

20 February 2015

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Dear Nicholas

OMAHA STAGE 1 GROUNDWATER INVESTIGATION REPORT

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1.0 Introduction

Watercare Services Ltd (WSL) wishes to re-apply for resource consent to operate irrigation of Treated Waste Water (TWW) from the Omaha Waste Water Treatment Plant (WWTP). Irrigation currently occurs at two sites: 1) a gum forest on WSL owned land at Omaha flats, and 2) onto areas of the Omaha Golf Course (OGC) at Mangatawhiri Spit.

Pattle Delamore Partners Ltd (PDP) was engaged by Watercare Services Ltd (WSL) to complete the field investigation works outlined in PDP's proposal dated 8 December 2014. This report contains the results of the completed Stage 1 investigation works and associated interpretation and recommendations for the remainder of the project.

1.1 Objectives and Scope of Works

The objectives of the investigation stages of the resource consenting programme are to further inform and strengthen the existing conceptual groundwater model so as to provide a reliable platform for undertaking assessment of the transport and fate of the TWW, and ultimately to inform an Assessment of Environmental Effects (AEE). The existing conceptual model is presented in PDP memo dated 1 August 2014 "Revised Version – Omaha Field Investigation Plan & Justification". The investigations have been broken into stages. The Stage 1 Investigations focus on specific aspects of the model which have the greatest uncertainty to provide interim results and support decisions for following investigation stages.

The contracted investigation items and deliverables for the Stage 1 work are outlined below:

- ∴ Land based coastline survey of the eastern and western sides of the Whangateau Harbour – south of the causeway, approximately within the adjacent southern bounds of the currently irrigated areas.
- ∴ Locating, assessing and sampling/monitoring of the existing monitoring wells.
- ∴ 10 (ten) hand augers to as deep as practicable at selected locations across Omaha Flats and the Mangatawhiri Spit.
- ∴ Water quality sampling of low-tide spring/seepage at Omaha Beach.
- ∴ Geophysical surveying of selected areas at both Omaha Flats and Mangatawhiri Spit. Geophysical investigations include Ground Penetrating Radar (GPR) and Electro-Magnetic (EM) surveying.
- ∴ Reporting of results, interpretations and recommendations.

2.0 Field Results/Observations

All field data completed within this investigation is collated and described in this section.

2.1 Land Based Coastal Survey

The surveys consisted of physically walking the coastal fringe areas of both the eastern and western sides of the Whangateau Harbour, south of the causeway. Figure 1 displays the approximate trace of the surveys. Details of the findings are presented below.

2.1.1 Eastern (Mangatawhiri Spit) side of the Whangateau Harbour

A total distance of 2.1 km (more or less) was traversed. Visited environments included areas of: the Kaihikatea forest, chenier plain and ridge, inter-tidal zone/mud flats, and creek banks. Key features noted from the survey are summarised in Table 1 below. Water quality results are provided in Appendix A.

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Table 1: Eastern Whangateau Coastline: Key Features			
Feature Description	Location	Findings / Observations	Action
Surface Water channel	SW1 on Figure 2 (~400 m SSE of causeway)	<ul style="list-style-type: none"> - Stream ~1 m wide and 150 m depth, widening and shallowing towards harbour, visible flow. - Shallow lithology is silty sand, with some organics - Water is brackish ~2500 uS/cm (near forest) 	<ul style="list-style-type: none"> - Channel traced to emerge from Kahikatea forest - Water samples collected near forest and near high tide mark (AES) - Hand auger completed
Surface Water channel	SW2 on Figure 2 (~1200 m SSE of causeway)	<ul style="list-style-type: none"> - Stream ~0.4 m wide, 50 mm depth, visible flow. - Water is likely brackish (taste) 	<ul style="list-style-type: none"> - Channel traced to emerge from Kahikatea forest
Surface Water channel	SW3 on Figure 2 (Southern extent of Kahikatea forest)	<ul style="list-style-type: none"> - Stream ~3m wide and est. ~0.5 m depth. Flow estimated >50 L/s. 	<ul style="list-style-type: none"> - Occurrence noted
Ponds/Erosional Tidal Channels	Numerous. Some examples shown of Figure 2.	<ul style="list-style-type: none"> - Some small ponds held water (estuary) and small fish, despite it being low tide - Erosional channels were sandy. Some extended eastward within 20 m of the Kahikatea forest edge - Water is brackish-saline (~5700 uS/cm) 	<ul style="list-style-type: none"> - Hand augers completed nearby
Chenier Ridge	Runs parallel to shoreline	<ul style="list-style-type: none"> - Elevation of chenier ridge ~1 m higher than surrounding chenier plain. - Several 'Washouts' or erosional channels through the chenier ridge were encountered 	<ul style="list-style-type: none"> - Hand auger completed on ridge
Variation in Kahikatea canopy height	Adjacent to SW1	<ul style="list-style-type: none"> - Vegetation appears of lower height and density 	<ul style="list-style-type: none"> - Occurrence noted

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2.1.2 Western (Omaha Flats) side of the Whangateau Harbour

A total distance of 1.2 km (more or less) was traversed. Visited environments included areas of: the locally termed 'sandstone ridge', salt marsh, inter-tidal zone/mud flats, and creek/drain mouths and banks. Key features noted from the survey are summarised in Table 2 below. Water quality results are provided in Appendix A.

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Table 2: Western Whangateau Coastline: Key Features			
Feature Description	Location	Findings / Observations	Action
Peat geology/outcrops	Intertidal zone south of causeway to at least as far south as WQ10 (shown on Figure 2)	<ul style="list-style-type: none"> - Peat outcrops near the low tide harbour channel consisted of a sandy peat, of estimated very stiff to hard soil strength. - Peat exposures/cuts near the high tide mark were noticeably softer/spongier - Large fibrous inclusions/logs/branches were visible within the peat on the intertidal zone 	<ul style="list-style-type: none"> - Occurrence noted
Surface water channel	WQ10 on Figure 2	<ul style="list-style-type: none"> - Man-made, open, drain present - Drain ~1.5 m wide, ~200 mm depth, visible flow - Water is brackish (EC = ~7800 uS/cm), transparent 	<ul style="list-style-type: none"> - Water quality sample collected (AES)
Surface water channel	Several locations along coastline	<ul style="list-style-type: none"> - Presence of numerous, open, man-made drains - Width variable, but typically ~1.5 m - Indurated (hardened) sand outcrops visible in southern drains - Yellow/orange sediments/deposits observed within drains >100 m upstream of mouth 	<ul style="list-style-type: none"> - Drain cut faces inspected. - Water quality sample locations assigned (AES)
Sub-surface drain	Omaha Airstrip	<ul style="list-style-type: none"> - Landowner show field staff a sub-surface nova-coil drain, said to drain area beneath air strip ~200 m inland - Flow emerging from drain estimated at least 20 mL/s - Water is fresh-brackish, moderately acidic, transparent but brown/tea stained in colour 	<ul style="list-style-type: none"> - Water quality sample collected (PDP)
Sandstone Ridge'	Observed outcrop is ~10-20 m inland from coastline, running adjacent to coastline	<ul style="list-style-type: none"> - Locally termed 'sandstone ridge'. - Fine to medium, brown, indurated sand formation - Information provided by landowner that 'ridge' runs southwards adjacent to shoreline 	<ul style="list-style-type: none"> - Occurrence noted

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2.2 Soil/Geology Investigations

To investigate shallow soil and geological units, hand augers were completed at selected locations across Omaha Flats and Mangatawhiri Spit. Locations of all 15 hand augers are presented in Figure 2, and hand auger logs are presented in Appendix B.

2.2.1 Mangatawhiri Spit (including OGC)

Four (4) hand augers were completed on the currently irrigated areas of the OGC. Results indicated that geology within the upper 4 m consists primarily of clean, fine to medium grained, grey/brown SAND. Sand is predominantly quartz and feldspar. One of the augers (HA10) did however display some silty organics, which was noticeably different from the other augers. Table 3 provides a summary of the hand augers completed within OGC.

HA#	Location	Findings / Observations
HA6	Nth irrigation block, western edge of OGC, ~60 m S of bore PAX	<ul style="list-style-type: none"> - Clean SAND to at least 1.2 m bGL - Shallow water table (~0.7 m bGL)
HA7	Nth irrigation block, eastern edge of OGC in dune area, ~200 m SE of HA6	<ul style="list-style-type: none"> - Clean SAND to at least 4.0 m depth - Water table greater than 4.0 m bGL
HA8	Sth irrigation block, eastern edge of OGC in dune area, ~100 m E of bore PCX	<ul style="list-style-type: none"> - Clean SAND to at least 4.0 m depth - Water table greater than 4.0 m bGL
HA10	Sth irrigation block, western edge of OGC near a small pond, ~250 m SSE of HA8	<ul style="list-style-type: none"> - Predominantly silty SAND to at least 1.5 m bGL. - Some organic material present below 1.0 m. - Shallow water table (~0.9 m bGL)

Five (5) shallow hand augers were also completed on the low-lying chenier plan, west of the Kahikatea forest. Geology in the upper 2 m consisted was predominantly silt and sand mixtures, with a very shallow watertable i.e. typically saturation between 0 m bGL and 0.4 m bGL. Saturated sand dominated material is suspected beneath the surficial silts and sands (i.e. >2 m bGL), as no auger returns were possible but it was still possible to rotate the auger.

2.2.2 Omaha Flats (including Omaha WWTP)

Four (4) hand augers were completed within the boundaries of the WSL Omaha WWTP, and another two (2) along the air strip (on privately held land). All locations were dominated by significant thicknesses of peat and/or organic silt material. Table 4 provides a summary of the hand augers completed on Omaha Flats.

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HA#	Location	Findings / Observations
HA1	Omaha WWTP, ~120 m NE of sign-in gate.	- PEAT/organic silt to at least 3.2 m - Shallow water table (~0.9 m bGL)
HA11	Omaha WWTP, ~230 m NE of sign-in gate.	- PEAT/organic silt to at least 4.0 m - Shallow water table (~0.8 m bGL)
HA2	Omaha WWTP gum forest, ~500 m NE of sign-in gate	- PEAT/organic silt to at least 4.3 m, sand lense at 2.6 - 2.8 m bGL - Deeper water table (~2.5 m bGL)
HA3	Omaha WWTP gum forest, ~250 m S of Jones Road gate	- PEAT/organic silt to at least 3.0 m - Shallow water table (~0.8 m bGL)
HA4	Private land, ~250 m along air strip from Jones road	- PEAT/organic silt to 2.2 m. SAND encountered beneath. - Shallow water table (~1.5 m bGL)
HA5	Private land, ~380 m along air strip from Jones road	- PEAT/organic silt to 1.5 m. SAND encountered beneath. - Shallow water table (~1.3 m bGL)

2.3 Geophysical Investigations

Two geophysical techniques were used during the investigations: Ground Penetrating Radar (GPR) and Electro-Magnetic (EM). Geophysics was deemed a favourable method of investigation due to the contrasting geophysical properties of the units of interest i.e. peat vs sand, fresh groundwater vs saline groundwater. The primary targets for the geophysics were (parenthesis indicates relevant geophysical method):

- ∴ The shallow geology – i.e. presence of sand or peat, peat lenses within sand, thickness of peat (GPR)
- ∴ Depth to water table (GPR)
- ∴ Geology and groundwater chemistry at greater depths i.e. 10 – 20 m bGL. (EM)

The geophysical surveys were planned by PDP in collaboration with Scantec Ltd (geophysical services contractor) and the WSL Omaha project team. The results of the two methods are described in the below sub-sections.

2.3.1 Mangatawhiri Spit

Ground Penetrating Radar

A total of survey distance of ~2 km was covered with the GPR. This consisted of a primary quasi N-S transect (Transect 1) along the long axis of the OGC irrigated area, as well as 5 secondary transects across the width of the OGC. A quasi-E-W transect (Transect 2), ~370 m was also completed on Broadlands Drive, from the round-a-bout to the start of the causeway. Figure 3 displays a trace of the geophysical surveys and names of the primary transects.

