Waingawa Groundwater Quality Study

Tim Baker
Environmental Science Department

For more information, contact the Greater Wellington Regional Council:

Wellington
PO Box 11646

T 04 384 5708
F 04 385 6960
www.gw.govt.nz

Masterton
PO Box 41

T 06 378 2484
F 06 378 2146
www.gw.govt.nz

GW/ESCI-G-122/17

January 2018

www.gw.govt.nz
info@gw.govt.nz

Report prepared by:	T Baker	Groundwater Scientist	
Report reviewed by:	P Crisp	Team Leader, Environmental Science	
	J Drewry	Senior Environmental Scientist	John Drewry
Report approved for release by:	L Butcher	Manager, Environmental Science	Date: January 2018

The report may be cited as:

Baker T. 2017. *Waingawa Groundwater Quality Study.* Greater Wellington Regional Council, Publication No. GW/ESCI-G-122/17, Wellington.

Executive summary

State of the Environment (SoE) monitoring by Greater Wellington Regional Council (GWRC) in the Taratahi Groundwater Zone (GWZ), located south of the Waiohine River has reported elevated nitrate-nitrogen (NO_3-N) concentrations in shallow groundwater and a spring fed stream (Parkvale Stream at Lowes Bush) for a number of years.

The source of these elevated concentrations has never been investigated but has often been attributed to the historic Waingawa Freezing Works. Groundwater monitoring undertaken for the Freezing Works up until 2000 indicated that activities associated with the discharge of freezing works waste had resulted in concentrations of both NO_3-N and ammoniacal-nitrogen (NH_4-N) exceeding drinking water standards. Monitoring of these plumes ceased in 2000 before the plumes of nitrate nitrogen had dissipated.

Because present day concentrations are still elevated, it has been questioned as to whether historic contamination is a contributing factor to the present day nitrate nitrogen observed in the catchment. These questions were not able to be answered with the data available to GWRC, and thus this report was commissioned to see if further investigation could help identify the source of the elevated nitrate nitrogen in groundwater near Lowes Bush.

A single round of groundwater sampling was undertaken to assess the spatial distribution of nitrate nitrogen across the study area. The first stage of the study was to conceptualise the hydrogeological setting. Geochemistry results were used to demonstrate that shallow groundwater is predominantly sourced via losses from the Waingawa River, which recharges the shallow Taratahi Aquifer. Age dating (tritium) also demonstrated that the mean residence time in the shallow aquifer is young, ranging from 4-5 years old at the Waingawa faultline to 5-6 years old at Lowes Bush on the Carterton faultline.

Capture zone analysis was used to delineate the total source capture zones for each of the bores. The delineated zones show that the capture zones are quite elongated and demonstrate that results from each well are only representative of a small part of the shallow aquifer.

Nitrate-nitrite-nitrogen (NNN, also referred to as total oxidised nitrogen) concentrations were measured at a total of 14 bores and five surface water sites. Concentrations of NNN ranged between 1.7 to 12 mg/L in groundwater and was largely absent from surface water with the exception of RSoE 45, Lowes Bush. This site had a NNN concentration of 5.5 mg/L, which is indicative of the site being a spring fed stream (i.e. groundwater sourced). This is the highest average NNN concentration of all surface water sites monitored in the Wellington Region.

The field-collected data were compared to modelled concentrations across the catchment and were found to correlate reasonably well with modelled/predicted data. The nitrogen leaching layer created as part of the Ruamahanga Whaitua modelling shows that across the entire catchment the average drainage concentration of nitrate is approximately 2.6 mg/L with a range from below background (i.e. < 1 mg/L) to 7.3 mg/L.

The spatial variability in NNN observed suggests that across this catchment, there are a range of nitrogen sources contributing to the catchment. In addition, the mean residence time of the groundwater indicates that the sources of nitrogen contribution to the present day concentrations are likely to be current day, or recent (i.e. last 5-6 years) rather than historic sources. Therefore, it is evident that even though there is elevated NNN downgradient of the former freezing works, it is not the result of a nitrogen plume that has been in the aquifer since the closure of the works in 1989. This supports the theory that diffuse discharges from current farming activities are a major contributor to the elevated NNN concentrations observed.

One thing all of the sites with elevated NNN concentrations do have in common is that they are located downgradient of soils with high nutrient leaching potential. In this case, the soils are all Brown Soils (Acidic orthic brown soils) that are typically described as being thin, well drained silty loams. These soils dominate the western Wairarapa valley floor and are typically found over the alluvial outwash fans that extend out from the Tararua Foothills. The correlation between elevated NNN results and the soil type warrants further investigation, in particular some consideration to land management practices and land use on this soil.

The results of the nitrogen isotope analyses suggest both inorganic (i.e. fertiliser) and organic (i.e. animal waste) sources of nitrogen across the catchment. Further analysis of nitrogen isotopes both in source waste streams and in groundwater could greatly improve the understanding of nitrogen dynamic in this catchment.

Given the young age of the groundwater, and the likelihood that any residual nitrogen in soils and groundwater from the freezing works (or other historical discharges such as the chicken farms and pet food factory) has long since attenuated, it is concluded that the elevated concentrations observed are a result of sources that are still present, or have recently been present in the catchment. These sources are likely to be permitted rural land uses such as pastoral based farming, cropping and grazing, consented activities such as dairy and piggery effluent discharges and potentially stormwater/wastewater discharges from industrial properties such as the sale yards, timber mill and fertiliser stores. Further monitoring is required to confirm the effects of these consented discharges.

Contents

1. Introduction

State of the Environment (SoE) monitoring by Greater Wellington Regional Council (GWRC) in the Taratahi Groundwater Zone (GWZ), located south of the Waiohine River has reported elevated nitrate nitrogen (NO_3-N) concentrations in shallow groundwater for a number of years.

GWRC routinely measures water quality at three sites in the area - two groundwater wells S26/0223 and S26/0299 and one spring fed stream (Lowes Bush) that is monitored as part of the Surface Water SoE Programme. Nitrate-nitrogen concentrations have ranged between 1.7 and 12.5 mg/L in the wells and between 2.1 and 6.2 mg/L in the Lowes Bush spring.

There are a range of potential sources for the nitrate nitrogen in the catchment, including:

- The predominantly pastoral (irrigated and non-irrigated) land used for sheep, beef and dairy farming

- Both historic and current discharges to land from commercial/industrial properties including two fertiliser stores, livestock sale yards, timber mill and chicken farms.

- The historic Waingawa Freezing Works. The Freezing Works operated between 1910 and 1990 and over this time discharged some of its liquid and solid waste to land and water around the factory. The effects of this discharge are well documented by a groundwater monitoring programme that operated between 1985 and 2000.

- Septic tanks from the numerous rural/lifestyle properties, particularly on Norfolk Road

The historic monitoring undertaken by Affco, the owners of the Freezing Works prior to closure, showed that there was a significant plume of nitrogen (ammoniacal-nitrogen and nitrate-nitrogen) in the shallow groundwater as a result of the discharge to land. This plume was monitored by Affco until the ammoniacal-nitrogen (NH_4-N) concentrations were generally at or below drinking water standards (i.e. 1.5 mg/L).

Because present day nitrate-nitrogen concentrations are still elevated, it has been questioned as to whether or not historic contamination is a contributing factor to the present day nitrogen observed in the catchment. These questions were not able to be answered with the data available to GWRC, and thus this report was commissioned to see if further investigation could help identify the source of the elevated nitrogen in groundwater.

1.1 Location

The Waingawa area is located on the south side of the Waingawa River, and in the context of the Greater Wellington proposed Natural Resource Plan (PNRP), is also referred to as the Taratahi groundwater zone (GWZ). For the purposes of this report, the study area comprises all of the Taratahi GWZ, and also includes the northern portion of the Fern Hill GWZ. This focus for this study was the area located south of the Wairarapa Faultline and north of the Carterton Faultline (Lowes Bush). The study area is shown on Figure 1.1.

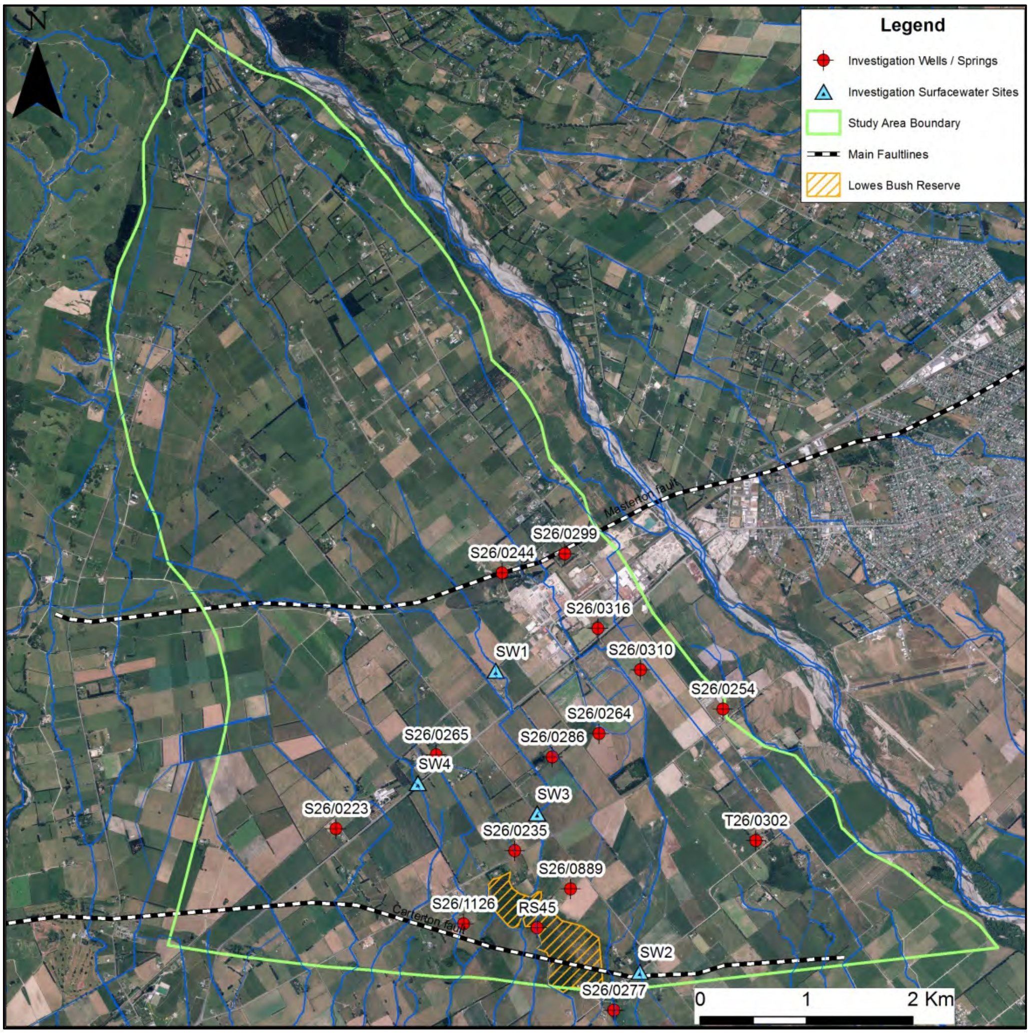

Figure 1.1: Study area comprising Taratahi and part Fern Hill Groundwater Zone

1.2 Objectives

The key objectives of this study were to:

- Characterise groundwater and spring fed stream quality (primarily all the major forms of nitrogen) along a flow line extending from upgradient of the former Waingawa Freezing Works to downgradient of Lowes Bush Reserve.

- Using the data collected in the exercise above, determine the source of elevated nitrate nitrogen concentrations at Parkvale Stream at Lowes Bush and in the groundwater aquifer downgradient of the former Waingawa Freezing Works.

- Conclude whether the elevated nitrate-nitrogen concentrations in the East Taratahi area are a result of historic contamination from the Waingawa Freezing Works waste or a result of more recent land use practices.

2. Physical setting

This section provides an overview of the soils, hydrology, hydrogeology, landuse and consented activities in the investigation area.

2.1 Soils

The study area is covered by a mixture of soil types, described by Gyopari and McAllister (2010) and Landcare Research (2017). The spatial distribution of soil types is shown on Figure 2.1 below.

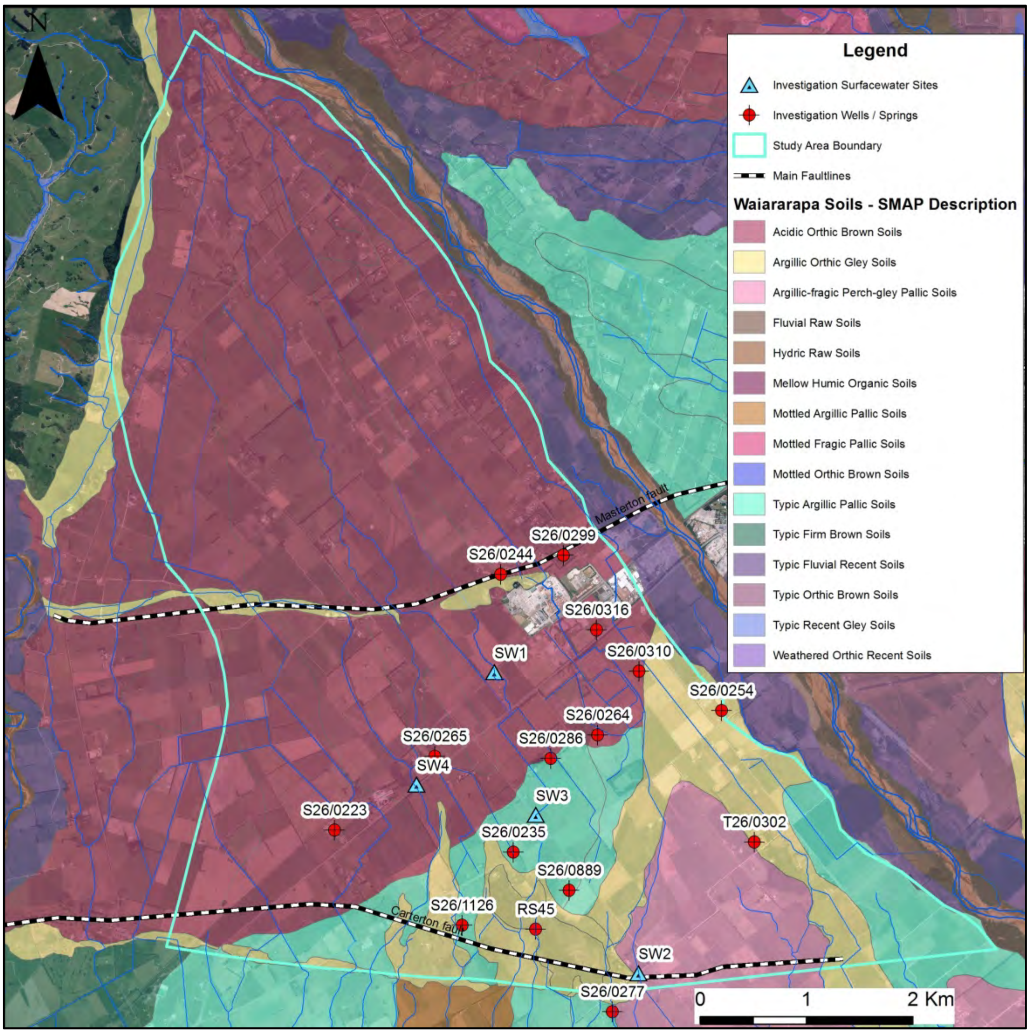

Figure 2.1: Soil types of the study area (Landcare, 2017)

Key characteristics of the soils relevant to this project include the permeability (i.e. how quickly rainfall will drain through the soils) and the vulnerability of the soils to nitrogen leaching (referred to in this report as S-map N-leaching). The drainage (which aligns strongly to the vulnerability of nitrogen leaching) from SMap (Landcare Research, 2017) is shown on Figure 2.2 below.

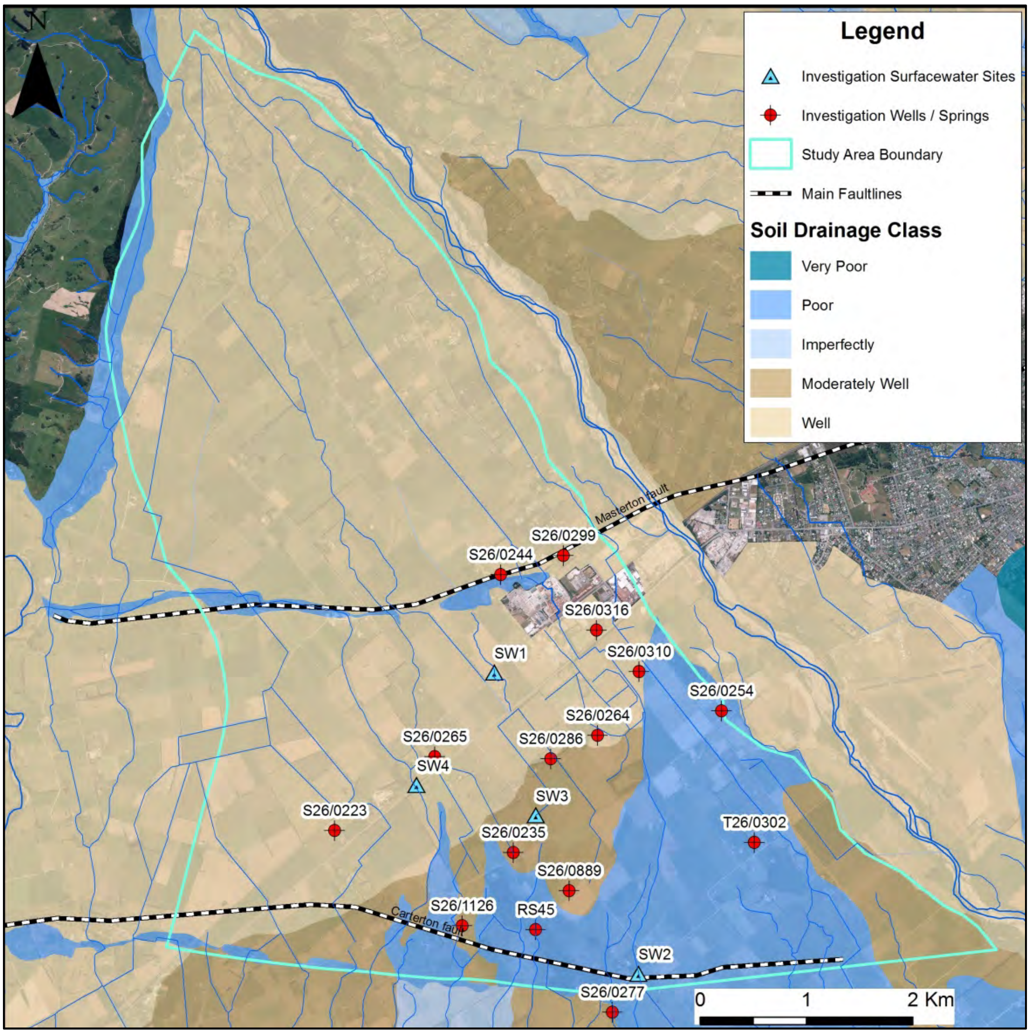

Figure 2.2: Soil drainage classes of the study area (Landcare Research, 2017)

Acidic Orthic Brown Soil (Brown soils) dominates much of the study area especially to the west. These soils are mainly yellow-brown shallow silt loams on a gravel substrate (Landcare Research, 2017). Soils are well to excessively drained and have moderate to rapid permeability profiles. S-map N-leaching vulnerability is considered very high for brown soils (Landcare Research, 2017).

Argllic Orthic Gley Soils (Gley soils) make up the second dominant group of soils representing organic rich, poorly drained silt loam over clay soils, occurring to a moderate to deep depth. These soils are poorly drained and tend to occur where the water table is high (Waingawa Wetland and Lowes Bush) and in the south east over the investigation area. The soils are oxygen-limited and reducing conditions are likely to be present. Permeability of soil is moderate to slow, while S-map N-leaching vulnerability is moderate to low.

Argillic-fragic Perch-gley Pallic Soil (Pallic soils) are located in the middle of the study area. These are yellow grey silty loam moderately stony shallow soils that are characteristic of a seasonally dry area. As the soils vary from moderate to excessively drained, nutrient leaching potential for nitrogen can range from moderate to high.

Recent Soils occur alongside the Waingawa River and floodplain. These shallow soils comprise loam stony gravels that are well to excessively drained with rapid permeability profiles. Nutrient leaching potential for nitrogen is considered very high (Landcare Research, 2017).

Raw Soils dominate the riverbed and immediate floodplain of the Waingawa River. These shallow sandy loam stony soils have rapid permeability profiles, are well drained and have high nutrient leaching potential for nitrogen.

2.2 DRASTIC vulnerability

Separate to the N-leaching vulnerability provided as part of the S-map soils layer, a DRASTIC assessment prepared by Brown (1994) for Greater Wellington provides a useful indication of the vulnerability of groundwater to general land use effects.

DRASTIC is a methodology developed by the USA National Water Well Association and uses a set of seven standard hydrogeological parameters to classify the vulnerability, or pollution potential of an aquifer. These parameters are depth to water table, net recharge, aquifer media, soil media, topography, impact of the vadose zone and hydraulic conductivity of the aquifer. These factors, which form the acronym DRASTIC, are used to infer the potential for contamination of the underlying aquifer.

The seven factors are incorporated into a ranking system that uses a combination of weightings and ratings to produce a numerical value, called the DRASTIC index. The resulting value is used to create a spatial layer which can be used to rank areas based on their contamination potential.

It should be acknowledged that for some of the input parameters there may now be more recent and updated data, however, overall the DRASTIC mapping produced in 1994 is largely based on data inputs that do not change significantly, and this is a useful tool to assess vulnerability at a catchment scale. The DRASTIC mapping for the study area is presented in Figure 2.3.

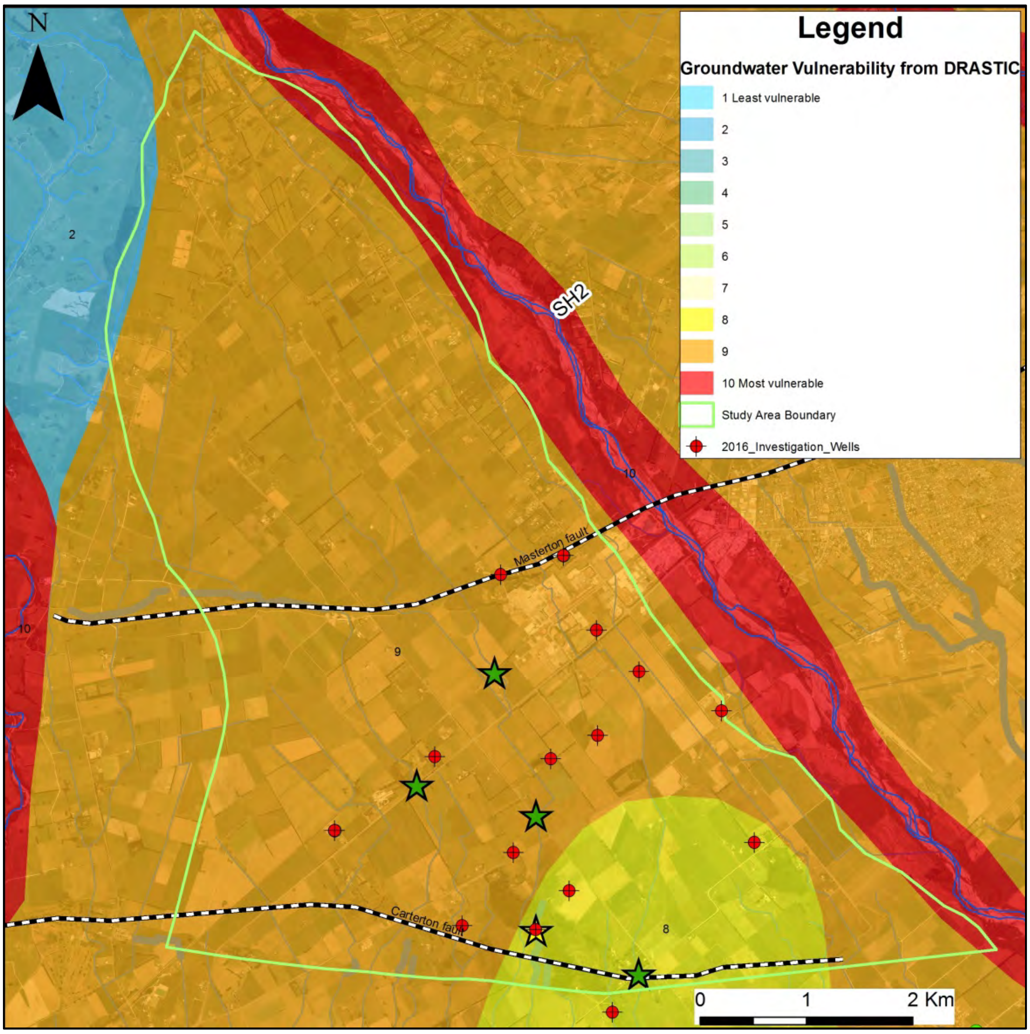

Figure 2.3: DRASTIC mapping for the study area (Source: Brown, 2004)

2.3 Hydrology

Rainfall over the study area ranges from 1,650 mm at the foothills of the Tararuas to 850 mm at the eastern boundary near the Ruamahanga River. (Gyopari & McAlister 2010).

