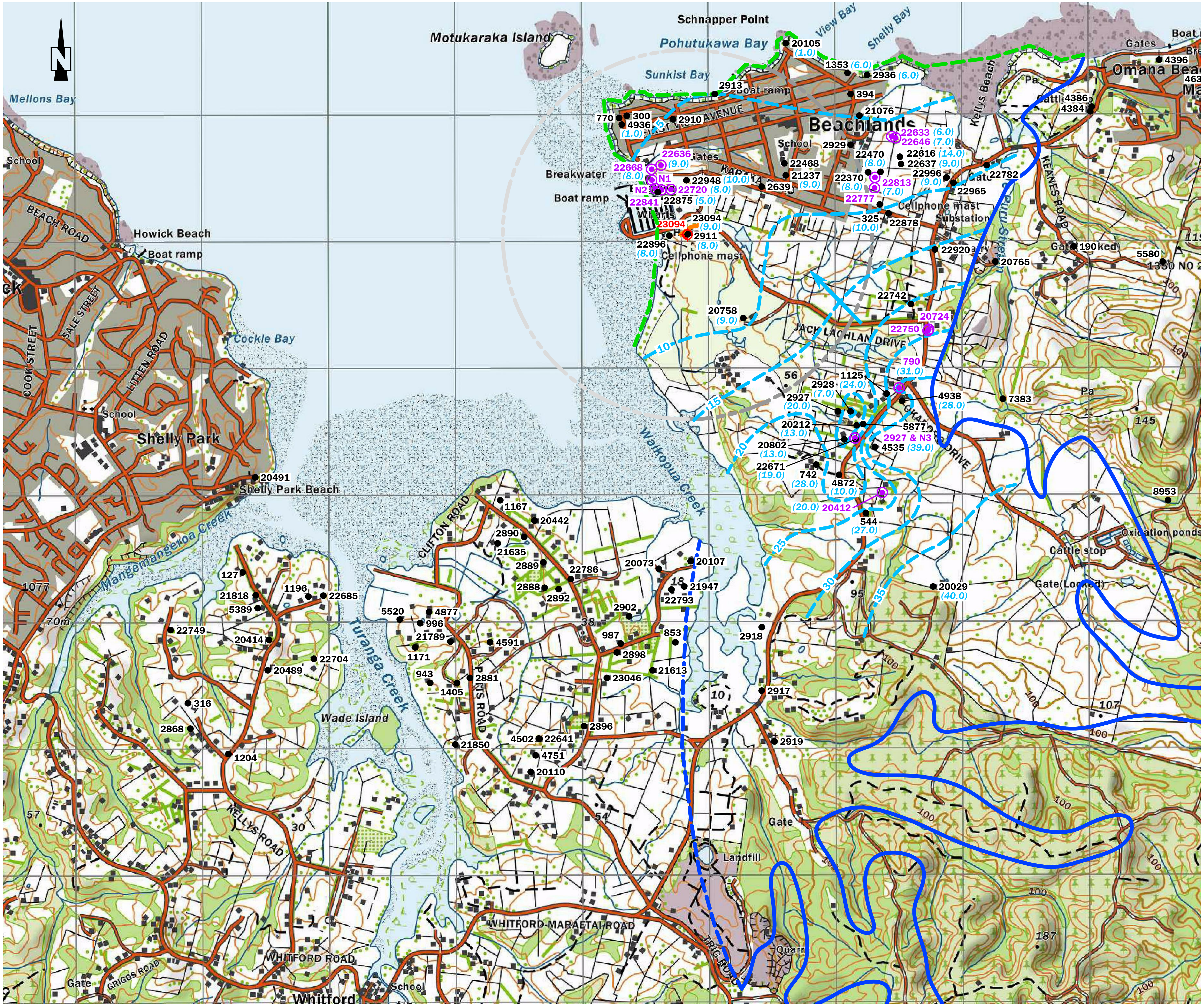
SOURCE:
1. AERIAL IMAGERY: EAGLE TECHNOLOGY, LINZ, STATSNZ, NIWA, NATURAL EARTH, © OPENSTREETMAP CONTRIBUTORS., EAGLE TECHNOLOGY, LAND INFORMATION NEW ZEALAND, GEBCO, COMMUNITY MAPS CONTRIBUTORS.
2. ELEVATION INFORMATION SOURCED FROM LINZ (AUCKLAND 1 M LIDAR 2016-2017).
3. WASTEWATER DISPERSAL PIPEWORK SOURCED FROM WATERCARE.