Imagery from the GPR, correlated with the hand auger logs, indicates that sandy material dominates the upper 10 m of geology at the locations surveyed (limit of equipment). Localised occurrences of high permittivity (potentially peat) were identified at varying depths and spatial locations. The groundwater table, identified where possible, was interpreted to be typically within 1-2 m bGL.

Transect 2, running approximately W-E along Broadlands Drive, did not provide the in-sight hoped for due to low penetration. This is suspected to be due to the presence of a highly conductive sub-base beneath Broadlands Drive. Subsequently, in-sight into the potential geology beneath the Kahikatea forest was not able to be attained from the GPR.

The GPR results overall matched well with the initial intrusive investigations, showing sandy material as the dominant lithology.

Cross-sectional GPR scans are provided in Figure 4 (note these have not been corrected for topography).

Electro Magnetic

TBC – awaiting results from Scantec

2.3.2 Omaha Flats

Ground Penetrating Radar

A total of survey distance of ~1.5 km was covered with the GPR. This consisted of a primary quasi SW-NE transect (Transect 3) through the middle of the Omaha WWTP irrigated area, as well as 3 secondary transects perpendicular across the width of the site. An additional transect (Transect 4), ~630 m in length, was completed quasi W-E along the air strip. Figure 3 displays a trace of the geophysical surveys and names of the primary transects.

Imagery from the GPR, correlated with the hand auger logs, indicates that peat/organic silt is likely to be present as the surficial unit, across the whole of the Omaha WWTP site. Thickness of the peat/organic silt across Omaha Flats at the locations surveyed can be summarised as:

- ∴ Typically between 2 m - 7.5 m thick from 0 m to ~230 m along Transect 3. Thickening to the east.
- ∴ Becoming very thick, possibly up to 20 m, between ~230 m – 330 m along transect (from point 3A).
- ∴ Thinning again to between 2 – 5 m thickness from ~330 m to 840 m (along Transect 3, to the end of the transect at point 3B).
- ∴ Thinning further to ~2.5 m thickness at ~180 m eastward along the air strip (~200 m east of point 4A)
- ∴ Thickening to between ~2.5 m to ~5 m at ~180 m to ~500 m along the air strip on Transect 4.
- ∴ Becoming <1.5 m or not present from ~500 m along Transect 4 to the Whangateau Harbour coastline (end of the transect 4).

The GPR imagery also indicates a unit of appreciable hardness to be present at shallow depths/at the surface, from approximately half way along the air strip towards the Whangateau Harbour coastline. This feature may be the locally termed 'sandstone ridge' which is known to be present in this vicinity.

Cross-sectional GPR scans are provided in Figure 5 and Figure 6 (note these have not been corrected for topography).

Electro Magnetic

TBC – awaiting results from Scantec.

2.4 Groundwater Monitoring Results

Groundwater monitoring and water quality sampling was planned for 10 bores located at both Omaha Flats and Mangatawhiri Spit. The following was achieved:

- ∴ Water level gauging and water quality sampling completed on 5 bores (Well 1, Well 2, Well 3, Well 4 (Omaha WWTP), and PAX (eastern edge of Kahikatea forest)).
- ∴ Water level gauging only completed at 1 bore (PCX – eastern edge of Kahikatea forest) – this was due to the bore having a joiner with a smaller diameter than the sampling pump.
- ∴ 4 bores at Mangatawhiri Spit (east of the OGC) are deemed to have been decommissioned/removed by the housing development at Omaha Beach.

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- ∴ 2 groundwater samples were collected from Omaha Beach, at the low tide seepage/spring area.

2.4.1 Groundwater Levels

Omaha Flats:

Groundwater levels measured on the 4 groundwater bores and 6 hand augers at Omaha Flats indicate that groundwater is generally very shallow i.e. ~1 m below groundwater level. Basic analysis of historical groundwater level data (provided by WSL) indicates the following averages and data spread, presented in Table 5:

Well ID	Recorded Level (Dec 2014) (m bGL)	Average depth to groundwater (m bGL)	Highest groundwater level (m bGL)		Lowest groundwater level (m bGL)	
			Level	Date	Level	Date
Well 1	1.06	0.7	0.37	23/09/1993	1.615	6/02/1992
Well 2	0.64	0.9	0.17	30/08/2001	1.92	25/01/2001
Well 3	0.67	0.6	0.28	6/09/2001	1.46	25/03/2013
Well 4	0.66	0.8	0.46	23/09/1993	1.245	10/03/1993

*True level cannot be determined with confidence as data suggests that groundwater level is above ground level.

HA2, located in the Omaha WWTP gum forest, appears anomalous however with a depth to groundwater of ~2.5 m bGL. As the bores and hand augers have not been surveyed for elevation, exact elevations, flow paths and groundwater gradients cannot currently be determined.

Mangatawhiri Spit:

Groundwater levels measured on the 2 groundwater bores and 9 hand augers on Mangatawhiri Spit indicate that groundwater is:

- ∴ Deeper than 4 m bGL in the high elevation dune regions (immediately east of OGC)
- ∴ Moderately shallow beneath the OGC - ~1-2 m b GL
- ∴ Shallow beneath the Kahikatea forest - ~0.7 m bGL at eastern edge of forest
- ∴ Very shallow on the chenier plain – 0 – 0.4 m bGL

Basic analysis of historical groundwater level data (provided by WSL) indicates the following averages and data spread, presented in Table 6.

Well ID	Recorded Level (Dec 2014) (m bGL)	Average depth to groundwater (m bGL)	Highest groundwater level (m bGL)		Lowest groundwater level (m bGL)	
			Level	Date	Level	Date
PAX	0.86	1.37	0.63	20/09/2005	1.55	25/03/2013
PCX	0.68	1.02	0.37	20/09/2005	1.33	25/03/2013

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2.4.2 Groundwater Chemistry

Mangatawhiri Spit

Only bore PAX, and two beach samples were able to be collected on Mangatawhiri Spit. Field parameters are presented in Table 7 below. Laboratory results are presented in Appendix C.

Well ID	Sample Date + Time	pH	EC FIELD (uS/cm)	REDOX (mV)	DO mg/L	Temp (°C)	Colour	Odour	Comments
PAX	12/12/2014 17:52	4.88	432	69	1.42	16.6	clear	none	
Beach1	16/12/2014 8:50	-	36000	85	-	-	clear	none	Taken within 10 mins of low tide
Beach2	11/12/2014 16:25	7.53	54351	230.1	5.29	22.7	clear	none	Taken ~70 mins before Low tide (ebb tide)

'-' = field instrument malfunction, unable to obtain field readings

Summary points for PAX bore (from samples collected by PDP December 2014):

- ∴ Sample taken using micro-purge technique
- ∴ Fresh groundwater, dominated by sodium and chloride ions – indicative of rain water and seawater mixing
- ∴ Moderately acidic
- ∴ Oxidised conditions – presence of dissolved oxygen, sulphate ions present
- ∴ Nitrate concentration very low (0.092 mg/L)

Summary points for the Beach samples (from samples collected by PDP December 2014):

- ∴ Beach samples taken near low tide, from a position above the visible low tide spring. Sample is obtained by digging down through the sand to the water table.
- ∴ Saline groundwater, dominated by sodium chloride. Heavily influenced by sea water.
- ∴ Neutral to slightly basic pH (slightly lower than sea water), total alkalinity circa that of sea water.
- ∴ Oxidised conditions – high dissolved oxygen content
- ∴ Notable Dissolved Organic Carbon
- ∴ Nitrate concentrations very low (0.002 mg/L)

Omaha Flats:

All four existing bores at Omaha Flat were able to be sampled. Field parameters are presented in Table 8 below. Laboratory results are presented in Appendix C.

Bore ID	Sample Date + Time	pH	EC FIELD (uS/cm)	REDOX (mV)	DO mg/L	Temp (°C)	Colour	Odour	Comments
Well 1	12/12/2014 12:32	6.65	492	-11.1	0.28	16.9	cloudy	H ₂ S or organic	Collected duplicate "Omaha 2"
Well 2	12/12/2014 14:06	5.92	358	-10.8	0.39	16.67	cloudy	H ₂ S or organic	Strong odour
Well 3	12/12/2014 16:20	5.31	510.9	57.8	0.33	15.6	clear	H ₂ S or organic	Strong odour, clear but dark brown colour (tannins?)
Well 4	12/12/2014 15:12	5.74	287.2	23.7	0.28	17.6	clear	H ₂ S or organic	Very slight odour, clear but orange brown colour (tannins)

Summary points for Omaha Flats groundwater (from samples collected by PDP December 2014):

- ✦ Samples taken using micro-purge technique.
- ✦ Fresh groundwater (all <600 uS/cm). Well 1, 2 and 4 dominated by sodium and bi-carbonate ions. Well 3 dominated by sodium and chloride ions, but with notable bi-carbonate.
- ✦ Slightly acidic.
- ✦ Near anoxic conditions; indicated by low dissolved oxygen, low redox. Presence of dissolved iron also indicates anoxic conditions.
- ✦ Notable Dissolved Organic Carbon (DOC).
- ✦ Nitrate concentrations very low (<0.04 mg/L).
- ✦ Groundwater 'tea' coloured/stained appearance.

2.4.3 Groundwater Sample Quality Assessment

All laboratory analysis was complete by Watercare Laboratory Services, 52 Aintree Ave, Auckland Airport.

One duplicate sample was taken during the sampling campaign. Relative Percent Difference (RPD) was calculated for all relevant analytes. Six analytes returned RPD's of >30%, however 5 of these were near the limit of detection and were subsequently deemed acceptable. Dissolved Organic Carbon (DOC) however, returned a value substantially greater than the limit of detection and an RPD of 40%. Although this is slightly over the generally accepted limit, the results have been used for the purposes of this report unchanged. PDP notes the potential limit of accuracy for DOC results from the assessment. RPD results are presented in Appendix C.

Total Kjeldahl Nitrogen (as N) was not received/processed by the laboratory within the recommended holding times for samples Beach1 and Beach 2. These results should subsequently be used with caution.

Ionic balance assessment was completed on all samples, with all returning balances within $\pm 5\%$; which is deemed acceptable. Field pH vs Laboratory pH assessment was also completed on all available samples. An acceptable correlation was returned with a R^2 value of 0.96. On average, laboratory pH was returned at ~ 0.4 unit higher than field pH. This is common where the majority of samples are slightly acidic. Carbonate equilibrium processes with the open atmosphere/atmosphere within the sample bottle act to degass or ingass CO_2 , subsequently effecting pH and alkalinity measured at the laboratory. Field pH is therefore used wherever possible, and laboratory alkalinity results should be pH corrected if required.

Overall the quality of the sample results was deemed acceptable for the purposes of this report.

3.0 Discussion and Recommendations

3.1 Mangatawhiri Spit

The investigations have confirmed that the surficial geology is dominated by sandy material beneath the irrigated areas of the OGC. Along the Mangatawhiri Spit, Whangateau Harbour coastline silt and sand mixtures, with appreciable organic content was present as the dominant surficial geology at the locations investigated. These results agree and support the geological aspects of the existing conceptual model. Geology beneath the Kahikatea forest remains uninvestigated at this stage, and no further developments to the conceptual model can be made at this stage. Further investigation is likely required to provide further conceptual information and to prove/disprove some hydrogeological aspects presented (by other parties) in the previous work, namely the low permeability 'bund'.