Water is diverted from the Waingawa River downstream of the confluence of the Atiwhatatu Stream at the consented rate of 480 L/s to supply the Taratahi Water Race. This is a gravity-fed unlined channel used to supply water for stock, limited irrigation and some potable supplies was constructed in the early 20th century. Carterton District Council (CDC) now manages the flow rate in the water race and the distribution water to stakeholders (Gyopari & McAlister 2010).

From the point of diversion from the Waingawa River, water in the Taratahi Water Race network is distributed into numerous channels which flow in a south-easterly direction over the Taratahi, Waingawa and Parkvale areas. Many of the water race channels merge with flow from natural water courses in the area before merging with the Parkvale spring system and eventually discharging to the Ruamahanga River at various points along the river’s reach (Gyopari & McAlister 2010).

2.4 Hydrogeology

2.4.1 Hydrogeological setting

A piezometric surface, based on a FEFLOW numerical groundwater model by Gyopari & McAlister (2010) shows groundwater generally flows parallel with the Waingawa River over the west of the area then deviates to a south-easterly flow just before SH2 (Figure 2.4).

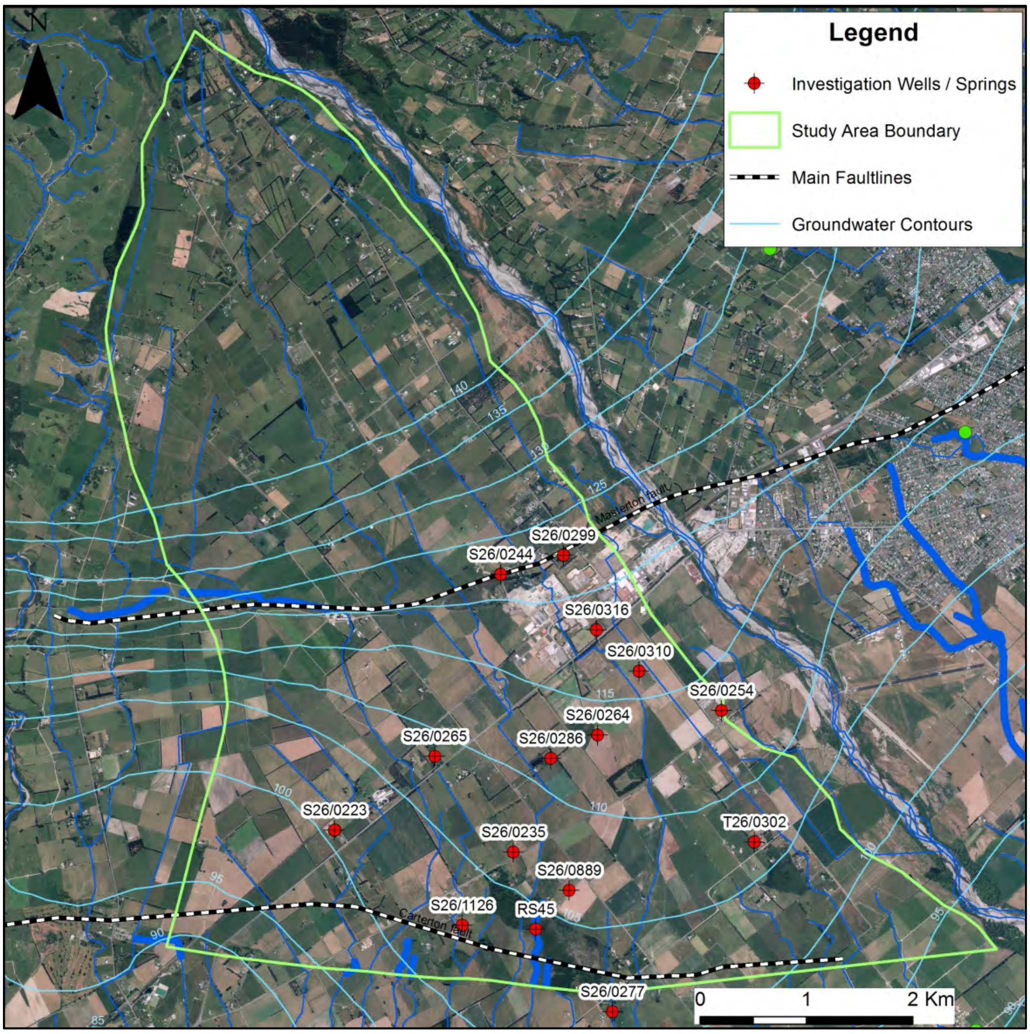

Figure 2.4: Piezometric contours across the study area

The hydrogeology of study area is dominated by the presence of unconsolidated alluvial fan sequences (Q2). Alluvial fans comprise greywacke-sourced gravels, sands and silts derived from erosion of the Tararua Range. This material was then lain down on the flat plains by Waingawa River during glacial periods in an environment of rapid deposition in the late Quaternary period.

Aquifers in these zones can range from unconfined to semi-confined and tend to have low to moderate transmissivity and hydraulic conductivity, and poor to moderate water yields. Taratahi and Parkvale groundwater aquifers are likely to have moderate degree of hydraulic connectivity (Category B management zone) with the Waingawa River, Taratahi Water Race and local springs, drains and streams with these features contributing to groundwater recharge. These zones can also receive considerable rainfall recharge to groundwater.

Further south, in the Fernhill-Tiffen groundwater management zone, the Q2 gravels are intercepted by late Quaternary Q4 gravels in a small area above Lowes Bush. Q4 gravel sequences also comprise poorly sorted clay-bound or silty sand gravels, but have very low transmissivity, hydraulic conductivity and poor water yields. As such, the unconfined groundwater aquifer is classed in the Category C management zone, indicating there is very little groundwater hydraulic connectivity with surface water in the area and that the aquifer is most likely is recharged by rainfall.

The Waingawa groundwater management zone comprises reworked recent/Holocene Q1 alluvium gravels in the immediate vicinity of the Waingawa River and floodplain. This forms unconfined aquifer systems which tend to have a medium to high transmissivity and hydraulic conductivity, and good water yields. Groundwater in this zone is classed in the Category A management zone and has a direct hydraulic connectivity with the Waingawa River.

2.4.2 Groundwater Recharge Zone

Of importance to the understanding of nutrient drainage is the amount of recharge that occurs over this part of the aquifer. Recharge is defined as the portion of rainfall that is not diverted to runoff or lost to evapotranspiration, but is lost to the ground. Zones of higher recharge increase the potential for greater ‘flushing’ of nutrient through the soil profile.

Rainfall recharge has been calculated by Gyopari & McAllister (2010) for the Waingawa area as part of the middle Ruamahanga Groundwater Modelling project. The calculation of rainfall recharge was based on a soil moisture balance technique that considers climatic inputs (rainfall, ET) and soil hydraulic parameters.

Recharge across the study area was calculated to be between 900 mm at the top of the study area beneath the foothills reducing dramatically to 300 mm at SH2.

2.4.3 Capture zones

Capture zones for the study wells were modelled by Mr Mike Toews of GNS Science using the methodology outlined in the Capture Zone delineation report prepared for Greater Wellington (Toews & Donath, 2015). Capture zones are defined by Toews & Donath (2015) as being the total source area that contributes groundwater to a well. The capture zones are shown on Figure 2.5.

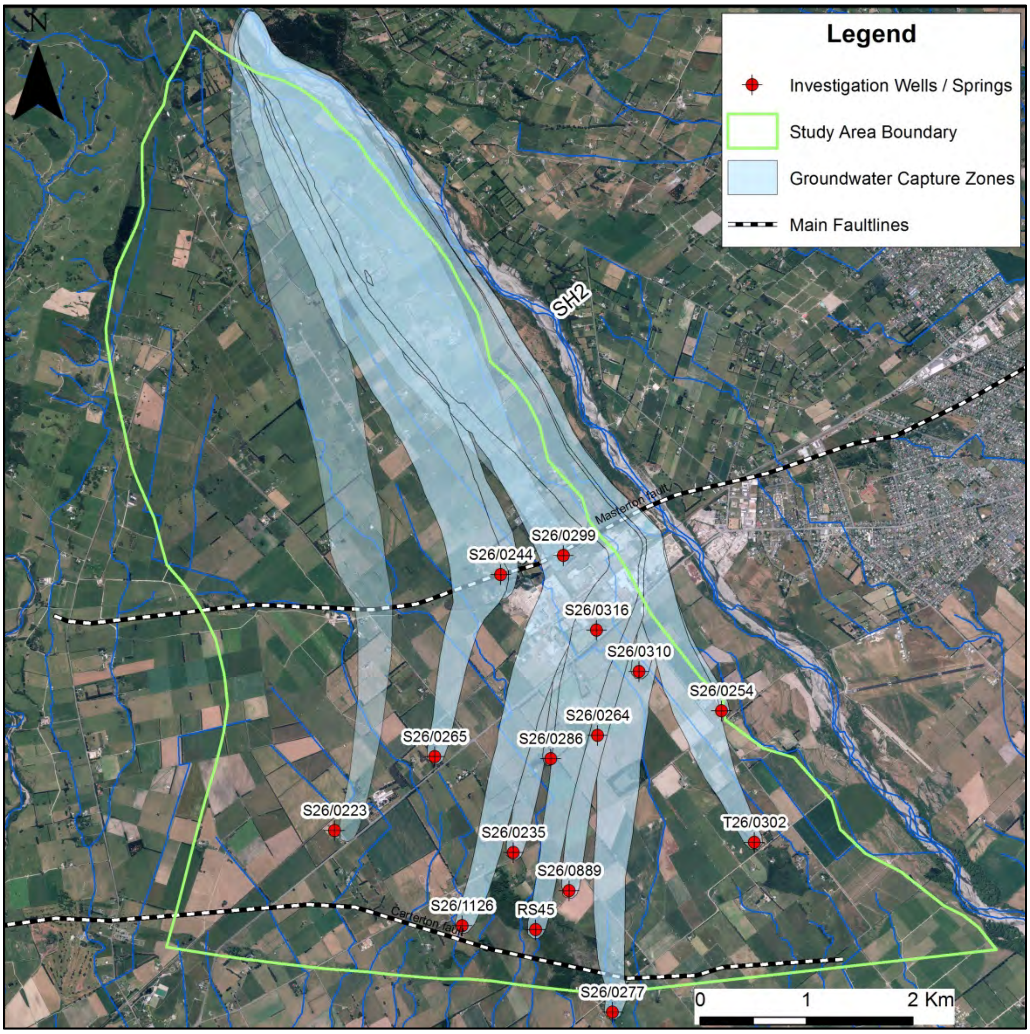

Figure 2.5: Groundwater capture zones

3. Potential nitrogen sources

This section describes the potential contaminant (nitrogen) sources in the catchment. Understanding the potential sources and their spatial distribution across the catchment allows an informed assessment of causality.

This section considers both current/active sources and historic sources across the catchment. Both diffuse (i.e. general pastoral farming) and point source discharges are addressed. The majority of the point source information was sourced from GWRC consent records.

3.1 Current day landuse

3.1.1 Landuse composition

Landuse information has been derived from the GWRC Whaitua landuse layer. This layer developed by GWRC using information from Greg Ordish in the Wairarapa Water Use Project Team, returned surveys from landowners in the area, Greater Wellington Regional Council staff local knowledge, Agribase 2012 and aerial photography.

The combined GWZ area is approximately 3547 ha. The distribution of landuse within the catchment is shown below in Table and on Figure 3.1.

Table 3.1: Landuse distribution within the study area

Landuse	Area (ha)	Percentage
Lifestyle	1172.8	33.06
Dairy / Dairy Support	841.5	23.72
Sheep / Beef / Finishing	837.5	23.61
Mixed	393.6	11.09
Non-urban Industrial	127.2	3.59
Deer Farming	68.1	1.92
Native Bush	41.2	1.16
Viticulture	34.0	0.96
Other Farming	15.6	0.44
Horticulture	12.3	0.35
Utility	3.0	0.09
Indigenous Forest	0.7	0.02
Recreation	0.2	0.01
TOTAL	3547.8	100.00

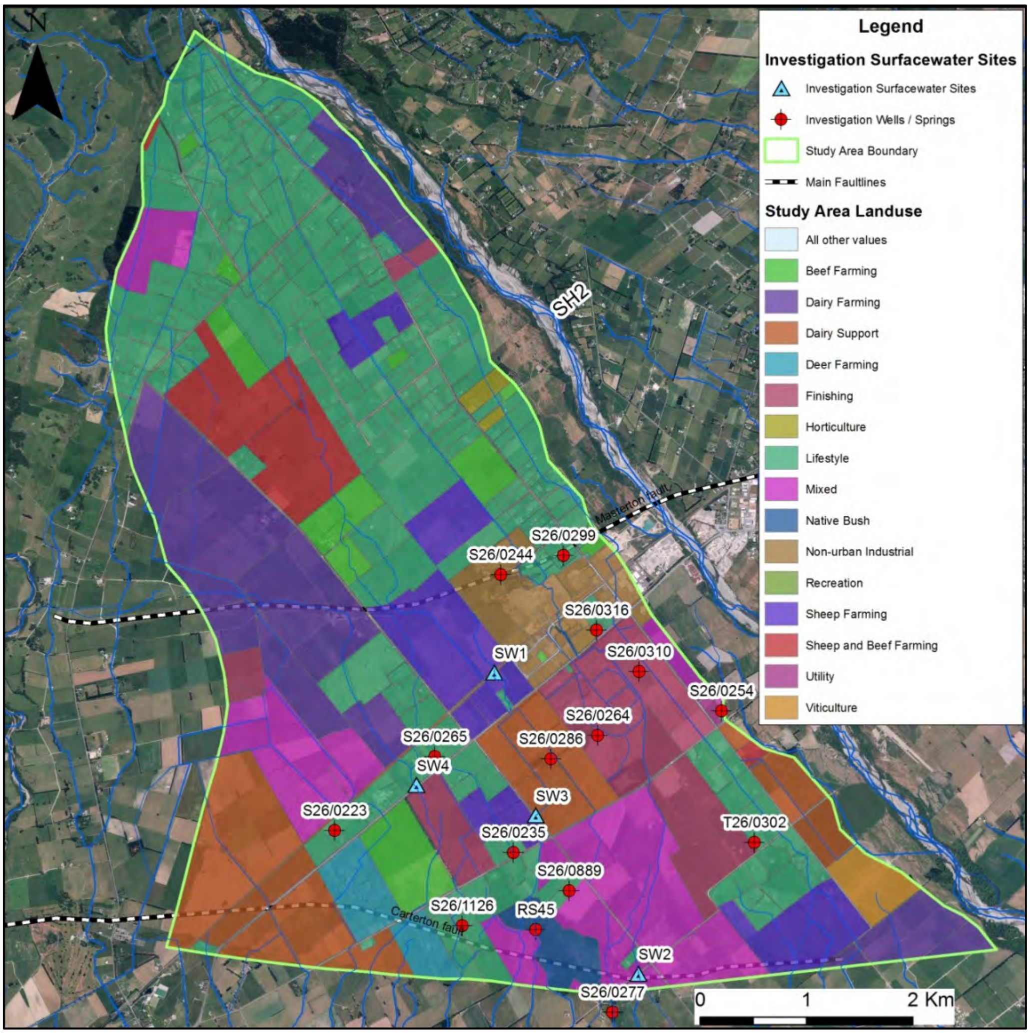

Figure 3.1: Study area landuse distribution

Lifestyle is the major landuse within the study area covering approximately 33% of the area, then dairy/dairy support (23%), followed by sheep/beef farming (23%) and then mixed farming (11%). Together, these pastoral based farming land uses account for approximately 57% of the catchment.

3.1.2 Nitrogen leaching from current landuses

Understanding the potential range of nitrogen leaching rates for the main landuses described above can help build up an understanding of the nitrogen balance for the catchment.

As part of the Ruamahanga Whaitua project, a block scale spatially distributed nitrogen leaching layer was created (Jacobs, 2017). The leaching rates in this were obtained from several sources:

- The Ministry for Primary Industries (MPI) (Parminter & Grinter, 2016) was engaged to model nutrient budgets using Overseer, for 16 example farm types in the Wairarapa (Muirhead et al, 2016). These farm types covered dairy, dairy support, sheep and beef and arable cropping. These example farm types were then extrapolated across the catchment and adjusted for the various soil and rainfall combinations at a block scale by Jacobs NZ Ltd (Jacobs, 2017).

- Leaching rates for remaining landuses were assigned by Jacobs using average data sourced a range of sources detailed in Table 3.2.

Table 3.1 presents the ranges of nitrogen leaching rates for the study area as calculated by Parminter & Grinter (2016) and Jacobs (2017). Because some of the values adopted by Jacobs are based on an average of multiple sources, the individual sources are not listed below. Readers should refer to Jacobs (2017) for details on the calculation of average leaching values. The spatial distribution of nitrogen leaching across the Waingawa area using this information is shown in Figure 3.2.

Table 3.2: Leaching rates used in the Ruamahanga Whaitua leaching layer

Landuse	Nitrogen leaching range (kg/ha/yr)	Data Source
Beef Farming	9 – 22.5	MPI, 2016
Dairy Farming	17.5 – 44.5	MPI, 2016
Dairy Support	11 – 84	MPI, 2016
Deer Farming	21 – 21	Refer to Jacobs, 2017
Finishing	8 – 22.5	Refer to Jacobs, 2017
Horticulture	7 – 7	Refer to Jacobs, 2017
Lifestyle	27 – 27	Refer to Jacobs, 2017
Mixed	39 – 39	MPI, 2016
Native Bush	1 – 1	Refer to Jacobs, 2017
Recreation	26 – 26	Refer to Jacobs, 2017
Sheep and Beef Farming	10.5 – 22.5	MPI, 2016
Sheep Farming	8 – 22.5	MPI, 2016
Utility	7 – 7	Refer to Jacobs, 2017
Viticulture	9 - 9	Refer to Jacobs, 2017

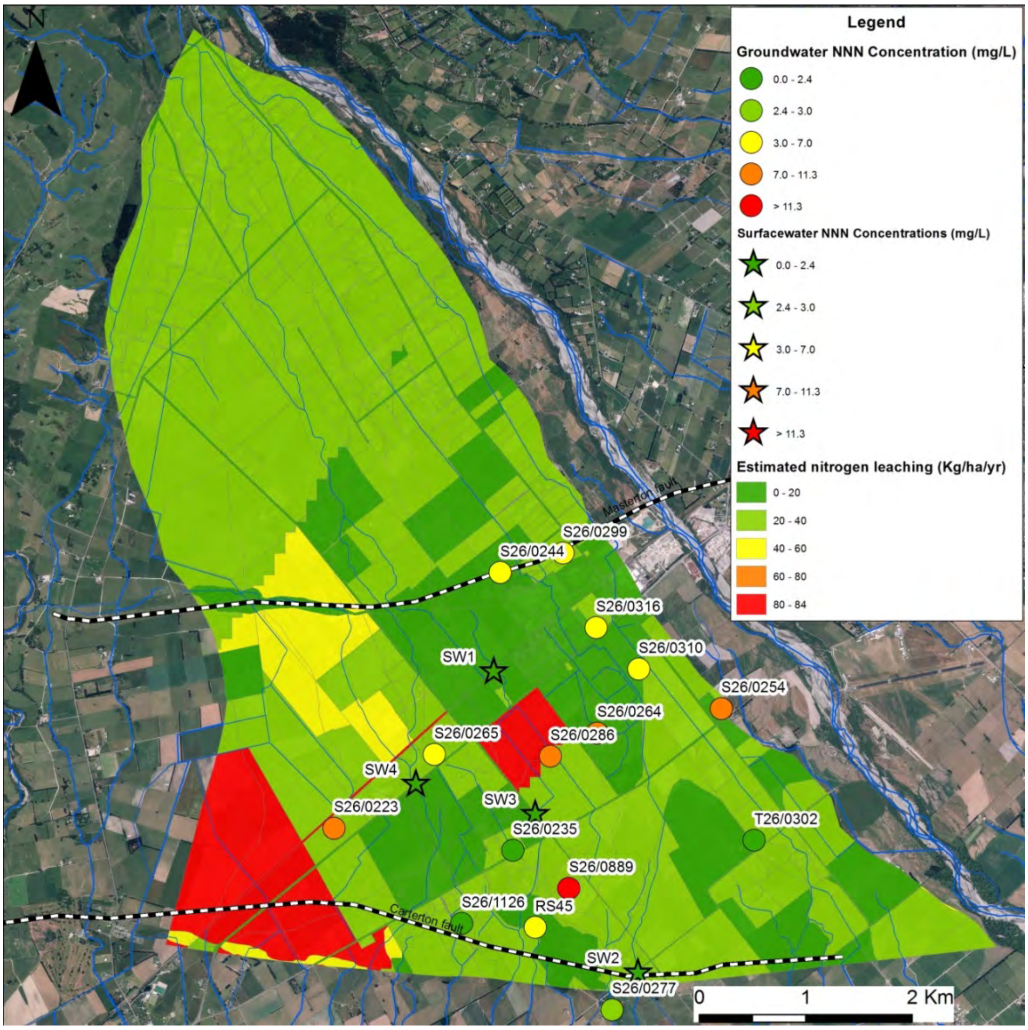

Figure 3.2: Spatial distribution of nitrogen leaching

Using the leaching rates summarised above, a calculation of the nitrate-nitrogen concentration in drainage water was made. This calculation was made at a block scale, using the drainage rates and rainfall totals provided in the Whaitua leaching layer. The results of this calculation are presented in Table 3.3.

Table 3.3: Drainage concentration calculation summary

Input	Value
Catchment nitrogen mass (kg/yr)	127,700
Catchment drainage (m^3/yr)	49,271,000
Catchment nitrogen drainage concentration (mg/L)	2.60
Min block scale drainage concentration (mg/L)	0.10
Max block scale drainage concentration (mg/L)	7.30

The results of the calculations presented above should only be used as an indicative estimation of nitrogen drainage, and not taken as an accurate quantification. This is for the following reasons:

- The Whaitua OVERSEER modelling was based on model runs for 16 ‘example’ farm types for the entire Ruamahanga catchment. The results from these model runs were then applied to all blocks across the catchment, adjusted for differences in annual rainfall across the valley and soil type variability.

- OVERSEER is a long term annual average model – so the drainage results need to be carefully compared to short term monitoring data that does not accurately represent long term average groundwater concentration.

- Leaching rates for landuses such as lifestyle, viticulture etc. were taken from literature values sourced from across New Zealand.

The calculations presented above indicate a catchment wide nitrogen drainage concentration of 2.6 mg/L. This is relatively low compared to the observed data, but it does range between 0.1 and 7.3 mg/L when considered at an individual block scale.

3.2 Affco New Zealand groundwater monitoring

As described previously, the historic Waingawa Freezing works operated between 1910 and 1989. The works were owned by Waitaki International Limited until 1989, when Affco purchased and closed the works.

Prior to the 1940s there is no record of how waste was managed and it is assumed that most waste went to the Waingawa River. Post 1941, the works discharged some of its liquid and solid waste to land and water around the factory. The effects of this discharge are well documented by a groundwater monitoring programme that operated between 1985 and 2000 (Terra Aqua Consultants, 2000).

The known areas of waste disposal are shown below on Figure 3.3. The total volumes and constituents of the waste disposed to each of these areas are unknown, but in summary the waste disposal areas were:

- Approximately 11 ha of land where solid waste (paunch, fats, animal organics) was landfilled in long parallel trenches post 1941. These trenches are above the water table. Recent excavations (Jacobs, 2015) showed that the waste was generally in a decomposed state)

- The former wastewater ponds (both aerobic and anaerobic). These covered and area of approximately 8 ha and operated between 1975 and 1990

- Approximately 40 ha of pasture land that was used for border dyke irrigation of the wastewater from the ponds. This irrigation scheme operated between 1975 and 1990.

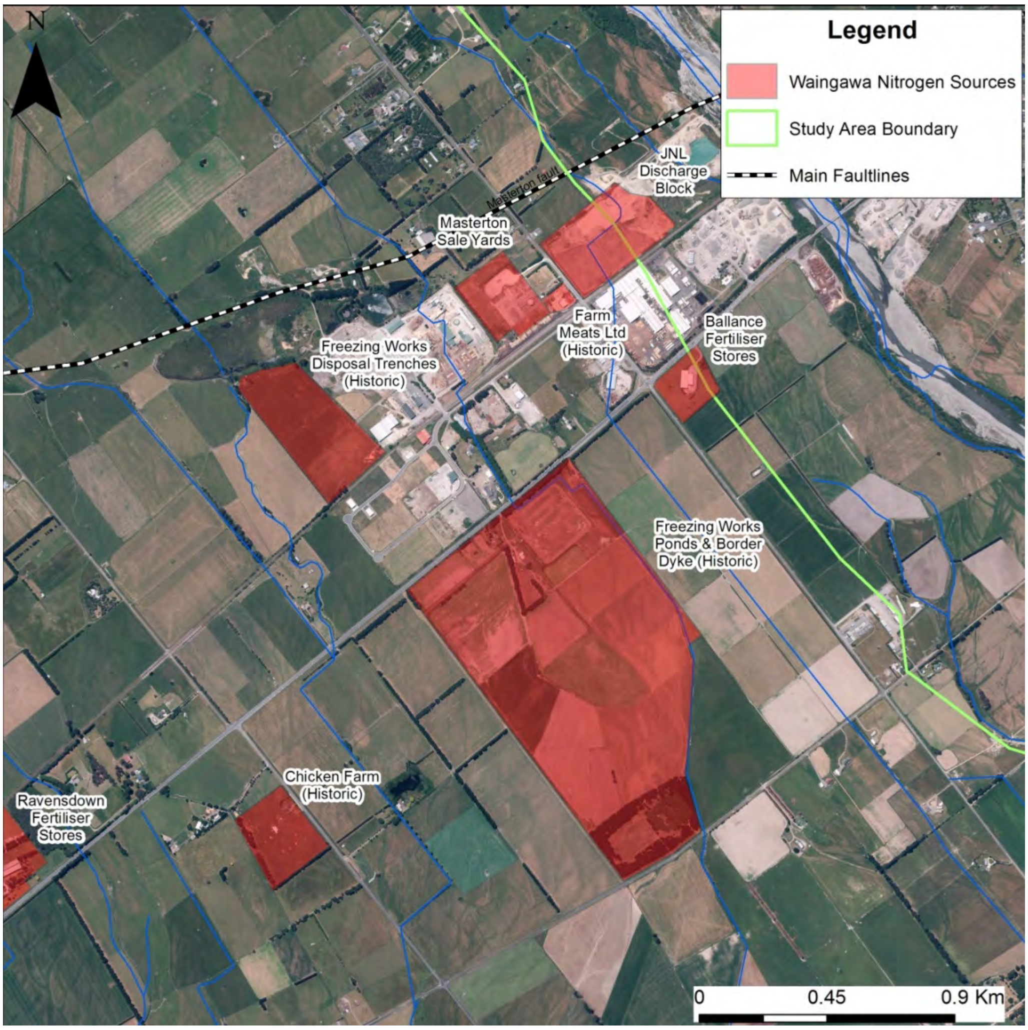

Figure 3.3: Waingawa Freezing Works waste disposal areas, and other commercial potential or historic nutrient sources

While the total mass of nitrogen applied to these areas is not known, an indication of the effects of these discharges can be obtained by reviewing the historical groundwater monitoring data collected by Affco.