0 100 200
METRES
SCALE : 1:7,500 (A4)

N

REVISION: 01 | DATE: JAN 24 | BY: JR
CLIENT: WATERCARE SERVICES LIMITED

A02803202_GIS001



KEY:

- 23094 New Production Well
- 22646 PDP Located Farm Well (ARC bore ID)
- 22996 Farm Well (ARC bore ID - if unknown Consent No is used)
- (6.0) Approximate Groundwater Level (m RL)
- General Groundwater Flow Direction
- Flow Cross Section
- Potential Extent of Aquifer within the Beachlands Waitemata Block
- 5 Approximate Groundwater Contours (m RL)
- Potential Zone of Influence

Source:
1. Base plan derived from Sheet_ R11 NZMS260 NZTopo 2004.
2. Bore data supplied by ARC, received 29/02/2008.
3. Groundwater levels derived from ARC database 29/02/2008 and additional ARC data received 10, 18 & 21/12/2009.

No.	Revision	Date	App.
B	Issued for Consent	Jan 10	
A	Issued for Review	Sep 09	

	By	Checked	Date
Designed	P.N.		Mar 09
Drawn	D.R.		Mar 09
Approved for issue:			
Approved for construction:			

This drawing is not for construction unless signed as approved

Client :

Pine Harbour Marina Ltd

Project :

Groundwater Supply AEE - Pine Harbour Marina Development

Title :