Groundwater information obtained from the investigation supports the existing understanding of groundwater flow patterns on the Mangatawhiri Spit, especially in the region of the OGC. That is, that the bulk of groundwater beneath the OGC irrigation blocks is likely to flow generally westward, towards the Kahikatea forest and then discharging to the Whangateau Harbour via either groundwater or surface water pathways. Some of the irrigated TWW in the higher elevation dune areas may flow eastwards towards Omaha Beach, but this is likely to be an overall small proportion

compared to what is flowing westward. However, additional information from a more comprehensive monitoring network is required to confirm this.

As discussed in the existing conceptual model, preferential groundwater flow paths are likely to exist due to natural variations in the shallow geology i.e. areas of higher permeability. Results from this investigation have provided further information on potential preferential flow paths. PDP identifies the following regions as potential preferential flow paths, based on the information currently available:

- ∴ Within the area of narrower, lower canopy height, and vegetation density within the Kahikatea forest and the associated surface water feature (labelled as SW1 of Figure 2).
- ∴ Within the area of narrower Kahikatea forest and the associated surface water feature (labelled SW2 on Figure 2).

Available groundwater chemistry data currently displays low concentrations of contaminants of concern, however historical data shows that higher readings have recorded previously, and the cause of these requires further investigation.

PDP recommends the works described in Table 9 to be completed at Mangatawhiri Spit.

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Table 9 - Mangatawhiri Spit Recommended Works		
#	Recommendation	Aimed Benefit
1	Installation of additional and replacement monitoring bores, at selected sites on Mangatawhiri Spit. Sites should include: <ul style="list-style-type: none"> - Upstream (East) of OGC irrigation - Downstream of OGC irrigation, but upstream of the Kahikatea forest i.e. near perimeter pest fence - Downstream of the Kahikatea forest - East of the conceptualised groundwater divide i.e. towards Omaha Beach 	<ul style="list-style-type: none"> - Provide additional geological information/ground truthing - Provide groundwater level information for flow direction assessment and model calibration - Provide information on 'background' water quality - Provide information on water quality leaving the TWW irrigation areas - Provide information on water quality emerging into the Whangateau Harbour - Provide information to help determine whether the Kahikatea forest is a source or sink for nutrients of interest.
2	Intrusive investigations i.e. hand augers within the bounds of the Kahikatea forest	<ul style="list-style-type: none"> - Provide information currently absent on the geology beneath the Kahikatea forest - Disprove/prove the low permeability 'bund/dam' used during previous resource consent process - Provide groundwater level information for flow direction assessment
3	Hydraulic testing of all groundwater wells	<ul style="list-style-type: none"> - Provide <i>in-situ</i> hydrogeological property information - For input into groundwater model - For input into groundwater travel time assessments
4	Survey all bores	<ul style="list-style-type: none"> - Enable assessment of true groundwater elevation, flow direction etc.
5	Update conceptual model	<ul style="list-style-type: none"> - To incorporate all new knowledge - To enable sound groundwater fate and transport assessment

Additional and replacement borehole locations are displayed in Figure 7.

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3.2 Omaha Flats

The investigations have shown that the surficial geology is dominated by peat/organic silt, at an average thickness of ~5 m across the Omaha WWTP irrigated area. Eastward of the Omaha WWTP, peat/organic silt geology was also dominant but thinner, at the locations investigated. These results agree and support the geological aspects of the existing conceptual model; however the spatial extent of the peat/organic silts observed during these investigations is greater than initially conceptualised. This is a development to the conceptual model.

Outcrop of an indurated (hard) sand unit was found to be present near and parallel to the Whangateau Harbour coastline. Outcrop were observed at the air strip and within man made drains ~300 m southwards along the coastline. The presence of this formation was not previously known. This is a development of the knowledge and will require incorporation into the conceptual model.

Groundwater information obtained from the investigation supports some of the existing understanding of groundwater flow patterns at Omaha Flats. That is, the bulk of groundwater beneath the OGC irrigation blocks is likely to be shallow and flow generally northeast from the site. The existing conceptual model was aware of the presence of the man-made drains in the vicinity of the Omaha WWTP. However, information gathered during this investigation has highlighted the scale and significance of the drains on the shallow groundwater regime. This is a development to the conceptual model. The drains are likely to impart significant control on the shallow groundwater system. The extent of their control requires further investigation.

PDP recommends the works described in Table 10 to be completed at Omaha Flats.

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Table 10 – Omaha Flats Recommended Works		
#	Recommendation	Aimed Benefit
6	Survey and monitor major drains in the vicinity of the Omaha WWTP	<ul style="list-style-type: none"> - Assessing influence of drains of the shallow groundwater system w.r.t groundwater flow paths and volume of groundwater received - Provide essential input information for a future analysis of the transport and fate of TWW
7	Hydraulic testing of all groundwater wells	<ul style="list-style-type: none"> - Provide <i>in-situ</i> hydrogeological property information - For input into groundwater model - For input into groundwater travel time assessments
8	Survey all bores	<ul style="list-style-type: none"> - Enable assessment of true groundwater elevation, flow direction etc.
9	Update conceptual model	<ul style="list-style-type: none"> - To incorporate all new knowledge - To enable sound groundwater fate and transport assessment

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3.3 Groundwater Chemistry Recommendations

Recommendation 10:

Historical water chemistry data supplied by WSL indicates higher concentrations of contaminants of interest have been recorded previously at both the Omaha WWTP and OGC i.e. nitrate concentrations up to 5 mg/L (March 2011). These results require investigation to determine whether they are real i.e. correlate with Omaha WWTP discharge patterns, or false positives i.e. through flawed sampling practice, and/or other potential causes.

Recommendation 11:

A number of different analytical techniques can be used to gather more detailed information on the transformations and fate of the TWW residuals in the groundwater. In particular, isotopes of Carbon, Nitrogen and Oxygen can be used in combination to determine several specific unknown attributes of the groundwater system, including:

- ∴ The source of the Dissolved Inorganic Carbon (DIC) in the groundwater i.e. from the natural geology (i.e. peat) or wastewater. This can give an indication of the proportions of natural groundwater and wastewater.
- ∴ The source of nitrate in the groundwater. This can be used to estimate the proportion of the measured nitrate which is sourced from wastewater, and the proportion from elsewhere.
- ∴ The amount of denitrification occurring. This can give an approximate percentage of the original nitrate concentration which has been lost to denitrification.

Measurement of these parameters should give an indication of the source of the nitrate (i.e. how much comes from the wastewater plant, and how much from other sources). It will also give an indication of the sources of DIC, and the proportion that wastewater contributed to the groundwater. It will also offer information on the extent of denitrification in the groundwater system (with support from baseline testing of the TWW applied through the irrigation system).

PDP recommends that the potential to use isotopic chemical analysis is investigated further, in collaboration with the project team, and a sampling plan devised if deemed feasible and beneficial.

4.0 Conclusion

The proposed Stage 1 field investigations have been completed successfully and valuable information for the project has been gathered and assessed. Please feel free to discuss any of the results and interpretations contained within this report with the under signed.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED

Aslan Perwick

D
R
A
F
T

Enclosed:

Figure 1: Completed Investigation Sites (Stage 1)

Figure 2: Investigation Site ID's and Key Observed Features

Figure 3: Geophysical Investigation Locations/Transects

Figure 4: Mangatawhiri Spit GPR Transects

Figure 5: Omaha WWTP GPR Transects

Figure 6: Air Strip GPR Transect

Figure 7: Mangatawhiri Spit Proposed Groundwater Bore Locations

Appendix A: Laboratory Water Chemistry Results (AES samples)

Appendix B: Hand Auger Logs

Appendix C: Laboratory Water Chemistry Results (PDP Samples)



FIGURE 1: COMPLETED INVESTIGATION SITES (STAGE 1)