Following the closure of the works in 1989, the anaerobic ponds on the eastern side of SH2 sat idle until the 1995. During the winter of 1995 the sludge in the ponds was excavated and spread over the surrounding 40 ha of farmland. The land was then cultivated, sown in crops that were harvested and returned to pasture by 1996 (PGWES, 1998).

Between 1985 and 2000 Affco undertook groundwater quality sampling at up to 25 wells in the area around the effluent disposal land, including in downgradient wells. By 1990 the monitoring programme had been reduced and refined to 13 bores located predominantly downgradient of the former Freezing Works and the effluent disposal area/ponds.

Groundwater samples collected from these wells were analysed for chloride, ammoniacal-nitrogen and nitrate-nitrogen. The nitrate-nitrogen results from the programme are presented below on Figure 3.4.

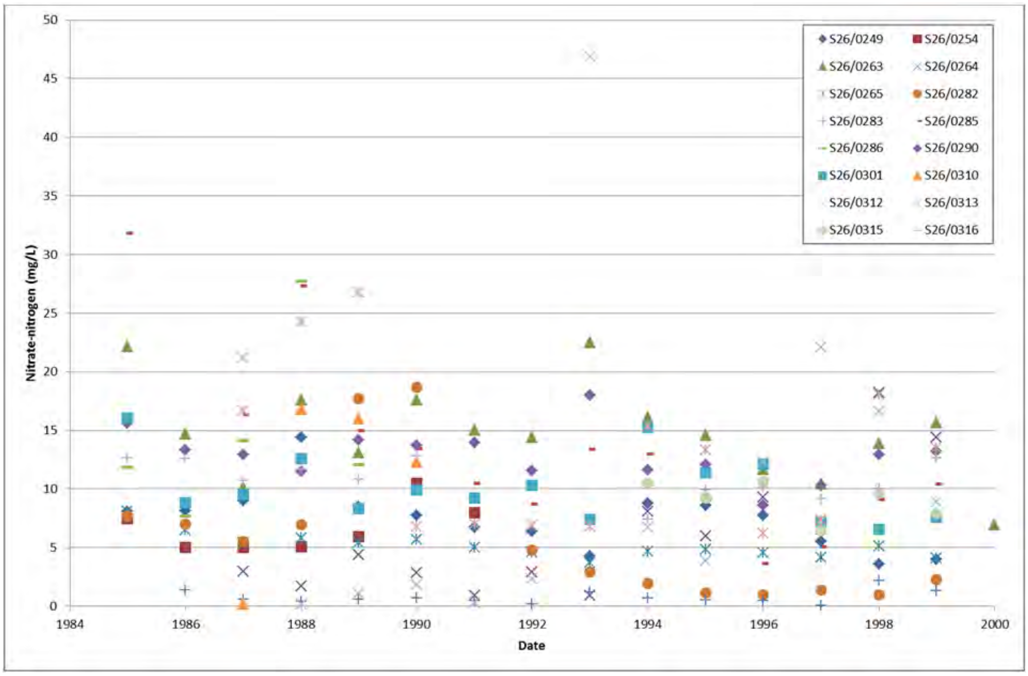

Figure 3.4: Affco nitrate monitoring results 1985 - 2000

The sampling programme finished mid 1999 following a report prepared by Professional Ground Water and Environmental Services (PGWES) which recommended that sampling cease when the concentrations of ammoniacal-nitrogen dropped below the New Zealand Drinking Water Maximum Allowable value of the time (1.5 mg/L). The findings and recommendations of the PGWES report were agreed within a peer review undertaken by Terra Aqua Consultants limited in 2000.

The nitrate nitrogen plumes measured in 1993 (pre-remediation) and 1999 (post-remediation) are shown below as Figures 3.5 and 3.6.

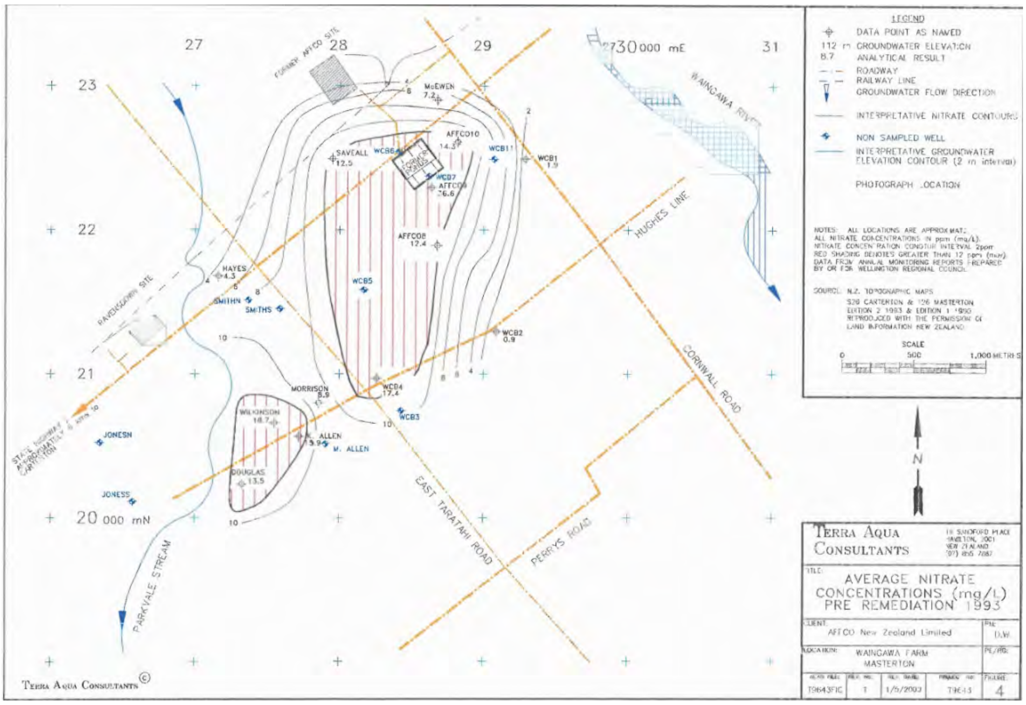

Figure 3.5: Nitrate nitrogen plume in 1993 (Terra Aqua Consultants, 2000)

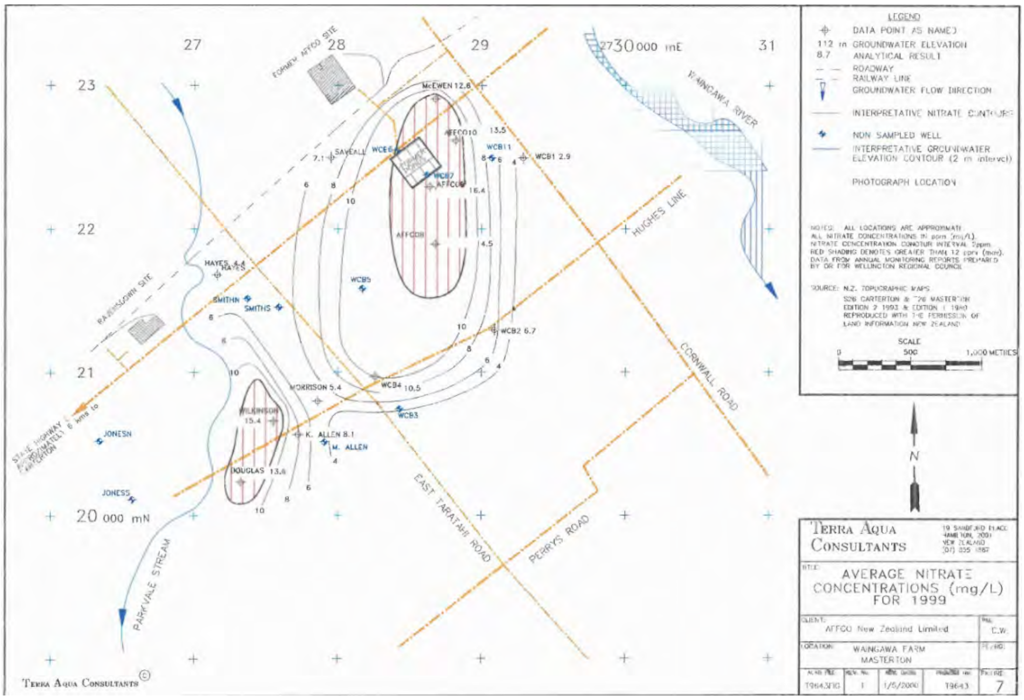

Figure 3.6: Nitrate nitrogen plume in 1999 (Terra Aqua Consultants, 2000)

When the monitoring ceased, the water quality was summarised by PGWES in the following points:

- Sampling of the anaerobic pond sludge pre and post the addition of calcium oxide in 1996 indicated a significant decrease in the sludge ammoniacal-nitrogen concentration (298 mg/L to 32 mg/L) coupled with a rise in pH (3.88 to 6.48).

- Chloride levels at all monitoring sites were at or close to background levels.

- Ammoniacal-nitrogen concentrations immediately downgradient of the ponds had decreased significantly post de-sludging that occurred in 1995.

- Nitrate-nitrogen concentrations remained above the NZDWS in seven bores at the end of 1999 (however ‘typical’ nitrate-nitrogen concentrations decreased from around 30 mg/L to 10 mg/L).

It is unclear why the driver to cease monitoring was the concentration of ammoniacal-nitrogen, and not nitrate-nitrogen. Nitrogen undergoes transformations so a reduction in ammoniacal-nitrogen does not necessarily reflect a reduction in the overall nitrogen mass present within the groundwater system.

In the oxic groundwater observed in the Waingawa area ammoniacal-nitrogen would be expected to undergo nitrification in which NH_4-N will oxidise to nitrite-nitrogen (NO_2-N) and then rapidly into nitrate-nitrogen (NO_3-N). So as NH_4-N decreases, NO_3-N increases. An example of this occurring at bore S26/0283 is shown in Figure 3.7.

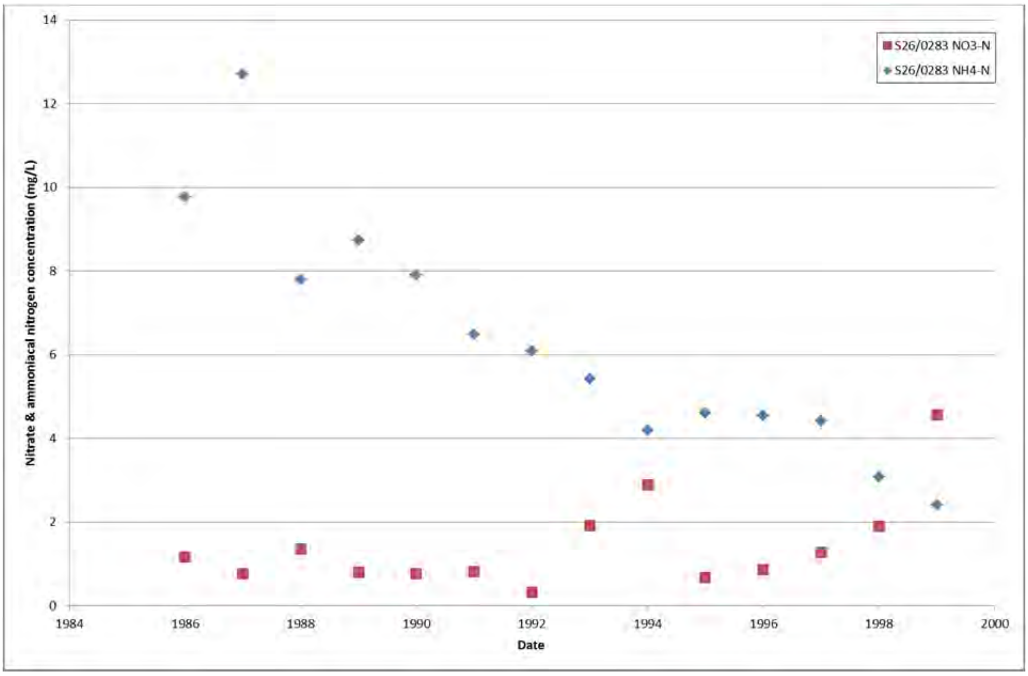

Figure 3.7: Bore S26/0283 Nitrate and ammoniacal nitrogen concentrations

It is unclear whether the peak of the nitrate-nitrogen plume concentration was observed in the wells at the end of monitoring in 2000, or whether the concentrations continued to increase at some wells after this time. This is discussed further in Section 6 below.

3.3 Other sources

There are numerous other active and historic sources of nitrate-nitrogen (apart from the Waingawa Freezing Works) in the catchment. These are discussed individually below, and the main ones shown on Figure 3.8. Note that farming land use not specifically shown is also a source of diffuse nitrogen.

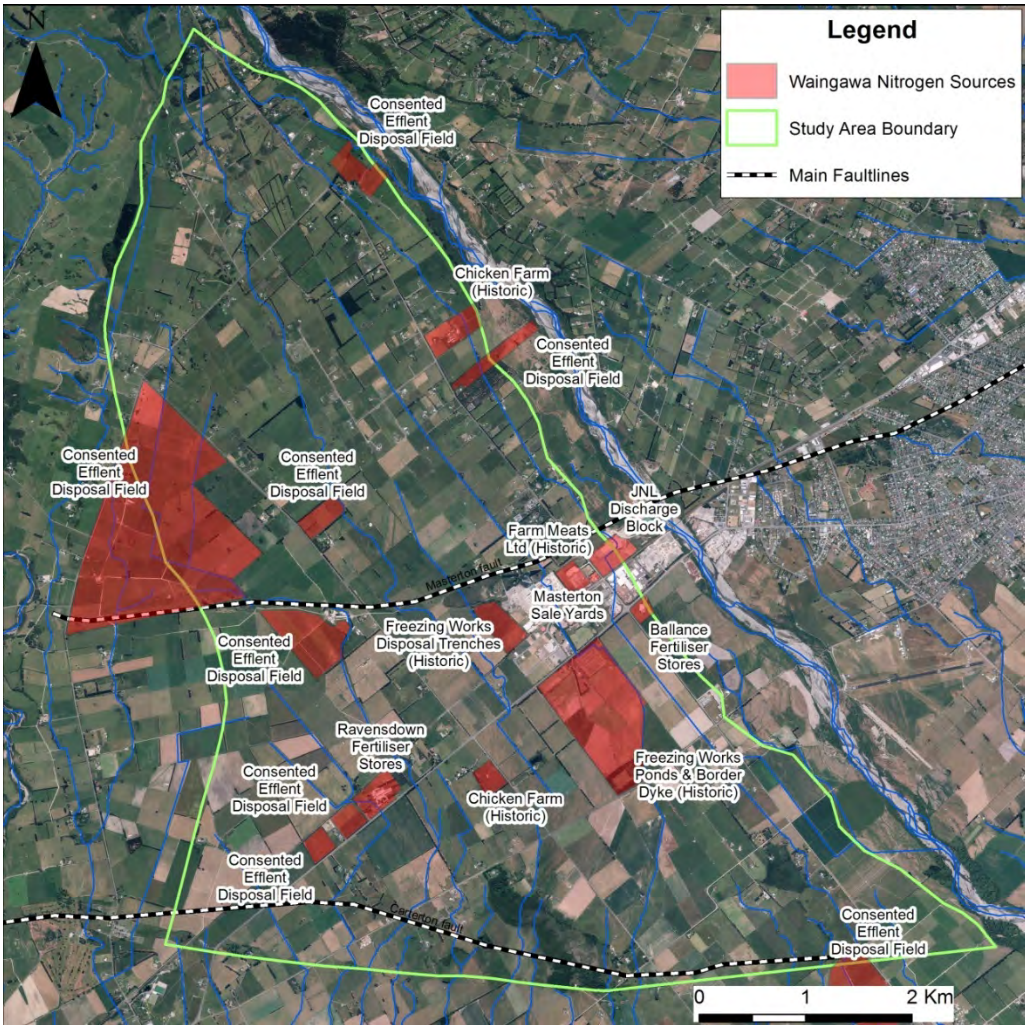

Figure 3.8: Other known nitrogen sources in the study area

3.3.1 Consented effluent disposal areas

The GWRC consents database holds records of eight consented effluent disposal fields in the study area. The majority of these are for dairy effluent discharges however the large block of land in the west of the study area is consented for the discharge of piggery effluent.

3.3.2 Historic chicken farms

Two chicken farms were historically located in the study area. A free range chicken farm operated at the SH2 end of East Taratahi Road. Aqua Terra Consultants (2000) attributed high nitrate (> 11 mg/L) concentrations in two wells (S26/0263, S26/0291) monitored by Affco to the chicken farm, rather than to the wastewater from the freezing works. It is not known when this chicken farm ceased operation, but it was still operating at the time of the Aqua Terra report, in 2000 and anecdotally had stopped operation by the mid 2000’s.

A second chicken farm operated on Norfolk Road prior to 2000. This farm was a battery hen type operation. It is unclear how wastewater from this operation was disposed of, however it is typical of chicken farms in the region to discharge to land.

3.3.3 Fertiliser companies

There are two fertiliser stores operating in the study catchment, owned by Ballance Agri-Nutrients and Ravensdown. The stores are used for the bulk storage of fertiliser products before being applied on-farm. The Ballance store is relatively new (early 2000s) and modern, whereas the Ravensdown store has been located on the site for a longer period of time.

Ballance holds an active consent for the discharge of storm water to land. Ravensdown does not currently hold any discharge consents.

There are no recorded environmental investigations of either of these stores, so it is unclear whether or not they could be contributing nitrogen to groundwater.

3.3.4 JNL Sawmill

JNL operates a timber treatment and sawmill plant on Norfolk Road, directly north of the historical freezing works. JNL hold resource consent to discharge up to 300 m^3/day of treated wastewater to land. This wastewater comes from the timer treatment process and log yard run-off.

The wastewater is understood to be discharged to a disposal field that is approximately 10 ha in area and planted in young eucalyptus trees. At the time of writing this report, it was unclear what the constituents of the wastewater were, however groundwater monitoring immediately down-gradient of the discharge shows that high concentrations of nitrate nitrogen are entering groundwater resulting in a 40 mg/L down-gradient concentration (The Wastewater Specialists, 2017).

3.3.5 Masterton Sale Yards

The Masterton Sale Yards (owned and operated by PGG Wrightson) are located on Norfolk Road, south of JNL and north of Kiwi Lumber. At this site, PGG Wrightson holds resource consent to discharge animal waste to land. The consent is currently in the process of renewal, and as such no information on the volumes or quality of wastewater discharged is available.

3.3.6 Farm Meats Limited

Farm Meats Limited operated on the corner of Norfolk Road Waingawa Road. The site was originally developed as the Waingawa Municipal Abattoir in the early 1900s. In 1973 it switched from municipal supply of meat to the manufacturing of pet food for the local area. Slaughtering occurred on the site until 1999 (URS, 2003).

Wastewater from the site is reported to have undergone some levels of primary treatment (settlement and filtration) before being discharged across neighbouring land (it is not clear which land) and post 1973 via soak pits.

4. Investigation methodology

4.1 Field sampling

Three rounds of surface and groundwater sampling were undertaken. Each round is described below.

The first round of sampling was contracted out to Opus (Wellington) and was undertaken between the 14th and 17th March 2016. Sampling was undertaken by Sam Warren (Opus) with assistance from Lindsay Annear (GWRC) for the first day of the field work.

The second and third rounds of sampling were undertaken on the 27 September and 8th December 2016 respectively. Sampling was carried out by Kasey Pitt and Lindsay Annear of GWRC.

All sampling was carried out in accordance with GWRCs River and Groundwater Quality State of the Environment monitoring programme procedure manuals.

4.2 QA/QC sample collection

The field meter (YSI Pro Plus) was calibrated on a daily basis by the field team. Records of calibration are provided in Appendix A

Upon review of the field results from the March 2017 monitoring, it appears that the electrical conductivity probe was giving erroneous reading and therefore no field electrical conductivity readings were obtained however the laboratory results are used.

No QA/QC samples (i.e. field duplicate and field blank) were collected as part of this field campaign given the limited scope and budget available.

Where possible, flow in the surface water sites was gauged using GWRC gauging equipment.

4.3 Sample shipment

All samples were shipped under chain of custody (provided in Appendix A) to Hill Laboratories in Hamilton and the GNS National Isotope Centre in Lower Hutt.

All of the samples shipped to Hill Laboratories arrived within 24 hours of shipment and the sample temperatures on arrival were reported to be between 0.3 and 10.2 °C on arrival.

4.4 Site selection

4.4.1 Groundwater sites

The justification and rationale for the selection of sites is discussed in detail in the Monitoring Proposal dated 1 March 2016 (Tidswell, 2016). In summary, the key considerations for the choice of sites were:

- Targeting locations along a flow line extending from upgradient of the former Waingawa Freezing works to down gradient of Lowes Bush Reserve

- Where possible, utilising wells that had a historical data record (i.e. GWRC monitoring wells, former Affco monitoring programme wells)

- Provide good spatial coverage of the unconfined Taratahi and Fernhill-Tiffen unconfined groundwater aquifers where suspected contamination plume from the Freezing Works may have migrated; and

- Help identify potential contaminant flow-paths from land effluent disposal areas to groundwater bores and surface water sites such as SoE sites RS45 Lowes Bush and S26/0223.

An initial group of wells were identified for sampling based on the above criteria. After receiving the results of the March sampling round, it became apparent that there was insufficient spatial coverage to allow a thorough assessment of nitrogen sources. An additional four wells were then selected and sampled in September and December 2017.

Table 4.1 presents a list of the wells that were sampled as part of this investigation. The location of the monitored wells is shown on Figure 1.1.

Table 4.1: Wells sampled in March 2016

ID	Name	Depth	Date of Sampling
S26/0235	Allen	8.0	14/03/16
S26/0265	Ashworth	6.9	16/03/16
S26/0316	McEwen	5.8	15/03/16
S26/0223	Nicholson	9.9	14/03/16
S26/0299	Graham	8.1	14/03/16
S26/0244	Waingawa Spring	0	14/03/16
S26/1126	Forest	15.0	17/03/16
S26/0277	Snow	6.4	17/03/16
T26/0302	Kim McMillian	9.0	16/03/16
S26/0254	Tulloch	6.2	16/03/16
S26/0286	Liang	3.13	27/03/16
S26/0889	Morgan	8.2	27/03/16
S26/0264	Busby 2	3.0	08/12/16
S26/0310	Busby 1	3.1	08/12/16

4.4.2 Surface water/spring sites

Surface water sampling locations were selected where contaminants are known to be elevated in the past (e.g. RSoE Site 45 Parkvale at Lowes Bush) and at key points along tributaries of the Parkvale Stream/Taratahi Water Race. The sites are listed in Table 4.2 below and shown on Figure 1.1.

Table 4.2: Surface water sites sampled in March 2016

ID	Name	Flow Estimate (L/s)
RSoE45	Parkvale at Lowes Bush	1.8
SW2	Parkvale Tributary at Railway Line South of Waingawa Wetland	3.0 – 4.0
SW3	Parkvale Tributary at Cnr Perrys and East Taratahi Rd	11.4
SW4	Parkvale Tributary at East Taratahi Rd	2.6
SW5	Parkvale Tributary at SH2 North of Ravensdown	5.9

4.4.3 Sampling and analysis plan

The sampling and analysis plan was prepared by Greater Wellington in March 2016. The same analytical suite was selected for both surface water and groundwater sites to allow for flow path delineation. The analytical suite selected for the study is presented below in Table 4.3.