Borehole Location Plan

solutions for your environment

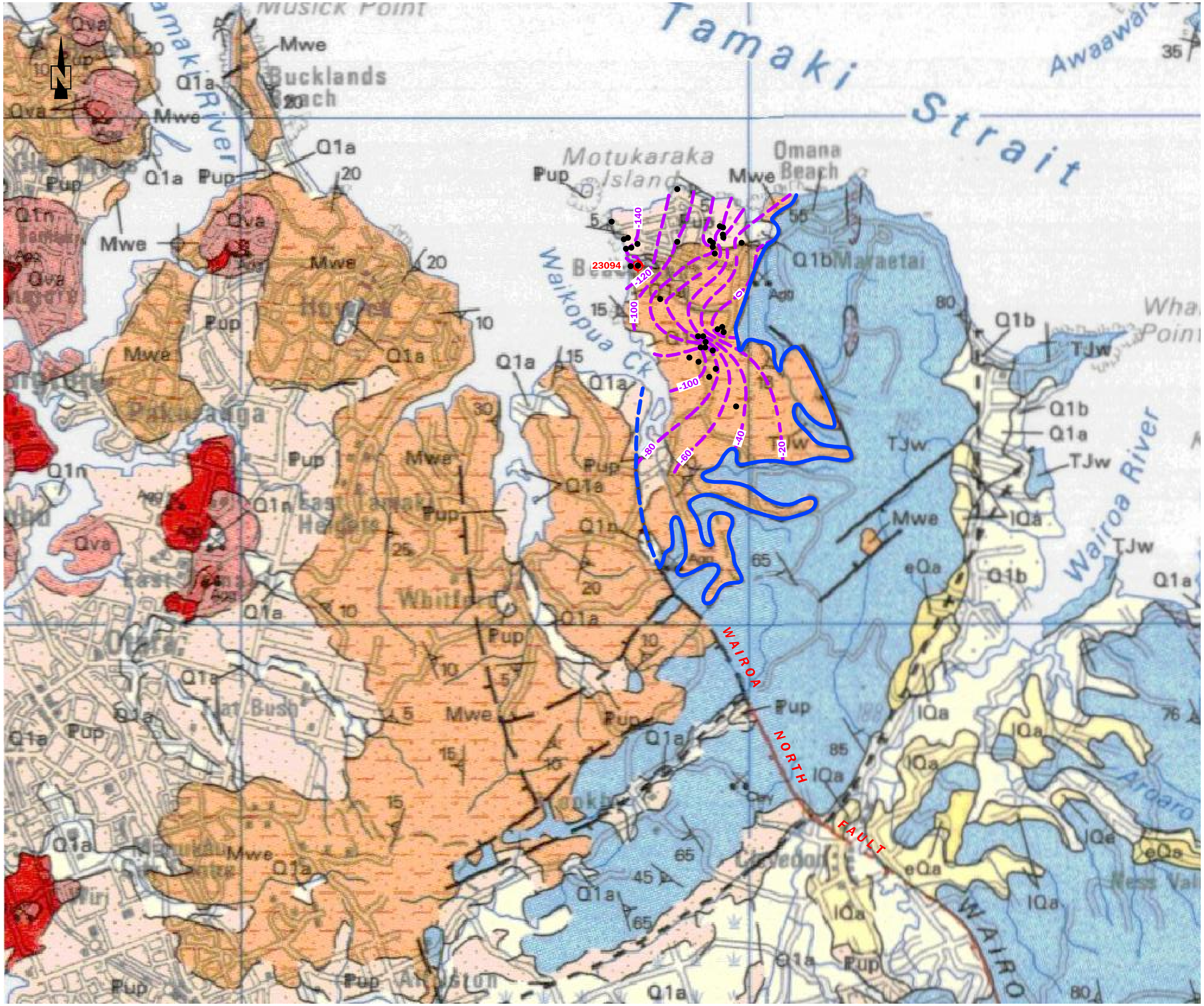
PATTLE DELAMORE PARTNERS LTD

Auckland Wellington Christchurch

Scale 1:30,000 (A3)

Project No. :	Figure No. :	Revision :
A02086410	2	B

Filed : A02086410D002.dwg   Image : A02086410I002.jpg



KEY:

- 23094 — New Production Well
- Potential Extent of Confined Aquifer within the Beachlands Waitemata Block
- -20 — Base of Waitemata Contours (m RL)
- Base of Waitemata Datapoints for Contours

Source:
1. Base plan derived from IGNS Map 3 (Auckland) 1:250,000, 2001.
2. Base of Waitemata contours derived from borehole log data received from ARC on 18 & 21/11/2009 (see Appendix E).

No.	Revision	Date	App.
B	Issued for Consent	Jan 10	
A	Issued for Review	Sep 09	

	By	Checked	Date
Designed	P.N.		Mar 09
Drawn	D.R.		Mar 09
Approved for issue:			
Approved for construction:			

This drawing is not for construction unless signed as approved

Client : Pine Harbour Marina Ltd

Project : Groundwater Supply AEE - Pine Harbour Marina Development

Title : Geology

pdp solutions for your environment

PATTLE DELAMORE PARTNERS LTD

Auckland Wellington Christchurch

Scale 1:75,000 (A3)

Project No. :	Figure No. :	Revision :
A02086410	3	B

Filed : A02086410D002.dwg Image : Map 3 (Auckland Area) 250k.jpg

PATTLE DELAMORE PARTNERS LTD
PDP House, Level 5
235 Broadway, Newmarket, Auckland 1023
PO Box 9528, Auckland 1149, New Zealand

Tel +64 9 523 6900
Web www.pdp.co.nz

solutions for your environment

memorandum

TO	Tanvir Bhamji	FROM	Khun Chueaphoodee
	Watercare Services Ltd	DATE	17 May 2024
RE	Beachlands Maraetai WWTP Options Assessment: Soil Sampling LA site – Factual Report		

1.0 Introduction

Watercare Services Limited (**Watercare**) is currently in the process of renewing its resource consent for the Beachlands Wastewater Treatment Plant (**WWTP**) with a focus on evaluating a land application scheme and stream hydraulic assessment. The assessment aims to identify the Best Practicable Option (**BPO**) for managing the treated wastewater discharge within the Beachlands catchment. Pattle Delamore Partners Ltd (PDP) has been engaged by Watercare to undertake assessment of land, 32PJ+Q2 Beachlands (Land parcel CT NA95C/569) identified within a larger area as potentially suitable for land treatment. Manaaki Whenua's S-Map indicates that the site features an approximately equal distribution of soil siblings Batonf (Mottled Orthic Brown Soil), Bushcroft*f* (Mottled Orthic Bown Soil), and Eureka*f* (Acidic Orthic Gley).

This memorandum has been prepared by PDP to describe the methodology used during its field investigations and presents the factual results of the field investigations completed on 25 October 2023. The primary goal of the work was to provide basic soil properties and hydrogeological information to develop the conceptual site model and to assess the suitability of the investigation area for the purposes of land treatment.