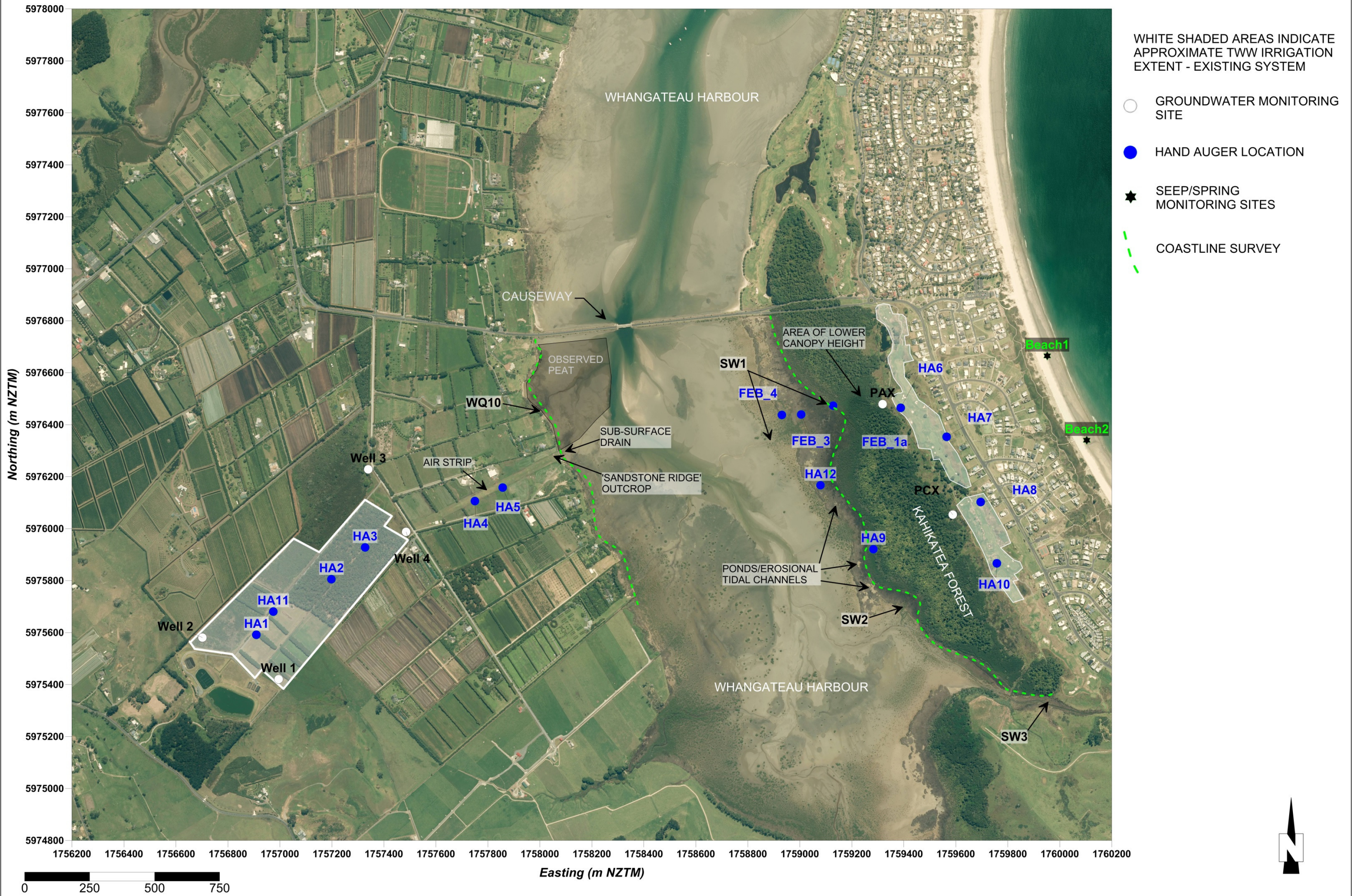


FIGURE 2: STAGE 1 INVESTIGATION: KEY FEATURES



FIGURE 3: GEOPHYSICAL INVESTIGATION LOCATIONS/TRANSECTS

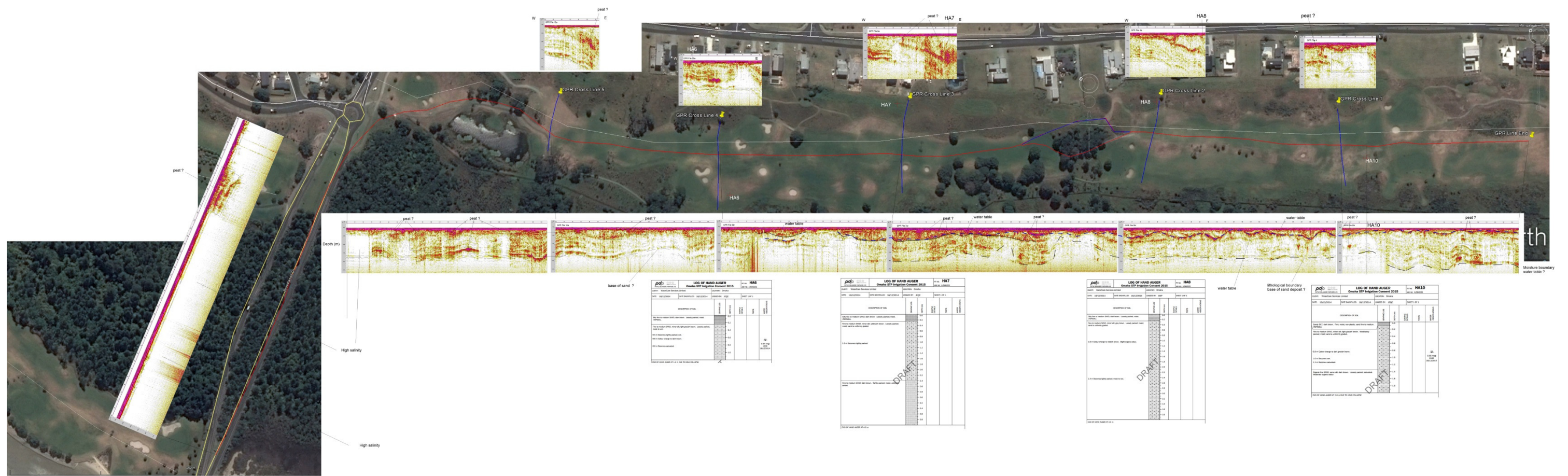


FIGURE 4 – MANGATAWHIRI SPIT GPR IMAGERY (DRAFT) – SCANTEC LTD

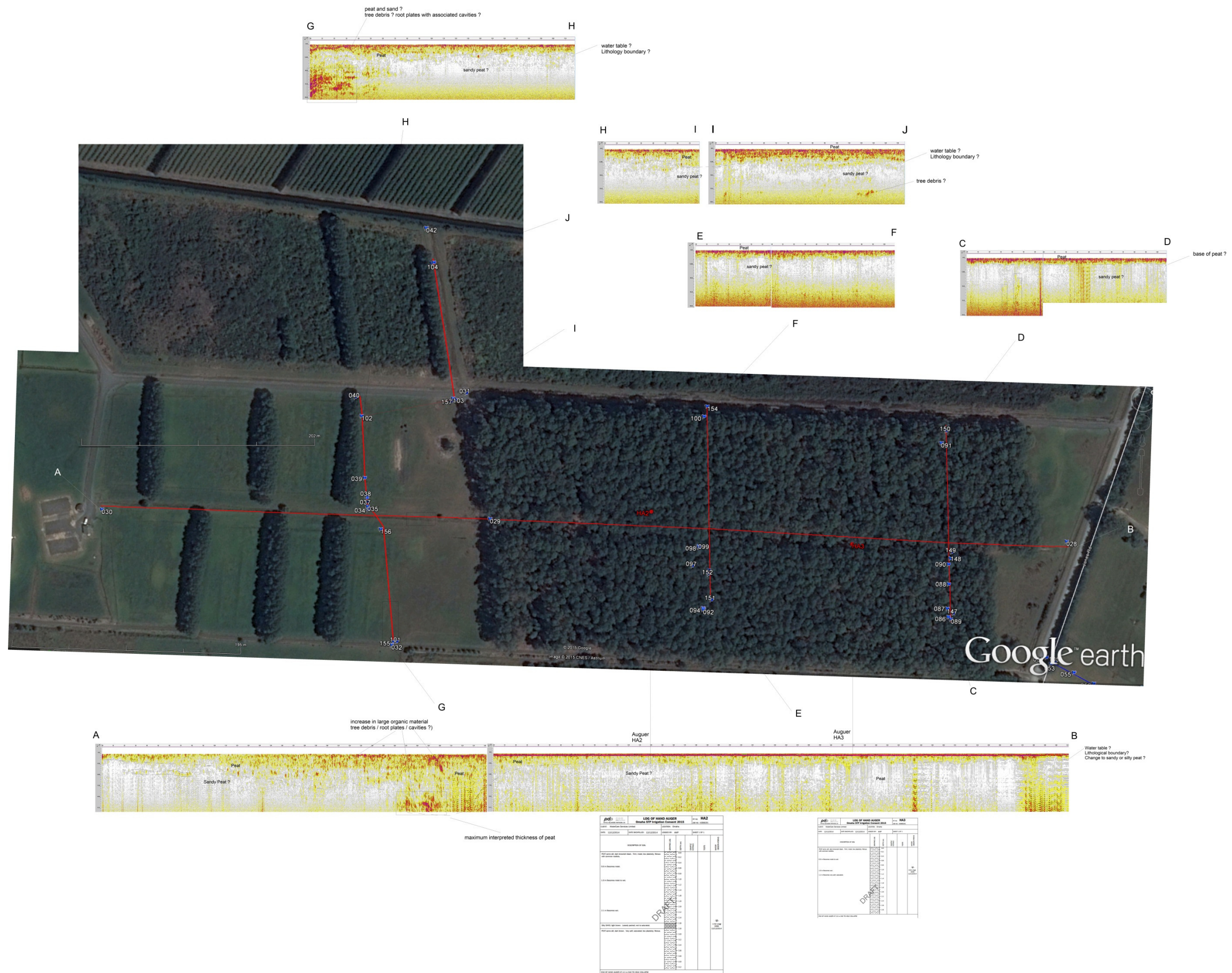


FIGURE 5 – OMAHA WWTP GPR IMAGERY (DRAFT) – SCANTEC LTD

LOG OF HAND AUGER		Omaha STP Irrigation Consent 2015		PT NO. HA4	
CLIENT: WaterCare Services Limited	LOCATION: Omaha	DATE: 11/12/2014	DATE BACKFILLED: 11/12/2014	LOGGED BY: JEQC	SHEET 1 OF 1
DEPTH (m)	DESCRIPTION OF SOIL	SAMPLE DETAILS	TESTS	WATER CONTENT (%)	WATER LOG
0.0	Organic SILT, dark greyish brown. Soft, dry, non-plastic. Highly organic.				
0.2	PEAT, dark brownish black. Firm, moist to wet, plastic; amorphous with some thin lenses of fibrous peat.				
0.4					
0.6					
0.8					
1.0	1.0 m Becomes very soft, wet to saturated.				
1.2					
1.4	1.3 m Becomes firm, amorphous.				
1.6					
1.8					
2.0	PEAT trace fine sand; dark brownish black. Firm; saturated; plastic; amorphous.				
2.2	Fine to medium SAND, some organic silt; dark reddish brown. Tightly packed; moist to wet, non-plastic.				
2.4	END OF HAND AUGER, REFUSAL AT 2.4 m				

LOG OF HAND AUGER		Omaha STP Irrigation Consent 2015		PT NO. HA5	
CLIENT: WaterCare Services Limited	LOCATION: Omaha	DATE: 11/12/2014	DATE BACKFILLED: 11/12/2014	LOGGED BY: JEQC	SHEET 1 OF 1
DEPTH (m)	DESCRIPTION OF SOIL	SAMPLE DETAILS	TESTS	WATER CONTENT (%)	WATER LOG
0.0	Organic SILT, minor fine sand; dark greyish brown. Soft to firm; dry, non-plastic. Contains nodules.				
0.2	PEAT, dark brown. Firm, moist to wet, plastic; amorphous with some thin lenses of fibrous peat.				
0.4	Fine to medium SAND, minor organic silt; light orange brown mottled dark brown. Loosely packed; moist; uniformly graded.				
0.6					
0.8	PEAT, dark brownish black. Soft to very soft; wet; amorphous with thin lenses of fibrous peat.				
1.0					
1.2					
1.4	1.3 m Becomes very soft; saturated.				
1.6	1.4 m Becomes firm to soft, inclusions of mesangium.				
1.8	Sandy PEAT; reddish black. Firm to soft; saturated; amorphous. Some fine to medium, uniformly graded.				
2.0	Silty fine to medium SAND; dark reddish brown. Tightly packed; saturated. High organic content.				
2.1	END OF HAND AUGER, REFUSAL AT 2.1 m				

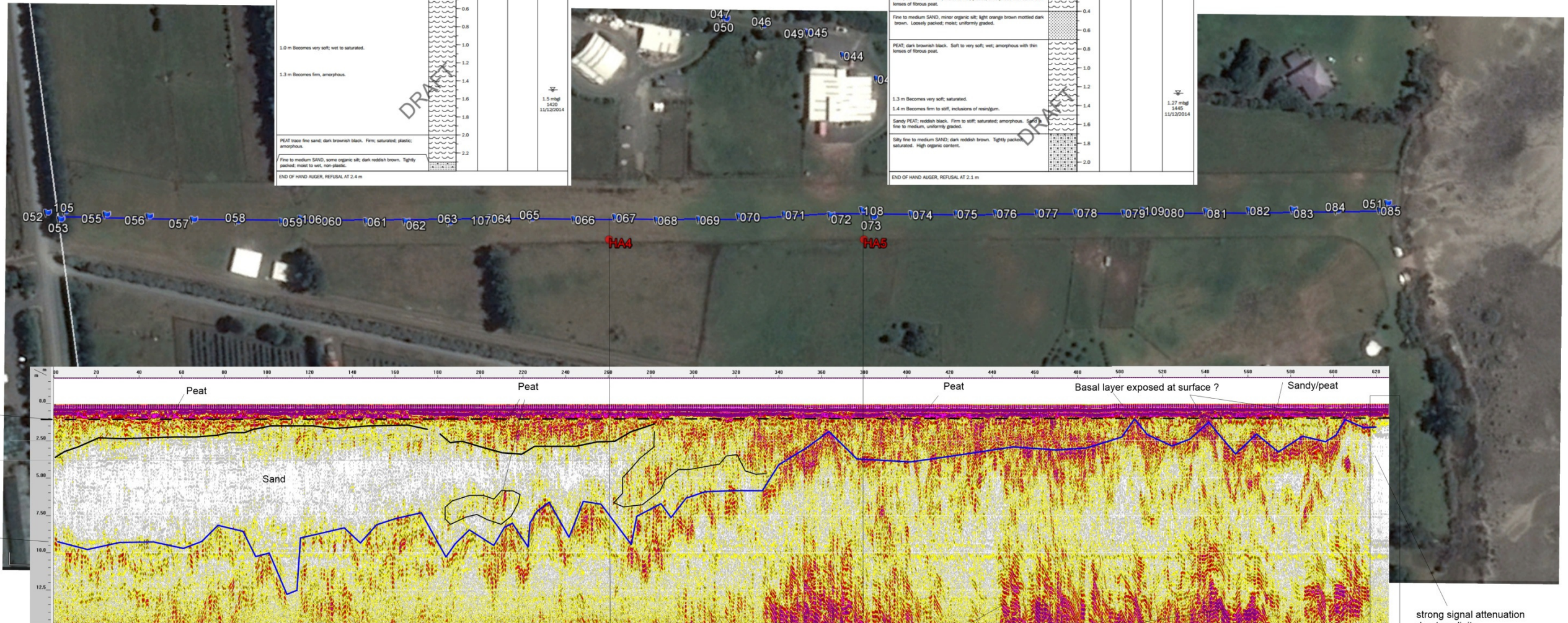


FIGURE 6 –AIR FIELD GPR IMAGERY (DRAFT) – SCANTEC LTD



FIGURE 7: PROPOSED GROUNDWATER BORE AND DRAIN MONITORING LOCATIONS

Appendix A
Laboratory Water Chemistry Results
(AES Samples)

Certificate of Analysis

Laboratory Reference: 140828-099

Attention:		Final Report:	107149-0
Client:	Watercare Services Ltd	Report Issue Date:	11-Sep-2014
Address:		Received Date:	28-Aug-2014
Client Reference:	JR & FEB	Quote Reference :	4887
Purchase Order:	C-12372-01		

Sample Details

	WATERS	WATERS	WATERS	WATERS
Lab Sample ID:	140828-099-1	140828-099-2	140828-099-3	140828-099-4
Client Sample ID:				
Sample Date/Time:	27/08/2014	27/08/2014	27/08/2014	27/08/2014
Description:	JR1 Sth	JR 2 (Causeway)	Feb 1B (Pax)	Feb 1 (C)

Chemistry Summary View

	mg/L	WATERS	WATERS	WATERS	WATERS
Nitrite (as N)	mg/L	<0.002	0.0075	<0.02	0.011
Total Nitrogen (as N)	mg/L	0.73	1.0	0.97	0.93
Total Oxidised Nitrogen (as N)	mg/L	<0.002	0.020	<0.02	0.011

General Testing

	mg/L	WATERS	WATERS	WATERS	WATERS
Ammoniacal Nitrogen (as N)	mg/L	0.39	0.075	0.021	0.24
Conductivity (at 25 °C)	mS/m	3020	783	256	1720
Dissolved Reactive Phosphorus (as P)	mg/L	0.0090	0.012	0.012	0.0080
Nitrate (as N)	mg/L	<0.002	0.013	<0.02	<0.002
pH (at room temp c. 20 °C)	pH unit	8.1	5.8	6.2	7.6
Total Kjeldahl Nitrogen (as N)	mg/L	0.67	0.87	0.91	0.85
Total Phosphorus (as P)	mg/L	0.017	0.023	0.018	0.019

Results marked with * are not accredited to International Accreditation New Zealand

Where samples have been supplied by the client they are tested as received. A dash indicates no test performed.

Reference Methods

The sample(s) referred to in this report were analysed by the following method(s)

Analyte	Method Reference	MDL	Samples	Location
Chemistry Summary View				
Nitrite (as N)	APHA (2012) 4500-NO2- B (Modified)	0.002 mg/L	All	Auckland
Total Nitrogen (as N)	APHA (2012) 4500-P J, 4500-NO3 F (Modified)	0.010 mg/L	All	Auckland
Total Oxidised Nitrogen (as N)	APHA (2012) 4500-NO3- F (Modified)	0.002 mg/L	All	Auckland
General Testing				
Ammoniacal Nitrogen (as N)	MEWAM, HMSO 1981, ISBN 0117516139	0.005 mg/L	All	Auckland
Conductivity (at 25 °C)	APHA (2012) 2510 B	0.5 mS/m	All	Auckland
Dissolved Reactive Phosphorus (as P)	APHA (2012) 4500-P B, F (Modified)	0.002 mg/L	All	Auckland
Nitrate (as N)	Nitrate-N Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N	0.002 mg/L	All	Auckland
pH (at room temp c. 20 °C)	APHA (2012) 4500-H B	0.1 pH unit	All	Auckland
Total Kjeldahl Nitrogen (as N)	APHA (2012) 4500-N org A, D	0.1 mg/L	All	Auckland
Total Phosphorus (as P)	APHA (2012) 4500-P B, J (Modified)	0.004 mg/L	All	Auckland

Preparations

Membrane Filtration (0.45 µm)	APHA (2012) 4500-P B (preliminary filtration)	All	Auckland
-------------------------------	---	-----	----------

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher. For more information please contact the Operations Manager.

Samples, with suitable preservation and stability of analytes, will be held by the laboratory for a period of two weeks after results have been reported, unless otherwise advised by the submitter.

This report may not be reproduced, except in full, without the written authority of the Operations Manager.



Tests indicated as
not accredited are outside
the scope of the
laboratory's accreditation

Report Signatory 11/09/2014

A handwritten signature in blue ink, appearing to read 'Carol Taylor'.

Carol Taylor
KTP Signatory

Appendix B
Hand Auger Logs

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA1**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 12/12/2014 DATE BACKFILLED: 12/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Organic SILT, some clay; dark brown. Firm; moist; slightly plastic. Contains clasts of gum/resin (~2-5 mm).		0.0			 0.93 mbgl 0900 12/12/2014
		0.2			
		0.4			
		0.6			
0.8 m Becomes soft; wet.		0.8			
		1.0			
1.1 m Becomes soft to very soft; saturated. Contains fibrous organic material.		1.2			
		1.4			
PEAT some silt; dark brownish black. Very soft; amorphous with minor wood fragments; saturated.		1.6			
1.35 - 3.5 m Significant core loss; very soft.		1.8			
		2.0			
2.0 m Hole squeeze.		2.2			
	2.4				
	2.6				
	2.8				
3.0 m Wood fragments.	3.0				

END OF HAND AUGER, REFUSAL AT 3.2 m

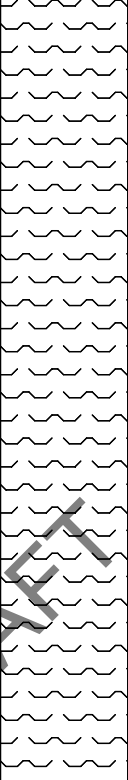
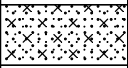

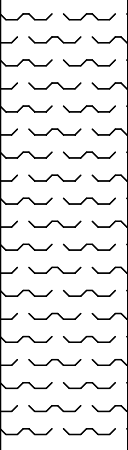
Notes: Standing water level at 0.93 m bgl at 0900 12/12/2014 Coordinates in NZTM	KEY Groundwater level Seepage inflow Grab sample PID Reading (ppm)	Method: Hand Auger Datum: Ground Level: -- Coordinates: 1756976 E, 5975697N Filename: AJ566201B001
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LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA2**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha





DATE: 12/12/2014 DATE BACKFILLED: 12/12/2014 LOGGED BY: AMP SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
PEAT some silt; dark brownish black. Firm; moist; low plasticity; fibrous with common rootlets. 0.8 m Becomes moist. 1.0 m Becomes moist to wet. 2.1 m Becomes wet.		0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4			
Silty SAND; light brown. Loosely packed; wet to saturated.		2.6			 2.52 mbgl 1000 12/12/2014
PEAT some silt; dark brown. Very soft; saturated; low plasticity; fibrous.		2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2			

END OF HAND AUGER AT 4.3 m DUE TO HOLE COLLAPSE

Notes: Standing water level at 2.52 m bgl at 1000 12/12/2014
Coordinates in NZTM

KEY

-  Groundwater level
-  Seepage inflow
-  Grab sample
-  PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1757219 E, 5975809 N

Filename: AJ566201B002

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA3**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 12/12/2014 DATE BACKFILLED: 12/12/2014 LOGGED BY: AMP SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
<p>PEAT some silt; dark brownish black. Firm; moist; low plasticity; fibrous with common rootlets.</p> <p>0.8 m Becomes moist to wet.</p> <p>1.0 m Becomes wet.</p> <p>1.2 m Becomes very soft; saturated.</p>		<p>0.0</p> <p>0.2</p> <p>0.4</p> <p>0.6</p> <p>0.8</p> <p>1.0</p> <p>1.2</p> <p>1.4</p> <p>1.6</p> <p>1.8</p> <p>2.0</p> <p>2.2</p> <p>2.4</p> <p>2.6</p> <p>2.8</p>			<p>▽</p> <p>0.91 mbgl 1030 12/12/2014</p>

DRAFT

END OF HAND AUGER AT 3.0 m DUE TO HOLE COLLAPSE

<p>Notes: Standing water level at 0.91 m bgl at 1030 12/12/2014 Coordinates in NZTM</p>	<p>KEY</p> <ul style="list-style-type: none"> ▽ Groundwater level ● Seepage inflow ● Grab sample × PID Reading (ppm) 	<p>Method: Hand Auger Datum: Ground Level: -- Coordinates: 1757345 E, 5975957 N Filename: AJ566201B003</p>
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LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA4**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 11/12/2014 DATE BACKFILLED: 11/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Organic SILT; dark greyish brown. Soft; dry; non-plastic. Highly organic.		0.0			
PEAT; dark brownish black. Firm; moist to wet; plastic; amorphous with some thin lenses of fibrous peat.		0.2			
		0.4			
		0.6			
		0.8			
1.0 m Becomes very soft; wet to saturated.		1.0			
		1.2			
1.3 m Becomes firm, amorphous.		1.4			
		1.6			
		1.8			
		2.0			
PEAT trace fine sand; dark brownish black. Firm; saturated; plastic; amorphous.		2.2			
Fine to medium SAND, some organic silt; dark reddish brown. Tightly packed; moist to wet, non-plastic.					

DRAFT

1.5 mbgl
 1420
 11/12/2014

END OF HAND AUGER, REFUSAL AT 2.4 m


Notes: Standing water level at 1.5 m bgl at 1420 11/12/2014
Coordinates in NZTM

- KEY**
- Groundwater level
 - Seepage inflow
 - Grab sample
 - PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1757881 E, 5976085 N
Filename: AJ566201B004





CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 11/12/2014 DATE BACKFILLED: 11/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Organic SILT, minor fine sand; dark greyish brown. Soft to firm; dry; non-plastic. Contains rootlets.	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	0.0 0.2			
PEAT; dark brown. Firm; moist to wet; plastic; amorphous with some thin lenses of fibrous peat.	~~~~~ ~~~~~ ~~~~~	0.4			
Fine to medium SAND, minor organic silt; light orange brown mottled dark brown. Loosely packed; moist; uniformly graded.	0.6			
PEAT; dark brownish black. Soft to very soft; wet; amorphous with thin lenses of fibrous peat.	~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~	0.8 1.0 1.2			
1.3 m Becomes very soft; saturated. 1.4 m Becomes firm to stiff, inclusions of resin/gum.	~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~ ~~~~~	1.4			 1.27 mbgl 1445 11/12/2014
Sandy PEAT; reddish black. Firm to stiff; saturated; amorphous. Sand is fine to medium, uniformly graded.	~~~~~ ~~~~~ ~~~~~	1.6			
Silty fine to medium SAND; dark reddish brown. Tightly packed; saturated. High organic content.	XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX XXXXXX	1.8 2.0			

END OF HAND AUGER, REFUSAL AT 2.1 m

Notes: Standing water level at 1.27 m bgl at 1445 11/12/2014
 Coordinates in NZTM

KEY
 Groundwater level
 Seepage inflow
 Grab sample
 PID Reading (ppm)

Method: Hand Auger
 Datum:
 Ground Level: --
 Coordinates: 1757857 E, 5976158 N
 Filename: AJ566201B005

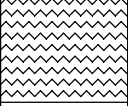
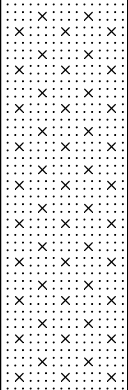

Logs based on New Zealand Geomechanics Society Field Description Guidelines (2005)

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA6**
JOB NO: AJ566201





CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 16/12/2014 DATE BACKFILLED: 16/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Silty fine to medium SAND; dark brown. Loosely packed; moist. (TOPSOIL).		0.0 0.2			
Fine to medium SAND, minor silt; light greyish brown. Loosely packed, moist to wet. 0.5 m Becomes tightly packed; wet. 0.6 m Colour change to dark brown. 0.8 m Becomes saturated.		0.4 0.6 0.8 1.0			 0.67 mbgl 1330 16/12/2014

END OF HAND AUGER AT 1.2 m DUE TO HOLE COLLAPSE

DRAFT


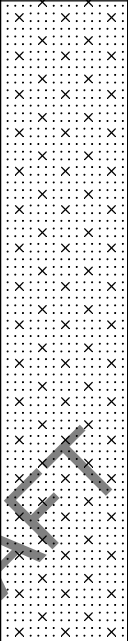
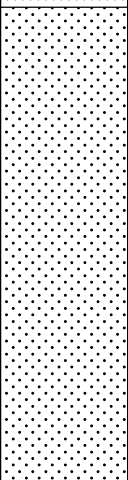
Notes: Standing water level at 0.67 m bgl at 1330 16/12/2014 Coordinates in NZTM	<p>KEY</p> <ul style="list-style-type: none">  Groundwater level  Seepage inflow  Grab sample  PID Reading (ppm) 	<p>Method: Hand Auger Datum: Ground Level: -- Coordinates: 1759393 E, 5976481 N Filename: AJ566201B006</p>
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LOG OF HAND AUGER Omaha STP Irrigation Consent 2015

PIT NO. **HA7**
JOB NO: AJ566201





CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 16/12/2014 DATE BACKFILLED: 16/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Silty fine to medium SAND; dark brown. Loosely packed; moist. (TOPSOIL).		0.0 0.2			
Fine to medium SAND, minor silt; yellowish brown. Loosely packed; moist; sand is uniformly graded. 1.0 m Becomes tightly packed.		0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2			
Fine to medium SAND; light brown. Tightly packed; moist; uniformly sorted.		2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8			

END OF HAND AUGER AT 4.0 m

Notes: No groundwater observed in excavation
Coordinates in NZTM

- KEY**
-  Groundwater level
 -  Seepage inflow
 -  Grab sample
 -  PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1759555 E, 5976362 N


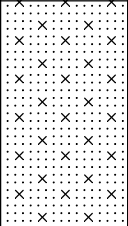
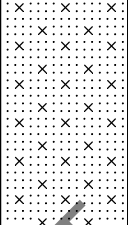
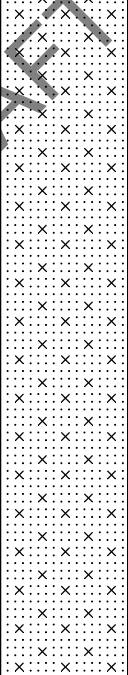
Filename: AJ566201B007

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA8**
JOB NO: AJ566201





CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 16/12/2014 DATE BACKFILLED: 16/12/2014 LOGGED BY: AMP SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Silty fine to medium SAND; dark brown. Loosely packed; moist. (TOPSOIL).		0.0 0.2			
Fine to medium SAND, minor silt; grey brown. Loosely packed; moist; sand is uniformly graded.		0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2			
1.0 m Colour change to reddish brown. Slight organic odour.		2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8			
2.4 m Becomes tightly packed; moist to wet.					

END OF HAND AUGER AT 4.0 m

Notes: No groundwater observed in excavation
Coordinates in NZTM

- KEY**
-  Groundwater level
 -  Seepage inflow
 -  Grab sample
 -  PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1759700 E, 5976081 N
Filename: AJ566201B008

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA9**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited		LOCATION: Omaha	
DATE: 16/12/2014	DATE BACKFILLED: 16/12/2014	LOGGED BY: AMP	SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Fine to medium SAND, minor silt; light grey with orange and brown streaks. Loosely packed; wet, saturated at 0.4 m.		0.0 0.2 0.4			 0.4 mbgl 1040 16/12/2014
Organic silty fine to medium SAND; dark grey. Loosely packed; saturated; sand is uniformly graded. Contains rootlets. Minor organic odour.		0.6 0.8			
1.0 m Colour change to reddish brown. Slight organic odour.		1.0			
Organic fine to medium sandy SILT; dark grey. Very soft; saturated. Contains shell fragments. Minor organic odour.		1.2 1.4			

END OF HAND AUGER, NO RETURNS AT 1.5 m

DRAFT

Notes: Standing water level at 0.4 m bgl at 1040 16/12/2014 Coordinates in NZTM	KEY Groundwater level Seepage inflow Grab sample PID Reading (ppm)	Method: Hand Auger Datum: Ground Level: -- Coordinates: 1759238 E, 5975870 N Filename: AJ566201B009
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LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA10**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 16/12/2014 DATE BACKFILLED: 16/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Sandy SILT; dark brown. Firm; moist; non-plastic; sand fine to medium. (TOPSOIL).		0.0			
Fine to medium SAND, minor silt; light greyish brown. Moderately packed; moist; sand is uniformly graded.		0.2			
0.8 m Colour change to dark greyish brown.		0.4			
1.0 m Becomes wet.		0.6			
1.1 m Becomes saturated.		0.8			
		1.0			 0.85 mbgl 1530 16/12/2014
		1.2			
Organic fine SAND, some silt; dark brown. Loosely packed; saturated. Moderate organic odour.		1.4			
		1.6			
		1.8			

END OF HAND AUGER AT 2.0 m DUE TO HOLE COLLAPSE

Notes: Standing water level at 0.85 m bgl at 1530 16/12/2014
Coordinates in NZTM

KEY

- Groundwater level
- Seepage inflow
- Grab sample
- PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1759757 E, 5975851 N
Filename: AJ566201B010

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 12/12/2014 DATE BACKFILLED: 12/12/2014 LOGGED BY: JEQC SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Organic SILT, minor clay; dark brown. Firm; moist; slightly plastic.		0.0 0.2			
Organic SILT, some clay; dark brown, mottled black. Firm; moist; plastic. Contains wood fragments and gum/resin. 0.8 m Becomes soft; wet. 0.9 m Becomes saturated.		0.4 0.6 0.8 1.0			 0.79 mbgl 0935 12/12/2014
PEAT, some silt; dark brownish black. Very soft to soft, saturated; amorphous with lenses of fibrous organic material. 1.1 - 4.2 m Significant core loss; very soft. 3.0 m Wood fragments. 4.0 m Strong hydrogen sulphide odour.		1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0			

END OF HAND AUGER AT 4.2 m DUE TO HOLE COLLAPSE

Notes: Standing water level at 0.79 m bgl at 0935 12/12/2014
Coordinates in NZTM

KEY	
	Groundwater level
	Seepage inflow
	Grab sample
	PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1756974 E, 5975681 N
Filename: AJ566201B011

LOG OF HAND AUGER
Omaha STP Irrigation Consent 2015

PIT NO. **HA12**
JOB NO: AJ566201

CLIENT: WaterCare Services Limited LOCATION: Omaha

DATE: 16/12/2014 DATE BACKFILLED: 16/12/2014 LOGGED BY: AMP SHEET 1 OF 1

DESCRIPTION OF SOIL	GRAPHIC LOG	DEPTH (m)	SAMPLE DETAILS	TESTS	WATER OBSERVATIONS
Silty fine to medium SAND; brownish grey. Loosely packed; saturated at 0.1 m.		0.0 0.2 0.4			 0.1 mbgl 1000 16/12/2014
Fine SAND; dark brownish grey. Loosely packed; saturated; sand is uniformly graded.		0.6 0.8			

END OF HAND AUGER, NO RETURNS AT 1.0 m

Notes: Standing water level at 0.1 m bgl at 1000 16/12/2014
Coordinates in NZTM

KEY

	Groundwater level
	Seepage inflow
	Grab sample
	PID Reading (ppm)

Method: Hand Auger
Datum:
Ground Level: --
Coordinates: 1759079 E, 5976167 N
Filename: AJ566201B012

Appendix C
Laboratory Water Chemistry Results
(PDP Samples)

Certificate of Analysis

Laboratory Reference: 141213-057

Attention:		Final Report:	120614-0	Replaces Report	120148-0
Client:	Watercare Services Ltd	Report Issue Date:	05-Jan-2015		
Address:		Received Date:	13-Dec-2014		
Client Reference:	Pattle Delamore Groundwater Samples	Quote Reference :	4887		
Purchase Order:	AJ566201				

Samples Beach2 and Omaha1 out of date.

Sample Details

	WATERS	WATERS	WATERS	WATERS
Lab Sample ID:	141213-057-1	141213-057-2	141213-057-3	141213-057-4
Client Sample ID:				
Sample Date/Time:	12/12/2014	12/12/2014	12/12/2014	12/12/2014
Description:	Well1	Well2	Well3	Well4

Chemistry Detailed

Anions by Ion Chromatography (0.45 µm Filtered)

	mg/L	mg/L	mg/L	mg/L
Chloride	25	26	81	26
Nitrate (as N)	0.030	0.031	0.024	0.018
Nitrite (as N)	<0.002	0.0035	0.0022	0.0031
Sulphate	12	11	17	0.39
Total Oxidised Nitrogen (as N) by Calculation	0.030 *	0.034 *	0.027 *	0.021 *

General Testing

	mg/L	mg/L	mg/L	mg/L
Ammoniacal Nitrogen (as N)	0.15	0.37	0.067	0.42
Anion Total	3.5 *	2.6 *	4.0 *	2.2 *
Bicarbonate Alkalinity (as HCO ₃)	160	99	82	86
CBOD ₅	1.1	4.0	2.8	4.2
Carbonate Alkalinity (as CO ₃)	<1.0	<1.0	<2.0	<1.0
Cation Total	3.5 *	2.9 *	4.7 *	2.4 *
Conductivity (at 25 °C)	34.7	26.4	44.9	22.6
Dissolved Ammoniacal Nitrogen (as N)	0.11	0.26	0.058	0.34
Dissolved Reactive Phosphorus (as P)	0.020	0.020	0.039	0.021
Hydroxide Alkalinity (as CaCO ₃)	<1.0	<1.0	<2.0	<1.0
meq/L Difference	0.43e-1 *	0.27 *	0.75 *	0.29 *
Percent Difference	0.61 *	4.9 *	8.6 *	6.3 *
pH (at room temp c. 20 °C)	pH unit 6.8	6.4	5.9	6.3
Sum of Anions + Cations	7.0 *	5.5 *	8.7 *	4.6 *
Total Alkalinity (as CaCO ₃)	130	81	68	71
Total Kjeldahl Nitrogen (as N)	0.66	1.2	1.7	1.2
Total Nitrogen (as N)	0.73	1.3	1.7	1.2
Total Phosphorus (as P)	0.083	0.085	0.16	0.094
Total Suspended Solids	12	210	2.7	25
Turbidity	NTU 34	300	8.8	18

Metals

Dissolved Metals by ICP-MS—Trace (Received Filtered)

	mg/L	mg/L	mg/L	mg/L
Arsenic (Dissolved)	0.00088	0.0024	0.00086	0.0026
Cadmium (Dissolved)	<0.00005	<0.00005	<0.00005	<0.00005
Calcium (Dissolved)	13	12	13	6.9
Chromium (Dissolved)	0.0015	0.0014	0.0031	0.0032
Copper (Dissolved)	0.00093	0.00051	0.0032	0.00042
Iron (Dissolved)	3.0	9.9	7.4	5.4
Lead (Dissolved)	0.00012	0.00012	0.00028	0.00014
Magnesium (Dissolved)	12	9.3	19	8.2
Manganese (Dissolved)	0.23	0.70	0.20	0.17
Nickel (Dissolved)	0.0016	0.0032	0.026	0.0010
Potassium (Dissolved)	6.8	3.0	5.6	7.1
Sodium (Dissolved)	37	24	48	23

Sample Details (continued)		WATERS	WATERS	WATERS	WATERS
Lab Sample ID:		141213-057-1	141213-057-2	141213-057-3	141213-057-4
Client Sample ID:					
Sample Date/Time:		12/12/2014	12/12/2014	12/12/2014	12/12/2014
Description:		Well1	Well2	Well3	Well4
Metals					
Dissolved Metals by ICP-MS—Trace (Received Filtered)					
Zinc (Dissolved)	mg/L	0.0076	0.0088	0.0094	0.0054
Organics					
Dissolved Organic Carbon (DOC) by Non-dispersive infrared detection					
Dissolved Organic Carbon	mg/L	24	220	230	65
Microbiology					
Escherichia coli by Membrane Filtration					
Escherichia coli	cfu/100 mL	1.6	<1.6	<1.6	<9.0
Faecal coliforms by Membrane Filtration					
Faecal coliforms	cfu/100 mL	<1.6	<9.0	<9.0	<9.0

Sample Details		WATERS	WATERS	WATERS	WATERS
Lab Sample ID:		141213-057-6	141213-057-8	141213-057-10	141213-057-15
Client Sample ID:					
Sample Date/Time:		12/12/2014	11/12/2014	11/12/2014	12/12/2014
Description:		PAX	Beach2	Omaha1	Omaha2
Chemistry Detailed					
Anions by Ion Chromatography (0.45 µm Filtered)					
Chloride	mg/L	74	20000	410	23
Nitrate (as N)	mg/L	0.0092	-	0.0055	0.0089
Nitrite (as N)	mg/L	<0.002	-	<0.004	<0.002
Sulphate	mg/L	42	2900	66	13
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.0092 *	-	0.0055 *	0.0089 *
General Testing					
Ammoniacal Nitrogen (as N)	mg/L	0.077	-	0.23	0.14
Ammoniacal Nitrogen (as N)	mg/L	-	0.020	-	-
Anion Total	meq/L	3.3 *	630 *	13 *	3.4 *
Bicarbonate Alkalinity (as HCO ₃)	mg/L	22	150	22	160
CBOD ₅	mg/L	0.94	2.9	1.4	1.1
Carbonate Alkalinity (as CO ₃)	mg/L	<1.0	15	<1.0	<1.0
Cation Total	meq/L	3.3 *	600 *	15 *	3.5 *
Conductivity (at 25 °C)	mS/m	39.5	5420	153	34.7
Dissolved Ammoniacal Nitrogen (as N)	mg/L	0.075	-	0.22	0.14
Dissolved Ammoniacal Nitrogen (as N)	mg/L	-	0.017	-	-
Dissolved Reactive Phosphorus (as P)	mg/L	0.025	0.068	0.010	0.013
Hydroxide Alkalinity (as CaCO ₃)	mg/L	<1.0	<1.0	<1.0	<1.0
meq/L Difference	meq/L	0.16e-1 *	29 *	1.3 *	0.53e-1 *
Nitrate (as N)	mg/L	-	<0.002	-	-
Nitrite (as N)	mg/L	-	<0.002	-	-
Percent Difference	%	0.24 *	2.4 *	4.8 *	0.76 *
pH (at room temp c. 20 °C)	pH unit	5.8	7.9	5.7	6.6
Sum of Anions + Cations	meq/L	6.7 *	1200 *	28 *	6.9 *
Total Alkalinity (as CaCO ₃)	mg/L	18	150	18	130
Total Kjeldahl Nitrogen (as N)	mg/L	-	0.23 *	-	-
Total Kjeldahl Nitrogen (as N)	mg/L	0.56	-	0.57	0.67
Total Nitrogen (as N)	mg/L	0.60	0.23	0.62	0.76
Total Oxidised Nitrogen (as N)	mg/L	-	<0.002	-	-
Total Phosphorus (as P)	mg/L	0.063	0.084	0.046	0.084
Total Suspended Solids	mg/L	3.0	27	2.3	7.0
Turbidity	NTU	1.7	7.5	2.4	35
Metals					
Dissolved Metals by ICP-MS—Trace (Received Filtered)					
Arsenic (Dissolved)	mg/L	0.0036	0.0042	0.00029	0.00087
Cadmium (Dissolved)	mg/L	<0.00005	0.000070	<0.00005	<0.00005
Calcium (Dissolved)	mg/L	11	430	15	13
Chromium (Dissolved)	mg/L	0.0047	0.0012	0.0021	0.0016
Copper (Dissolved)	mg/L	<0.0002	<0.002	<0.0002	<0.0002
Iron (Dissolved)	mg/L	4.0	0.0027	0.82	2.8

Sample Details (continued)	WATERS	WATERS	WATERS	WATERS
Lab Sample ID:	141213-057-6	141213-057-8	141213-057-10	141213-057-15
Client Sample ID:				
Sample Date/Time:	12/12/2014	11/12/2014	11/12/2014	12/12/2014
Description:	PAX	Beach2	Omaha1	Omaha2
Metals				
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Lead (Dissolved) mg/L	0.00023	0.00010	0.00010	<0.0001
Magnesium (Dissolved) mg/L	8.5	1200	31	12
Manganese (Dissolved) mg/L	0.076	0.041	0.053	0.24
Nickel (Dissolved) mg/L	0.0036	0.00048	0.00027	0.0017
Potassium (Dissolved) mg/L	0.31	450	11	5.7
Sodium (Dissolved) mg/L	44	11000	250	37
Zinc (Dissolved) mg/L	0.014	0.0035	0.0046	0.0040
Organics				
Dissolved Organic Carbon (DOC) by Non-dispersive infrared detection				
Dissolved Organic Carbon mg/L	9.8	2.6	17	16
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli cfu/100 mL	<1.6	<1.6	68	1.6
Faecal coliforms by Membrane Filtration				
Faecal coliforms cfu/100 mL	<1.6	<1.6	140	<1.6

Results marked with * are not accredited to International Accreditation New Zealand

Where samples have been supplied by the client they are tested as received. A dash indicates no test performed.

Reference Methods				
The sample(s) referred to in this report were analysed by the following method(s)				
Analyte	Method Reference	MDL	Samples	Location
Chemistry Detailed				
Anions by Ion Chromatography (0.45 µm Filtered)				
Chloride	APHA (online edition) 4110 B (Modified)	0.02 mg/L	All	Auckland
Nitrate (as N)	APHA (online edition) 4110 B (Modified)	0.002 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
Nitrite (as N)	APHA (online edition) 4110 B (Modified)	0.002 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
Sulphate	APHA (online edition) 4110 B (Modified)	0.02 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Calculation	APHA (online edition) 4110 B (Modified)	0.002 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
General Testing				
Ammoniacal Nitrogen (as N) by Flow Analysis	APHA (online edition) 4500-NH3 G (modified)	0.005 mg/L	8	Auckland
Ammoniacal Nitrogen (as N) by Colorimetry/Discrete Analyser	MEWAM, HMSO 1981, ISBN 0117516139	0.005 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
Anion Total by Calculation	APHA (online edition) 1030 E	meq/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Cation Total by Calculation	APHA (online edition) 1030 E	meq/L	All	Auckland
Carbonaceous Biochemical Oxygen Demand, CBOD5 by Electrode	APHA (online edition) 5210 B	0.5 mg/L	All	Auckland
Conductivity (at 25 °C) by Electrode	APHA (online edition) 2510 B	0.5 mS/m	All	Auckland
Dissolved Ammoniacal Nitrogen (as N) by Flow Analysis	APHA (online edition) 4500-NH3 G (modified)	0.005 mg/L	8	Auckland
Dissolved Ammoniacal Nitrogen (as N) by Colorimetry/Discrete Analyser	MEWAM, HMSO 1981, ISBN 0117516139	0.005 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
Dissolved Reactive Phosphorus (as P) by Colorimetry/Discrete Analyser	APHA (online edition) 4500-P B, F (modified)	0.002 mg/L	All	Auckland
Hydroxide Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
meq/L Difference by Calculation	APHA (online edition) 1030 E	meq/L	All	Auckland
Nitrate (as N) by Calculation	Nitrate-N Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N	0.002 mg/L	8	Auckland
Nitrite (as N) by Flow Analysis (0.45 µm Filtered)	APHA (online edition) 4500-NO2 B (modified)	0.002 mg/L	8	Auckland
Percent Difference by Calculation	APHA (online edition) 1030 E		All	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland
Sum of Anions + Cations by Calculation	APHA (online edition) 1030 E		All	Auckland
Total Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Kjeldahl Nitrogen (as N) by Calculation	Calculation	0.02 mg/L	8	Auckland
Total Kjeldahl Nitrogen (as N) by Sulphuric Acid Digestion (with mercuric ion)	APHA (online edition) 4500-N org A, D	0.1 mg/L	1, 2, 3, 4, 6, 10, 15	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J, 4500-NO3 F (modified)	0.010 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Automated Cadmium Reduction/Flow Analysis	APHA (online edition) 4500-NO3 F (modified)	0.002 mg/L	8	Auckland

General Testing

Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/DiAPHA (online edition) 4500-P B, J (modified)	0.004 mg/L	All	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	All Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	All Auckland

Metals**Dissolved Metals by ICP-MS—Trace (Received Filtered)**

Arsenic (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	All Auckland
Cadmium (Dissolved)	US EPA 200.8 (Modified)	0.00005 mg/L	All Auckland
Calcium (Dissolved)	US EPA 200.8 (Modified)	0.010 mg/L	All Auckland
Chromium (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	All Auckland
Copper (Dissolved)	US EPA 200.8 (Modified)	0.0002 mg/L	All Auckland
Iron (Dissolved)	US EPA 200.8 (Modified)	0.002 mg/L	All Auckland
Lead (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	All Auckland
Magnesium (Dissolved)	US EPA 200.8 (Modified)	0.001 mg/L	All Auckland
Manganese (Dissolved)	US EPA 200.8 (Modified)	0.0005 mg/L	All Auckland
Nickel (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	All Auckland
Potassium (Dissolved)	US EPA 200.8 (Modified)	0.05 mg/L	All Auckland
Sodium (Dissolved)	US EPA 200.8 (Modified)	0.1 mg/L	All Auckland
Zinc (Dissolved)	US EPA 200.8 (Modified)	0.001 mg/L	All Auckland

Organics**Dissolved Organic Carbon (DOC) by Non-dispersive infrared detection**

Dissolved Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	All Auckland
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Microbiology**Escherichia coli by Membrane Filtration**

Escherichia coli	USEPA Method 1603 (2002)	2 cfu/100 mL	All Auckland
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Faecal coliforms by Membrane Filtration

Faecal coliforms	APHA (online edition) 9222 D	2 cfu/100 mL	All Auckland
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Preparations

Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)	All	Auckland
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*The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.
For more information please contact the Operations Manager.*

Samples, with suitable preservation and stability of analytes, will be held by the laboratory for a period of two weeks after results have been reported, unless otherwise advised by the submitter.

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Tests indicated as not accredited are outside the scope of the laboratory's accreditation

Report Signatory 05/01/2015

Anel Du Preez
KTP Signatory

Certificate of Analysis

Laboratory Reference: 141217-160

Attention:		Final Report:	121022-0
Client:	Watercare Services Ltd	Report Issue Date:	07-Jan-2015
Address:		Received Date:	17-Dec-2014
Client Reference:	Pattle Delamore	Quote Reference :	4887
Purchase Order:	tbc		

Please note: Samples received out of date range

Sample Details

	WATERS	WATERS
Lab Sample ID:	141217-160-1	141217-160-2
Client Sample ID:		
Sample Date/Time:	16/12/2014	16/12/2014
Description:	Beach 1	Pond East

Chemistry Detailed

Anions by Ion Chromatography (0.45 µm Filtered)

	mg/L	14000	1700
Chloride	mg/L	14000	1700
Sulphate	mg/L	2100	300

General Testing

	mg/L	0.013	-
Ammoniacal Nitrogen (as N)	mg/L	0.013	-
Anion Total	meq/L	450 *	-
Bicarbonate Alkalinity (as HCO ₃)	mg/L	170	-
CBOD ₅	mg/L	<0.5	-
Carbonate Alkalinity (as CO ₃)	mg/L	12	-
Cation Total	meq/L	430 *	-
Conductivity (at 25 °C)	mS/m	4040	571
Dissolved Ammoniacal Nitrogen (as N)	mg/L	0.017	0.062
Dissolved Reactive Phosphorus (as P)	mg/L	0.069	-
Hydroxide Alkalinity (as CaCO ₃)	mg/L	<1.0	-
meq/L Difference	meq/L	24 *	-
Nitrate (as N)	mg/L	4.2	-
Nitrite (as N)	mg/L	0.0054	-
Percent Difference	%	2.8 *	-
pH (at room temp c. 20 °C)	pH unit	7.8	7.2
Sum of Anions + Cations	meq/L	880 *	-
Total Alkalinity (as CaCO ₃)	mg/L	160	40
Total Kjeldahl Nitrogen (as N)	mg/L	0.39 *	-
Total Kjeldahl Nitrogen (as N)	mg/L	-	6.8
Total Nitrogen (as N)	mg/L	4.6	7.4
Total Oxidised Nitrogen (as N)	mg/L	4.2	-
Total Phosphorus (as P)	mg/L	0.11	-
Total Suspended Solids	mg/L	3.6	-
Turbidity	NTU	18	-

Metals

Dissolved Metals by ICP-MS—Trace

	mg/L	-	26
Calcium (Dissolved)	mg/L	-	26
Iron (Dissolved)	mg/L	-	0.36
Magnesium (Dissolved)	mg/L	-	83
Potassium (Dissolved)	mg/L	-	36
Sodium (Dissolved)	mg/L	-	870

Dissolved Metals by ICP-MS—Trace (Received Filtered)

	mg/L	<0.01	-
Arsenic (Dissolved)	mg/L	<0.01	-
Cadmium (Dissolved)	mg/L	<0.005	-
Calcium (Dissolved)	mg/L	290	-
Chromium (Dissolved)	mg/L	<0.01	-
Copper (Dissolved)	mg/L	<0.02	-
Iron (Dissolved)	mg/L	<0.2	-

Sample Details (continued)	WATERS	WATERS
Lab Sample ID:	141217-160-1	141217-160-2
Client Sample ID:		
Sample Date/Time:	16/12/2014	16/12/2014
Description:	Beach 1	Pond East

Metals

Dissolved Metals by ICP-MS—Trace (Received Filtered)

Element	Unit	141217-160-1	141217-160-2
Lead (Dissolved)	mg/L	<0.01	-
Magnesium (Dissolved)	mg/L	860	-
Manganese (Dissolved)	mg/L	<0.05	-
Nickel (Dissolved)	mg/L	<0.01	-
Potassium (Dissolved)	mg/L	270	-
Sodium (Dissolved)	mg/L	7700	-
Zinc (Dissolved)	mg/L	<0.1	-

Organics

Dissolved Organic Carbon (DOC) by Non-dispersive infrared detection

Parameter	Unit	141217-160-1	141217-160-2
Dissolved Organic Carbon	mg/L	1.3	-

Microbiology

Escherichia coli by Membrane Filtration

Parameter	Unit	141217-160-1	141217-160-2
Escherichia coli	cfu/100 mL	<1.6	-

Faecal coliforms by Membrane Filtration

Parameter	Unit	141217-160-1	141217-160-2
Faecal coliforms	cfu/100 mL	<1.6	-

Results marked with * are not accredited to International Accreditation New Zealand

Where samples have been supplied by the client they are tested as received. A dash indicates no test performed.

Reference Methods

The sample(s) referred to in this report were analysed by the following method(s)

Chemistry Detailed

Anions by Ion Chromatography (0.45 µm Filtered)

Analyte	Method Reference	MDL	Samples	Location
Chloride	APHA (online edition) 4110 B (Modified)	0.02 mg/L	All	Auckland
Sulphate	APHA (online edition) 4110 B (Modified)	0.02 mg/L	All	Auckland

General Testing

Parameter	Method Reference	MDL	Samples	Location
Ammoniacal Nitrogen (as N) by Flow Analysis	APHA (online edition) 4500-NH3 G (modified)	0.005 mg/L	1	Auckland
Anion Total by Calculation	APHA (online edition) 1030 E	meq/L	1	Auckland
Bicarbonate Alkalinity (as HCO ₃) by Titration	APHA (online edition) 2320 B	1 mg/L	1	Auckland
Carbonate Alkalinity (as CO ₃) by Titration	APHA (online edition) 2320 B	1 mg/L	1	Auckland
Cation Total by Calculation	APHA (online edition) 1030 E	meq/L	1	Auckland
Carbonaceous Biochemical Oxygen Demand, CBOD ₅ by Electrode	APHA (online edition) 5210 B	0.5 mg/L	1	Auckland
Conductivity (at 25 °C) by Electrode	APHA (online edition) 2510 B	0.5 mS/m	All	Auckland
Dissolved Ammoniacal Nitrogen (as N) by Flow Analysis	APHA (online edition) 4500-NH3 G (modified)	0.005 mg/L	All	Auckland
Dissolved Reactive Phosphorus (as P) by Colorimetry/Discrete Analy	APHA (online edition) 4500-P B, F (modified)	0.002 mg/L	1	Auckland
Hydroxide Alkalinity (as CaCO ₃) by Titration	APHA (online edition) 2320 B	1 mg/L	1	Auckland
meq/L Difference by Calculation	APHA (online edition) 1030 E	meq/L	1	Auckland
Nitrate (as N) by Calculation	Nitrate-N Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N	0.002 mg/L	1	Auckland
Nitrite (as N) by Flow Analysis (0.45 µm Filtered)	APHA (online edition) 4500-NO ₂ B (modified)	0.002 mg/L	1	Auckland
Percent Difference by Calculation	APHA (online edition) 1030 E		1	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland
Sum of Anions + Cations by Calculation	APHA (online edition) 1030 E		1	Auckland
Total Alkalinity (as CaCO ₃) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Kjeldahl Nitrogen (as N) by Calculation	Calculation	0.02 mg/L	1	Auckland
Total Kjeldahl Nitrogen (as N) by Sulphuric Acid Digestion (with merc	APHA (online edition) 4500-N org A, D	0.1 mg/L	2	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J, 4500-NO ₃ F (modified)	0.010 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Automated Cadmium Reduction/Fl	APHA (online edition) 4500-NO ₃ F (modified)	0.002 mg/L	1	Auckland
Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/D	APHA (online edition) 4500-P B, J (modified)	0.004 mg/L	1	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	1	Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	1	Auckland

Metals

Dissolved Metals by ICP-MS—Trace

Element	Method Reference	MDL	Samples	Location
Calcium (Dissolved)	US EPA 200.8 (Modified)	0.010 mg/L	2	Auckland
Iron (Dissolved)	US EPA 200.8 (Modified)	0.002 mg/L	2	Auckland
Magnesium (Dissolved)	US EPA 200.8 (Modified)	0.001 mg/L	2	Auckland
Potassium (Dissolved)	US EPA 200.8 (Modified)	0.05 mg/L	2	Auckland

Metals				
Dissolved Metals by ICP-MS—Trace				
Sodium (Dissolved)	US EPA 200.8 (Modified)	0.1 mg/L	2	Auckland
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Arsenic (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	1	Auckland
Cadmium (Dissolved)	US EPA 200.8 (Modified)	0.00005 mg/L	1	Auckland
Calcium (Dissolved)	US EPA 200.8 (Modified)	0.010 mg/L	1	Auckland
Chromium (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	1	Auckland
Copper (Dissolved)	US EPA 200.8 (Modified)	0.0002 mg/L	1	Auckland
Iron (Dissolved)	US EPA 200.8 (Modified)	0.002 mg/L	1	Auckland
Lead (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	1	Auckland
Magnesium (Dissolved)	US EPA 200.8 (Modified)	0.001 mg/L	1	Auckland
Manganese (Dissolved)	US EPA 200.8 (Modified)	0.0005 mg/L	1	Auckland
Nickel (Dissolved)	US EPA 200.8 (Modified)	0.00010 mg/L	1	Auckland
Potassium (Dissolved)	US EPA 200.8 (Modified)	0.05 mg/L	1	Auckland
Sodium (Dissolved)	US EPA 200.8 (Modified)	0.1 mg/L	1	Auckland
Zinc (Dissolved)	US EPA 200.8 (Modified)	0.001 mg/L	1	Auckland
Organics				
Dissolved Organic Carbon (DOC) by Non-dispersive infrared detection				
Dissolved Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	1	Auckland
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603 (2002)	2 cfu/100 mL	1	Auckland
Faecal coliforms by Membrane Filtration				
Faecal coliforms	APHA (online edition) 9222 D	2 cfu/100 mL	1	Auckland
Preparations				
0.45 µm Filtration for Dissolved Metals	APHA (online edition) 3010B (modified)		2	Auckland
Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)		All	Auckland
<i>The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher. For more information please contact the Operations Manager.</i>				

Samples, with suitable preservation and stability of analytes, will be held by the laboratory for a period of two weeks after results have been reported, unless otherwise advised by the submitter.

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Report Signatory 07/01/2015

Robyn Abernethy
KTP Signatory

Omaha Stage 1 Investigations - RPD Assessment

		Ammoniacal Nitrogen (by colorimetry/discrete analyser)	Arsenic	Bicarbonate Alkalinity as CaCO3	Cadmium	Calcium	Carbonate Alkalinity as CaCO3	CBOD	Chloride	Chromium	Copper
	Unit	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DATE	Well 1	0.15	0.00088	160	0.00005	13	1	1.1	25	0.0015	0.00093
12/12/2014	Omaha2	0.14	0.00087	160	0.00005	13	1	1.1	23	0.0016	0.00020
	RPD	6.9	1.1	0.0	0.0	0.0	0.0	0.0	8.3	6.5	129.2

		Dissolved Ammoniacal Nitrogen (by Colorimetry/Discrete Analyser)	Dissolved Organic Carbon	Dissolved Reactive Phosphorus	E. coli	Electrical Conductivity @ 25°C	Faecal coliforms	Hydroxide Alkalinity as CaCO3	Iron	Lead	Magnesium
	Unit	mg/L	mg/L	mg/L	cfu/100 mL	mS/m	cfu/100 mL	mg/L	mg/L	mg/L	mg/L
12/12/2014	Well 1	0.11	24	0.02	1.6	34.7	1.6	1	3	0.00012	12
	Omaha2	0.14	16	0.013	1.6	34.7	1.6	1	2.8	0.00010	12
	RPD	24.0	40.0	42.4	0.0	0.0	0.0	0.0	6.9	18.2	0.0

		Manganese	Nickel	Nitrate (by Ion Chromatography)	Nitrite (by Ion Chromatography)	pH Lab Value	Potassium	Sodium	Sulfate as SO4 - Turbidimetric	Total Alkalinity as CaCO3	Total Kjeldahl Nitrogen (by sulphuric acid digestion)
	Unit	mg/L	mg/L	mg/L	mg/L	units	mg/L	mg/L	mg/L	mg/L	mg/L
DATE	Well 1	0.230	0.00160	0.03	0.002	6.8	6.8	37	12	130	0.66
12/12/2014	Omaha2	0.240	0.00170	0.0089	0.002	6.6	5.7	37	13	130	0.67
	RPD	4.3	6.1	108.5	0.0	3.0	17.6	0.0	8.0	0.0	1.5

		Total Nitrogen (by persulfate digestion)	Total Oxidised Nitrogen (by Ion Chromatography)	Total Phosphorus	Turbidity by Nephelometry	Zinc
	Unit	mg/L	mg/L	mg/L	mg/L	mg/L
DATE	Well 1	0.73	0.03	0.083	34	0.00760
12/12/2014	Omaha2	0.76	0.0089	0.084	35	0.00400
	RPD	4.0	108.5	1.2	2.9	62.1

 Indicates >30% RPD