Table 4.3: Analytical suite for groundwater and surface water

Analyte	Field / Laboratory
Temperature (^{o}C)	Field
Dissolved oxygen (mg/L)	Field
pH	Field
Conductivity (µs/cm)	Field
Total nitrogen	Hill Laboratories
Ammoniacal-nitrogen	Hill Laboratories
Nitrate-nitrite-nitrogen	Hill Laboratories
Total Kjeldahl nitrogen	Hill Laboratories
Total phosphorus	Hill Laboratories
Dissolved reactive phosphorus	Hill Laboratories
Total organic carbon	Hill Laboratories
Anions/cations (Sodium, potassium, calcium, magnesium, chloride, sulphate, total alkalinity and silica)	Hill Laboratories

A select number of sites were chosen by GWRC to be analysed for nitrogen (15N), oxygen 18 (18O) and deuterium (2H) stable isotopes and tritium (age) dating analyses. The sites selected were S26/0223 (Nicholson), S26/0299 (Graham), S26/0235 (Allen) and RSoE 45 (Parkvale at Lowes Bush). In addition, sites S26/0889, S26/0286, S26/0310 and S26/0264 had just 15N isotope analysed.

The analyses undertaken on these samples are listed in Table 4.4.

Table 4.4: Analytical suite for isotope analyses

Analyte	Laboratory
Tritium and stable isotope	GNS Laboratory, Lower Hutt
Oxygen 18 ($\delta^{18}O$) and deuterium (δ^2H)	GNS Laboratory, Lower Hutt
Nitrogen-15	GNS Laboratory, Lower Hutt

5. Results

5.1 Field Parameters

A summary of the field results from the groundwater and surface water sites is presented below in Table 5.1. Overall, the field results, particularly electrical conductivity and dissolved oxygen were very similar indicating that water at each site is likely to be sourced from a similar hydrogeological environment.

The groundwater samples had moderate to high dissolved oxygen and low conductivity indicating oxygen-rich (oxic) conditions, possibly of a river source origin. The exceptions to this were wells T26/0302 and S26/1126 which had very low dissolved oxygen and higher conductivity indicating oxygen-poor (anoxic) conditions.

Table 5.1: Summary of field parameters

Parameter	Range	
	Minimum	Maximum
All wells (excluding T26/0302 & S26/1126)		
Temperature (°c)	11.9	17.1
Conductivity (Lab/Field)	108	206
Dissolved Oxygen (%)	0.0	78.2
pH	5.61	6.66
T26/0302 & S26/1126		
Temperature (°c)	9.6	15.0
Conductivity (Lab)	306	363
Dissolved Oxygen (%)	0.0	0.4
pH	6.6	7.13
Surface Water		
Temperature (°c)	13.9	23.1
Conductivity (Lab)	70	186
Dissolved Oxygen (%)	52.8	109
pH	6.3	6.9

5.2 Groundwater chemistry

5.2.1 Major ion chemistry

Analysis of the major ion and cations was undertaken to provide an indication of the prevailing geochemical conditions at each site. Different geochemical conditions (i.e. anoxic or oxic) can influence the attenuation of land use indicators such as nitrogen and phosphorus.

In this study the major indicator parameters of iron, manganese, carbonate and bicarbonate were not included in the original analytical suite therefore reducing the ability to characterise the water in high detail. This is discussed further in the recommendation section.

The major ions of potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), chloride (Cl) and sulphate (SO_4) however, are able to provide an initial assessment of the water chemistry. For ease of interpretation, these parameters are plotted on a Schoeller plot, presented below in Figure 5.1. Schoeller plots show the relative concentrations of each ion for several samples. The full chemistry results are tabulated in Appendix B.

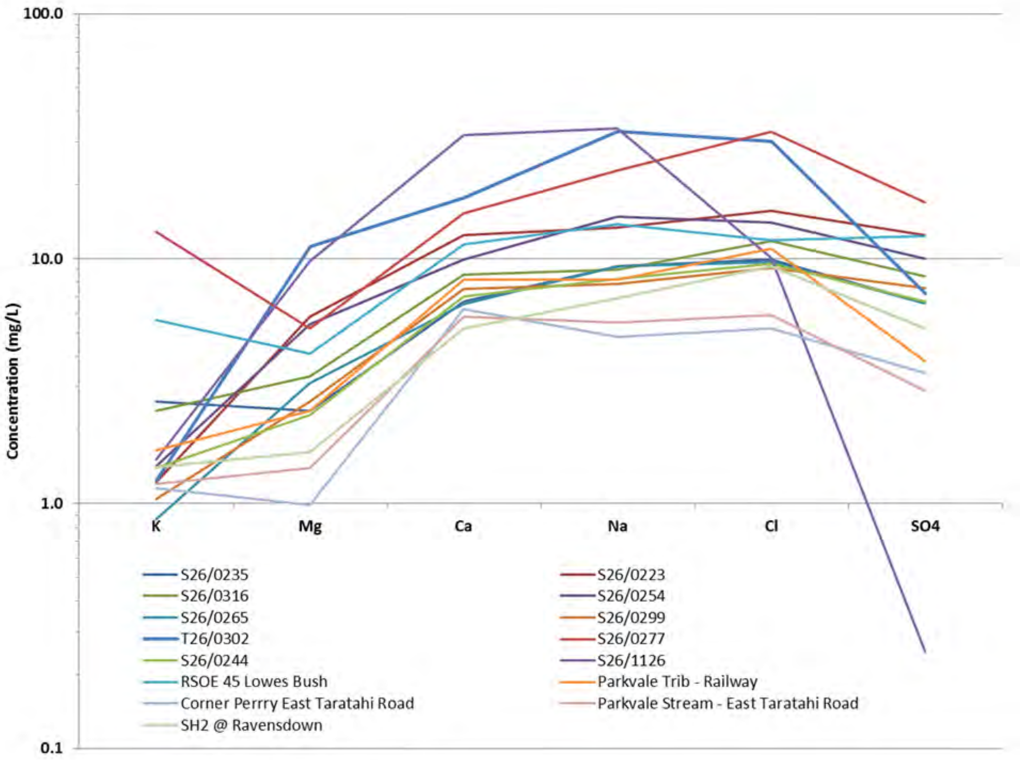

Figure 5.1: Scholler plot of major ion chemistry

Figure 5.1 shows that chemistry at the majority of sites (both groundwater and surface water) is very similar. The chemical signature indicates a type of water described by GNS (Tidswell et al., 2012) as:

- Classified as sub-cluster A1c (refer to Tidswell et al. (2012) for further description);
- Likely to be located in unconfined or semi-confined aquifer systems;
- Is recharged by a mix of river-recharge (dominant source) and rainfall recharge over an area of intensive landuse resulting in a signature of human impact; and
- Has a chemical signature more indicative of surface water as a result of the river recharge influence.

The outlying sample sites on the graph were S26/1126 (displaying signs of a reduced groundwater with elevated Ca/Mg/Na and reduced SO_4), S26/0277 (increased land use impact with elevated K and SO_4) and T26/0302 (elevated Mg/Ca/Na and Cl). These sites are located in close proximity to the Carterton faultline, and the difference in groundwater chemistry may be an indication that deeper groundwater is upwelling in this area.

5.2.2 Nutrients

Unlike the major ion chemistry which was very similar in both groundwater and surface water, the difference in nutrient concentrations of groundwater and surface water is marked. The nitrate-nitrite nitrogen results are shown in Figure 5.2.

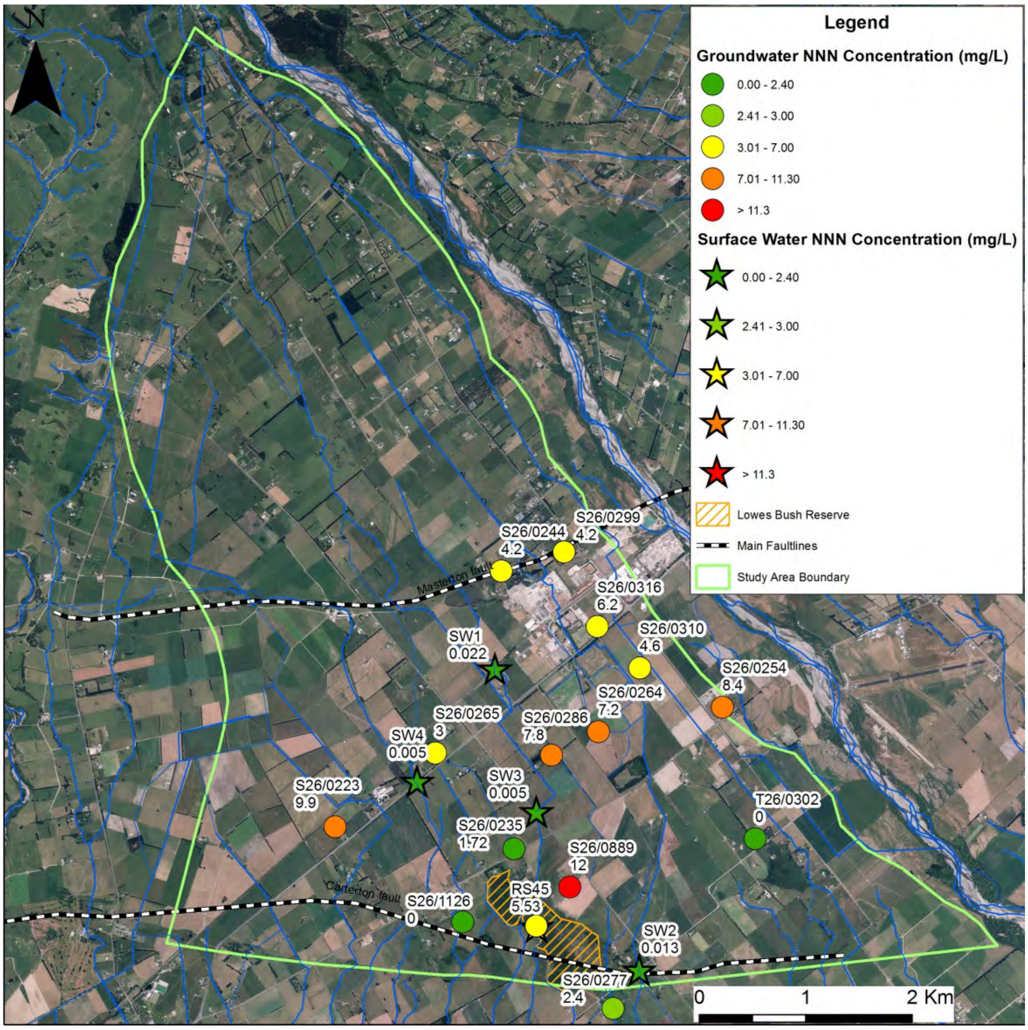

Figure 5.2: Nitrate-nitrite nitrogen results

The graphs show the results for nitrate-nitrite nitrogen (Figure 5.3), ammoniacal-nitrogen (Figure 5.4), total Kjeldahl nitrogen (Figure 5.5) and dissolved reactive phosphorus (Figure 5.6).

The sites on the graph are ordered by (approximate) increasing distance downstream from the Waingawa Wetland, i.e. up-gradient to down-gradient. There is a general pattern of increasing nitrogen as groundwater moves down the aquifer, although there are a couple of exceptions to this (i.e. S26/0265 & S26/0235). Groundwater sites are listed first and the surface water sites second.

The site RSOE 45, Lowes bush is a spring and therefore more representative of groundwater rather than the water race fed surface water.

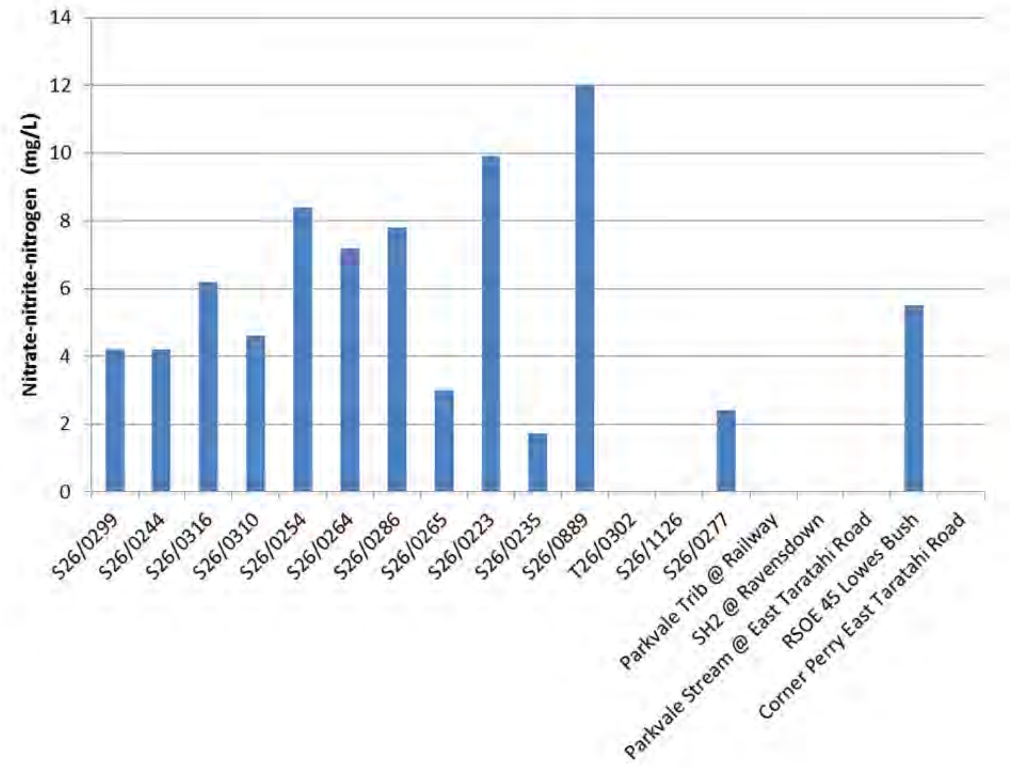

Figure 5.3: Nitrate-nitrite nitrogen concentrations

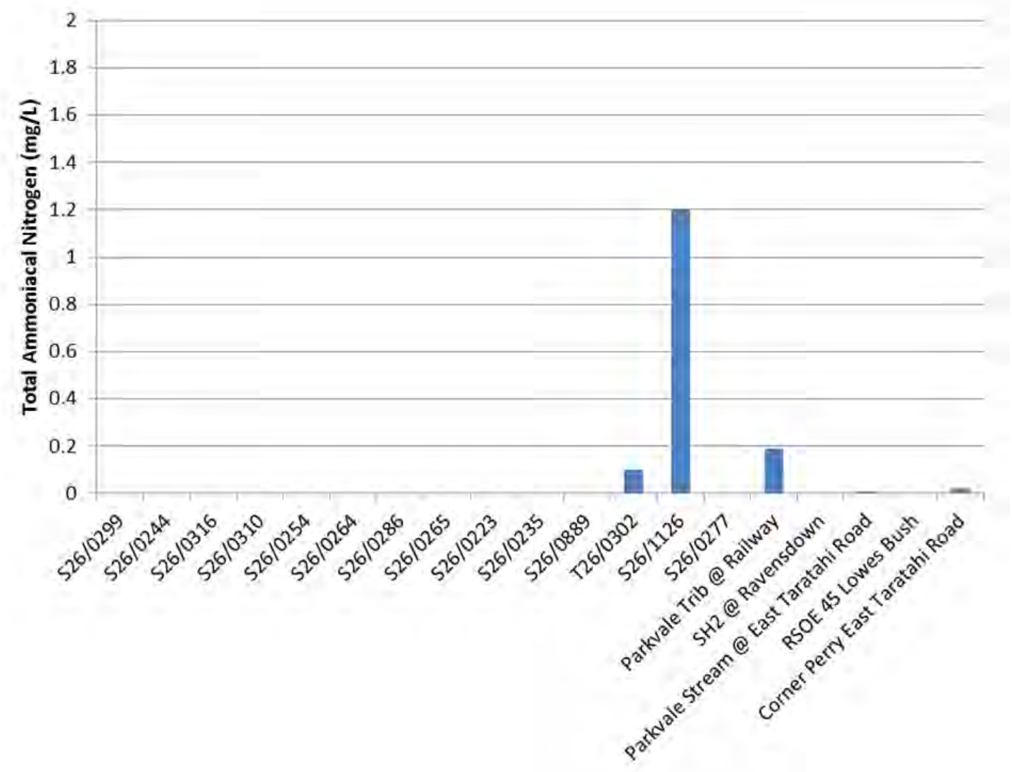

Figure 5.4: Ammoniacal nitrogen concentrations

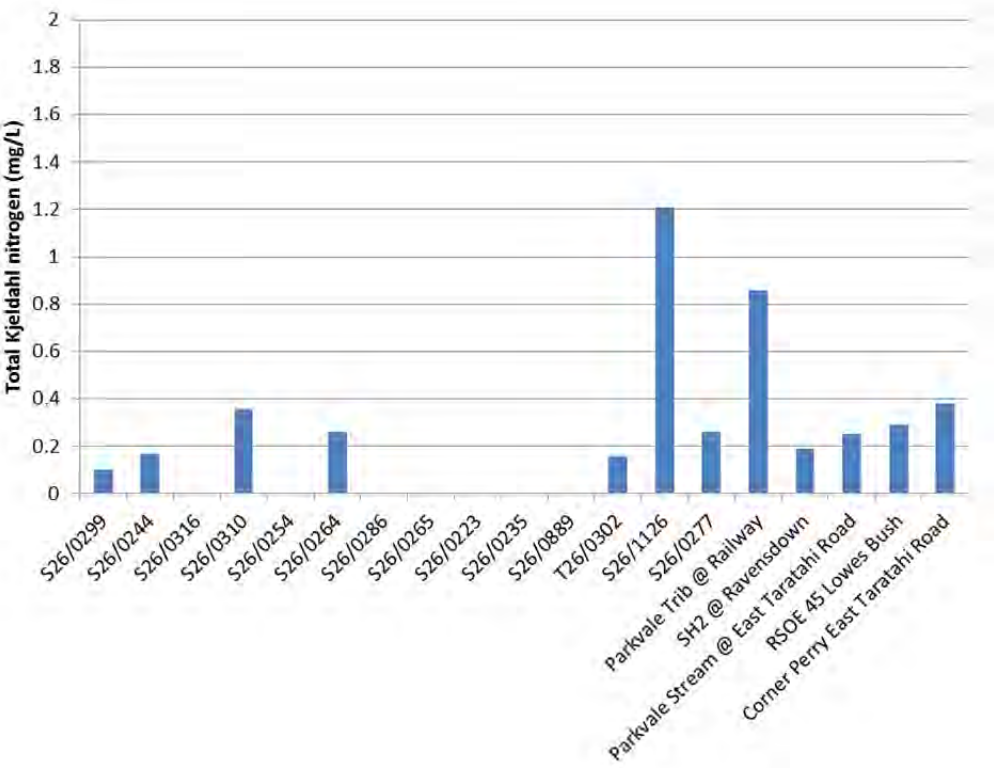

Figure 5.5: Total Kjeldahl nitrogen concentrations

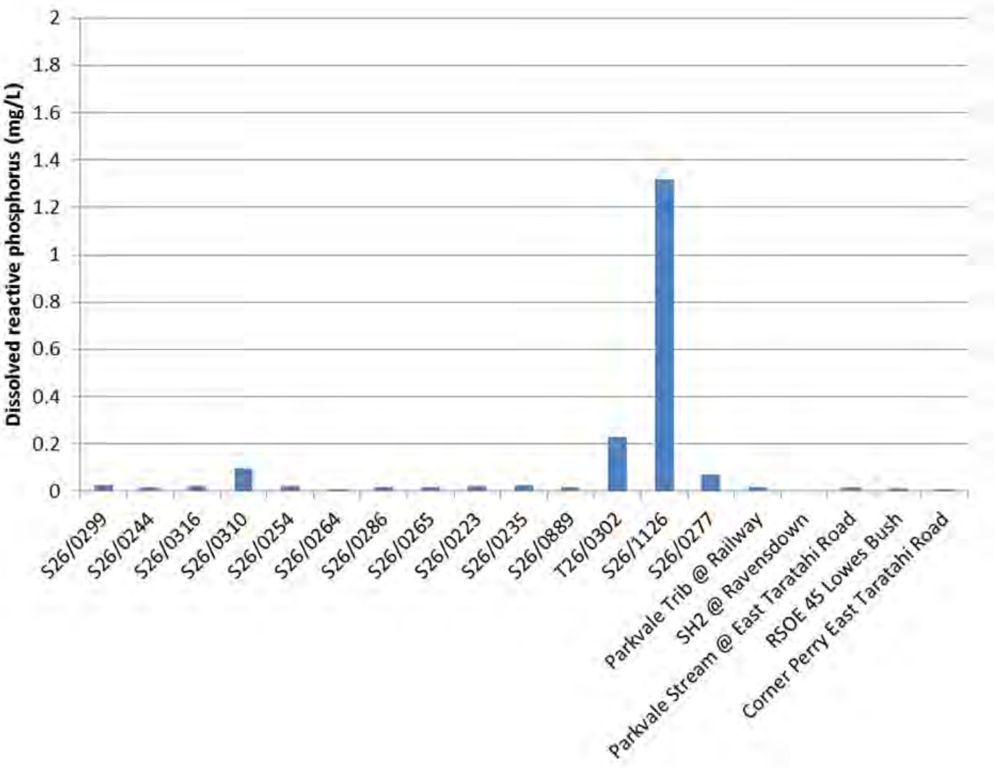

Figure 5.6: Dissolved reactive phosphorus concentrations

Nitrate-nitrite nitrogen (NNN) was present in all of the groundwater sites with the exception of T26/0302 and S26/1126 which are the anoxic wells (low dissolved oxygen). NNN ranged from 1.7 to 12 mg/L.

In the case of nitrate-nitrogen, background concentrations (non-anthropogenic) are low - typically less than 1 mg/L (Daughney & Reeves, 2005; Morgenstern and Daughney, 2012). Concentrations above 1 mg/L nitrate-nitrogen are generally considered elevated and having been influenced by humans (Daughney and Reeves, 2005; Morgenstern and Daughney, 2012). NNN was absent from the surface water sites with the exception of RSoE 45, Lowes Bush. This site had a NNN concentration of 5.5 mg/L, indicative that the site is a spring fed stream (i.e. groundwater sourced).

Ammoniacal-nitrogen was present above the ANZECC (2000) guideline value (0.021 mg/L) for lowland aquatic ecosystems in the Parkvale Tributary at Railway and the Taratahi Water Race @ Cnr Perry/East Taratahi Road. It was also present at elevated concentrations in T26/0302 & S26/1126; however these wells show anoxic and reducing conditions, therefore the presence of NH_4-N in place of oxidised nitrogen is expected.

Total Kjeldahl nitrogen (TKN), which is a measure of the total concentration of organic nitrogen and ammonia, was present in all of the surface water samples, and S26/0299 and S26/0244 (Waingawa spring). In oxic surface water, the presence of TKN indicates a recent source of nitrogen such as effluent or fertiliser. In anoxic groundwater, such as S26/1126 and T26/0302, the elevated TKN is likely to be a measure of the ammoniacal-nitrogen in the sample.

Dissolved reactive phosphorus was present above the ANZECC (2000) guideline value (0.01 mg/L) for lowland aquatic ecosystems in all surface water sites except for the Taratahi Water Race @ SH2 and Ravensdown @ Cnr Perry/East Taratahi Road. DRP was only present in the anoxic groundwater sites indicating that it is a reflection of rock-water interaction, not land use effects (S26/1126 and T26/0302).

5.3 Oxygen isotopes

Previous studies in the Wairarapa by Gunn et al (1987) and Morgenstern (2005) interpreted and summarised the δ18O analyses collected in the Wairarapa between 1983 and 2005. From these two studies the 18O range for each type of recharge source were inferred, and are presented below in Table 5.2.

Table 5.2: Oxygen 18 Source (Gunn et al, 1987; Morgenstern, 2005)

Inferred Source	Delta 18O (‰) Range
River Recharge	$\delta^{18}O$ ~ -5.4 to -5.9
River / Rainfall Recharge	$\delta^{18}O$ ~ -5.9 to -6.8
Rainfall Recharge	$\delta^{18}O$ ~ -6.8 to -7.5

Table 5.3 presents the results of the stable isotopes of water, Oxygen 18 (δ18O) and deuterium (δ2H) that were analysed in a total of four samples, three being groundwater and one being a surface water site. The original laboratory reports from GNS are provided in Appendix B. Overall the results indicate that the primary recharge source of the groundwater/spring water sampled for this study is river recharge (from the Waingawa River).

Table 5.3: Stable isotope results

Site	Collection Date/Time (Start)	Delta 2H (‰)	Delta 18O (‰)	Inferred Recharge Source
S26/0223	14/03/2016	-34.3	-5.81	River
S26/0299	14/03/2016	-32.3	-5.74	River
S26/0235	14/03/2016	-30.9	-5.48	River
RSoE Lowes Bush	14/03/2016	-33.5	-5.94	River / rainfall

5.4 Nitrogen-15 isotope

Another isotopic tool that has been used to identify the source of nitrates is Nitrogen-15 (15N) isotope. The relative abundance of the heavier 15N isotope to Nitrogen-14 (14N) compared to N_2 in air is expressed in parts per thousand relative to the international standard (Stewart et al., 2011) and reported as δ15N.

The δ15N value of nitrate nitrogen depends on the source of the nitrate and can be used to help identify whether it is from an animal, fertiliser or human source.

Stewart et al. (2011) summarised the range of nitrogen isotope vales presented by a number of researchers (e.g., Fogg et al., 1998; Kendall, 1998; Stewart et al., 2006). Fogg et al. (1998) listed δ15N values for soil water beneath animal waste, inorganic fertiliser, natural (soil organic nitrogen), and sewer septic sources. They found values typically ranged from +8 to +25‰, –3 to +2‰, –3 to +10‰, and +7 to +15‰ respectively for these sources. The δ15N ranges are presented below in Table 5.4.