2.0 Investigations

PDP caried out soil assessments at three to four locations (refer Figure 1, Appendix A) at the 32PJ+Q2 Beachlands site on 25 October 2023 including:

- Field soil infiltration testing using a Guelph Permeameter at 4 locations on the property;
- Field soil sampling at depths of 0 – 75 mm for topsoil, 75 – 150 mm for subsoil, and 0 – 150 mm for the whole soil profile along 160 m transect for laboratory nutrient assay and heavy metals assessment;
- Offsite hydraulic conductivity laboratory testing soil infiltration cores of topsoil (0 – 75 mm) and shallow sub soils (range between 110 – 340 mm depending on location); and
- Shallow soil profile observations at a depth of 0 – 150 mm within the area of hydraulic core extraction

Soil sampling was carried out along an approximately 100 m long transect as shown in Appendix A. The sampling locations along the transect were chosen to give representative coverage of both flat and sloping areas within the land parcel. Areas where stock faeces were present were avoided due to the risk of affecting the nutrient sampling results. Areas such as troughs, fence lines and gateways were also avoided. An ArcGIS application was used to record testing site and sampling transect locations. The GPS accuracy is expected to be within 4 m, which is considered suitable for the purposes of soil monitoring at this scale.

The weather during the investigation period was characterised by morning overcast conditions with intermittent drizzle, clearing to fine and sunny in the afternoon. Information related to rainfall was obtained post-investigation based on climate data obtained at a personal weather station coded IAUCKLAN744. There was of 8 mm of rainfall in the preceding 3 days. The temperature was approximately 19 °C on the day. A total of 62 mm rainfall total was recorded for the month of October.

2.1 Onsite Soil Infiltration Testing Methodology – Geulph Permeameter

In-situ infiltration testing was conducted using a Guelph Permeameter at two depths across four locations, shown in Appendix A. All tests were conducted on slightly sloped pastureland. 6 cm wide and 15 cm deep cylindrical boreholes were initially dug at each location. The rate of constant outflow of water, together with the diameter of the borehole, and height of water in the borehole, were then used to determine hydraulic conductivity of the soil. The tests were completed in the near surface topsoil, at a depth of 15 cm with a head of 10 cm. A second measurement was taken at a depth of ~30 cm with a head of approximately 15 cm per borehole. The infiltration rate was then recorded in intervals ranging from 30 seconds to 2 minutes depending on the rate of fall per test in accordance with PDP 2023 methodology. Infiltration rates were observed until steady state infiltration rates had been achieved; durations ranged from 8 – 30 minutes per test at each depth.

2.2 Soil Sampling Methodology for Nutrient Assay and Heavy Metals

Composite soil samples were taken using a manual soil corer to collect approximately 36 soil cores along ethe 160 m transect to form a single composite sample for each depth range at each transect (see Appendix A for transect locations). Three composite samples were collected from each location at depths from
0 – 75 mm, 75 – 150 mm, and 0 – 150 mm below ground level (BGL) for nutrient and heavy metals sampling. Soil samples were couriered to Hill Laboratories for analysis.

2.3 Methelodology for Core Collection for Offsite Hydraulic Conductivity Laboratory Testing

Six undisturbed soil cores were collected from the sampling location at three points along the transect (See Appendix A) in accordance with "Field guide to taking core samples for physical analyses" published by Landcare Research.

Stainless steel rings (100 mm diameter, 750 mm deep) were provided by Landcare Research to collect and retain each core sample.

Cores were usually taken on pasture free soil, but pasture was trimmed from any cores containing pasture, and a stainless-steel ring was gently tapped into the soil surface. The steel ring, with the soil core sample intact, was carefully removed from the soil. Both ends of the sample were trimmed to leave an almost flat surface approximately 5 mm above the liner. A second core was taken at each location at approximately 300 mm depth for analysis of the subsoil. The steel rings, with sample intact, were individually sealed in cling film, to prevent moisture loss, and transported to the Landcare Research Soil Physics Laboratory for analysis of unsaturated hydraulic conductivity (K_{-40}).