Table 5.4: Nitrogen 15 source (after Stewart et al., 2011)

Inferred Source	δ15N (‰) Range
Inorganic Fertilisers	-3.0 to 2.0
Natural Soil Organic Matter	-3.0 to 10.0
Animal waste	8.0 to 25.0
Septic waste	7.0 to 15.0

Table 5.5 presents the results of the nitrogen-15 isotopes analysis that were analysed as part of this study. The original laboratory reports from GNS are provided in Appendix B.

Table 5.5: Nitrogen isotope results

Site	Collection Date/Time (Start)	Delta 15N (‰)	Delta 18O (‰)	NO3-N (mg/L)	Inferred Nitrogen source
S26/0223	14/03/2016	-2.2	-5.81	9.9	NH4 in Fertiliser
S26/0299	14/03/2016	-1.5	-5.74	4.22	NH4 in Fertiliser
S26/0235	14/03/2016	2.7	-5.48	1.72	NH4 in Fertiliser / Soil Organic nitrogen
S26/0889	27/09/2016	8.5	5.3	12.0	Animal / Septic Waste
S26/0286	27/09/2016	7.8	5.8	7.8	Animal / Septic Waste
S26/0310	08/12/2016	15.1	9.8	4.63	Animal / Septic Waste
S26/0264	08/12/2016	14.3	6.8	7.17	Animal / Septic Waste
RSoE Lowes Bush	14/03/2016	4.6	-5.94	5.53	Mixed

These results are also shown visually on Figure 5.7. The δ15N results are plotted against the corresponding nitrate nitrogen values. On the left of the plot, the shaded line shows the typical δ15N range of soil organic nitrogen, and on the right hand site the shaded bars show the range of δ15N values for inorganic fertilisers and animal waste/septic sewage.

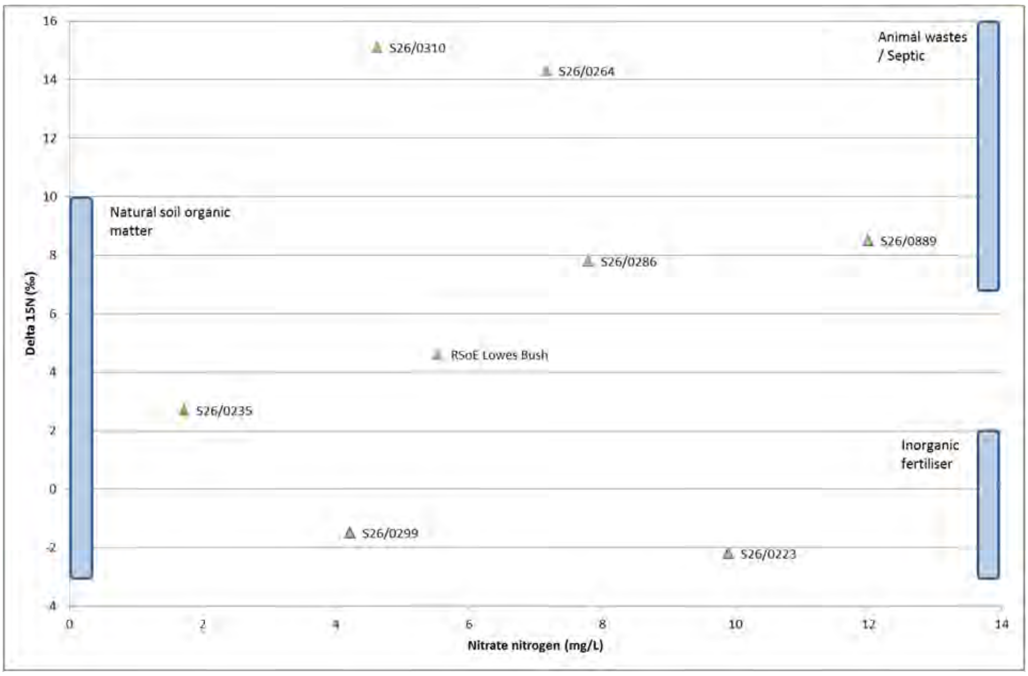

Figure 5.7: δ15N and nitrate nitrogen results

The results from S26/0223 and S26/0299 show a strong fertiliser nitrogen signature. S26/0235 and Lowes bush have mixed source signatures, but given the elevated nitrate nitrogen concentrations at the sites, the source is unlikely to be natural soil organic nitrogen which would be expected to have a nitrate concentration at or below background (i.e. < 1 mg/L). The remaining sites have δ15N signatures indicative of animal waste (manure/urine) and/or septic waste. The results are also shown spatially on Figure 5.8.

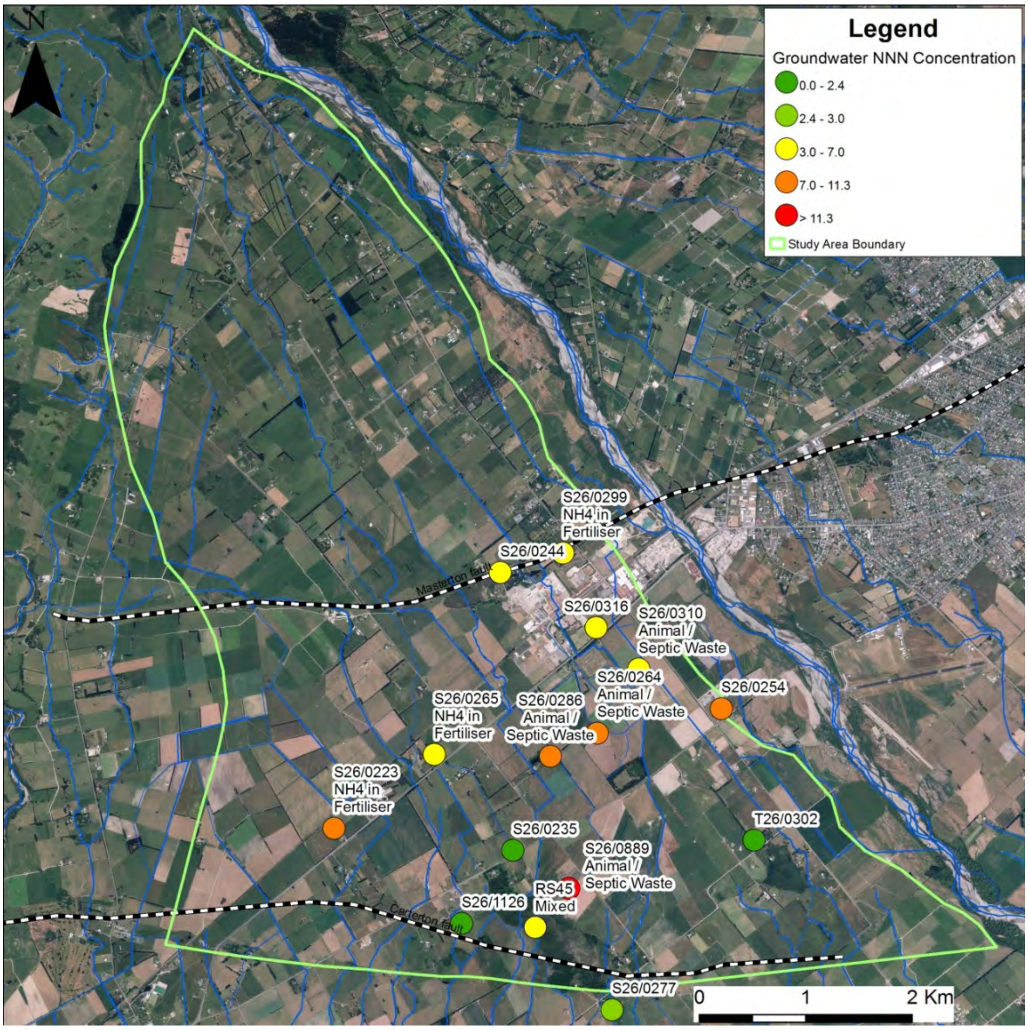

Figure 5.8: Spatial distribution of interpreted δ15N results

5.5 Age dating – tritium results

Tritium is produced naturally in the atmosphere by cosmic rays, but large amounts were also released into the atmosphere in the early 1960s during nuclear bomb tests, giving rain and surface water high tritium concentration at this time. Surface water becomes separated from the atmospheric tritium source when it infiltrates into the ground, and the tritium concentration in the groundwater then decreases over time due to radioactive decay. The tritium concentration in the groundwater is therefore a function of the time the water has been underground.

Historical sampling of tritium has not been undertaken at any of the current study sites however one nearby site, Waingawa Spring (S26/0244) has previously been sampled in 1983 and 2005 indicating a mean residence time (MRT) of 1 year old.

The tritium results from the current investigation are presented in Table 5.6. Following a phone conversation with Mr Rob van der Raaij of GNS, an initial high level assessment of the MRT was obtained. These results were assessed using an exponential flow model and assuming 70% mixing.

Table 5.6: Tritium results

Site	Collection Date/Time (Start)	Tritium Result	Tritium Result Error	Mean Residence Time (yr)*
S26/0244	2/06/1983	4.21	0.20	1
S26/0244	3/05/2005	1.91	0.05	1
S26/0223	14/03/2016	1.670	0.040	4 – 5
S26/0299	14/03/2016	1.760	0.041	4 – 5
S26/0235	14/03/2016	1.691	0.041	4 – 5
RSoE Lowes Bush	14/03/2016	1.649	0.039	5 - 6

*Van der Raaij, pers. Comm., 10 August 2016)

6. Synthesis – key findings

This section draws on the findings from the groundwater sampling, review of historic and current consents and modelling of nutrient leaching in the study area to address the three main objectives discussed above in Section 1.2. These objectives were to characterise the groundwater and spring fed water quality in the study area, determine the likely source of contamination to Parkvale Stream (at Lowes Bush) and to conclude whether the source of elevated nutrients in groundwater were sourced from the site of the historic freezing works. Limitations of the study and knowledge gaps are also presented in this section.

6.1 Conceptualisation

The results of this investigation have supported the hydrogeological conceptualisation of the Taratahi, Parkvale and Fernhill-Tiffen groundwater zones previously described by Gyopari and McAllister (2010) and Hughes and Gyopari (2014). Confirmation of this hydrogeological conceptualisation is important in order to accurately interpret the chemical and isotopic data collected.

The conceptualisation of the hydrogeological setting can be briefly summarised by the following points:

- The major ion chemistry and isotopic data indicates that shallow groundwater is predominantly sourced via losses from the Waingawa River, which recharges the shallow Taratahi Aquifer.

- Groundwater emanates adjacent to the Waingawa River at the base of the foothills, and flows in a southerly direction toward the Parkvale area. Along the way, shallow groundwater emerges as springs at the Carterton fault line at Waingawa, and also at a splinter fault at Carters Line/Taratahi Road (the location of Lowes Bush).

- The mean residence time (a broad indicator of age) of groundwater in shallow aquifers is relatively low, indicating that the groundwater is young. Results show that groundwater at S26/0299 (just up-gradient of the former Freezing Works) is between 4 and 5 years old, while water at the Lowes Bush spring is estimated at 5 – 6 years old.

It is important to remember that groundwater sampled at any point in the aquifer will reflect the convergence of many flow paths each with different travel times. As such, the residence time represents the mean of all travel times, not the absolute age of the groundwater. Research completed by GNS indicates that distributions are typically skewed to older travel times (Daughney et. al., 2013).

In the context of this study area, this means that the shallow groundwater in which the nitrogen plume was last reported in 2000, is likely to have been refreshed many times since the cessation of effluent irrigation (28 years ago) and the remediation (22 years ago).

The presence of 'young' groundwater is also backed up by the presence of shallow and highly permeable pallic and brown soils across the study area, particularly to the west of SH2 which is the recharge zone for the aquifer. These soils are classified by Landcare Research (2017) as having a high potential for nutrient leaching.

From this, we can conclude:

- The nitrogen observed in shallow groundwater downgradient of the Freezing works today, is not a slow moving historical plume that has been present since 2000 (i.e. not residual contamination).

- The nitrogen observed in shallow groundwater across the study area is likely to be from sources that are still present (either in the soil profile or recently applied/discharged onto land).

6.2 Landuse impacts

6.2.1 Diffuse sources

Diffuse sources of nitrogen (i.e. widespread leaching as a result of the overlying landuse) were assessed using the nitrogen leaching layer created as part of the Ruamahanga Whaitua catchment modelling project. The origins of this layer are discussed in Section 3. The leaching layer shows that across the entire catchment (Figure 3.2) the average drainage concentration of nitrogen is approximately 2.6 mg/L with a range from below background (i.e. < 1 mg/L) to 7.3 mg/L.

Drainage concentrations (the concentration of nitrogen in water leaving the base of the root zone) provide a broad indication of the long term nitrogen inputs from farming leached into groundwater. The average concentration nitrogen across the study area predicted by the leaching layer (2.6 mg/L) is lower than the average nitrate-nitrogen concentration in groundwater measured in this study (6.2 mg/L); however the study area is not spatially representative of the entire catchment as it is limited to the central part of the catchment.

In addition, as demonstrated by the capture zone analysis presented in Section 2.4, the groundwater samples collected are only representative of a discrete area of the catchment as demonstrated by the elongated flow paths.

These results also need to be considered with a degree of uncertainty, as the OVERSEER modelling was limited to 16 representative farms across the Wairarapa that were used to model the entire catchment, not farms specific to the study area. Nevertheless, the OVERSEER results provide a useful indication of how nitrogen leaching can vary between neighbouring landuses, even if the calculated leaching rates may not be specific to this study catchment.

For example, the highest OVERSEER modelled leaching rates (at a block scale) are from dairy support, dairy farming and mixed (sheep & beef plus cropping) which result in modelled drainage concentrations of between 3.5 and 7.3 mg/L of nitrogen. These are in the same order of magnitude as the study results.

When the observed nitrogen concentrations are compared to the predicted concentrations for their respective groundwater capture zones, it is evident that the observed concentrations of nitrate in shallow groundwater are reflective of the current landuse use within their respective CPZ, rather than the presence of a historical plume. This is further supported by the fact that high concentration of nitrate-nitrogen were observed well outside of the influence of the historically freezing works (i.e. S26/0223, S26/0299) which indicates that high nitrate concentrations in the catchment are not necessarily attributable to a historic source.

Overall, from the assessment of diffuse sources we can conclude that:

- The variability of observed nitrate concentrations aligns with the variability in modelled leaching rates, and is likely to reflect the long narrow capture zones of each bore

- With the exception of the JNL discharge monitoring, the observed nitrate concentrations are generally reflective of modelled leaching rates

- The elevated concentrations observed both adjacent to and down gradient of the former Freezing Works are of a concentration that could be attributed to present day land use practices.

6.2.2 Freezing Works waste

The historic effects of the Freezing Works wastewater discharges on groundwater are well documented with a groundwater quality monitoring showing nitrate-nitrogen concentrations decreased from a range of range of 8 - 30 mg/L in 1985 to a range of 3 - 17 mg L in 1999.

Five of these historical wells were able to be located, accessed and sampled as part of this study; the results are compared to the historical results on Figure 6.1 below.

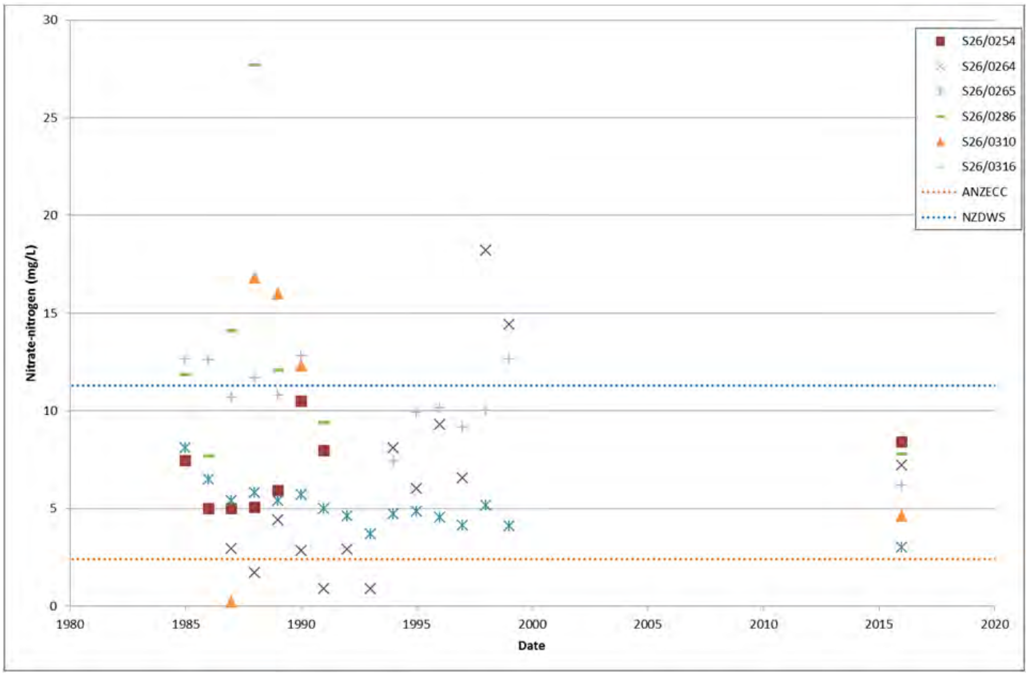

Figure 6.1: Historic and current nitrate concentrations

The nitrate-nitrogen results from the 2016 monitoring of the between 2000 and 2016 show that S26/0264 decreased from 15 mg/L to 7.1 mg/L; S26/0265 decreased from 4 to 2.5 mg/L and S25/0316 decreased from 13 to 6 mg/L.

In addition, wells S26/0254 and S26/0286 that were last sampled in 1991 (pre-remediation) were re-sampled. In both these wells nitrate-nitrogen was relatively stable at 9.4 vs 7.8 mg/L in S26/0286) and at 7.9 vs 8.4 mg/L in S26/0254. This may be a reflection of the fact that sampling ended in 1991 before the peak concentrations were observed.

As discussed in Section 6.2.1 above, all of the 2016 groundwater quality results were comparable to the drainage nitrate-nitrogen concentrations from the overlying landuses as predicted by OVERSEER. The nitrate-nitrogen concentrations in the area of the plume would not be expected to reduce to background level, but to levels that are reflective of the type of farming activities currently undertaken in the area.

While the observed nitrate-nitrogen concentrations in groundwater appear to be consistent with modelled current landuse drainage values, there is still a question as to whether nitrogen applied (or buried) historically could be contributing to the observed high nitrogen concentrations at sites downgradient of the Freezing Works.

In the areas where wastewater was flood irrigated to land this is highly unlikely. The soils in the area are typically thin, stony and highly permeable. There is low potential for the long term build-up of organic nitrogen as most wastewater applied to land will have leached from the system. In addition, significant decomposition of any residual organic material will have occurred since the cessation of the wastewater disposal 27 years (R Muirhead, personal communication, 23 May 2017) leading to the conclusion that any effects of effluent disposal at the site are likely to have attenuated.

The area of buried offal and paunch (Figure 3.4) to the west of SH2 could potentially provide a source of nitrogen. There is evidence (S Laurenson, personal communication, 23 May 2017) that some (mainly stomach content) forms of organic material can persist for long periods in the soil and act as a nitrogen source during this time.

However, the closest well downgradient of the burial areas (S26/0265) only has a nitrate concentration of 3.1 mg/L which is not high in comparison to the range of values observed across the study area. Completing sampling of wells closer to the paunch trenches could further support this conclusion, however based on the above evidence it seems unlikely that the results will be significantly different.

A further check is the analysis of nitrogen source, which in this study was assessed through the nitrogen isotope analyses, and discussed below.

6.3 Nitrogen isotope analyses

The nitrogen isotope results presented in Section 5.4 show that there are mixed sources of nitrogen across the study area, and indicate that no single source is responsible for all of the elevated nitrogen concentrations.

The two sources of nitrogen in the study area wells are from fertiliser or animal/septic waste inputs. Because of the elevated nitrate concentrations across all sites, the likelihood of the nitrogen being naturally sourced (i.e. soil organic nitrogen) is low.

Downgradient of the former wastewater disposal area, wells S26/0264, S26/0286 and S26/0889 all have an isotopic signature that is likely to be indicative of an animal waste or septic source. The isotopic signature of the nitrogen produced by the freezing works was never tested, but it is likely to be similar to an animal waste. However, given young age of the groundwater, and low probability that organic nitrogen spread over 20 years ago still persists in soil it is considered highly unlikely that residual freezing works waste is responsible for present day nitrogen concentrations.

Whilst wells S26/0264, S26/0286 and S26/0889 are downgradient of the former Freezing Works land disposal areas, they are also down gradient of two active discharge permits – the JNL discharge and the PGG Wrightson Masterton Sale Yards consent and also down-gradient of the historic Farm Meats discharge. The isotopic signature of these discharges is unknown, but in the case of the Sale Yards, it seems reasonable to assume it will have an isotopic signature reflective of animal waste.

There is no known groundwater monitoring at the Sale Yards but monitoring of the JNL discharge has reported groundwater concentrations of up to 40 mg/L nitrate nitrogen. Given this, it is possible that the JNL discharge is a contributor to the high nitrogen concentrations observed in the aquifer. Further work to identify the mass of nitrogen discharged and undertaking isotopic analysis could assist with determining the source in this area.

Wells S26/0265 and S26/0223 have nitrate-nitrogen concentrations of 3.0 and 9.9 mg/L respectively. Both of these wells had nitrogen isotope signatures indicative of a fertiliser source. These wells are downgradient of mixed sheep, beef and dairy land. S26/0223 is also located close to the Ravensdown Fertiliser Factory. Groundwater is not monitored at Ravensdown.

Overall, the results of the nitrogen isotope analyses support the conclusion above that there are multiple and spatially variable sources of nitrogen across the wider catchment, and that observed contamination is not attributable to a single source. In addition, given the linear nature of groundwater flow paths in this aquifer means that isotopic analyses at a single well are only likely to be reflective of a small part of the shallow aquifer, not representative of the entire aquifer.

6.4 Aquifer (Soil) vulnerability

As discussed above, elevated nitrate concentrations have been observed across the entire study area and based on the information available, do not appear to be related to a single source.

The widespread presence of elevated nitrate concentrations from a range of discharge sources indicates that the aquifer within the study area is vulnerable to nitrate leaching. The monitoring results suggest that regardless of the type and scale of discharge (diffuse from agricultural sources, current active discharges, historic land discharges), the activity of applying nutrients to land in this area results in leaching that is causing elevated groundwater nitrate concentrations.

The reasons for the vulnerability are primarily related to soil type and the relatively shallow depth to groundwater. As discussed in Section 2.1, the soils of the study area are predominantly medium well to well drained, shallow to very shallow silty brown soils that as a result are vulnerable to nitrogen leaching. These soils have a SMap vulnerability classification of high and very high, and a DRASTIC category (refer to Section 2.1) of 9 or 10 which are the two most vulnerable groundwater classifications.

This level of vulnerability is likely to be part of the reason for widespread elevated nitrate concentrations observed and brings into question the suitability of some land use practices on these well drained soils.

6.5 Summary

Groundwater sampling was undertaken to assess the spatial distribution of nitrate-nitrogen across the study area. The first stage of the study was to conceptualise the hydrogeological setting. Geochemistry results were used to demonstrate that shallow groundwater is predominantly sourced via losses from the Waingawa River, which recharges the shallow Taratahi Aquifer. Age dating has also demonstrated that the mean residence time in the shallow aquifer is young ranging from 4-5 years old at the Waingawa faultline to 5-6 years old at Lowes Bush on the Carterton faultline.

Capture zone analysis was used to delineate the total source capture zones for each of the bores. The delineated zones show that the capture zones are quite elongated and demonstrate that results from each well are only representative of a small part of the shallow aquifer.

The nitrate-nitrite nitrogen concentrations were measured at a total of 14 bores and five surface water sites. Concentrations ranged between 1.7 to 12 mg/L in groundwater and was largely absent from surface water with the exception of RSoE 45, Lowes Bush. This site had a NNN concentration of 5.5 mg/L, which is indicative that the site is a spring fed stream (i.e. groundwater sourced).

When the field collected data are compared to the modelled concentrations expected across the catchment, the data correlate reasonably well. The nitrogen leaching layer created as part of the Ruamahanga Whaitua modelling shows that across the entire catchment (Figure 3.2) the average drainage concentration of nitrate-nitrogen is approximately 2.6 mg/L with a range from below background (i.e. < 1 mg/L) to 7.3 mg/L.

The spatial variability in NNN demonstrates that across this catchment, there is a range of nitrogen sources contributing to the catchment. In addition, the mean residence time of the groundwater indicates that the sources of nitrogen contribution to the present day concentrations are likely to be current day, or recent (i.e. last 5-6 years) rather than historic sources. Therefore, it is evident that even though there is elevated NNN downgradient of the former freezing works, it is not the result of a nitrogen plume that has been in the aquifer since the closure of the works in 1989.

One thing all of the sites with elevated NNN concentrations do have in common is that they are located downgradient of soils with high nutrient leaching potential. In this case, the soils are all Brown Soils (Acidic orthic brown soils) that are typically described as being thin, well drained silty loams. These soils dominate the western Wairarapa valley floor and are typically found over the alluvial outwash fans that extend out from the Tararua Foothills. The correlation between elevated NNN results and the soil type warrants further investigation, in particular, some consideration to the land management practices on these soils.