3.0 Results

3.1 General Soil observations

Pasture was approximately 5 – 10 cm, comprised of typical dense pasture across the investigated site at all sampling locations. No ponding or signs of water were observed at the site. However, it was noted that the soil was relatively wet due to rainfall on preceding days. Topsoils at all sampling points were typical brown, allophanic soil with little variation both visually and in texture. Topsoil was generally denser and wet with a layer of dryer and crumblier subsoil. Large rocks and stones were observed throughout the site.

Groundwater was not observed in any locations and is assumed to be below 0.5 m BGL.

3.2 Onsite Soil infiltration Testing – Geulph Permeameter

From the known reservoir dimensions, water head height, borehole radius, and soil texture category, the field measured saturated hydraulic conductivities (K_{fs}) were calculated and are presented in Table 1 below.

Table 1: Summary of Guelph Permeameter Soil Infiltration Testing

Location	Testing Depth (mm)	K_{fs} (m/s)	Clean Water Infiltration Capacity (mm/hr)	Longer-Term Lower-End Estimated Treated Wastewater Infiltration Capacity Range (mm/day)[1]
GP1	150	5.7×10^{-7}	2.06	1.98 – 4.94
GP1	300	2.3×10^{-8}	0.08	0.08 – 0.20
GP2	150	6.4×10^{-7}	2.29	2.20 – 5.50
GP2	300	3.9×10^{-7}	1.42	1.36 – 3.40
GP3[2]	150	8.7×10^{-6}	31.32	30.07 – 75.17
GP3	300	2.1×10^{-7}	0.75	0.72 – 1.80
GP4	150	8.6×10^{-7}	3.11	2.98 – 7.46
GP4	300	7.8×10^{-8}	0.28	0.27 – 0.68
Average topsoil[3]		6.9×10^{-7}	2.45	2.35 – 5.87
Average subsoil[3]		1.6×10^{-7}	0.59	0.57 – 1.43

Notes:

1. *4-10% of clean water infiltration capacity used as per US EPA (2006).*
2. *Test results from GP3 were outliers which are not indicative of expected soil properties at the site and were excluded from average infiltration capacity calculations.*
3. *Calculated as arithmetic mean, GP3 results were excluded from the calculations.*

The testing was conducted on a day with mixed weather conditions with light showers in the morning and clear sunny weather in the afternoon.

Slowest clean water infiltration capacity 2.06 mm/hr for topsoil and 0.08 mm/hr subsoil were observed at sampling location GP1 and the fastest infiltration capacity for both depths were observed at location GP4 with 3.11 mm/hr observed for topsoil and 0.28 mm/hr for subsoil.

Overall, the average clean water hydraulic conductivity of the topsoil is in line with what can be expected from silty clay soil with the average permeability of 2.45 mm/hr. The average clean water hydraulic conductivity of the subsoil is also in line with what can be expected from clayey soil at 0.6 mm/hr.

Clean water was used for the testing. It should be noted that lower infiltration rates are expected with irrigation of treated wastewater which may promote suspended solids and/or biofilm within soil pore space, which acts to reduce soil permeability over time.

3.3 Offsite Soil Bulk Density and hydraulic Conductivity

Soil bulk density and hydraulic conductivity of the soil cores are presented in Table 2.

Table 2: Offsite Soil Bulk Density and Hydraulic Conductivity Results.

Location	Sample Name	Depth (mm)	Bulk Density (g/cm^3)	K_{sat} (mm/hr)	K_{40} (mm/hr)
GP1	TS1-917	0 – 100	0.92	6	2
	TS2-817	0 – 100	0.81	168	23
	SS1-863	110 – 290	**1.46**	4	2
	SS2-973	240 – 300	**1.45**	2	2
GP2	TS1-958	0 – 100	0.82	59	16
	TS2-980	0 – 100	0.87	9	1
	SS1-882	240 – 300	1.06	28	22
	SS2-972	240 – 340	1.06	165	108
GP3	TS1-857	0 – 100	0.90	367	25
	TS2-860	0 – 100	0.90	196	47
	SS1-788	240 – 300	1.10	43	35
	SS2-976	240 – 300	1.12	175	73
Average topsoil[2]			0.87	61	11
Average subsoil[2]			1.20	69	40

Notes:

1. *Topsoil K_{sat} and K_{40} test results from GP3 were considered outliers which are not indicative of expected soil properties at the investigated site.*
2. *Calculated as arithmetic mean, topsoil K_{sat} and K_{40} results for samples collected at GP3 were excluded.*

Unsaturated hydraulic conductivity provides a good indication of soil permeability at near-saturated conditions (that are typical of field saturated levels) and the sustainable hydraulic loading rate which allows for drainage through smaller pores, with larger pores air-filled to assist with soil and plant health.

Target bulk density ranges for allophanic and all other soils are 0.5 – 1.3 g/cm^3 and 0.6 – 1.4 g/cm^3, respectively (Sparling , et al., 2008). In general, the bulk density across the sampling locations is within the guideline ranges except for the subsoil sampled at GP1 indicating some compaction of the soil in this area.

3.4 Soil Sampling for Nutrient Assay and Heavy Metals

3.4.1 Soil Nutrient Assay Results

Soil nutrient testing results for investigated site are presented in Table 3. The results shown are mean values from 36 samples per depth along the transect.

Table 3: Soil Nutrient Testing Results at Different Sampling Depths

Parameter	Guideline Value	0 - 75 mm Depth	75 - 150 mm Depth	0 - 150 mm Depth
pH	5.5 - 6.3[1]	5.7	5.9	5.7
Olsen P (mg/L)	20 – 50[2]	**14**	**11**	**15**
Potassium, K (me/100 g)	0.5 – 0.8[3]	0.69	0.7	0.68
Calcium, Ca (me/100 g)	-	5.9	3.7	4.5
Magnesium, Mg (me/100 g)	1 – 3[3]	2.16	1.17	1.54
Sodium, Na (me/100 g)	0.2 – 0.5[3]	**0.15**	**0.11**	**0.12**
C/N Ratio	8 – 12[2]	**14.1**	**13.8**	**14.3**
Anion Storage Capacity, ASC (%)	30 – 60[3]	43	**64**	57
Total Carbon, TC (%)	3.5 – 12[4]	10.1	7.4	8
Total Nitrogen, TN (%)	0.35 - 0.7[1]	0.72	0.54	0.56
Cation Exchange Capacity, CEC (me/100g)	12 – 25	19	17	16
Base Saturation				
K (%)	2 – 5[3]	3.7	4	4.2
Ca (%)	50 – 75[3]	32	21	28
Mg (%)	5 – 15[3]	11.6	6.7	9.5
Na (%)	1 – 2[3]	**0.8**	**0.6**	**0.7**
Total (%)	-	48.1	32.3	42.4

Notes:
1. *Derived from Provisional Targets for Soil Quality Indicators in New Zealand (Sparling et al. 2008) for pasture on all soils except Organic.*
2. *Derived from Provisional Targets for Soil Quality Indicators in New Zealand (Sparling et al. 2008) for pasture on sedimentary & allophonic soils.*
3. Derived from Technical Note: Soil Tests & Interpretation (Version 5) by Hill Laboratories.
4. *Derived from Provisional Targets for Soil Quality Indicators in New Zealand (Sparling et al. 2008) for all soil orders and land use.*
5. *Values outside of guideline ranges are shown in **bold**.*

Soil nutrients results indicated:

- The nutrient levels, namely Olsen P, Sodium, and Magnesium in the soils are generally sub-optimal for pasture yield.
- Olsen P levels are below the optimal range for pasture across the soil profile.
- In general, sodium levels are slightly below the optimum range for pasture growth. Sodium is only of secondary importance in the soil test as its uptake by plants is large dependent on the plant species involved and the potassium status.

- Total nitrogen levels are within guideline range and carbon levels are on the higher end of the recommended which results in elevated C/N ratios across soil profile. Normally low nitrogen can favour the growth of less desirable or lower-quality forage species, which can affect pasture quality and livestock nutrition.
- Anion Storage Capacity (ASC) levels are generally on the higher end of the guideline range. ASC level in the sub soil is slightly above the guideline values in the subsoil indicating an increased capacity for phosphorus retention. This can be beneficial in preventing phosphorus runoff into water bodies; however, elevated ASC levels cab can also reduce phosphorus availability to plants.

3.4.1 Soil Heavy Metal Results

Heavy metal sampling results for the site are presented in Table 4.