Overall, the results of the nitrogen isotope analyses support the conclusion above that there are multiple and spatially variable sources of nitrogen across the wider catchment, and that observed contamination is not attributable to a single source. In addition, given the linear nature of groundwater flow paths in this aquifer means that isotopic analyses at a single well are only likely to be reflective of a small part of the shallow aquifer, and not necessarily representative of the rest of the shallow aquifer.

7. Recommendations

Whilst this report has provided a summary of the likely sources and spatial distribution of nitrogen across the shallow aquifer of the Taratahi Groundwater Zone the results are based on a single round of groundwater monitoring that has been compared to historical results. As such, there are a number of recommendations that could assist with refining the understanding of the concentration and behaviour of nutrients groundwater. These are:

- Undertake another round of groundwater sampling across the wider groundwater zone, during late winter/spring. Consideration should be given to extending the sampling area in a downgradient direction so that an assessment of how far downgradient the effects of nitrogen leaching beneath the Brown soils extends (i.e. does it travel into the Parkvale groundwater zone, or all emerge as spring flow?)

- Compare the results of this study to groundwater quality in areas with similar soils and physical characteristics to determine if leaching of nutrients beneath Brown soils is widespread

- Consider undertaking nitrogen isotope analysis on the discharges from consented point sources so to increase the certainty when using nitrogen isotope data to track plumes

- Once the Ruamahanga whaitua model reports are published, the results from this study should be ‘ground-truthed’ against the modelling predictions for nitrate nitrogen to determine the usefulness of the model as a predictive tool at a sub-catchment scale.

Acknowledgements

We would like to thank to following people who have all contributed to this study:

- Sheree Tidswell, Greater Wellington Environmental Scientist (Groundwater quality) who designed the initial study and instigated the project;

- Kasey Pitt, Lindsay Annear (GWRC) and Samwell Warren (Opus) who between them identified suitable wells and undertook the sampling; and

- Dr Philippa Crisp and Dr John Drewry who both reviewed the report.

References

Brown, LB. 1994. Compilation of a groundwater contamination vulnerability map of the Wellington region. Institute of Geological Sciences Limited Report No. 43.

Daughney, C.J. and Reeves, R. 2005. Definition of hydrochemical facies for New Zealand’s groundwaters using data from the National Groundwater Monitoring Programme. Journal of Hydrology (NZ) 44: (2): 105 -130.

Daughney, C.J., Morgenstern, U. & Stewart, M. 2013. Welcome to the Water Dating Course. Unpublished proceeding of the Water dating course run by GNS Science, 22-23 May 2013.

Fogg, G.E.; Rolston, D.E.; Decker, D.L.; Louie, D.T.; Grismer, M.E. 1998: Spatial variation in nitrogen isotope values beneath nitrate contamination sources. Ground Water 36 (3): 418-426.

Gunn I., Butcher G. and Stewart M.K. 1987. Groundwater studies on the Wairarapa plains using isotopic and chemical data. In: Smith D.K. (Compilers) Proceedings of the groundwater chemistry workshop. Auckland Regional Water Board, Technical Publication 41, pp. 139–155.

Gyopari M and McAlister D. 2010. Wairarapa Valley groundwater resource investigation: Middle Valley catchment hydrogeology and modelling. Greater Wellington Regional Council, Publication No. GW/EMI-T-10/73, Wellington.

Hughes B and Gyopari M. 2011. Wairarapa Valley groundwater resource investigation: Proposed framework for conjunctive water management. Greater Wellington Regional Council, Publication No. GW/EMI-T-11/53, Wellington.

Jacobs New Zealand Limited, 2017. Kiwi Lumber Preliminary Site Investigation and Detailed Site Investigation. Report No. AE04873-R-01

Jacobs New Zealand Limited, 2017. Ruamahanga Whaitua Baseline Source Model Report. In press.

Kendall, C. 1998: Tracing nitrogen sources and cycles in catchments. Chapter 16 in Isotope Tracers in Catchment Hydrology. Kendall, C.; McDonnell, J.J. (eds.). Elsevier, pp. 519-576.

Landcare Research, 2017. *S-map Soil Report*. Retrieved from https://smap.landcareresearch.co.nz/

Morgenstern, U. 2005. Wairarapa Valley Groundwater - Residence time, flow pattern and hydrochemistry trends. Institute of Geological and Nuclear Sciences Science Report 2005/33 prepared for Greater Wellington Regional Council.

Morgenstern, U., Daughney, C.J, 2012. Groundwater age for identification of impacts of land-use intensification and natural hydrochemical evolution on groundwater quality - The National Groundwater Monitoring Programme of New Zealand. Journal of Hydrology, 456-457: 79-93.

Muirhead, R., Monaghan, R., Smith, C. and Stantiall, J. 2016. Modelling Farm-scale Mitigation Options for the Ruamahanga Whaitua Collaborative Modelling Project. AgResearch report prepared for MPI. Report No. RE500/2016/059.

Parminter, T. and Grinter, J. 2016. Farm-scale Modelling Report. Ruamahanga Whaitua Collaborative Modelling Project. MPI Information report No: 2016/22

Professional Groundwater and Environmental Services, 1998. Monitoring Review – Discharge to Land Consent - Affco NZ Ltd. Report prepared for Consents and Compliance Sections, Wairarapap Division, Wellington Regional Council.

Professional Groundwater and Environmental Services, 1999. Monitoring Review – Discharge to Land Consent - Affco NZ Ltd. Report prepared for Consents and Compliance Sections, Wairarapap Division, Wellington Regional Council.

Stewart, M., Stevens, G., Thomas, J., van der Raaij, R. & Trompetter, V. 2011. Nitrate sources and residence times of groundwater in the Waimea Plains, Nelson. *Journal of Hydrology (New Zealand)* Vol. 50, No. 2 (November 2011), pp. 313-338

Toews, MW and Donath, F. 2015. Capture Zone delineation of community water supply wells and State of the Environment monitoring wells in the Greater Wellington Region, GNS Science report 2015/06. 69 p.

Terra Aqua Consultants, 2000. Assessment of Nitrate Impacts at Waingawa Farm, Masterton. Prepared for AFFCO New Zealand Limited.

The Wastewater Specialists, 2017. Groundwater Nitrate Investigations. Unpublished report prepared for Juken New Zealand Limited in support of resource consent WAR 090296.

Tidswell, 2016. Sampling proposal for environmental monitoring in the Waingawa/Taratahi area. Unpublished internal memo.

Tidswell, S., Conwell, C. and Milne, JR. 2012. Groundwater quality in the Wellington Region - State and Trends. Greater Wellington regional Council report number GW/EMI-T-12/140.

URS, 2003. Phase I Environmental Site Assessment. Report prepared for Farm Meats 2000 Limited.

Appendix A

Field Sheets, COC and Calibration Records

DAY 1

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

RSoE site RS 45	Cowes Bush.	

Screen: - m / - m
Depth: m
Location:
Contact Details:
Collection Instructions:

Flow - 1.8 l/s - gauged by Matt

GPS Coordinates :
MP:
MP R/L:
Fitting Required:

Date: 14/3/16
Collected by: SAM . WARREN
Time: 13:30 NZST / [✓ NZDT]

Bore w/l: ______ mm above/below MP
Volume ÷ Rate ÷ 60 =

Pump on: Yes / No
Time pump on:
Depth of water:
Diameter Bore:
Calculated bore volume *3: litres
Est. discharge rate: l/s
Required purge time: min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				13:25					13:30
Temp	°C	YSI	± 0.5 °C	13.9					13.9
Cond	µScm⁻¹	Pro Plus.	± 3 %	755.8					755.8
DO	%			72.5					72.4
DO	mg/l		± 0.3 mg/L	7.47					7.45
pH			± 0.1 pH Unit	6.49					6.30

Sample Appearance at completion of Pumping:
Clear / Turbid Colourless / Colour ______ Odourless / Odour ______

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional ______

Comments:
Surface water sample 1.8 l/s - Part Trib @ Cowes Bush.
d. hard to get clean sample - very shallow RIVER.

DAY 1

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0244	SPRING	

Screen: - m / - m

Depth: m

Location:

Contact Details:

Collection Instructions: — DUNCAN @ KIWI LUMBER OFFICE

WAINGAWA SPRING

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 14 MARCH

Collected by: SAM.

Time: 09:40 NZST / [✓ NZDT]

Bore w/l: ______ ~~mm above/below~~ MP

~~Volume ÷ Rate ÷ 60 =~~

Pump on: Yes / [✓ No]

Time pump on: ______

Depth of water: ______

Diameter Bore: ______

Calculated bore volume *3: ______ litres

Est. discharge rate: ______ l/s

Required purge time: ______ min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				09:40					09:45
Temp	°C	YSI PRO PLUS	± 0.5 °C	15.7.					15.7.
Cond	µScm-1		± 3 %	756					756
DO	%			62.9					62.8
DO	mg/l		± 0.3 mg/L	6.24					6.23
pH			± 0.1 pH Unit	6.9					6.9

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional ______

Comments:

SURFACE WATER SAMPLE 1-2 l/s

DAY 1

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0235	Simpson	

Screen: - m / - m

Depth: m

Location:

Contact Details: Vicky Simpson

Collection Instructions: 0274462839
vickyscott_9@xtra.co.nz
345 Hughes Line R.D.7
Masterton.

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 14/3/16

Collected by: SAM .W

Time: ~~3070~~ 16:00 NZST / [✓ NZDT]

Bore w/l: 3070 mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No

Time pump on: All day.

Depth of water:

Diameter Bore:

Calculated bore volume *3: litres

Est. discharge rate: l/s

Required purge time: min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ________ [✓ Odourless] / Odour ________

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				3:40	3:45	3:50	3:55		16:00
Temp	°C	YSI Pro Plus	± 0.5 °C	28.4	18.7	17.2	17.1		17.1
Cond	µScm-1		± 3 %	754.1	756	754	754		754.2
DO	%			69.9	~~65.5~~ 70.6	67.6	68.1		68.0
DO	mg/l		± 0.3 mg/L	5.41	~~9~~ 6.57	6.45	6.51		6.48
pH			± 0.1 pH Unit	6.1	5.86	5.59	5.63		5.61

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ________ [✓ Odourless] / Odour ________

Analysis: ☐ Routine Chemical ☐ Pesticide ☐ Bacteria ☐ Additional ________

Comments:

DAY 1
Consignment # 58999

Drink from Bor.
Bore behind house
Sampled from tap

DAY 1

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

NICHOLSON.	S26/0223	

Screen: - m / - m

Depth: m

Location:

Contact Details: 0272262556.

Collection Instructions: ELIZABETH NICOLSON

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 14/3/16.

Collected by: SAM. WARREN

Time: 11:10 NZST / [✓ NZDT]

Bore w/l: 7150 mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: Yes / [✓ No]

Time pump on: 11:46.

Depth of water: ~2m 2000

Diameter Bore: 150mm

Calculated bore volume *3: litres

Est. discharge rate: 0.2 l/s 9L in 48sec

Required purge time: 5 - 10 min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				11:45	11:50	11:58	11:05		11:10
Temp	°C	YSI Pro	± 0.5 °C	19.2	14.3	14.1	14.0		14.1
Cond	μScm^{-1}	PLUS	± 3 %	756 6	756.6	756.4	756.3		756.3
DO	%			75.0	72.7	72.5	72.7		72.0
DO	mg/l		± 0.3 mg/L	7.01	7.43	7.44	7.48		7.41
pH			± 0.1 pH Unit	5.93	5.64	5.63.	5.67.		5.68

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional ______

Comments:

AGE ISO SAMPLES TAKEN'
CFC Stable iso
SFC N15
TRITIUM

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

DAY 1

GRAHAM .	S26/0299	

Screen: - m / - m

Depth: m

Location:

Contact Details: N GRAHAM 06 3788218 .

Collection Instructions:

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 16/3/16

Collected by: SAMUELL WARREN

Time: NZST / [✓ NZDT]

Bore w/l: 4549 mm above/[✓ below] MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No

Time pump on: ~~10:25~~ Pump going on arrival

Depth of water: ~~4549~~ ~3m

Diameter Bore: 150 mm 9c - 38m

Calculated bore volume *3: litres

Est. discharge rate: 0.3 l/s

Required purge time: 4. min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				10:25	10:30	10:40	10:45		10:50
Temp	°C	YSI Pro Plus	± 0.5 °C	16.2	15.6	15.6	15.7		15.7
Cond	µScm^{-1}		± 3 %	755.3	755.2	755.2	755.1		755.1
DO	%			89.9	85.2	84.4	84.5		84.6
DO	mg/l		± 0.3 mg/L	8.82	8.47	8.38	8.33		8.34
pH			± 0.1 pH Unit	7.	6.13	5.96	5.96		5.97.

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Analysis: ☐ Routine Chemical ☐ Bacteria

☐ Pesticide ☐ Additional

Comments:

ISO SAMPLING DONE stable ISO

CFC

SF6

TRITIUM. N_{15}

DAY 2

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0316	McEWEN	

Screen: - m / - m
Depth: m
Location:
Contact Details: 06 377 4585
Collection Instructions:
Back of house – talk to owner – sample from inside

GPS Coordinates :
MP:
MP R/L:
Fitting Required:

Date: 15/3/16
Collected by: SAM.W
Time: 10:50 NZST / [✓ NZDT]

BORE DEPTH 6.5m

Bore w/l: 5880 mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No
Time pump on: Pump supplies house
Depth of water: ~700m
Diameter Bore: ~1000mm.
Calculated bore volume *3: litres
Est. discharge rate: 0.5 l/s
Required purge time: ~20 min

~~1000~~
R=500 × π
D=400 : 2000
1500×2000
40000/

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				10:30	10:35	10:40	10:45		10:~~45~~50
Temp	°C	YSI PRO PLUS	± 0.5 °C	15.3	15.3	15.3	15.4		15.3
Cond	µScm^{-1}		± 3 %	749.7	749.0	749.0	749.8		749.8
DO	%			77.1	78.3	78.4	78.6		78.2
DO	mg/l		± 0.3 mg/L	7.73	7.85	7.85	7.86		7.83
pH			± 0.1 pH Unit	6.47	5.98	5.75	5.72		5.73

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Analysis:
☐ Routine Chemical
☐ Pesticide
☐ Bacteria
☐ Additional

Comments:
Bore behind house under caseing
Sampled from tap inside – laundry room
Concrete well.

→ DAY 2

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

PARKVALE TRIB	RAILWAY	

Screen: - m / - m

Depth: m

Location:

Contact Details:

Collection Instructions: STREAM - DOWNSTREAM OF CULVERT.
— NO GAUGING — WEEDY - SOFT BED SHALLOW)
Rought 4 l/S.

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 15/3/16.

Collected by: SAM.

Time: 11:25. NZST / [✓ NZDT]

Bore w/l: ______ mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: Yes / [✓ No]

Time pump on:

Depth of water:

Diameter Bore:

Calculated bore volume *3: litres

Est. discharge rate: l/s

Required purge time: min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ~~Odourless~~ / [✓ Odour] slightly effluent smell

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				11:20					11:25
Temp	°C	YSI PRO	± 0.5 °C	22.1					22.7
Cond	μScm⁻¹	PLUS.	± 3 %	764.8					749.8
DO	%			59.5					58.9
DO	mg/l		± 0.3 mg/L	5.22					57.1
pH			± 0.1 pH Unit	6.52					6.62

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid ~~Colourless~~ / [✓ Colour] slightly brown Odourless / [✓ Odour] slight effluent smell

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional

Comments:
Some sediment in sample - hard to get clean
sample — multiple filters needed per sample.
Too weedy to ~~see~~ guage! roughly 3-4 l/s.

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

DAY 2

CORNER PERRY & EAST TARATAHI

Screen: - m / - m
Depth: m
Location:

GPS Coordinates :
MP:
MP R/L:
Fitting Required:

Contact Details:
Collection Instructions: Downstream of culvet culvet - high outflow. Surface water - 11.4 l/s.

Date: 15/3/16
Collected by: SAM. W
Time: 14:30 NZST / [✓ NZDT]

Bore w/l: ______ mm above/below MP
Volume ÷ Rate ÷ 60 =

Pump on: Yes / No
Time pump on: ______
Depth of water: ______
Diameter Bore: ______
Calculated bore volume *3: ______ litres
Est. discharge rate: ______ l/s
Required purge time: ______ min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid   Colourless / [✓ Colour] light brown   Odourless / [✓ Odour] soil

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				14:15	14:20	14:25			14:30
Temp	°C	350 PRO	± 0.5 °C	22.8	22.9	23.1			23.1
Cond	µScm^{-1}	PLUS	± 3 %	769.8	749.8	749.8			749.8
DO	%	YSI		109.8	104.9	105.2			109.1
DO	mg/l		± 0.3 mg/L	9.44	9.02	9.00			902
pH			± 0.1 pH Unit	7.19	6.87	6.92			6.91

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid   Colourless / [✓ Colour] light brown/yellow   Odourless / [✓ Odour] soil

Analysis: ☐ Routine Chemical ☐ Pesticide ☐ Bacteria ☐ Additional ______

Comments:
Surface water sample.
Culvet gauged - hard to get any accuracy in flow meter
Cows in ~~&~~ waterrace upstream
-11.4 l/s

DAY2

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

PARKVALE Stream	EAST TARATAHI Road.	

Screen: - m / - m

Depth: m

Location: upstream of culvet

Contact Details:

Collection Instructions:

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Surface Water take - 2.6 l/S.

Date: 15/3/16.

Collected by: SAM.

Time: 15:05 NZST / [✓ NZDT]

Surface Water

Bore w/l: ______ mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: Yes / No

Time pump on:

Depth of water:

Diameter Bore:

Calculated bore volume *3: litres

Est. discharge rate: l/s

Required purge time: min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless / Colour] slight Yellow tinge [✓ Odourless / Odour] methany / effluent

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				14:47,	14:50	14:55	15:00		15:05
Temp	°C	350 Y	± 0.5 °C	20.9	20.9	20.9	21		21
Cond	µScm⁻¹	PROF PLUS	± 3 %	749.9	749.9	749.9	749.7		74.7
DO	%			89.0	72.5	74.7	71.4		71.8
DO	mg/l		± 0.3 mg/L	8.62	6.46.	6.60	6.60		6.58
pH			± 0.1 pH Unit	6.91	6.82.	6.83	6.89		6.89.

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid Colourless / [✓ Colour] slight Yellow tinge. Odourless / Odour

Analysis: ☐ Routine Chemical ☐ Pesticide ☐ Bacteria ☐ Additional

Comments:

Surface Water Sample

Very weedy - had to clear a section

Day2

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

SH2	Ravensdown	

Screen: - m / - m

Depth: m

Location:

Contact Details:

Collection Instructions:

upstream of culvert

GAUGING – SH2 – 5.9 l/s.

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 15/3/16

Collected by: Sam.

Time: 13:15 NZST / [✓ NZDT]

Bore w/l: ______ mm above/below MP

Volume ÷ Rate ÷ 60 =

~~**Pump on:** Yes / No~~

Time pump on: ______

Depth of water: ______

Diameter Bore: ______

Calculated bore volume *3: ______ litres

Est. discharge rate: ______ l/s

Required purge time: ______ min

Sample Appearance at commencement of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				13:00	13:05	13:10			13:15
Temp	°C	Pro Plus	± 0.5 °C	19.8	19.5	19.7			19.7
Cond	µScm⁻¹	YSI	± 3 %	750.2	750.2	750.2			750.1
DO	%			61.7	53.1	52.9			52.8.
DO	mg/l		± 0.3 mg/L	5.61	4.86	4.84			4.81
pH			± 0.1 pH Unit	7.21	6.93	6.32			3.34

Sample Appearance at completion of Pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Analysis:

☐ Routine Chemical

☐ Pesticide

☐ Bacteria

☐ Additional ______

Comments:

lots of weed

clean sample hard to aquire.

had to clean a section to gauge.

Tuesday – 15/3/16 Consignment # 59000

H58448

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0254	Tulloch	

Screen: - m / - m

Depth: m

Location: Between two posts far side of paddock

Contact Details:

Collection Instructions:

Ring Ron - 027 449 7603 courtesy.
Steve Williams - Trust power 021 976 450

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 18/3/16

Collected by: SAM / LINDSAY

Time: 12:15 NZST / [✓ NZDT]

Bore w/l: 5121 mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: Yes / [✓ No]

Time pump on: 11:45.

Depth of water:

Diameter Bore: 75mm.

Calculated bore volume *3: litres

Est. discharge rate: l/s

Required purge time: min

Required purge. 30L. – Ended up purging ove 100L.

Sample Appearance at commencement of Pumping:
Clear / [✓ Turbid] Colourless / [✓ Colour] ORANGE / RED [✓ Odourless] / Odour

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				11:48	12:00	12:05	12:10		12:15
Temp	°C	YSI PRO	± 0.5 °C	14.3	14.1	14.1	14.1		14.1
Cond	µScm⁻¹	Plus	± 3 %	757	757.0	757.1	757.2		757.2
DO	%			68.0	55.0	54.7	55.1		55.6
DO	mg/l		± 0.3 mg/L	5.98	5.65	5.62	5.66		5.70
pH			± 0.1 pH Unit	5.86	5.80	5.79	5.79		5.78

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / [✓ Colour] slight orange tinge Odourless / Odour

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional

Comments:
Rusty at start of pumping started to clear after 3 min. Situated between two post.

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0265	ASHWORTH	

Screen: - m / - m
Depth: m
Location:

GPS Coordinates :
MP:
MP R/L:
Fitting Required:

Contact Details: 021 763304
Collection Instructions: Back behind house
drive through ~~m~~ middle gate

Date: 16/3/16
Collected by: SAM / LINDSEY
Time: ~~9:42~~ 10:08 NZST [✓ NZDT]

Bore w/l: 3.735 mm above/[✓ below] MP
Volume ÷ Rate ÷ 60 =

Pump on: Yes [✓ No]
Time pump on: 9:42
Depth of water: 6.910 — 3.757.
Diameter Bore: 100mm
Calculated bore volume *3: litres
Est. discharge rate: l/s
Required purge time: min
24 L - volume measured purge

Sample Appearance at commencement of Pumping:
Clear / [✓ Turbid] Colourless / [✓ Colour] BROWN [✓ Odourless] / Odour

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				9.42	9:45	9:55	10:00	10:05	10:08
Temp	°C	Prof Pro	± 0.5 °C	14.9	14.7	16.2	14.2	14.2	14.2
Cond	µScm⁻¹	Plus	± 3 %	756.6	756	756.7	756.7	756.0	756.0
DO	%	YSI		77.6	81.9	77.4	76.8	76.3	76.5
DO	mg/l		± 0.3 mg/L	7.76	8.32	7.94	7.87	7.82	7.85
pH			± 0.1 pH Unit	6.30	6.41	5.71	5.7	5.7	5.7

FLOW STABALISED.

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid Colourless / [✓ Colour] [✓ Odourless] / Odour

Analysis:
☐ Routine Chemical
☐ Pesticide
☐ Bacteria
☐ Additional

Comments:

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

T260302	McMillan	

Screen: - m / - m

Depth: m

Location:

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Contact Details: Kim McMillan 063788690

Collection Instructions: Pump in shed (green)
Sample from tap on fence

Date: 16/3/16

Collected by: SMJ / LUWOSA+

Time: 13:00 NZST / [✓ NZDT]

2.1m @ end of pumping

Bore w/l: ______ mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / ~~No~~ — pump services house continually used all d.

Time pump on: 12:40.

Depth of water:

Diameter Bore:

Bore sealed

Calculated bore volume *3: litres

Est. discharge rate: l/s 54sec 10
5 "

Required purge time: min 5.41/s.

estimated purge time → 5 min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ______ ~~Odourless~~ / [✓ Odour] eggy

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				12:44	12:50	12:55			13:00
Temp	°C	YSI Professional	± 0.5 °C	14.1	14.0	16.0			14.0
Cond	µScm^{-1}	Plus.	± 3 %	757.4	757.5	757.5			757.6
DO	%			1.9	1	0.6			0.4
DO	mg/l		± 0.3 mg/L	0.19.	0.10	0.06.			0.04
pH			± 0.1 pH Unit	~~[illegible]~~	6.62	6.65,			6.66
				6.44.					

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ______ Odourless / [✓ Odour] Eggy.

Analysis: ☐ Routine Chemical
☐ Pesticide
☐ Bacteria
☐ Additional ______

Comments:
turned second tap on to increase flow.

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

#1 58991

DAY 4

S26/0277 | SNOW

Screen: - m / - m

Depth: m

Location:

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Contact Details: Joan snow - 306 Perrys Road RD7 - 377 4941.

Collection Instructions:
By chook house - near tank - go through door on right. old pump and new pump.
→ told New pump.

Date: 17/3/16

Collected by: SAM . LU

Time: 09:40 NZST / [✓ NZDT]

Bore w/l: ~~mm above/below MP~~

Volume ÷ Rate ÷ 60 =

Pump on: Yes / [✓ No]

Time pump on: 09:40

Depth of water: —

Diameter Bore: —

Calculated bore volume *3: litres

Est. discharge rate: 0.1 l/s

Required purge time: min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				09:45	0950	10:00	10:05		10:10.
Temp	°C	YSI Pro Plus	± 0.5 °C	17.9	17.3	17.3	17.3		17.4
Cond	µScm⁻¹		± 3 %	760.1	760.1	760.1	760.1		760.1
DO	%			74.3	72.0	72.2	72.1		71.6
DO	mg/l		± 0.3 mg/L	7.05	6.90	6.93	6.89		6.87.
pH			± 0.1 pH Unit	7.43	7.08	6.98	6.93		6.92

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Analysis: ☐ Routine Chemical ☐ Bacteria
☐ Pesticide ☐ Additional

Comments:
SAMPLED FROM TAP OUT CYLINDER cylinder small / ~10L
Purge ~~for~~ time of cylinder — 1min.
Bore depth 6.44m. — CANT DIP or Measure bore - ~~bet~~ cap below ground lcve

PAX 4

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/1126.	FOREST	

Screen: - m / - m

Depth: m

Location: Behind garage in pump shed

Contact Details: MAGGY FOREST - 021 189 0326.