Table 4: Soil Heavy Metal Testing Results at Different Sampling Depths

Parameter	Units	Guideline Limit Value	0 - 75 mm Depth	75 - 150 mm Depth	0 - 150 mm Depth
'Total' Arsenic	mg/kg	20[1]	2.4	3.2	2.6
'Total' Cadmium	mg/kg	1.5[2]	0.3	0.27	0.25
'Total' Chromium	mg/kg	300[1]	14.2	13.4	12.1
'Total' Cobalt	mg/kg	-	1.93	3	2.2
'Total' Copper	mg/kg	150[3]	5	5	5
'Total' Iron	mg/kg	-	15,000	22,000	17,100
'Total' Lead	mg/kg	530[1]	7.7	10.7	7.7
'Total' Manganese	mg/kg	-	191	192	170
'Total' Mercury	mg/kg	1[4]	<0.12	0.14	<0.12
'Total' Nickel	mg/kg	60[4]	6.8	7.2	6.1
'Total' Zinc	mg/kg	190[1]	24	22	22

Notes:

1. *Guideline limits derived from Eco-SGVs for agricultural land for all soil types published in Development of soil guideline values for the protection of ecological receptor (Updated) (Manaaki Whenua Landcare Research, 2019).*
2. *Derived from Eco-SGVs for all soil types and biomagnification.*
3. *Derived Eco-SGVs for typical aged soil.*
4. *Derived from Guidelines for the Safe Application of Biosolids to Land in New Zealand (Water, N. Z., & Wastes Association.)*

Soil heavy metal sampling results are well below guideline limits across all soil depths.

3.5 Soil Profile

A soil profile photograph was taken of the excavated pit formed by the soil infiltration core removal process at each location. The soil profile photographs are shown in Appendix B. Generally, the soil profiles across all sampling locations can be described as having compact silty topsoil and clayey sub soil. Soil profile at sampling point GP1 was observed to be relatively more compact and wet with texture similar to that of gley compared to other sampling locations.

4.0 Conclusions

The site investigations have provided information regarding the hydraulic conductivities, heavy metal, and nutrients of the soil within the identified area. This information can be used to give a high-level understanding of the characteristics of the soils in the potential land application area close to the existing wastewater treatment plant.

The soil found below the approximately 0.2 – 0.3 m of topsoil across the sampling locations at the site generally matched those identified by Manaaki Whenua's S-Map database.

In-situ soil infiltration testing results using Guelph permeameter were in line with what can be expected in silty clay and clay soils for topsoil, and subsoil, respectively. Soil nutrient test resulting shows sub-optimal phosphorus levels for pasture yield. The soil also contains relatively high anion storage capacity (ASC) indicating increased capacity for phosphorus retention.

Laboratory soil hydraulic conductivity tests are highly variable across the samples. In general, the average bulk density results are within the target ranges.

5.0 References

Cavanagh, Jo-Anne E. 2016. *User Guide: Background soil concentrations and soil guideline values for the protection of ecological receptors (Eco-SGVs) – Consultation Draft.* Lincoln, Canterbury, New Zealand : Landcare Research, 2016.

Hill Laboratoreis . 2024. Technical Note: Soil Tests & Interpretation (Version 5). [Online] 7 February 2024. https://www.hill-laboratories.com/assets/Documents/Guides/3196v5-Technical-Note-Soil-Tests-and-Interpretation.pdf.

Landcare Research. S-Map Online. [Online] [Cited: 7 February 2024.] https://smap.landcareresearch.co.nz/maps-and-tools/app/.

New Zealand Water and Wastes Association. 2003. *Guidelines for the Safe Application of Biosolids to Land in New Zealand.* Wellington : Ministry for the Environment, 2003.

Smith, J. E. 2006. *PROCESS DESIGN MANUAL FOR LAND TREATMENT OF MUNICIPAL WASTEWATER.* Washington, DC : U.S. Environmental Protection Agency, 2006.

Sparling , Graham, Lilburne, Linda and Vojvodic-Vukovic, Maja. 2008. *Provisional Targets for Soil Quality Indicators in New Zealand.* Lincoln, Canterbury, New Zealand : Manaaki Whenua Press, 2008.

6.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Watercare Services Ltd, Hill Laboratories and Maanaki Whenua/Landcare Research. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This memorandum has been prepared by PDP on the specific instructions of Watercare Services Ltd for the limited purposes described in the memorandum. PDP accepts no liability if the memorandum is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Prepared by

Khun Chueaphoodee

Environmental Engineer

Reviewed by

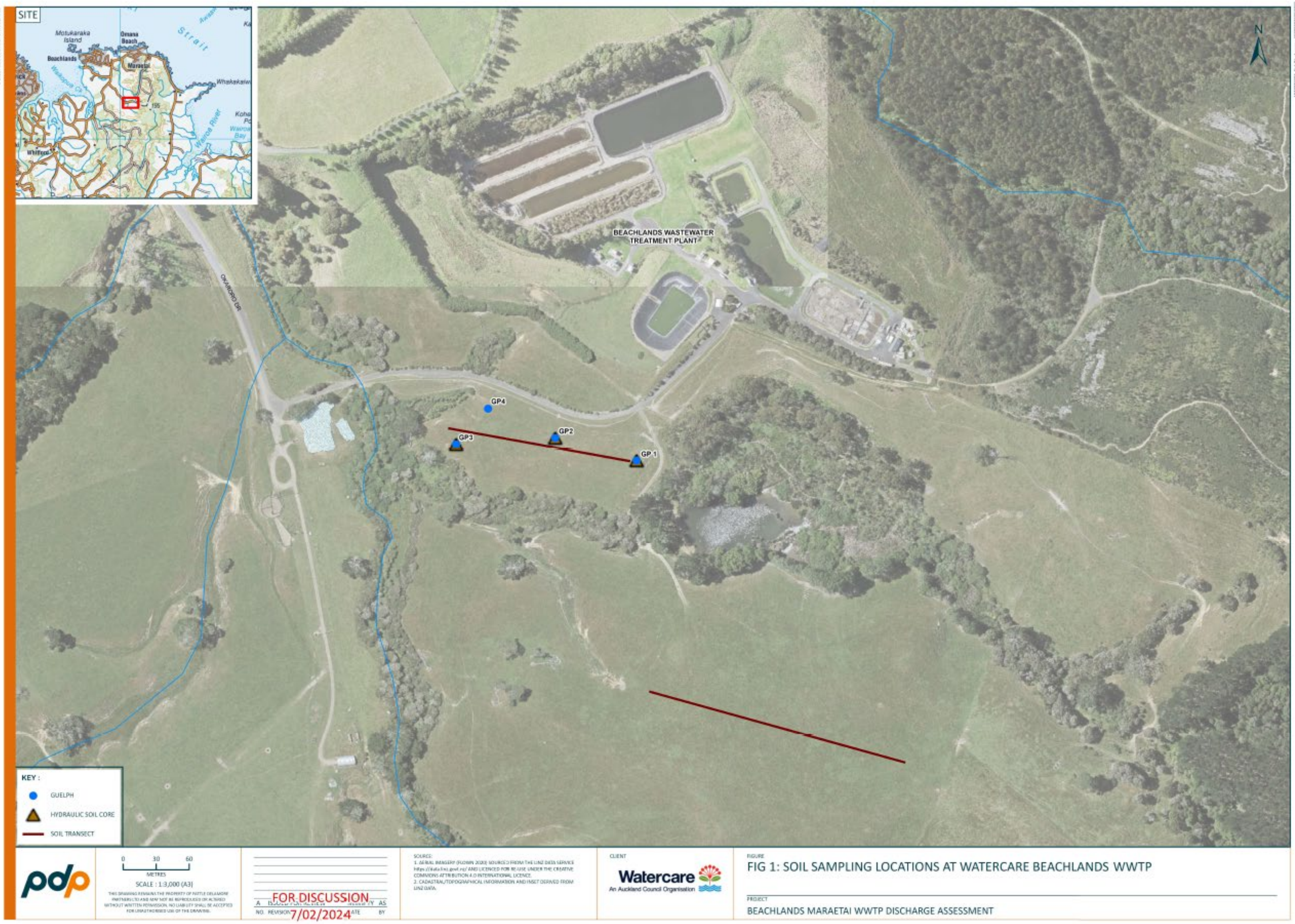
Oliver Hunt

Senior Environmental Engineer

Approved by

Alan Pattle

Technical Director - Water and Geotechnics



Appendix A: Soil Sampling Locations at Water Beachlands WWTP

Appendix B: Soil Profile and Site Photographs

Soil Profile at Sampling Point GP1

Soil Profile at Sampling Point GP2

Soil Profile at Sampling Point GP3

Photograph of the site in the morning

Photograph of the site in the afternoon

Close-up Photograph of the Pasture on Site