Collection Instructions:
collected from tap outside pump shed (unfilered tap).

GPS Coordinates :

MP:

MP R/L:

Fitting Required:

Date: 17/3/10

Collected by: SAM. W

Time: 11:50 NZST / [✓ NZDT]

Bore w/l: ______ mm above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No

Time pump on: Pump running since morning

Depth of water: ______

Diameter Bore: ______

Calculated bore volume *3: ______ litres

Est. discharge rate: ______ l/s

Required purge time: ______ min

Sample Appearance at commencement of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Parameter	Units	Meter	Criteria	Start Time	Intermediate Times				Final Time
				11:35	11:40	11:45			11:50
Temp	°C	Pro Plus	± 0.5 °C	14.8	14.9	14.9			15.0
Cond	µScm^{-1}	YSI	± 3 %	759.6	759.6	759.6			759.4
DO	%			1.3	0.9	0.05			0.4
DO	mg/l		± 0.3 mg/L	0.13	0.09	0.06			0.04
pH			± 0.1 pH Unit	7.11	7.11	7.13			7.13

Sample Appearance at completion of Pumping:
[✓ Clear] / Turbid [✓ Colourless] / Colour ______ [✓ Odourless] / Odour ______

Analysis: ☐ Routine Chemical ☐ Pesticide ☐ Bacteria ☐ Additional ______

Comments:
Bore depth. 15m
Casing - 300mm above ground.
Diameter. 160mm

consignment #.
58997.

Bore #	NAME	CONTACT	#	DAY.	Consignment #
S26/0244	St [illegible]	Duncan -	h[illegible] lumber office	MONDAY	58999
R50L 45	Lowes Bush.	Richard	—	Monday	
S26/0299	Graham	Graham.	? 063778218	Monday	
S26/0233	Nicolson.	Elizabeth Nicolson.	027226 2556.	Monday	
S26/0235.	Simpson	Vicky Simpson	0274462839	Monday	
S26/0316.	McEwen	0	06377458	Tuesday	59000
Parkvale Trib @ Railway.	—	—	—	Tuesday	
Corner Perry & east Taratahi.	—	—		Tes.	
Parkvale stream East Taratahi	—	—			
SH2 Ravensdown					
S26/0254	Tulloch.			wed	58998
S26/0265			021763 304	wed Wed.	
T26/0302	McMillan	Kim McMillan	06 378 8690.		
S26/1126	Fores.	Maggy forest	021 189 0326.	Thu'	58997
S26/0277.	Snow.	Joan snow	377 4941	Thu	

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

	S26/0310	

Screen: - m / - m

Depth: 3 m

Diameter: mm

Location:

Contact Details:

Collection Instructions:

Grid ref:

MP:

MP R/L:

Use:

Fitting Required: 12v pump

Date: 8/12/16

Collected By: KP

Time: 14:13 **NZST**

Bore w/l: 1880 **mm** above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No

Time pump on: 13:56

Calculated bore volume *3: 44 litres 165L

Est. discharge rate: ·25 l/s

Required purge time: 11 min

Sample Appearance at commencement of pumping:

[✓ Clear]/Turbid [✓ Colourless]/Colour Odourless/[✓ Odour] slight organic

Parameter	Unit	Meter	Criteria	Start Time	Intermediate Times				Final Time
				13:58	14.03	14:08			14:13
Temp	°C	Ysipro+	± 0.5°C	13.8	13.9	13.9			13.9
SP Cond	μScm^{-1}	↓	± 3%	168.4	166.0	166.5			168.9
DO	%	↓		14.4	17.0	14.7			9.6
DO	Mg/l	↓	±0 .3mg/L	1.49	1.65	1.49			0.90
pH		↓	± 0.1 pH Unit	5.38	5.37	5.35			5.3

Sample Appearance at completion of pumping:

Clear/Turbid Colourless/Colour [✓ Odourless]/Odour

Analysis:

☐ Routine Chemical

☐ Pesticide

☐ Bacteria

☒ Additional

Comments:

Water level after pumping 2500mm

GW GROUNDWATER STATE OF ENVIRONMENT FIELD SHEET

S26/0264

Screen: - m / - m

Depth: 3.1 m

Diameter: mm

Location:

Contact Details:

Collection Instructions:

Grid ref:

MP:

MP R/L:

Use:

Fitting Required: 12v pump

Date: 8/12/16

Collected By: KP

Time: NZST

Bore w/l: 2340 **mm** above/below MP

Pump on: [✓ Yes] / No

Time pump on: 12:55

Calculated bore volume *3: 45 litres 112L

Est. discharge rate: .25 l/s

Volume ÷ Rate ÷ 60 =

Required purge time: 8 min

Sample Appearance at commencement of pumping:

[✓ Clear] / Turbid w/ wires Colourless / [✓ Colour] Odourless / [✓ Odour] organic

Parameter	Unit	Meter	Criteria	Start Time	Intermediate Times				Final Time
				12:57	13:02	13:07			13:12
Temp	°C	Ysi pro+	± 0.5°C	13.9	13.9	13.9			13.9
SpCond	µScm^{-1}	↓	± 3%	166.1	165.8	165.8			166.0
DO	%	↓		14.4	11.4	12.7			12.4
DO	Mg/l	↓	±0 .3mg/L	1.51	1.18	1.16			1.24
pH		↓	± 0.1 pH Unit	6.21	5.66	5.63			5.62

Sample Appearance at completion of pumping:

[✓ Clear] / Turbid [✓ Colourless] / Colour [✓ Odourless] / Odour

Analysis:

☐ Routine Chemical

☐ Pesticide

☐ Bacteria

☒ Additional

Comments:

Water level after pumping =

Some gas in water

recharged well + no drop in flow rate.

	S26/0286	

Screen: - m / - m

Depth: 3.13m A w/L 2.42m

Diameter: 220 mm

Location: paddock behind pond 8.3m W of stream

Contact Details: Diane Liang

Collection Instructions: 12v pump used.

Grid ref:

MP:

MP R/L:

Use:

Fitting Required:

Date: 27/9/16

Collected By: KP + LA

Time: 10:55 **NZST**

Bore w/l: 710 **mm** above/below MP

Volume ÷ Rate ÷ 60 =

Pump on: [✓ Yes] / No

Time pump on: 1022

Calculated bore volume *3: 297 litres

Est. discharge rate: ·16 l/s

Required purge time: ~~28~~ 32 min

Sample Appearance at commencement of pumping:

[✓ Clear]/Turbid [✓ Colourless]/Colour [✓ Odourless]/Odour

Parameter	Unit	Meter	Criteria	Start Time	Intermediate Times				Final Time
				10:26	10:31	10:36	10:41	10:48	10:55
Temp	°C	Ysipro+	± 0.5°C	12.0	12.0	12.0	12.1	12.0	11.9
SP Cond	µScm⁻¹		± 3%	149.5	149.3	149.0	148.9	148.8	148.6
DO	%			62.3	60.7	59.8	60.5	59.9	59.8
DO	Mg/l		±0 .3mg/L	6.59	6.44	6.34	6.40	6.34	6.34
pH			± 0.1 pH Unit	5.77	5.62	5.59	5.59	5.58	5.58

Sample Appearance at completion of pumping:

[✓ Clear]/Turbid [✓ Colourless]/Colour [✓ Odourless]/Odour

Analysis:

☐ Routine Chemical
☐ Pesticide
☐ Bacteria
☐ Additional

Comments: Some gas in water

Consignment # 64335

Morgan	S26/0889	

Screen: - m / - m

Grid ref:

Depth: 8·2m

A w/L 6·26m

MP: 370mm high

Diameter: 150 mm

MP R/L:

Use:

Location: Morgan
E Toratahi rd

Fitting Required:

Contact Details:

Collection Instructions: 12v pump.

Date: 27/09/16

Pump on: [✓ Yes] / No

Collected By: KP + LA

Time pump on: 11:37

Time: 12:18 NZST

Calculated bore volume *3: 333 litres

Bore w/l: 1920 mm above/below MP

Est. discharge rate: ·16 l/s

Volume ÷ Rate ÷ 60 =

Required purge time: 35 min

Sample Appearance at commencement of pumping:

Clear/[✓ Turbid] w/ fines Colourless/[✓ Colour] rust orange [✓ Odourless]/Odour

Parameter	Unit	Meter	Criteria	Start Time	Intermediate Times				Final Time
				11:40	11:48	11:54	12:02	12:10	12:18
Temp	°C	YSIpro+	± 0.5°C	13.0	13.0	12.9	13.0	13.1	12.9
sp Cond	μScm^{-1}	↓	± 3%	205.1	205.7	205.7	206.1	2065	206.7
DO	%			72.4	81.8	84.3	84.8	858	86.2
DO	Mg/l		±0 .3mg/L	7.49	8.47	8.73	8.79	8.86	8.94
pH			± 0.1 pH Unit	5.93	5.91	5.90	5.90	5.90	5.90

water clearer | reasonably clear

Sample Appearance at completion of pumping:

[✓ Clear]/Turbid [✓ Colourless]/Colour [✓ Odourless]/Odour

Analysis:

☐ Routine Chemical

☐ Pesticide

☐ Bacteria

☐ Additional

Comments:

More discoloured @ 11:44

11:57 – Water clear.

final water level 1·94m.

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALYSIS REQUEST

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALAND

Job No: **155 1869** Date Recv: 15-Mar-16 05:37
Received by: Jennifer Singlewood
3115518698

Client
Name Greater Wellington Regional Council 11449
Address C/- Accounts, PO Box 11646
Wellington 6142
Phone 04 384 5708 Fax 04 385 6960
Client Reference Waingawa study (GW and SW)
Quote No 74984 Order No 219590

Primary Contact S Tidswell 131619
Submitted By S Tidswell 131619
Charge To Greater Wellington Regional Council 11449

Results To ☐ *Mail Primary Contact* ☐ *Mail Submitter*
☐ *Fax Results*
☐ *Email Results*

Office use *Job No:*

CHAIN OF CUS

Sent to Hill Laboratories
☐ *Please tick if you require COC to be emailed back*
Date & Time: 14/3/16
Name: SAM. W
Signature:

Received at Hill Laboratories
Date & Time: 15/03/2016 10:46
Name:
Signature:

Condition ☐ *Room Temp* ☐ *Chilled* ☐ *Frozen*
Temp: 0.3

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

Consignment no: 58999

Priority ☐ **Low** ☑ **Normal** ☐ **High**
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 8 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW), Surface Water (SW)

No.	*Sample Name*	*Sample Date/Time*	*Sample Type*	*Tests Required*
1	Groundwater		GW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4N, NO2N, NOxN, DRP, Silica, SO4, TKN, TP
2	Surface water		SW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4Nt, NO2Nt, NOxNt, DRPt, Silica, SO4, TKN, TP
3	S26/0235		GW	
4	RSOE 45		SW	
5	S26/0299		GW	
6	WAINGAWA SPRING		SW/GW	
7	S26/0223		GW	
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

Job Information Summary

Page 1 of 2

Client: Greater Wellington Regional Council
Contact: S Tidswell
C/- Greater Wellington Regional Council
C/- Accounts
PO Box 11646
Wellington 6142

Lab No: 1551869
Date Registered: 15-Mar-2016 10:46 am
Priority: Normal
Quote No: 74984
Order No: 219590
Client Reference: Waingawa study (GW and SW)
Add. Client Ref: Consignment No:58999
Submitted By: S Tidswell
Charge To: Greater Wellington Regional Council
Target Date: 29-Mar-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	S26/0235 14-Mar-2016 4:00 pm	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	RSOE 45 Lowes Bus 14-Mar-2016 1:30 pm	Surface Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N Trace; Nitrite-N Trace; Nitrate-N + Nitrite-N Trace; Dissolved Reactive Phosphorus (trace); Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
3	S26/029G 14-Mar-2016 10:50 am	Ground Water	UP1L, S250, TOC125, UPF100, cFN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
4	Waingawa Spring 14-Mar-2016 9:45 am	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
5	S26/0223 14-Mar-2016 11:10 am	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-5
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
pH	pH meter. APHA 4500-H$^+$ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-5
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1, 3-5
Total Ammoniacal-N Trace	Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH_3 H 22nd ed. 2012.	0.005 g/m^3	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1, 3-5
Nitrite-N Trace	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1, 3-5
Nitrate-N + Nitrite-N Trace	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-5
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1, 3-5
Dissolved Reactive Phosphorus (trace)	Filtered sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-5
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-5
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-5

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALYSIS

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALAND

Job No: **155 2621**
Date Recv: 16-Mar-16 05:35
Received by: Jennifer Singlewood

Office use *Job No:* 3115526214

Client
Name Greater Wellington Regional Council 11449
Address C/- Accounts, PO Box 11646
Wellington 6142
Phone 04 384 5708 *Fax* 04 385 6960
Client Reference Waingawa study (GW and SW)
Quote No 74984 *Order No* 219590

Primary Contact S Tidswell 131619
Submitted By S Tidswell 131619
Charge To Greater Wellington Regional Council 11449

Results To ☐ *Mail Primary Contact* ☐ *Mail Submitter*
☐ *Fax Results*
☐ *Email Results*

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ *Please tick if you require COC to be emailed back*
Date & Time: 15/3/16 16:30
Name: SAM. W
Signature:

Received at Hill Laboratories
Date & Time: 16/03/2016 11:28
Name: Doris
Signature:

Condition
☐ *Room Temp* ☐ *Chilled* ☐ *Frozen*
Temp: 4·1

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

Consignment no: 59000

Priority ☐ **Low** ☑ **Normal** ☐ **High**
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 8 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW), Surface Water (SW)

No.	*Sample Name*	*Sample Date/Time*	*Sample Type*	*Tests Required*
1	Groundwater		GW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4N, NO2N, NOxN, DRP, Silica, SO4, TKN, TP
2	Surface water		SW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4Nt, NO2Nt, NOxNt, DRPt, Silica, SO4, TKN, TP
3	PARKVALE STREAM - EAST TARATAHI ROAD	15/3/16 12:05		
4	CORNER PERRI EAST TARATAHI ROAD	15/3/16 14:30		
5	PARKVALE TRIB - RAILWAY	15/3/16 11:25		
6	S26/0316	15/3/16 10:50		
7	~~PA~~ SH2 @ RAVENSDOWN	15/3/16 13:15		
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz

Job Information Summary

Client: Greater Wellington Regional Council
Contact: S Tidswell
C/- Greater Wellington Regional Council
C/- Accounts
PO Box 11646
Wellington 6142

Lab No: 1552621
Date Registered: 16-Mar-2016 11:17 am
Priority: Normal
Quote No: 74984
Order No: 219590
Client Reference: Waingawa study (GW and SW)
Add. Client Ref: 59000
Submitted By: S Tidswell
Charge To: Greater Wellington Regional Council
Target Date: 30-Mar-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	Parkvale Stream - East Taratahi Road 15-Mar-2016 3:05 pm	Surface Water	UP1L, S250, FN100, UPF100, TOC125	Total Nitrogen; Nitrate-N; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; Chloride; Total Ammoniacal-N Trace; Nitrite-N Trace; Nitrate-N + Nitrite-N Trace; Dissolved Reactive Phosphorus (trace); Reactive Silica; Sulphate; Total Organic Carbon (TOC); pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	Corner Perrry East Taratahi Road 15-Mar-2016 2:30 pm	Surface Water	UP1L, S250, FN100, UPF100, cTOC125	Total Nitrogen; Nitrate-N; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; Chloride; Total Ammoniacal-N Trace; Nitrite-N Trace; Nitrate-N + Nitrite-N Trace; Dissolved Reactive Phosphorus (trace); Reactive Silica; Sulphate; Total Organic Carbon (TOC); pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
3	Parkvale Trib - Railway 15-Mar-2016 11:25 am	Surface Water	UP1L, S250, FN100, UPF100, TOC125	Total Nitrogen; Nitrate-N; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; Chloride; Total Ammoniacal-N Trace; Nitrite-N Trace; Nitrate-N + Nitrite-N Trace; Dissolved Reactive Phosphorus (trace); Reactive Silica; Sulphate; Total Organic Carbon (TOC); pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
4	S26/0316 15-Mar-2016 10:50 am	Ground Water	UP1L, S250, FN100, UPF100, TOC125	Total Nitrogen; Nitrate-N; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Total Organic Carbon (TOC); pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
5	SH2 @ Ravensdown 15-Mar-2016 1:15 pm	Surface Water	UP1L, S250, FN100, UPF100, cTOC125	Total Nitrogen; Nitrate-N; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; Chloride; Total Ammoniacal-N Trace; Nitrite-N Trace; Nitrate-N + Nitrite-N Trace; Dissolved Reactive Phosphorus (trace); Reactive Silica; Sulphate; Total Organic Carbon (TOC); pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-5
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-5
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	4
Total Ammoniacal-N Trace	Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH_3 H 22nd ed. 2012.	0.005 g/m^3	1-3, 5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrite-N Trace	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-3, 5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N + Nitrite-N Trace	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-3, 5
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-5
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Reactive Phosphorus (trace)	Filtered sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-3, 5
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-5
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-5
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-5

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALY

R J Hill Laboratories Lt
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW Z

2000
2001
co.nz
co.nz

Job No: **155 3389** Date Recv: 17-Mar-16 05:34
Received by: Jennifer Singlewood
3115533891

Office use

Client
Name Greater Wellington Regional Council 11449
Address C/- Accounts, PO Box 11646
Wellington 6142
Phone 04 384 5708 *Fax* 04 385 6960
Client Reference Waingawa study (GW and SW)
Quote No 74984 *Order No* 219590

Primary Contact S Tidswell 131619
Submitted By S Tidswell 131619
Charge To Greater Wellington Regional Council 11449

Results To ☐ *Mail Primary Contact* ☐ *Mail Submitter*
☐ *Fax Results*
☐ *Email Results*

ADDITIONAL INFORMATION

consignment no: 58998

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ *Please tick if you require COC to be emailed back*
Date & Time: 16/3/16. 15:30
Name: SAM WARREN
Signature:

Received at Hill Laboratories
Date & Time: 17.3.16 10:44
Name: Kat Prendergast
Signature:

Condition
☐ *Room Temp* ☐ *Chilled* ☐ *Frozen*
Temp: 2.3

☐ Sample & Analysis details checked
Signature:

Priority ☐ **Low** ☑ **Normal** ☐ **High**
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 8 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW), Surface Water (SW)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	Groundwater		GW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4N, NO2N, NOxN, DRP, Silica, SO4, TKN, TP
2	Surface water		SW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4Nt, NO2Nt, NOxNt, DRPt, Silica, SO4, TKN, TP
3	S26/0254	16/3/16 12:15 NZDT.	GW.	As specified by Sheree Tidswell GW SoE standard
4	S26/0265	16/3/16 10:08 NZDT	GW	
5	T26/0302	16/3/16 12:00 NZDT.	GW:	
6				
7				
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

Job Information Summary

Page 1 of 2

Client: Greater Wellington Regional Council
Contact: S Tidswell
C/- Greater Wellington Regional Council
C/- Accounts
PO Box 11646
Wellington 6142

Lab No: 1553389
Date Registered: 17-Mar-2016 10:47 am
Priority: Normal
Quote No: 74984
Order No: 219590
Client Reference: Waingawa study (GW and SW)
Add. Client Ref: Consignment No:58998
Submitted By: S Tidswell
Charge To: Greater Wellington Regional Council
Target Date: 24-Mar-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	S26/0254 16-Mar-2016 12:15 pm	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	S26/0265 16-Mar-2016 10:08 am	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
3	T26/0302 16-Mar-2016 1:00 pm	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-3
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-3
pH	pH meter. APHA 4500-H$^+$ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-3
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-3
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-3
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-3
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-3
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-3
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-3
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-3
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-3

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALYSIS REQUEST

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALAND

Job No: **155 4073**
Date Recv: 18-Mar-16 05:33
Received by: Jennifer Singlewood

3115540732

Client
Name Greater Wellington Regional Council 11449
Address C/- Accounts, PO Box 11646
Wellington 6142
Phone 04 384 5708 Fax 04 385 6960
Client Reference Waingawa study (GW and SW)
Quote No 74984 Order No 219590

Primary Contact S Tidswell 131619
Submitted By S Tidswell 131619
Charge To Greater Wellington Regional Council 11449

Results To ☐ Mail Primary Contact ☐ Mail Submitter
☐ Fax Results
☐ Email Results

Office use *Job No*

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ *Please tick if you require COC to be emailed back*
Date & Time: 17/3/16 14:00
Name: SAM CW
Signature:

Received at Hill Laboratories
Date & Time: 18/3/16 10:44
Name: Ron Pendergast
Signature:

Condition ☐ *Room Temp* ☐ *Chilled* ☐ *Frozen*
Temp: 10.2

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

Consignment no: 5899T

Priority ☐ Low ☑ Normal ☐ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 8 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW), Surface Water (SW)

No.	*Sample Name*	*Sample Date/Time*	*Sample Type*	*Tests Required*
1	Groundwater		GW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4N, NO2N, NOxN, DRP, Silica, SO4, TKN, TP
2	Surface water		SW	TN, NO3N, TOC, pH, EC, Alk, CaDt, MgDt, K_Dt, NaDt, Cl, NH4Nt, NO2Nt, NOxNt, DRPt, Silica, SO4, TKN, TP
3	S26/0271	17/3/16 9:40 NZDT	GW	
4	S26/1126.	17/3/16 11:10 NZDT	GW	
5				
6				
7				
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

Job Information Summary

Client:	Greater Wellington Regional Council	**Lab No:**	1554073
Contact:	S Tidswell C/- Greater Wellington Regional Council C/- Accounts PO Box 11646 Wellington 6142	**Date Registered:**	18-Mar-2016 10:47 am
		Priority:	Normal
		Quote No:	74984
		Order No:	219590 J
		Client Reference:	Waingawa study (GW and SW)
		Add. Client Ref:	
		Submitted By:	S Tidswell
		Charge To:	Greater Wellington Regional Council
		Target Date:	29-Mar-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	S26/0277 17-Mar-2016 10:10 am	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	S26/1126 17-Mar-2016 11:50 am	Ground Water	UP1L, S250, TOC125, UPF100, FN100	Total Nitrogen; Nitrate-N; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrite-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Reactive Silica; Sulphate; Dissolved Calcium; Dissolved Magnesium; Dissolved Potassium; Dissolved Sodium; pH; Electrical Conductivity (EC); Total Alkalinity; Total Kjeldahl Nitrogen (TKN); Total Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2
pH	pH meter. APHA 4500-H$^+$ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl$^-$ E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

Hill Laboratories
BETTER TESTING BETTER RESULTS

ANALYSIS

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALAND

Job No: **165 5530**
Date Recv: 28-Sep-16 05:36
Received by: Lisa Bailey
3116555305

Client
Name Greater Wellington Regional Council 11449
Address C/- Accounts, PO Box 11646
Wellington 6142
Phone 04 384 5708 Fax 04 385 6960
Client Reference Waingawa bores
Quote No 80146 Order No

Primary Contact Kasey Pitt 219949
Submitted By Kasey Pitt 219949
Charge To Greater Wellington Regional Council 11449
Results To ☐ Mail Primary Contact ☐ Mail Submitter
☐ Fax Results
☐ Email Results

Office use Job No:

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ Please tick if you require COC to be emailed back
Date & Time: 27/9/16
Name: KP
Signature: Kasey

Received at Hill Laboratories
Date & Time: 29/9/16 1356
Name: Shar Murray
Signature:

Condition
☐ Room Temp ☐ Chilled ☐ Frozen
Temp: 2.3

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

Consignment #
64335

Priority ☐ Low ☑ Normal ☐ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)
NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types
Ground Water (GW)

Requested Reporting Date:

all samples collected 27/09/16 NZST

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
~~1~~	~~S26/0285~~		GW	TN, Cl, ~~NH4N, NOxN, DRP, TOC, TKN~~, TP
~~2~~	~~S26/0264~~		GW	~~TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP~~
3	~~S26/0312~~		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
~~4~~	S26/0283		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
5	S26/0286 laing	10:55	GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
~~6~~	~~S26/0313~~		GW	~~TN, Cl, NH4N, NOxN, DRP, TOC, TKN~~, TP
7	S26/0889 ~~Extra~~ Morgan	12:18	GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz

Job Information Summary

Page 1 of 1

Client: Greater Wellington Regional Council
Contact: Kasey Pitt
C/- Greater Wellington Regional Council
C/- Accounts
PO Box 11646
Wellington 6142

Lab No: 1655530
Date Registered: 28-Sep-2016 1:56 pm
Priority: Normal
Quote No: 80146
Order No: 225109
Client Reference: Waingawa bores
Add. Client Ref: Consignment number: 64335
Submitted By: Kasey Pitt
Charge To: Greater Wellington Regional Council
Target Date: 05-Oct-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	S26/0286 Laing 27-Sep-2016 10:55 am	Ground Water	S250, UP250, TOC125, UPF100	Total Nitrogen; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	S26/0889 Morgan 27-Sep-2016 12:18 pm	Ground Water	S250, UP250, TOC125, UPF100	Total Nitrogen; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Total Kjeldahl Nitrogen (TKN); Total Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALYSI

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALAND
Web.

Job No:
169 4171
Date Recv: 09-Dec-16 05:40
Received by: Lisa Bailey
3116941719

Client
Name: Greater Wellington Regional Council 11449
Address: C/- Accounts, PO Box 11646
Wellington 6142
Phone: 04 384 5708 Fax: 04 385 6960
Client Reference: Waingawa bores
Quote No: 80146 Order No:
Primary Contact Kasey Pitt 219949
Submitted By Kasey Pitt 219949
Charge To Greater Wellington Regional Council 11449
Results To ☐ Mail Primary Contact ☐ Mail Submitter
☐ Fax Results
☐ Email Results

Office use Job No:

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ Please tick if you require COC to be emailed back
Date & Time: 8/12/16
Name: KP
Signature: Kasey Pitt

Received at Hill Laboratories
Date & Time: 09/12/16 1321
Name: Kris Workman
Signature:

Condition
☐ Room Temp ☐ Chilled ☐ Frozen
Temp: 4.1

☐ Sample & Analysis details checked
Signature:

Priority ☐ Low ☑ Normal ☐ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

ADDITIONAL INFORMATION

Consignment number #64342

Quoted Sample Types

Requested Reporting Date:

Ground Water (GW) Samples collected 8/12/16 NEST

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	S26/0285		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
2	S26/0264	13:12	GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
3	S26/0312		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
4	S26/0283		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
5	S26/0286		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
6	S26/0313		GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
7	Extra S26/0310	14:13	GW	TN, Cl, NH4N, NOxN, DRP, TOC, TKN, TP
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

Job Information Summary

Page 1 of 1

Client:	Greater Wellington Regional Council	**Lab No:**	1694171
Contact:	Kasey Pitt	**Date Registered:**	09-Dec-2016 1:20 pm
	C/- Greater Wellington Regional Council	**Priority:**	Normal
	C/- Accounts	**Quote No:**	80146
	PO Box 11646	**Order No:**	225109
	Wellington 6142	**Client Reference:**	Waingawa bores
		Add. Client Ref:	Consignment Number #64342
		Submitted By:	Kasey Pitt
		Charge To:	Greater Wellington Regional Council
		Target Date:	16-Dec-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	S26/0264 08-Dec-2016 1:12 pm	Ground Water	S250, UP250, TOC125, UPF100	Total Nitrogen; Total Organic Carbon (TOC); Chloride; Total Ammoniacal-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus; Total Kjeldahl Nitrogen (TKN); Total Phosphorus
2	S26/0310 08-Dec-2016 2:13 pm	Ground Water	S250, UP250, TOC125, cUPF100	Total Nitrogen; Total Organic Carbon (TOC); Total Kjeldahl Nitrogen (TKN); Total Phosphorus; Chloride; Total Ammoniacal-N; Nitrate-N + Nitrite-N; Dissolved Reactive Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

XXXX

HORIZONS REGIONAL COUNCIL
HANDHELD METER CALIBRATION FORM

horizons regional council

Meter ID:	Ysi prot	**Date:**	27/9/16
Staff Member:	KP	**Time:**	06:10 NZST
Run Name:	Waignawa additional		

BAROMETRIC PRESSURE CHECKS

Handheld Meter Reading:	mbar
Manawatu at Victoria Avenue:	mbar

3 POINT pH CALIBRATION

	Calibration Value	Temperature	mV pH Value
pH 7 (calibration)	6 91	17.0 °C	-32.4
pH 4 (calibration)	3.97	17.0 °C	139.2
pH 10 (calibration)	9.89	16.9 °C	-205.6

CONDUCTIVITY CALIBRATION

	Specific Conductivity	Temperature
0.001M handheld reading	µs/cm	°C
0.01M calibration value	1211 µs/cm	16.9 °C
0.001M handheld reading	µs/cm	°C

Pass Calibration 0.001M check value is between 120-175 µs/cm

Y / N

DISSOLVED OXYGEN CALIBRATION

DO% (after calibration)	99.8 %	Temperature
DO mg/L (after calibration)	mg/L	16.7 °C

Pass Calibration 99.7%-100.3%

Y / N

ORP CALIBRATION

	Calibration ORP Value	Temperature
ORP (Calibration)	mV	°C

END OF DAY CHECKS

Staff Member:	KP	**Time:**	16:23 NZST

	Handheld	Temperature	Allowable Range	Passed
pH				
pH 7 Buffer	7.03	17.3 °C	6.80 -7.20	[✓ Y] / N
Specific Conductivity	Handheld	Temperature	Allowable Range	
0.001M	1242 µs/cm	17.3 °C	120 - 175	[✓ Y] / N
ORP	Handheld	Temperature	Allowable Range	
ORP Check	mV	°C	200 - 280	Y / N

COMMENTS:

Appendix B

Laboratory Reports

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1551869 SUPv1
Contact:	Philippa Crisp	**Date Registered:**	15-Mar-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	23-Mar-2016
	C/- Accounts	**Quote No:**	74984
	PO Box 11646	**Order No:**	219590
	Wellington 6142	**Client Reference:**	Waingawa study (GW and SW)
		Add. Client Ref:	Consignment No:58999
		Submitted By:	S Tidswell

Sample Type: Aqueous

Sample Name:		S26/0235 14-Mar-2016 4:00 pm	RSOE 45 Lowes Bus 14-Mar-2016 1:30 pm	S26/029G 14-Mar-2016 10:50 am	Waingawa Spring 14-Mar-2016 9:45 am
Lab Number:		1551869.1	1551869.2	1551869.3	1551869.4
pH	pH Units	6.6 ± 0.2	6.8 ± 0.2	6.3 ± 0.2	6.0 ± 0.2
Total Alkalinity	g/m^3 as $CaCO_3$	22.2 ± 1.2	28.7 ± 1.4	13.30 ± 0.85	12.30 ± 0.83
Electrical Conductivity (EC)	mS/m	11.1 ± 0.3	18.6 ± 0.4	11.2 ± 0.3	11.0 ± 0.3
Dissolved Calcium	g/m^3	6.66 ± 0.42	11.40 ± 0.72	7.53 ± 0.48	6.98 ± 0.44
Dissolved Magnesium	g/m^3	2.35 ± 0.16	4.05 ± 0.28	2.56 ± 0.18	2.31 ± 0.16
Dissolved Potassium	g/m^3	2.63 ± 0.20	5.56 ± 0.41	1.044 ± 0.083	1.40 ± 0.11
Dissolved Sodium	g/m^3	9.3 ± 1.0	13.8 ± 1.5	7.88 ± 0.85	8.28 ± 0.89
Chloride	g/m^3	9.89 ± 0.69	11.88 ± 0.79	9.21 ± 0.65	9.50 ± 0.67
Total Nitrogen	g/m^3	1.81 ± 0.22	5.82 ± 0.74	4.32 ± 0.52	4.40 ± 0.52
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	< 0.005 ± 0.0034	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrite-N	g/m^3	< 0.002 ± 0.0014	0.00266 ± 0.00078	< 0.002 ± 0.0014	< 0.002 ± 0.0014
Nitrate-N	g/m^3	1.72 ± 0.21	5.53 ± 0.74	4.22 ± 0.51	4.23 ± 0.51
Nitrate-N + Nitrite-N	g/m^3	1.72 ± 0.21	5.53 ± 0.74	4.22 ± 0.51	4.23 ± 0.51
Total Kjeldahl Nitrogen (TKN)	g/m^3	< 0.10 ± 0.067	0.287 ± 0.069	0.101 ± 0.067	0.169 ± 0.068
Dissolved Reactive Phosphorus	g/m^3	0.0245 ± 0.0044	0.0145 ± 0.0014	0.0245 ± 0.0044	0.0165 ± 0.0036
Total Phosphorus	g/m^3	0.0265 ± 0.0046	0.0175 ± 0.0036	0.0215 ± 0.0040 [#1]	0.0145 ± 0.0034 [#1]
Reactive Silica	g/m^3 as SiO_2	13.28 ± 0.28	17.72 ± 0.37	13.87 ± 0.29	15.11 ± 0.31
Sulphate	g/m^3	6.64 ± 0.53	12.38 ± 0.82	7.63 ± 0.58	6.72 ± 0.53
Total Organic Carbon (TOC)	g/m^3	0.9 ± 1.8	2.3 ± 1.9	0.8 ± 1.4	< 0.5 ± 2.0

Sample Name:		S26/0223 14-Mar-2016 11:10 am			
Lab Number:		1551869.5			
pH	pH Units	6.1 ± 0.2	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	17.90 ± 0.98	-	-	-
Electrical Conductivity (EC)	mS/m	20.0 ± 0.5	-	-	-
Dissolved Calcium	g/m^3	12.49 ± 0.79	-	-	-
Dissolved Magnesium	g/m^3	5.79 ± 0.39	-	-	-
Dissolved Potassium	g/m^3	1.223 ± 0.095	-	-	-
Dissolved Sodium	g/m^3	13.4 ± 1.5	-	-	-
Chloride	g/m^3	15.7 ± 1.0	-	-	-
Total Nitrogen	g/m^3	9.9 ± 1.2	-	-	-
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	-	-	-
Nitrite-N	g/m^3	< 0.002 ± 0.0014	-	-	-
Nitrate-N	g/m^3	9.9 ± 1.2	-	-	-
Nitrate-N + Nitrite-N	g/m^3	9.9 ± 1.2	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	< 0.10 ± 0.067	-	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0215 ± 0.0041	-	-	-

Sample Type: Aqueous

Sample Name:		S26/0223 14-Mar-2016 11:10 am			
Lab Number:		1551869.5			
Total Phosphorus	g/m^3	0.0185 ± 0.0037 [#1]	-	-	-
Reactive Silica	g/m^3 as SiO_2	17.21 ± 0.36	-	-	-
Sulphate	g/m^3	12.46 ± 0.83	-	-	-
Total Organic Carbon (TOC)	g/m^3	< 0.5 ± 1.6	-	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

[#1] It has been noted that the result for Dissolved Reactive Phosphorus was greater than that for Total Phosphorus, but within the analytical variation of these methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-5
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-5
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-5
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1, 3-5
Total Ammoniacal-N Trace	Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH_3 H 22nd ed. 2012.	0.005 g/m^3	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1, 3-5
Nitrite-N Trace	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1, 3-5
Nitrate-N + Nitrite-N Trace	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1, 3-5
Dissolved Reactive Phosphorus (trace)	Filtered sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-5
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-5
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1552621 SUPv1
Contact:	Philippa Crisp	**Date Registered:**	16-Mar-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	24-Mar-2016
	C/- Accounts	**Quote No:**	74984
	PO Box 11646	**Order No:**	219590
	Wellington 6142	**Client Reference:**	Waingawa study (GW and SW)
		Add. Client Ref:	59000
		Submitted By:	S Tidswell

Sample Type: Aqueous

Sample Name:		Parkvale Stream - East Taratahi Road 15-Mar-2016 3:05 pm	Corner Perrry East Taratahi Road 15-Mar-2016 2:30 pm	Parkvale Trib - Railway 15-Mar-2016 11:25 am	S26/0316 15-Mar-2016 10:50 am
Lab Number:		1552621.1	1552621.2	1552621.3	1552621.4
pH	pH Units	7.6 ± 0.2	7.1 ± 0.2	7.0 ± 0.2	6.2 ± 0.2
Total Alkalinity	g/m^3 as $CaCO_3$	21.5 ± 1.1	20.5 ± 1.1	33.9 ± 1.6	15.10 ± 0.90
Electrical Conductivity (EC)	mS/m	7.0 ± 0.2	6.6 ± 0.2	11.2 ± 0.3	14.4 ± 0.3
Dissolved Calcium	g/m^3	5.80 ± 0.37	6.24 ± 0.40	8.16 ± 0.52	8.64 ± 0.55
Dissolved Magnesium	g/m^3	1.399 ± 0.095	0.993 ± 0.068	2.43 ± 0.17	3.31 ± 0.23
Dissolved Potassium	g/m^3	1.197 ± 0.094	1.156 ± 0.091	1.65 ± 0.13	2.43 ± 0.18
Dissolved Sodium	g/m^3	5.47 ± 0.59	4.80 ± 0.52	8.19 ± 0.88	9.01 ± 0.97
Chloride	g/m^3	5.94 ± 0.50	5.18 ± 0.47	10.99 ± 0.75	11.84 ± 0.79
Total Nitrogen	g/m^3	0.255 ± 0.068	0.393 ± 0.070	0.885 ± 0.081	6.29 ± 0.75
Total Ammoniacal-N	g/m^3	0.0071 ± 0.0035	0.0234 ± 0.0051	0.192 ± 0.033	< 0.010 ± 0.0067
Nitrite-N	g/m^3	0.00110 ± 0.00068	0.00136 ± 0.00069	0.00471 ± 0.0010	< 0.002 ± 0.0014
Nitrate-N	g/m^3	0.0043 ± 0.0012	0.0121 ± 0.0021	0.0170 ± 0.0032	6.21 ± 0.75
Nitrate-N + Nitrite-N	g/m^3	0.00540 ± 0.00097	0.0135 ± 0.0020	0.0218 ± 0.0030	6.21 ± 0.75
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.249 ± 0.068	0.379 ± 0.070	0.863 ± 0.081	< 0.10 ± 0.067
Dissolved Reactive Phosphorus	g/m^3	0.0152 ± 0.0015	0.00638 ± 0.00086	0.0192 ± 0.0018	0.0220 ± 0.0042 [#1]
Total Phosphorus	g/m^3	0.0340 ± 0.0055	0.0310 ± 0.0051	0.096 ± 0.014	0.0200 ± 0.0039 [#1]
Reactive Silica	g/m^3 as SiO_2	1.544 ± 0.074	3.138 ± 0.092	10.25 ± 0.22	16.62 ± 0.34
Sulphate	g/m^3	2.94 ± 0.39	3.45 ± 0.40	3.75 ± 0.41	8.46 ± 0.62
Total Organic Carbon (TOC)	g/m^3	4.5 ± 1.6	2.7 ± 1.5	8.7 ± 2.9	1.1 ± 1.1

Sample Name:		SH2 @ Ravensdown 15-Mar-2016 1:15 pm			
Lab Number:		1552621.5			
pH	pH Units	7.3 ± 0.2	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	18.6 ± 1.0	-	-	-
Electrical Conductivity (EC)	mS/m	8.2 ± 0.2	-	-	-
Dissolved Calcium	g/m^3	5.17 ± 0.33	-	-	-
Dissolved Magnesium	g/m^3	1.63 ± 0.12	-	-	-
Dissolved Potassium	g/m^3	1.41 ± 0.11	-	-	-
Dissolved Sodium	g/m^3	6.88 ± 0.74	-	-	-
Chloride	g/m^3	9.30 ± 0.66	-	-	-
Total Nitrogen	g/m^3	0.200 ± 0.068	-	-	-
Total Ammoniacal-N	g/m^3	< 0.005 ± 0.0034	-	-	-
Nitrite-N	g/m^3	< 0.0010 ± 0.00067	-	-	-
Nitrate-N	g/m^3	0.0051 ± 0.0013	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.0057 ± 0.0011	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.194 ± 0.068	-	-	-
Dissolved Reactive Phosphorus	g/m^3	0.00135 ± 0.00068 [#1]	-	-	-

Sample Type: Aqueous

	Sample Name:	SH2 @ Ravensdown 15-Mar-2016 1:15 pm			
	Lab Number:	1552621.5			
Total Phosphorus	g/m^3	0.0130 ± 0.0032 [#1]	-	-	-
Reactive Silica	g/m^3 as SiO_2	2.106 ± 0.079	-	-	-
Sulphate	g/m^3	5.15 ± 0.46	-	-	-
Total Organic Carbon (TOC)	g/m^3	3.3 ± 1.5	-	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

[#1] It has been noted that the result for Dissolved Reactive Phosphorus was greater than that for Total Phosphorus, but within the analytical variation of these methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-5
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-5
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-5
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-5
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	4
Total Ammoniacal-N Trace	Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH_3 H 22nd ed. 2012.	0.005 g/m^3	1-3, 5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrite-N Trace	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-3, 5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N + Nitrite-N Trace	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-3, 5
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Reactive Phosphorus (trace)	Filtered sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-3, 5
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-5
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-5
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Carole Rodger-Carroll

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel	+64 7 858 2000
Fax	+64 7 858 2001
Email	mail@hill-labs.co.nz
Web	www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1553389 SUPv1
Contact:	Philippa Crisp	**Date Registered:**	17-Mar-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	22-Mar-2016
	C/- Accounts	**Quote No:**	74984
	PO Box 11646	**Order No:**	219590
	Wellington 6142	**Client Reference:**	Waingawa study (GW and SW)
		Add. Client Ref:	Consignment No:58998
		Submitted By:	S Tidswell

Sample Type: Aqueous

Sample Name:		S26/0254 16-Mar-2016 12:15 pm	S26/0265 16-Mar-2016 10:08 am	T26/0302 16-Mar-2016 1:00 pm	
Lab Number:		1553389.1	1553389.2	1553389.3	
pH	pH Units	6.2 ± 0.2	6.1 ± 0.2	6.9 ± 0.2	-
Total Alkalinity	g/m^3 as $CaCO_3$	20.4 ± 1.1	17.90 ± 0.98	108.1 ± 4.4	-
Electrical Conductivity (EC)	mS/m	17.4 ± 0.4	10.8 ± 0.3	30.9 ± 0.7	-
Dissolved Calcium	g/m^3	9.86 ± 0.62	6.55 ± 0.42	17.7 ± 1.2	-
Dissolved Magnesium	g/m^3	5.38 ± 0.37	3.12 ± 0.21	11.23 ± 0.76	-
Dissolved Potassium	g/m^3	1.42 ± 0.11	0.862 ± 0.071	1.251 ± 0.097	-
Dissolved Sodium	g/m^3	14.8 ± 1.6	9.3 ± 1.0	33.0 ± 3.6	-
Chloride	g/m^3	13.98 ± 0.91	9.74 ± 0.68	29.6 ± 1.9	-
Total Nitrogen	g/m^3	8.5 ± 1.1	3.13 ± 0.38	0.156 ± 0.067	-
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	< 0.010 ± 0.0067	0.100 ± 0.011	-
Nitrite-N	g/m^3	< 0.002 ± 0.0014	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-
Nitrate-N	g/m^3	8.4 ± 1.1	3.05 ± 0.37	< 0.002 ± 0.0019	-
Nitrate-N + Nitrite-N	g/m^3	8.4 ± 1.1	3.05 ± 0.37	< 0.002 ± 0.0014	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	< 0.10 ± 0.067	< 0.10 ± 0.067	0.155 ± 0.067	-
Dissolved Reactive Phosphorus	g/m^3	0.0215 ± 0.0041 [#1]	0.0185 ± 0.0038	0.232 ± 0.034 [#1]	-
Total Phosphorus	g/m^3	0.0210 ± 0.0040 [#1]	0.0190 ± 0.0038	0.216 ± 0.031 [#1]	-
Reactive Silica	g/m^3 as SiO_2	19.12 ± 0.39	14.37 ± 0.30	32.02 ± 0.65	-
Sulphate	g/m^3	9.99 ± 0.69	6.56 ± 0.53	7.18 ± 0.55	-
Total Organic Carbon (TOC)	g/m^3	< 0.5 ± 1.4	0.6 ± 1.2	< 0.5 ± 5.9	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

[#1] It has been noted that the result for Dissolved Reactive Phosphorus was greater than that for Total Phosphorus, but within the analytical variation of these methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-3
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-3

ilac-MRA IANZ ACCREDITED LABORATORY

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-3
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-3
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-3
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-3
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-3
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-3
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-3
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-3
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-3
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1554073 SUPv1
Contact:	S Tidswell	**Date Registered:**	18-Mar-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	24-Mar-2016
	C/- Accounts	**Quote No:**	74984
	PO Box 11646	**Order No:**	219590 J
	Wellington 6142	**Client Reference:**	Waingawa study (GW and SW)
		Submitted By:	S Tidswell

Sample Type: Aqueous

Sample Name:		S26/0277 17-Mar-2016 10:10 am	S26/1126 17-Mar-2016 11:50 am		
Lab Number:		1554073.1	1554073.2		
pH	pH Units	7.3 ± 0.2	7.0 ± 0.2	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	47.1 ± 2.0	179.3 ± 7.3	-	-
Electrical Conductivity (EC)	mS/m	26.8 ± 0.6	36.3 ± 0.8	-	-
Dissolved Calcium	g/m^3	15.28 ± 0.96	31.6 ± 2.0	-	-
Dissolved Magnesium	g/m^3	5.23 ± 0.36	9.82 ± 0.66	-	-
Dissolved Potassium	g/m^3	12.89 ± 0.94	1.51 ± 0.12	-	-
Dissolved Sodium	g/m^3	23.0 ± 2.5	33.9 ± 3.7	-	-
Chloride	g/m^3	33.1 ± 2.1	10.05 ± 0.70	-	-
Total Nitrogen	g/m^3	2.64 ± 0.30	1.212 ± 0.092	-	-
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	1.198 ± 0.097	-	-
Nitrite-N	g/m^3	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Nitrate-N	g/m^3	2.37 ± 0.29	< 0.002 ± 0.0019	-	-
Nitrate-N + Nitrite-N	g/m^3	2.37 ± 0.29	< 0.002 ± 0.0014	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.264 ± 0.068	1.212 ± 0.092	-	-
Dissolved Reactive Phosphorus	g/m^3	0.072 ± 0.011	1.32 ± 0.20	-	-
Total Phosphorus	g/m^3	0.071 ± 0.011 [#1]	1.47 ± 0.21	-	-
Reactive Silica	g/m^3 as SiO_2	21.15 ± 0.43	33.62 ± 0.68	-	-
Sulphate	g/m^3	17.0 ± 1.1	< 0.5 ± 0.35	-	-
Total Organic Carbon (TOC)	g/m^3	1.2 ± 2.8	< 0.5 ± 9.3	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

[#1] It has been noted that the result for Dissolved Reactive Phosphorus was greater than that for Total Phosphorus, but within the analytical variation of these methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 22nd ed. 2012.	0.10 g/m^3 as SiO_2	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1694171 SUPv1
Contact:	Kasey Pitt	**Date Received:**	09-Dec-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	16-Dec-2016
	C/- Accounts	**Quote No:**	80146
	PO Box 11646	**Order No:**	225109
	Wellington 6142	**Client Reference:**	Waingawa bores
		Add. Client Ref:	Consignment Number #64342
		Submitted By:	Kasey Pitt

Sample Type: Aqueous

Sample Name:		S26/0264 08-Dec-2016 1:12 pm	S26/0310 08-Dec-2016 2:13 pm		
Lab Number:		1694171.1	1694171.2		
Chloride	g/m^3	13.03 ± 0.86	23.1 ± 1.5	-	-
Total Nitrogen	g/m^3	7.43 ± 0.87	4.99 ± 0.56	-	-
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	< 0.010 ± 0.0067	-	-
Nitrate-N + Nitrite-N	g/m^3	7.17 ± 0.87	4.63 ± 0.56	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.261 ± 0.068	0.362 ± 0.070	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0095 ± 0.0030 [#1]	0.096 ± 0.015	-	-
Total Phosphorus	g/m^3	0.0090 ± 0.0029 [#1]	0.107 ± 0.016	-	-
Total Organic Carbon (TOC)	g/m^3	1.3 ± 2.1	3.1 ± 1.9	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

[#1] It has been noted that the result for Dissolved Reactive Phosphorus was greater than that for Total Phosphorus, but within the analytical variation of these methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Carole Rodgers-Carroll

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Greater Wellington Regional Council	**Lab No:**	1655530 SUPv1
Contact:	Kasey Pitt	**Date Received:**	28-Sep-2016
	C/- Greater Wellington Regional Council	**Date Reported:**	05-Oct-2016
	C/- Accounts	**Quote No:**	80146
	PO Box 11646	**Order No:**	225109
	Wellington 6142	**Client Reference:**	Waingawa bores
		Add. Client Ref:	Consignment number: 64335
		Submitted By:	Kasey Pitt

Sample Type: Aqueous

Sample Name:		S26/0286 Laing 27-Sep-2016 10:55 am	S26/0889 Morgan 27-Sep-2016 12:18 pm		
Lab Number:		1655530.1	1655530.2		
Chloride	g/m^3	17.1 ± 1.1	16.7 ± 1.1	-	-
Total Nitrogen	g/m^3	7.86 ± 0.94	12.0 ± 1.5	-	-
Total Ammoniacal-N	g/m^3	< 0.010 ± 0.0067	< 0.010 ± 0.0067	-	-
Nitrate-N + Nitrite-N	g/m^3	7.79 ± 0.94	12.0 ± 1.5	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	< 0.10 ± 0.067	< 0.10 ± 0.067	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0170 ± 0.0036	0.0190 ± 0.0038	-	-
Total Phosphorus	g/m^3	0.0183 ± 0.0037	0.0213 ± 0.0040	-	-
Total Organic Carbon (TOC)	g/m^3	0.8 ± 2.0	1.1 ± 1.8	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

The customer has indicated that the sampling time was recorded as NZ Standard Time (NZST). The sampling time has been reported as supplied in NZST. It should be noted any other times reported by Hill Laboratories will have been corrected for New Zealand Daylight Saving Time (NZDT), where applicable.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total Phosphorus Digestion	Acid persulphate digestion.	-	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 C (modified) 22nd ed. 2012.	0.5 g/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental