30 June 2017

POVERTY BAY MANAGED AQUIFER RECHARGE TRIAL

Initial Injection Test

Submitted to:
Gisborne District Council

Report Number: 1415771-7410-023-R-Rev0

Distribution:

Mark Joblin (Gisborne District Council)
Dennis Crone (Gisborne District Council)

REPORT

Golder Associates

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Gisborne District Council (GDC) is investigating water management options in the Poverty Bay region with the aim of improving water security for all users. One option under investigation is the use of Managed Aquifer Recharge (MAR), to replenish and sustain groundwater yields from aquifers beneath the Poverty Bay Flats.

A MAR trial targeting the Makauri Aquifer has been initiated by GDC. The trial is based on taking water from the Waipaoa River via the Kaiaponi Farms irrigation water supply infiltration gallery and injecting the water, following treatment, into the Makauri Aquifer. The Kaiaponi MAR site is located on the Kaiaponi Farms property, on Bushmere Road. So far the trial has been designed, the necessary resource consents obtained, two bores have been drilled, headworks and delivery system has been constructed and initial testing of the system has started. This report outlines the results from the pre-injection trial as per condition 38 of Resource Consent (DW-2016-107113-00):

38) *Following the pre-injection trial of 10,000 m^3 the consent holder shall provide a report to the GDC Manager on the performance of this preliminary trial, with particular reference to the water quality and water quantity effects that arose. Any updates to the Management Plan referred to in condition 35 that are required based on the results of the preliminary trial shall be made and re-certified in writing by the GDC Manager. The commencement of the main trial shall not commence until this reporting and potential re-certification (if required) has been completed.*

2.0 BORE INSTALLATION

2.1 Pilot Bore

Drilling of the pilot bore at Kaiaponi Farm was started on 20 March 2017 and was completed as a monitoring bore on 31 March 2017. It has been assigned the GDC bore number GPE065. A copy of the drillers log for the pilot bore is provided in Appendix A. A summary of the bore structure is provided in Table 1.

2.2 Injection Bore

The injection bore was drilled and installed between 3 April 2017 and 24 April 2017. Development of this bore was carried out through a process of pumping and surging on 27 April 2017. The injection bore has been assigned the GDC bore number GPE066. A copy of the drillers log for the pilot bore is provided in Appendix A. A summary of the bore structure is provided in Table 1.

Table 1: Bore structure summary.

Parameter	Pilot bore	Injection bore
GDC ID	GPE065	GPE066
Easting	2938345	2938328
Northing	6276377	6276389
Distance from injection bore (m)	23	-
Bore depth (m bgl)	92	73.5
Screened interval (m bgl)	69.2 – 72.6	69.5 – 72
Casing internal diameter and material	50 mm PVC	225 mm uPVC
Height of casing above ground level (m)		1.3

3.0 AQUIFER CHARACTERISATION

3.1 Geology

Based on the lithologies intersected during the drilling program (refer drillers logs in Appendix A and Table 2 below, it appears that the Makauri Aquifer beneath the Pilot Trial site may be split into two layers. The upper layer is three metres thick and is at a level consistent with the general gradient and depth of the Makauri Aquifer beneath the Poverty Bay Flats. The lower layer, although thicker at approximately six metres, is considerably deeper than the regional aquifer trend would indicate for the position of the Makauri Aquifer. In addition, there is an 11 m thick clay aquitard between the two layers.

The hydraulic connection between the deeper layer and the wider Makauri Aquifer that is used as a horticultural water source is in doubt. For this reason the pilot bore monitoring well screen was installed in the shallower layer.

An air lift test was performed in this monitoring well and a hydraulic reaction to the test was detected in the nearest monitored well screened in the Makauri Aquifer approximately 100 m from the site (refer Section 3.2.1 and Appendix B). For this reason, the screen depth for the injection bore was targeted at the upper Makauri Aquifer layer.

Table 2: Lithological sequence.

Top of unit (m bgl)	Base of unit (m bgl)	Description	Interpretation
0	1	Topsoil	Aquitard
1	26	Clay	
26	31.2	Gravel	Aquifer
31	69	Clay	Aquitard
69	72.6	Gravel	Makauri Aquifer
72.6	84.8	Clay	Aquitard
84.8	91	Gravel	Basal split of Makauri Aquifer?
91	92	Clay	Aquitard

3.2 Hydraulic Test Program

3.2.1 Air lift test on pilot bore monitoring well

An air lift test was performed in the pilot bore monitoring well on 30 March 2017 to gain an indication of the aquifer hydraulic characteristics prior to installation of the injection bore.

Air lifting was undertaken at an average rate of 1.8 L/s for 120 minutes. The recovery phase of the air lift test was monitored in the pilot bore and the entire test was monitored in an unused private bore GPE010 some 190 m away.

The drawdown and recovery data was analysed to provide an indication of the aquifer parameters to support the design process for the injection bore. The parameters and results of this preliminary test are presented in Table 3. The analysis sheets are provided in Appendix B.

Table 3: Pilot bore monitoring well air lift test.

Parameter	Pilot bore	GPE010
Distance from Pilot Bore (m)	-	190
Period of air lift (minutes)	120	-
Average rate of water abstraction (L/s)	1.8	-
Static water level (m btoc)	8.74	8.345
Maximum drawdown (m)	NA(1)	0.06
Recovery period monitored (minutes)	77	75
Aquifer transmissivity (m^2/day) (2)	NA(1)	692 – 1,070
Aquifer hydraulic conductivity (m/day) (2)	NA(1)	231 - 357
Aquifer storativity (m^3/m^3) (2)	NA(1)	1.7×10^{-4}

Note: 1) Could not be measured due to the nature of the test.
2) Initial estimate only for injection bore planning and design purposes.

3.2.2 Stepped rate test on injection bore

A stepped rate pumping test was carried out in the injection bore on 4 May 2017 at four flow rates (7 L/s, 10 L/s, 13 L/s and 16 L/s). The flow rates were checked regularly to maintain constant flow during each step. The first three steps were pumped for 120 minutes each. The duration of the last step at 16 L/s had to be cut back to 100 minutes due to large and increasing drawdown of the water column in the bore (refer to drawdown chart provided in Appendix B).

Toward the end of the stepped rate test an issue was encountered with large drawdown and accurate measurement of the flow rates. Both of these issues were due to the presence of dissolved gas (refer to Section 3.3.3) within the aquifer water, that degassed when depressurised. The drawdown of water in the bore during the final pumping stage resulted in depressurisation of the aquifer in the immediate vicinity of the bore sufficient to cause degassing in the gravels surrounding the well screen. The collected gas caused temporary clogging of the well screen, leading to reduced flow into the bore and increased drawdown in the bore. Once initiated this process let to a rapid increase in drawdown within the injection bore, although pressure responses in the aquifer at the Pilot Bore monitoring well did not reflect this drawdown.

Analysis of the stepped rate test results indicated that the bore would have the capacity to accepted water injection at rates of between (between 10 L/s and 22 L/s). Gas in the existing aquifer water would not influence the rate at which water can be injected to the aquifer.

3.2.3 Constant rate test on injection bore

A constant rate pumping test was started at 9:30 am on 5 May 2017 and recovery started on 8 May 2017 at 9:30 am. The pumping rate was controlled at 13 L/s to reduce the risk of uncontrolled drawdown in the injection bore due to degassing, as occurred in the stepped rate test.

Under the pumping rate of 13 L/s, the water level in the injection bore dropped from 8.3 m to 13 m bgl after three days of pumping. The maximum drawdown of 4.7 m indicated that injection rates at least equivalent to this flow should be able to be achieved.

The drawdown and recovery curves from the constant rate test are documented in Appendix B. The analyses of these curves to derive aquifer parameters are also presented in Appendix B. The hydraulic parameters derived from these analyses are presented in Table 4.

Table 4: Analysis results from injection bore constant rate test.

Test curve analysis (1)	Distance from injection bore (m)	Transmissivity (m^2/day)	Hydraulic conductivity (m/day)	Storativity (m^3/m^3)
Injection bore (GPE066) drawdown (2)	-	250	80	-
Injection bore (GPE066) recovery	-	600	200	-
Pilot bore (GPE065) drawdown	23	770	260	3.0×10^{-4}
Pilot bore(GPE065) recovery	23	600	200	
GPE010 drawdown	190	780	260	1.6×10^{-5}
GPE010 recovery	190	610	210	
GPE030 drawdown	365	760	250	1.8×10^{-5}
GPE030 recovery	365	580	190	
Interpreted aquifer parameters		600 – 800		2×10^{-5} – 3.0×10^{-4}.

Note: 1) Analysis results rounded to two significant figures.
2) Lower confidence in the result of this analysis.

The pumping test analyses indicate the aquifer transmissivity is between 600 m^2/day and 800 m^2/day and the storativity is between 1.5×10^{-5} and 3×10^{-4}. No indications of hydraulic boundary conditions were identified during analysis of the test data. It is however recognised that the aquifer changes laterally in thickness, which means the calculated transmissivity and storativity are likely to differ for different monitoring wells.

The aquifer properties described above are similar to those used during the pre-feasibility assessment to project expected water level responses in nearby bores. Two of the nearby bores gave very consistent responses to the test and the analyses are indicating similar aquifer properties (GPE010 and GPE030). The data from two other bores monitored during the test (GPE012 and GPF105), located close to each other approximately 1 km southeast from the site, showed water level responses that appear to have been affected by more local domestic pumping. This interference means that with the drawdown and recovery data from these two bores has not been analysed.

Given the results of the constant rate pumping test, the estimated flow rates for injection of between 10 L/s and 22 L/s were considered reasonable, in advance of any injection testing.

3.3 Hydrogeochemistry

3.3.1 Geochemistry

Samples of aquifer material obtained from both the 69 m to 72 m layer and the 85 m to 92 m deep gravel layers intersected in the pilot bore were sent to Waikato University for analysis.

X-Ray Fluorescence analysis of the samples was undertaken to provide information on the major element composition of the geological material. The high calcium concentrations measured in both samples are consistent with the presence of limestone in the aquifer, which was expected based on the nature of the catchment geology. The two samples contain trace elements at concentrations that are mostly lower than their average crustal abundance (Appendix C). Arsenic and sulphur are only present at low concentrations. From this data we consider it unlikely that there are significant concentrations of sulphur-bearing minerals in the local aquifer.

XRD analysis was undertaken to determine mineral content of the rock samples (Figure 1). The XRD results showed the sample to be quartz dominated with some calcium carbonate (from shell fragments and limestone).

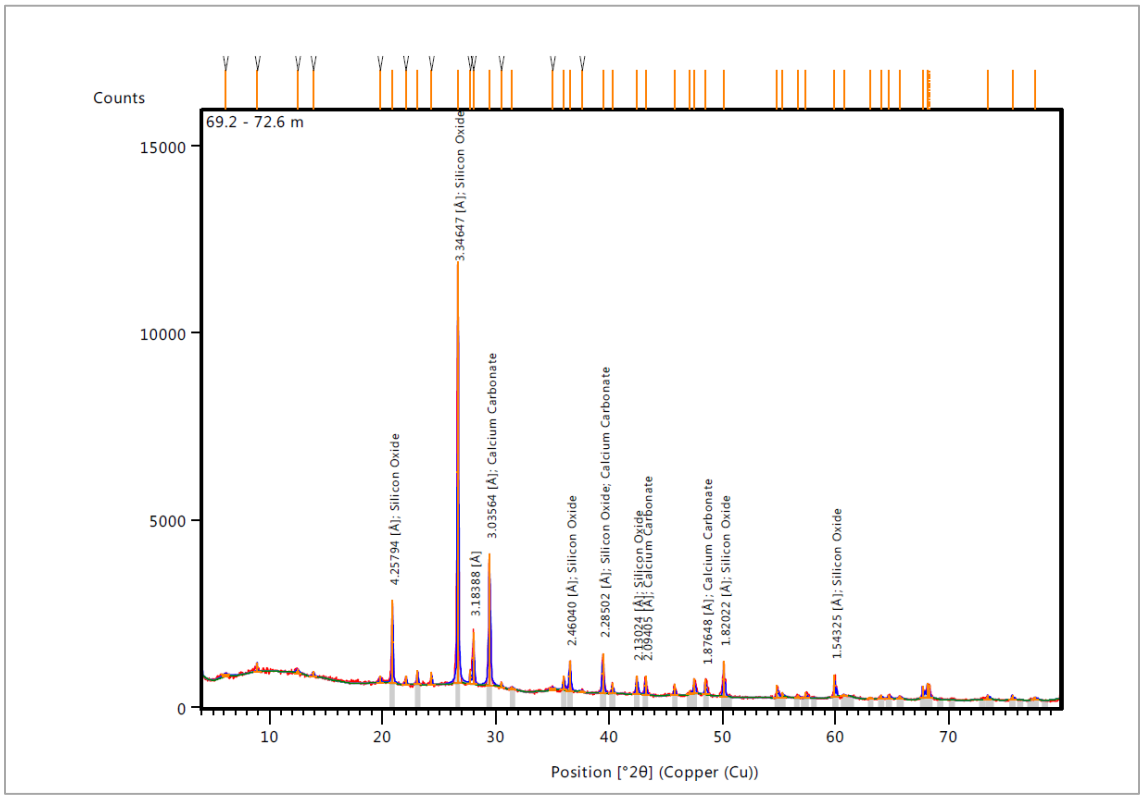


Figure 1: XRD analysis results.

3.3.2 Water quality

The groundwater quality data derived from sampling of the MAR pilot bore are very consistent with those from GDP115. The data from GDP115 were used as a basis for the iron oxidation modelling undertaken in support of the Assessment of Environmental Effects (Golder 2015).

A comparison of the major elements distribution in water samples from the pilot bore and a collection of other bores screened in the Makauri Aquifer is presented as a Piper Diagram in Figure 2. The major ion distributions in groundwater samples from bores within five kilometres of the injection bore are very similar to the sample obtained from the pilot bore. The scatter in major ion distributions increases slightly in bores further away.

3.3.3 Dissolved gas

During the pumping tests a significant volume of gas was released from the discharged water within the stilling basin adjacent to the injection bore. Based on general knowledge of the aquifer chemistry, it was initially assumed that the primary components of the discharged gas would be methane and carbon dioxide.

The Health and Safety procedures for this initial test program were modified as soon as the gas discharges from the aquifer water were identified, to manage any risk resulting from methane degassing. Testing of the gas above the basin and in the mouth of the discharge pipe did not identify a critical lack of oxygen.

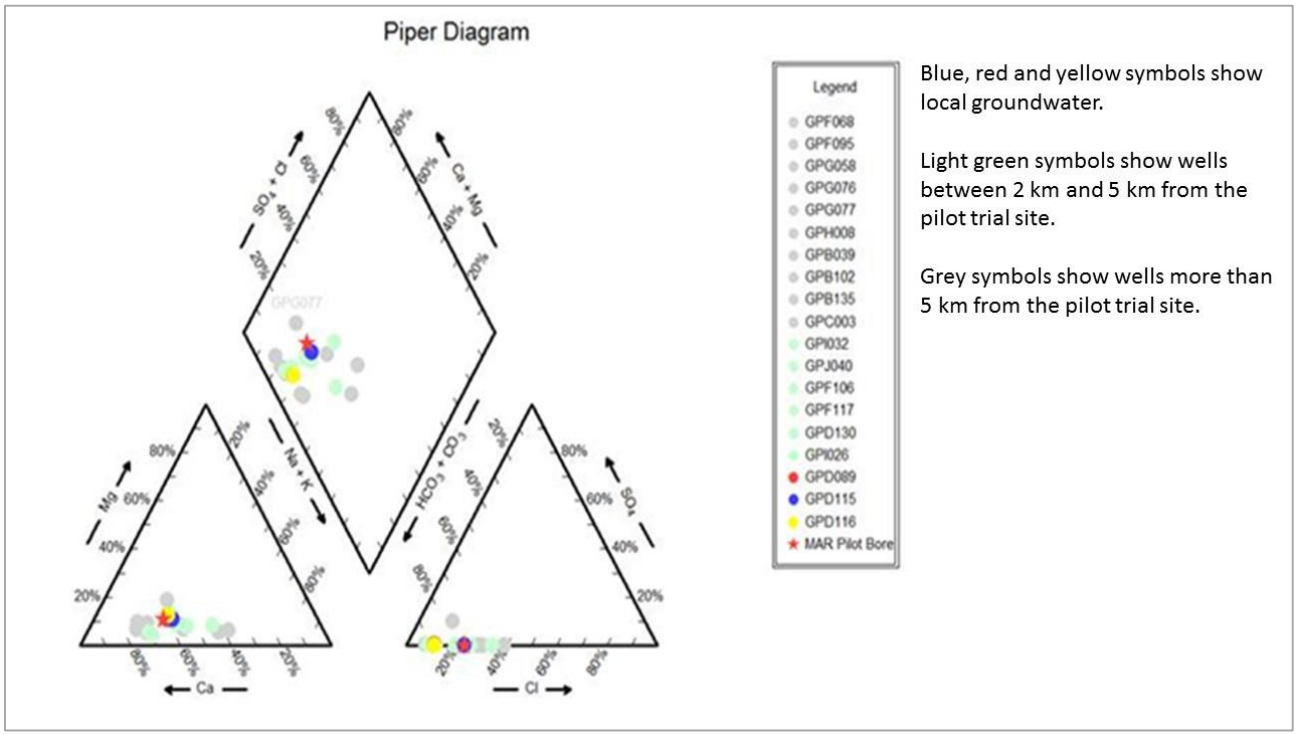


Figure 2: Major ion characteristics for water from wells screened in the Makauri Aquifer.

Sampling and analysis of the gas from the bore was undertaken during the initial testing program for the bore headworks and injection system. Landfill gas monitoring equipment, which can differentiate between gasses and provide relative percentages present, was used to evaluate the gas components.

During the sampling and analysis of the discharged gas, it was identified that both methane and oxygen were present in the sample in significant quantities. As this combination would not be chemically stable or naturally present in the dissolved gases in the aquifer, it was assumed that some mixing of air with the aquifer gases had occurred during the sampling and analysis. It was further assumed that 100 % of the oxygen in the sample was derived from air leakage, with corresponding fractions of nitrogen and other gases that naturally occur in the atmosphere. The components of each of the constituent gases derived from leakage could then be calculated and the residue components were assumed to be derived from the aquifer water. The calculation and the derived components of the dissolved gases in the aquifer water are presented in Table 5.

Due to the potential presence of methane gas at the site, health and safety precautions need to be taken when working in the area, especially when pumping out of the bore, but also following periods of operational rests. Additional air release valves have been added to the pipework design to facilitate gas release. Gas meters have been used on site during pipework installation.

The potential need for geochemical modelling of the dissolved gas has been assessed. It was concluded that a clear health and safety management approach for the pumping tests and trial period is a more worthwhile course of action than further modelling. When the site is used as an injection well it is unlikely that aquifer gas bubbles will form within the bore or the immediately surrounding aquifer, as the aquifer pressure is being increased rather than lowered.

Table 5: Calculated aquifer gas components.

Parameter	Sample (%)	Sample corrected (1) (%)	Average air constituents (%)	Air fraction (2) (%)	Aquifer fraction (3) (%)	Aquifer gas (%)
CH_4	29.7	29.1	0	0	29.1	49.5
CO_2	4.7	4.6	0.03	0.01	4.6	7.8
O_2	8.8	8.6	20.95	8.6	0.0	0.0
CO	2	2.0	0	0	2.0	3.3
H_2S	0	0.0	0	0	0.0	0.0
Balance (4)	56.8	55.7	79.02	32.5	23.1	39.4
Sum	102	100	100	41.2	58.8	100

Note: 1) Corrected to total of 100 %.
2) Based on assumption that 100 % of O^2 is derived from air leakage into sample.
3) Corrected sample components minus air components.
4) Primarily nitrogen, minor argon and trace other gases.

The low sulphate concentrations in water from almost all of the groundwater bores that were evaluated previously suggests that reducing conditions (and dissolved methane) are present in the Makauri Aquifer beneath much of the Poverty Bay Flats.

4.0 INJECTION TESTS

4.1 Stepped Rate Tests

A series of stepped rate injection tests were undertaken between 22 May 2017 and 7 June 2017. The objective of these tests was to:

1) Evaluate the rate at which water could potentially be introduced through the injection bore to the aquifer.

2) Identify factors limiting the rate at which water could be injected and, if possible, take steps to address the factors to improve injection rates.

Analysis of the data from the tests undertaken during the above period provides a good indication of the rates at which water can be introduced to the aquifer through the injection bore (GPE066).

Issues identified during these injection tests were primarily operational in nature. The main issues are summarised below.

- The Kaiaponi Farms water supply pump is located at the end of a pipeline approximately 570 m in length. Changing the power input to the pump does not result in an immediate change in flow rate at the injection bore but rather a gradual change over a period of up to 10 minutes. This issue has been addressed through defining a clear start-up procedure in the Operation Plan. During the constant rate injection test and for most of the Pilot Trial injection period these delays do not represent an issue.
- The Kaiaponi Farms water supply pump is optimised for a flow rate of approximately 25 L/s. At progressively lower flows the operation of the pump becomes less stable and the flows generated at pre-defined pump settings become less consistent. This issue has been addressed by setting a minimum operational flow for start-up purposes and operating the pump at the highest achievable flow for the constant rate injection test.

- Butterfly valves are used to control water flow at the off-take from the Kaiaponi water supply system and in the injection bore headworks. Flows through these valves are very sensitive to changes in position when the valve is almost closed. Rapid closure of some of these valves can result in unstable water level changes in the injection bore. This issue has been addressed through developing clear start-up procedures and incorporating these in the Operations Plan.
- During the initial stepped rate tests it was identified that entrainment of air bubbles in the injected water resulted in temporary clogging of the well screen with bubbles at flows above approximately 7.5 L/s. This in turn led to rapid rises in water level within the injection bore. This situation could also be triggered by sudden changes in flows at lower injection rates. This issue has been resolved through:
  - Modifying the inflow system at the well head through installation of a drop tube with a constriction at the terminal end. Instability due to air entrapment was not subsequently observed during the test.
  - Procedures for manually operating the butterfly valves in the Kaiaponi water line off-take and the headworks have been developed to minimise the risk of abrupt changes in flow rates to the injection bore. These procedures have been incorporated in the Operations Plan.

A compilation of the data from the various stepped rate tests is summarised in Figure 4. Each of the recorded datasets is presented in terms of water depth below the top of the injection bore casing, as these projections are used for planning of a full 100,000 m^3 injection test. The projections have been extended on the log scale chart (Figure 4) for a trial period of 100,000 minutes (slightly less than 80 days). The reasons for this time scale are presented in Section 4.2.

The stepped rate tests were performed at flows of up to 12.9 L/s. This flow was considered to be at the top end of the flows achievable through the drop tube installed in the injection bore based on engineering calculations of flows through a circular orifice and observations made during the testing process supported this expectation. Based on the outcomes from the stepped rate tests presented in Figure 4, operating the injection trial for a period of approximately 80 days at a flow rate of 12.9 L/s would result in a change in water level in the injection bore of approximately 2.5 m (Figure 5). The static water level at the end of these tests of 8.3 m below the top of the injection well casing, so there was adequate capacity in the bore to accept this injection rate.

4.2 Constant Rate Test

4.2.1 Pressure responses

A constant rate injection test was started on 13 June 2017 with the objective of injecting 10,000 m^3 into the Makauri Aquifer and enable the outcomes to be documented as required under the resource consent. Due to premature triggering of a shut-down relay, the test finished at 3:19 AM on Monday 19 June. During this time water totalling 8,811 m^3 was injected to the Makauri Aquifer (Figure 3).

Summary information on the constant rate injection test is presented in Table 6. Injection flow rates during the test were not manually changed, however some minor changes in rate did occur (see Table 6). The reasons for the changes were unclear, as the test generally operated at a relatively constant flow.

The water level data from the constant rate injection test is presented in Figure 4, separated into Main Test stages 1 and 2 corresponding to the two periods of slightly different flows. The flows are higher than was achieved during the earlier tests and the corresponding projected rise in water level in the bore over a period of 100,000 minutes (77 days) is therefore also higher. At the highest flow rate achieved (15.5 L/s) the water level in the injection bore is projected to be approximately 4.2 m below the top of the bore casing at the end of the full trial. In addition there will be natural rise in the regional groundwater pressure. The projected level is considered suitable to cover the expected rise.

At a consistent flow rate of 15.1 L/s to 15.5 L/s, the planned injection volume of 100,000 m^3 could be achieved in between 100,000 and 110,000 minutes (74 to 77 days). The logarithmic time scale in Figure 4 extends to 100,000 minutes for this reason.

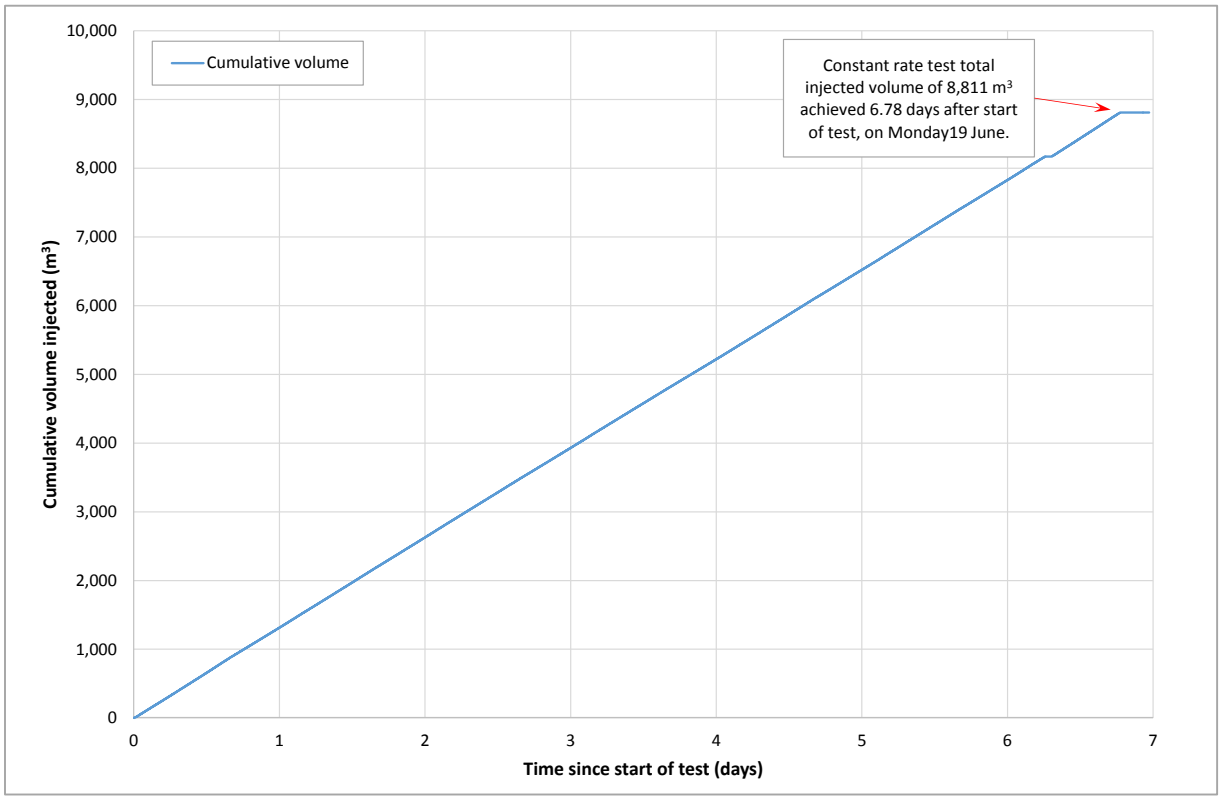


Figure 3: Cumulative water volume injected during constant rate test.

Table 6: Constant rate injection test summary data.

Parameter	Start date / time	Finish date / time	Period (minutes)	Average flow rate (L/s)	Injected volume (m^3)	Resulting injection bore water level change (m) (1)
Flow stage 1	12/6/2017 08:44	13/6/2017 00:38	954	15.5	881	2.558
Flow stage 2	13/6/2017 00:38	14/6/2017 00:29	1,430	15.1	1,299	2.685
Flow stage 3	14/6/2017 00:29	18/6/2017 14:54	6,625	15.1	5,990	2.835
Temporary shutdown	18/6/2017 14:54	18/6/2017 15:59	65	0	0	N/A
Flow stage 4 (2)	18/6/2017 15:59	19/6/2017 03:19	680	15.8	641	2.886
Overall	12/6/2017 08:44	19/6/2017 03:19	9,755 (6.97 days)	15.2	8,811	2.886

Note: 1) Estimated average at the end of the injection stage.
2) This stage was too short and the water levels too variable to provide adequate data to make 100,000 minute water level projections for the Pilot Trial.

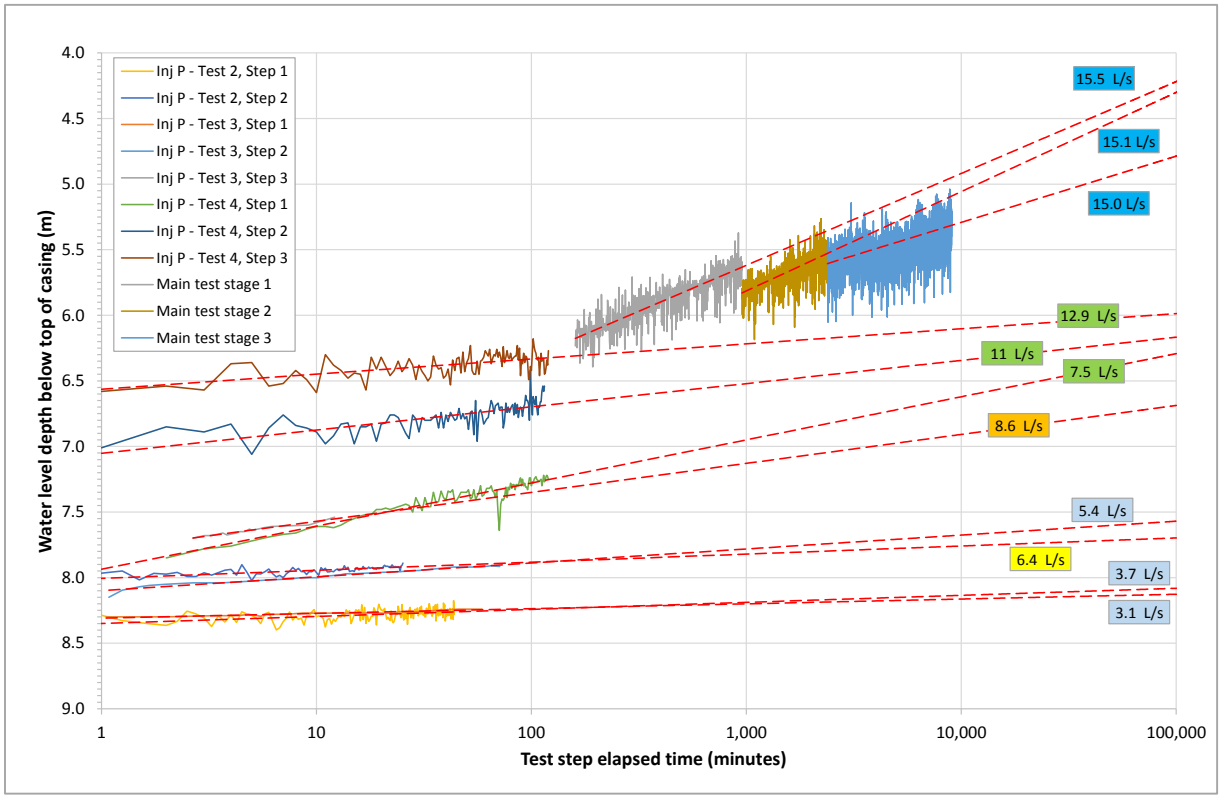


Figure 4: Injection bore water level trend curves and projections under different injection rates.

Calculated rises in water level within the injection bore by the end of the full pilot trial under a range of injection flow rates are presented in Table 7. These projections are presented visually in Figure 5, together with an indication of the potential effect of turbulence at the well screen on the final water level in the bore.

Table 7: Projected rise in injection bore water level at end of full pilot trial period.

Test step / stage	Flow rate (L/s)	Projected injection bore water level (m btoc)	Bore water level rise after 100,000 minutes (m)
Test 3, Step 1	3.1	8.13	0.17
Test 2, Step 1	3.7	8.08	0.22
Test 3, Step 2	5.4	7.57	0.73
Test 2, Step 2	6.4	7.70	0.60
Test 4, Step 1	7.5	6.29	2.01
Test 3, Step 3	8.6	6.69	1.61
Test 4, Step 2	11	6.17	2.13
Test 4, Step 3	12.9	5.99	2.31
Main test, Stage 3	15.1	4.79	3.51
Main test, Stage 2	15.1	4.30	4.00
Main test, Stage 1	15.5	4.22	4.08

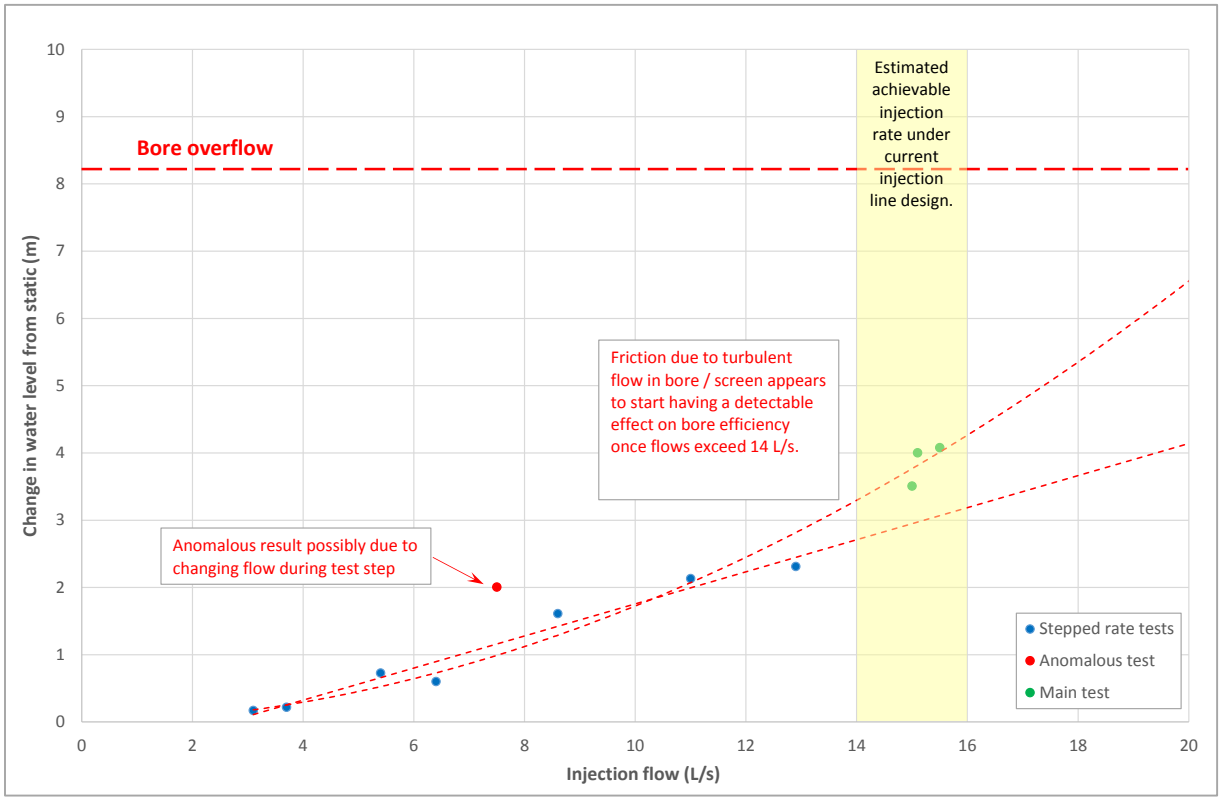


Figure 5: Projected changes in injection bore water level at the end of 100,000 minute (77 day) trial.

Water levels in the pilot monitoring bore (GPE 065) were very sensitive to changes in injection rates at the injection bore. Following the unplanned shut-downs, the water level recovery curves recorded from the monitoring bore were very similar to those recorded from the injection bore (Figure 6).

Water level responses in nearby bores (Figure 7) have been observed in the manual water level data. Bores GPE010 and GOE030 both showed a rise of approximately 1.3 m during injection. This is as expected as these bores responded rapidly to the pumping test. Small responses in other nearby bores may be present but are not obvious in the manual records. Further information will be gained in the full trial by using automated water level data.

4.2.2 Water quality responses

Temperature responses – Breakthrough observations

The natural groundwater temperature in the Makauri Aquifer in the area of the injection bore is approximately 14.7ºC. The temperature of the water pumped from the intake gallery during the constant rate injection test varied on a 24 hour cycle, between 9.5ºC and 10.3ºC.

Water temperature was monitored inside the screened sections of the injection bore and the pilot monitoring bore during the stepped rate tests and the constant rate injection test. At the start of the constant rate test the water temperature in both bores was similar. Following the start of the test the water temperature in the injection bore decreased almost immediately. The water temperature in the pilot monitoring bore started to decrease approximately 328 minutes after the start of the test (Figure 8). This response indicates the injected water took a little less than 328 minutes to radiate outward a distance of 23 m from the injection bore. At that time about 294 m^3 of water had been injected during the constant rate test.

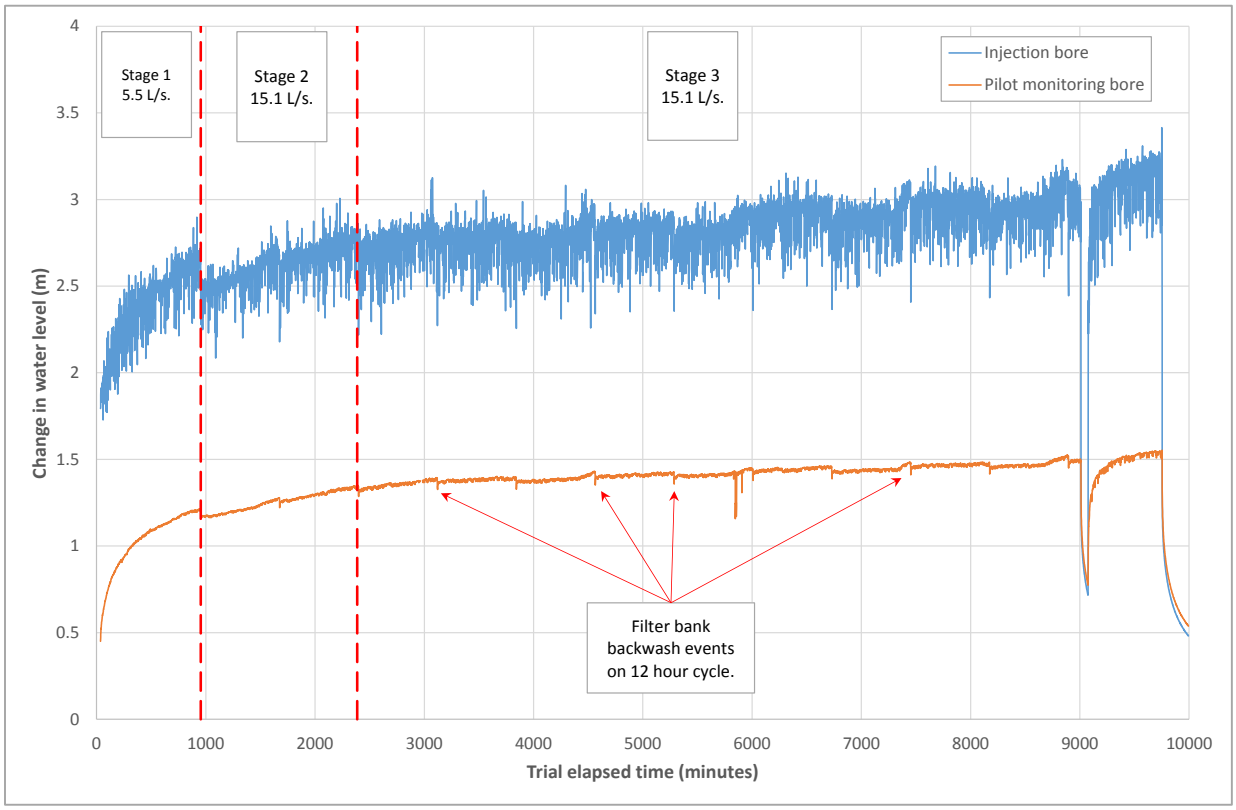


Figure 6: Water level increases in injection bore and pilot monitoring bore.

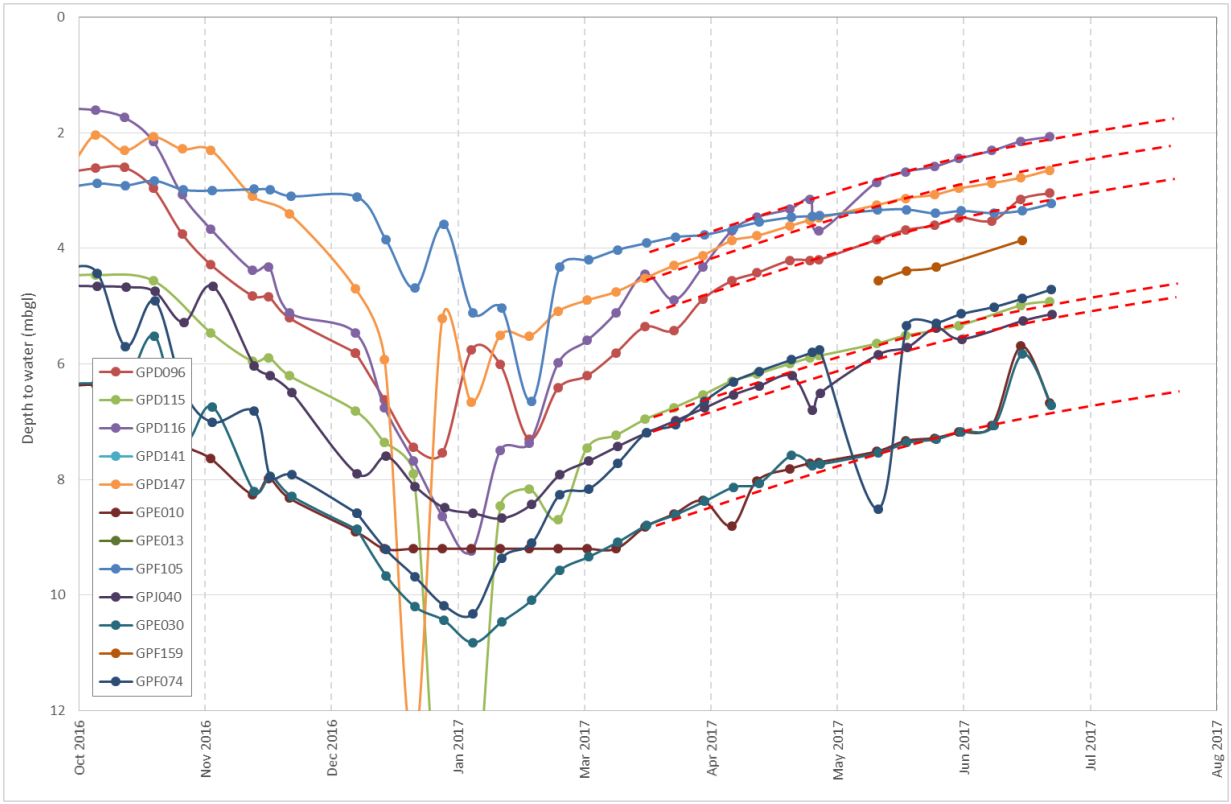


Figure 7: Manual groundwater levels in nearby monitoring bores.

The breakthrough can be used to calculate the time it will take for the bubble of injected water to reach various distances. The time it will take to reach GPE010 is estimated to be 16 days based on an injection rate of 15 L/s (Table 8). Following the full trial the radius of the bubble is expected to reach 420 m.

Table 8: Expected distances and travel times for injected water bubble.

Parameter	Full trial	Breakthrough at GPE010	Units
Water volume	100,000	20,404	m^3
Thickness	3	3	m
Porosity	0.06	0.06	
Area	176,929	113,354	m^2
Radius of water quality influence	420	190	m
Inflow rate	15	15	L/s
	1,296	1,296	m^3/day
Time required for influence to be detected	77	16	days

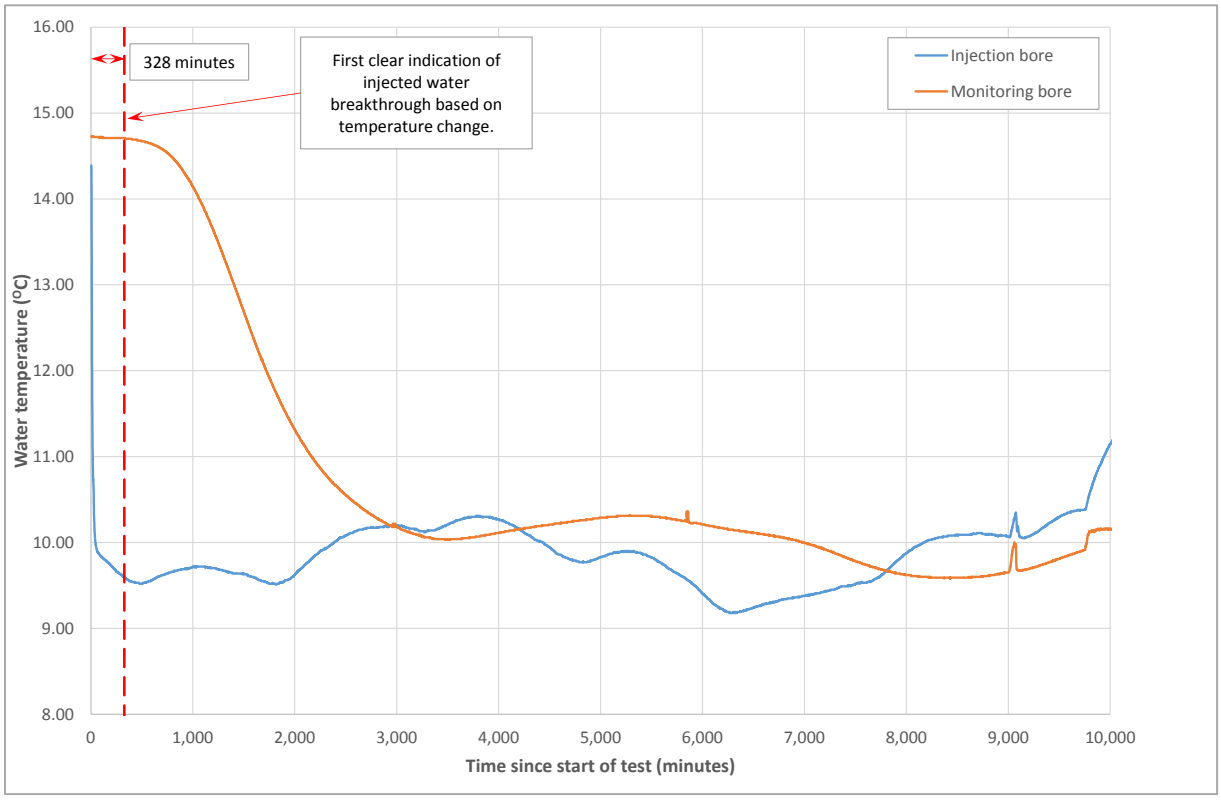


Figure 8: Temperature breakthrough curve recorded in pilot monitoring bore.

Water quality samples

Water samples have been taken from bores GPE066 (injection), GPE065 (monitoring) and GPE010 for full chemical analysis. The results of these analyses will be assessed as they are received. Initial water injected during commissioning of the trial and subsequently pumped out of the injection bore showed no unexpected

water quality changes. The injected water was resting in the aquifer/bore for approximately 11 days before being pumped out. These analysis results are included in Appendix C.

Microbiological responses

Groundwater and injected water has been tested for microbiological content using *Escherichia coli* (*E.coli*) as an indicator. The trial sampling procedure requires some refinement to ensure samples are representative. Results are available for the injection bore following initial commissioning (6 June 2017) and for injection bore and monitoring bores following the pre-injection trial of 8,811 m^3 (Table 9). Some increase in *E.coli* is observed in these results. However, a larger number of samples is required in order to be able to draw any conclusions as to the rate of die off and transport of *E.coli* in the Makauri Aquifer.

Table 9: Initial microbiological results.

Site/Bore	Date	*Escherichia coli* (cfu/100 mL)
Injection Bore GPE066	8 May 2017	<1.6
Injection Bore GPE066	6 June 2017	1.6
Monitoring Bore GPE065	23 June 2017	6.6
Monitoring Bore GPE010	23 June 2017	<1.6
Injection Bore GPE066	26 June 2017	6.5

The bubble of injected water will propagate outwards slowly and based on the observed break through at GPE065 the projected travel time to reach GPE010 is 16 days. Therefore the bubble of water with potentially higher E.coli levels is expected to be limited in extent. Much information can be gained during the early stages of the trial on the rates of decay of the bacterial content in the aquifer. This information is very important to support the planning of future trials and for the development of any larger scale groundwater replenishment scheme for the Poverty Bay Flats. Therefore Golder recommends that the trial be continued as proposed to gain further information on the microbiological transport characteristics of the Makauri Aquifer.

In continuing with the trial as proposed, it is important to recognise that any risks posed by potential localised microbiological contamination of the aquifer for aquifer users are very small. The site was specifically chosen for the trial as it is a substantial distance from any active bores, with the water travel time to these bores exceeding the period of the untreated stage of the trial.

5.0 CONCLUSIONS

Golder considers that the full trial (100,000 m^3) can proceed based on the initial results gained from the commissioning and initial injection of 8,811 m^3 (Table 10). The pre-injection trial has shown that suitable flow rates can be achieved through the delivery system and injected with expected water level responses in the injection bore, and nearby bores. The travel times of the injected bubble are as expected and a small bubble of injected water (to a radius of approximately 420 m) is expected.

Further information on the microbiological transport characteristics of the Makauri Aquifer can be gained with further injection and appropriate testing. The bubble of injected water is only expected to reach 420 m from the bore following 77 days of injection at a rate of 15 L/s, so is not expected to significantly impact on water users.

Table 10: Recommendations for project decision stages.

Step	Decision - Reasoning
Step 1	**Proceed** ■ Coarse gravel layer suitable for trial identified from 69 to 72 m bgl. ■ Preliminary airlift test performed on pilot bore gave indications of a high aquifer hydraulic conductivity.
Step 2	**Proceed** ■ XRF and initial XRD analysis results raised no issues ■ Pumping test shows highly transmissive layer suitable for injection. ■ Pumping test issues due to de-gassing, which is not considered a significant concern for injection based on expected geochemical responses.
Step 3	**Proceed** ■ Injection rates have been set at approximately 15 L/s with suitable projected long term water levels in the injection bore. ■ Water level responses in surrounding bores are as expected based on available information. ■ Time for the injected water to reach GPE065 was as expected based on analytical projections. ■ Further information on the microbiological transport characteristics of the Makauri Aquifer can be gained with further injection and appropriate testing.
Step 4	To be completed

6.0 LIMITATIONS

Your attention is drawn to the document, “Report Limitations”, as provided in Appendix D below. The statements presented in that document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks to which this report relates which are associated with this project. The document is not intended to exclude or otherwise limit the obligations necessarily imposed by law on Golder Associates (NZ) Limited, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

7.0 REFERENCES

Golder 2015. Poverty Bay managed aquifer recharge. Pilot trial – hydrogeology and water quality. Report produced for Gisborne District Council by Golder Associates (NZ) Limited. Golder report 1415771-7410-006.

APPENDIX A

Borehole Logs

F2.7 Drillers Bore Log / Well Completion Report

CONSENT NUMBER	PERMIT NUMBER	E : 2938345
		N : 6276377

OWNER / OCCUPIER	Gisborne District Council
POSTAL ADDRESS	PO Box 747, Gisborne, 4040
SITE / PROPERTY ADDRESS	Kaiaponi Farms, Matawai Road, Gisborne
Rapid Number / St or Rd Number	

START DATE	20-03-2017	FINISH DATE	31-03-2017

DEPTH FROM SURFACE TOP (M)	DEPTH FROM SURFACE BOTTOM (M)	DESCRIPTION OF GROUND PASSED THROUGH
0	1	Topsoil
1	6	Brown Clay
6	25	Blue Clay
25	26	Blue Clay Shell
26	31.2	Blue Gravel
31.2	36.2	Blue Clay
36.2	36.4	Blue Clay Wood
36.4	69.2	Blue Clay
69.2	72.6	Gravel
72.6	84.8	Blue Clay
84.8	91	Gravel
91	92	Blue Clay

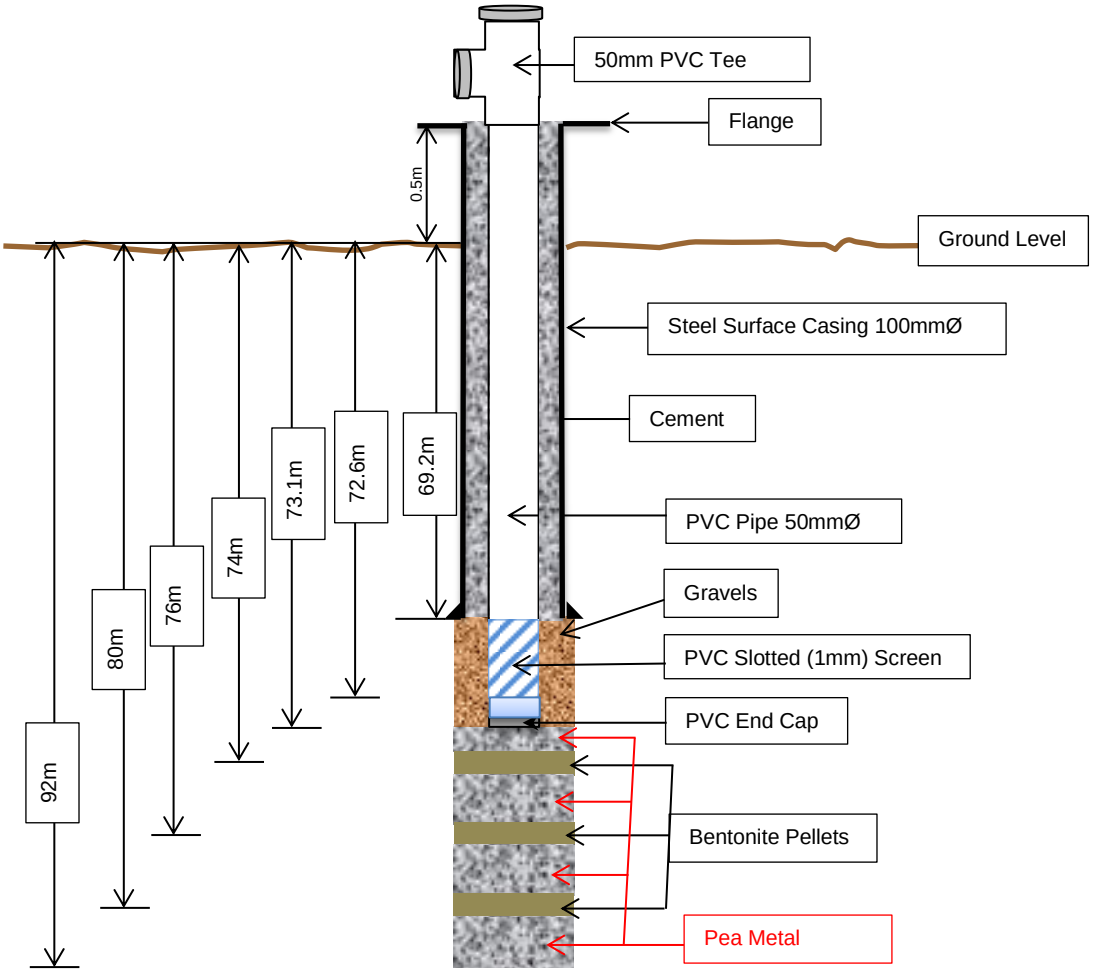
SCREEN DIAGRAM

SEE PAGE 2

WELL / BORE CONSTRUCTION		PUMPING TEST	
BORE DEPTH (m)	92	**STATIC WATER LEVEL (m)**	-8.74
CASING DEPTH (m)	69.2	**PUMPING RATE (LPS)**	
CASING DIAMETER (mm)	100 Steel	**ARTESIAN JET (“)**	
SCREEN ASSEMBLY :		**DRAWDOWN (m)**	
DIAMETER (mm)	50 PVC	**DURATION OF PUMPING (hrs)**	
TOTAL LENGTH (m)	3.4		
FROM TOP	69.2m	**WATER QUALITY:**	
TO BASE	73.1m	**OBSERVATION ON SITE**	
SLOT SIZE / TYPE	1mm Slot PVC	**ANALYSED BY**	
OPEN HOLE	**From bottom of casing to Bottom of well** **m**	**m**	

GENERAL COMMENTS	
COMPLETED AND	
INSPECTED BY	

GDC Pilot Bore - Single Zone PVC Screened Well



F2.7 Drillers Bore Log / Well Completion Report

CONSENT NUMBER	PERMIT NUMBER	E : 2938328
		N : 6276389

OWNER / OCCUPIER	Gisborne District Council
POSTAL ADDRESS	PO Box 747, Gisborne, 4040
SITE / PROPERTY ADDRESS	Kaiaponi Farms, Matawai Road, Gisborne
Rapid Number / St or Rd Number	

START DATE	05-04-2017	**FINISH DATE**	10-05-2017

DEPTH FROM SURFACE TOP (M)	DEPTH FROM SURFACE BOTTOM (M)	DESCRIPTION OF GROUND PASSED THROUGH
0	1	Topsoil
1	6	Brown Clay
6	25	Blue Clay
25	26	Blue Clay Shell
26	31.2	Blue Gravel
31.2	36.2	Blue Clay
36.2	36.4	Blue Clay Wood
36.4	69.2	Blue Clay
69.2	72.6	Gravel
72.6	73.5	Blue Clay

SCREEN DIAGRAM

SEE PAGE 2

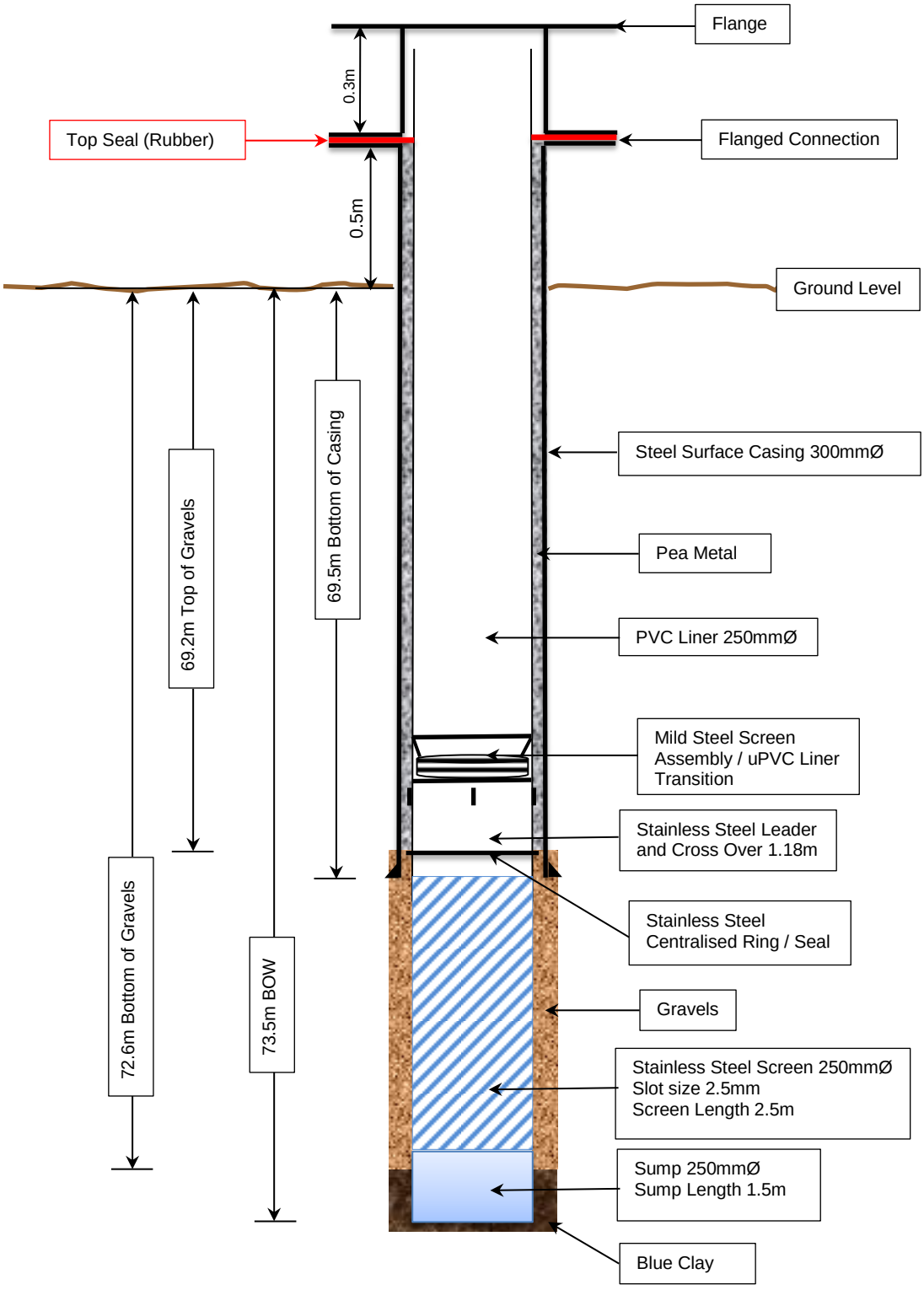
WELL / BORE CONSTRUCTION | **PUMPING TEST**

ALL MEASUREMENTS ARE FROM GROUND LEVEL

BORE DEPTH (m)	73.5	**STATIC WATER LEVEL (m)**	-7.45
CASING DEPTH (m)	69.5	**PUMPING RATE (LPS)**	** See Below*
CASING DIAMETER (mm)	300 Steel with 250mm PVC Liner	**ARTESIAN JET (")**	----------
SCREEN ASSEMBLY :		**DRAWDOWN from SWL (m)**	** See Below*
DIAMETER (mm)	250	**DURATION OF PUMPING (hrs)**	** See Below*
TOTAL LENGTH (m)	5.18		
FROM TOP	68.32m	**WATER QUALITY:**	
TO BASE	73.5m	**OBSERVATION ON SITE**	
SLOT SIZE / TYPE	2.5mm Slot Stainless Steel	**ANALYSED BY**	
OPEN HOLE	**From bottom of casing to Bottom of well** **m**	**m**	

GENERAL COMMENTS	** Refer to stepped and constant rate field sheets*
COMPLETED AND INSPECTED BY	Chris Wallace

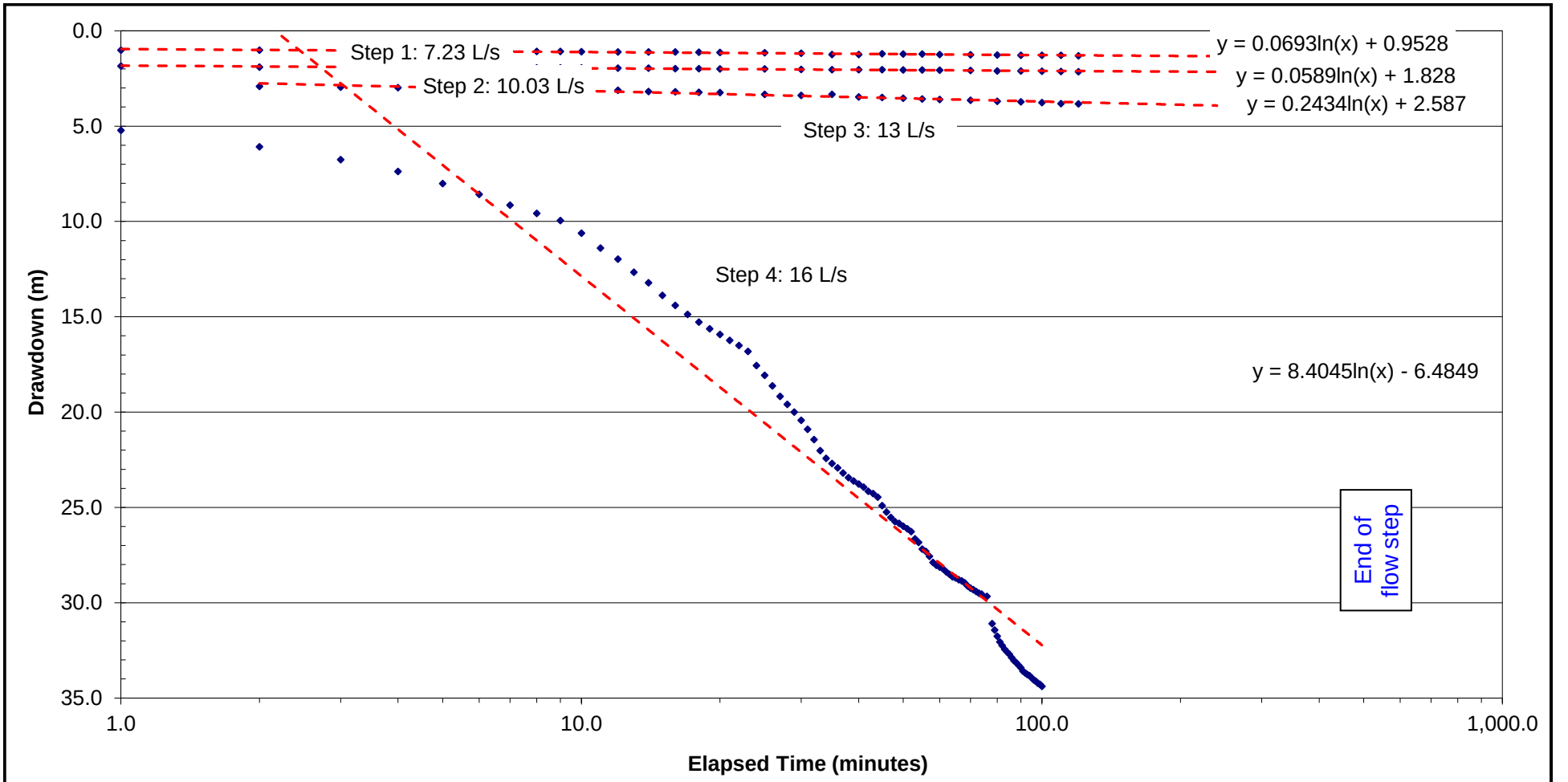
GDC Injection Bore



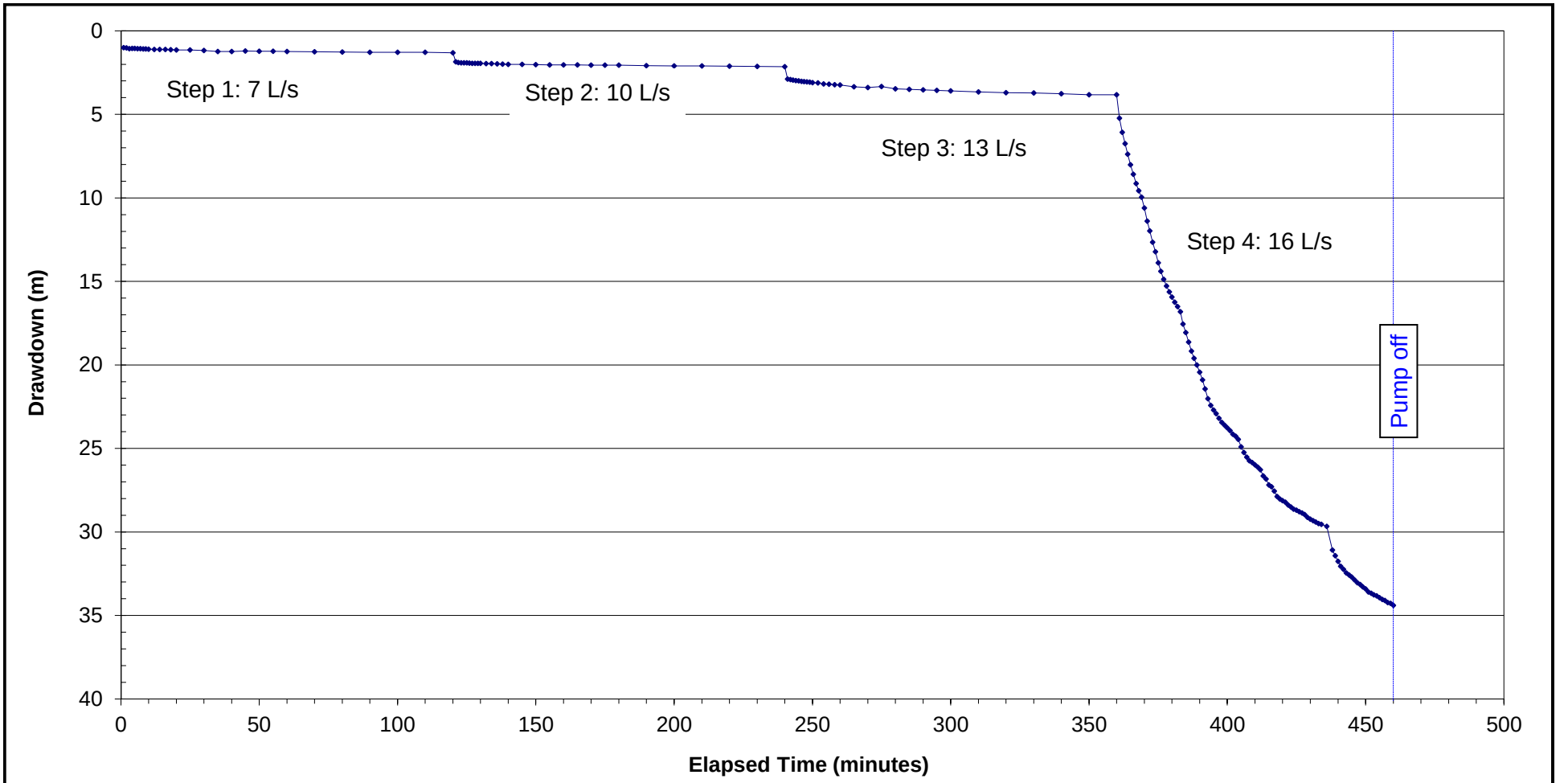
Not to Scale

APPENDIX B

Pumping Test Analysis Sheets



MAR Makauri Injection Bore Bushmere Road	TITLE	**Stepped Rate Pumping Test Drawdown, May 2017 Log - Normal Scale plot**		
Golder Associates	DRAWN	C. Houlbrooke	DATE	JOB NO. 1415771
	CHECKED	B. Sinclair	SCALE na	DWG. NO. na
	REVIEWED		FILE NO. na	FIGURE NO. B4

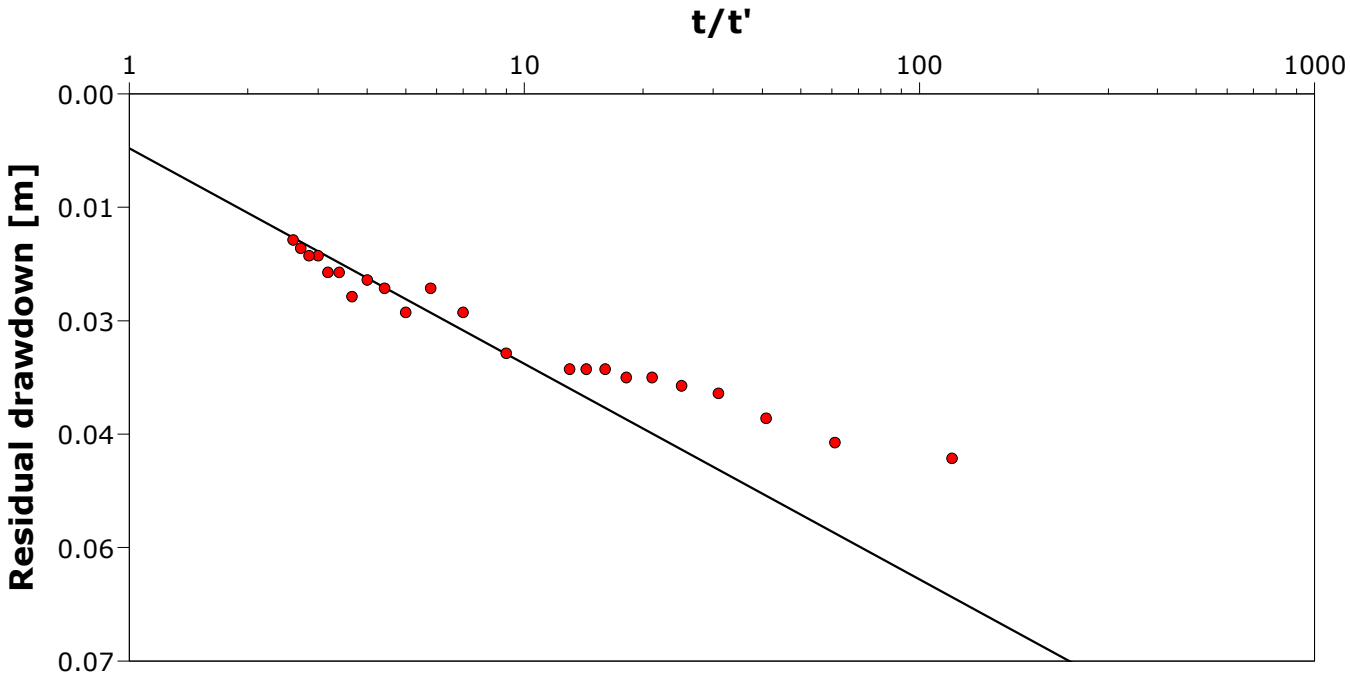


MAR Makauri Injection Bore Bushmere Road	TITLE	**Stepped Rate Pumping Test Drawdown and Recovery, Normal - Normal Scale Plot**		
Golder Associates	DRAWN	C. Houlbrooke	DATE	JOB NO. 1415771
	CHECKED	B. Sinclair	SCALE na	DWG. NO. na
	REVIEWED		FILE NO. na	FIGURE NO. B3

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

Pumping Test Analysis Report	B
Project: GDC MAR	
Number:	
Client:	

Location: Kaiaponi	Pumping Test: MAR GDC Piezo airlift	Pumping Well: MAR piezo
Test Conducted by: GDC and Honnors Drilling		Test Date: 30/03/2017
Analysis Performed by: C Houlbrooke	Theis recovery	Analysis Date: 30/03/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 1.8 [l/s]	



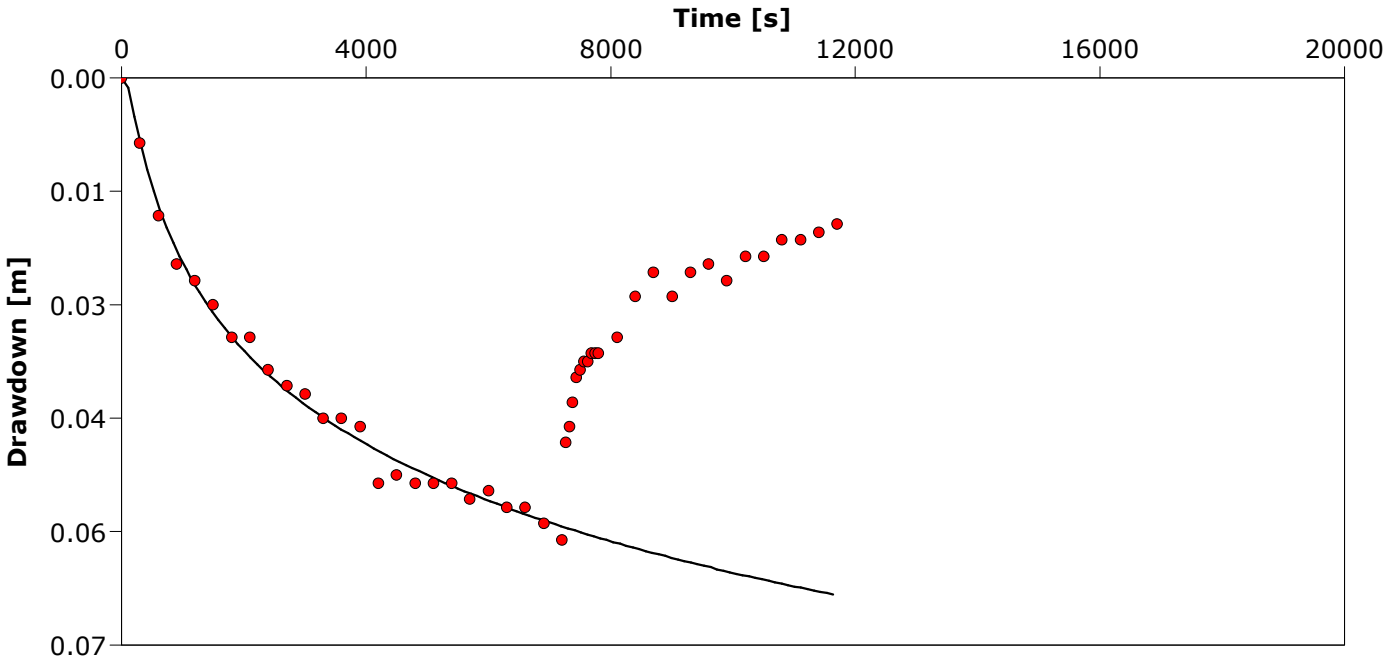
Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
GPE010	1.07×10^{3}	3.57×10^{2}	190.0	

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

Pumping Test Analysis Report	B
Project: GDC MAR	
Number:	
Client:	

Location: Kaiaponi	Pumping Test: MAR GDC Piezo airlift	Pumping Well: MAR piezo
Test Conducted by: GDC and Honnors Drilling		Test Date: 30/03/2017
Analysis Performed by: C Houlbrooke	Theis drawdown	Analysis Date: 30/03/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 1.8 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
GPE010	6.92×10^{2}	2.31×10^{2}	1.67×10^{-4}	190.0	

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

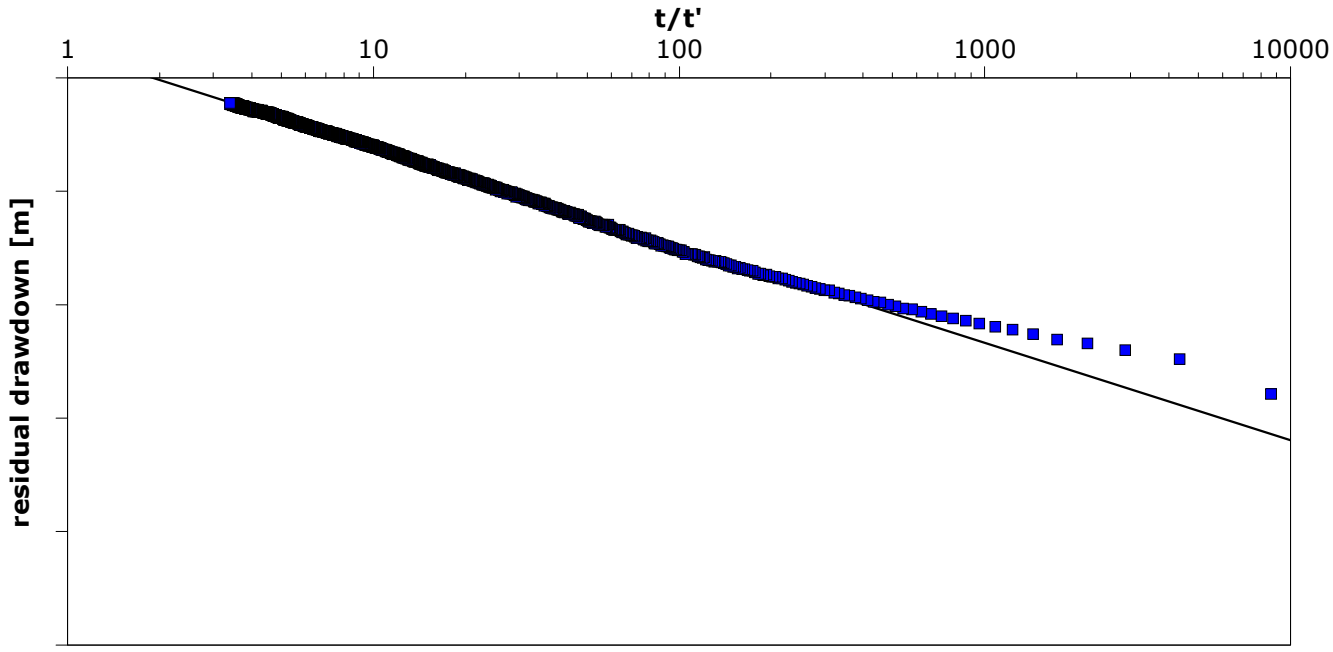
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by: C Houlbrooke	Recovery - Pupmed well	Analysis Date: 17/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
GPE066	5.99×10^{2}	2.00×10^{2}	0.13	

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

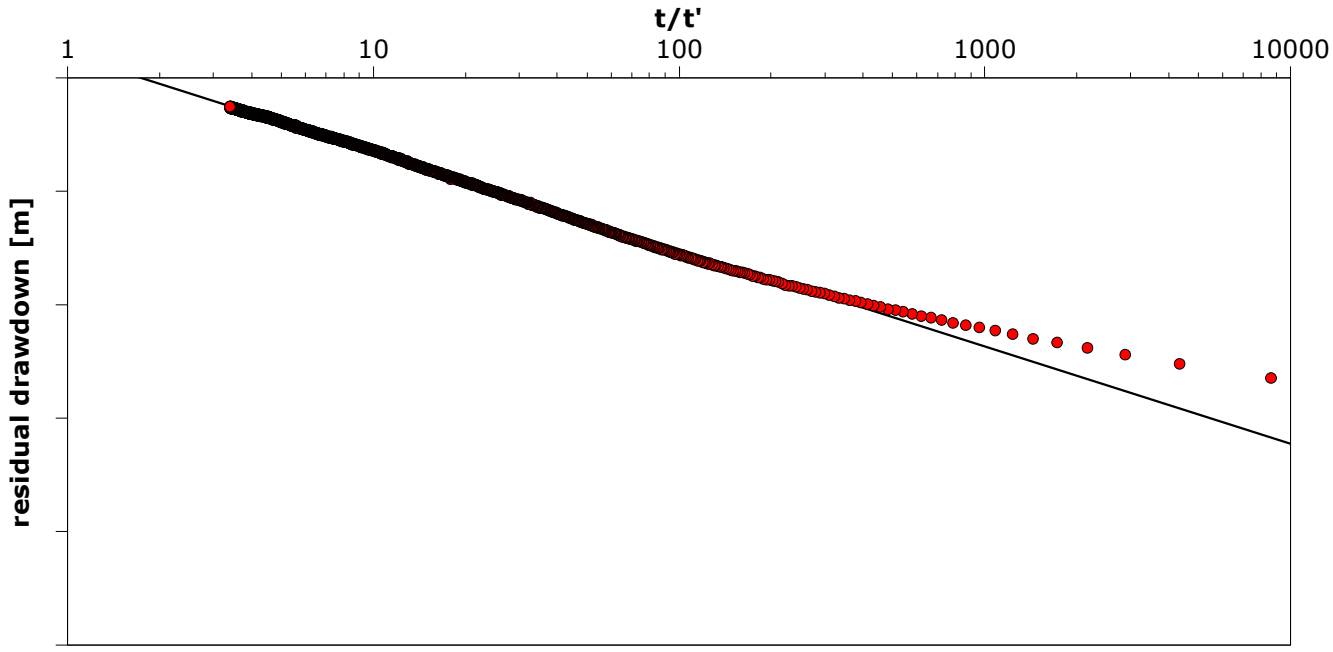
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by: C Houlbrooke	GPE065 Recovery	Analysis Date: 17/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
GPE065	5.99×10^2	2.00×10^2	22.0	

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

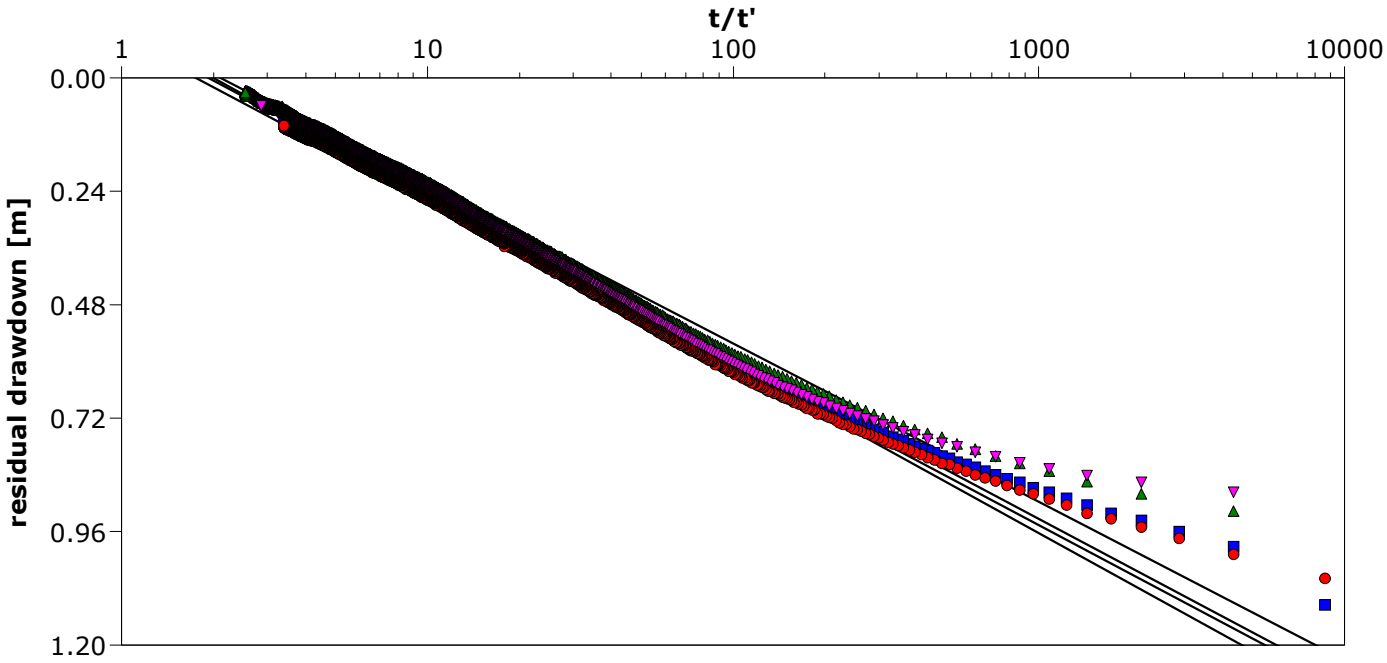
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by: C Houlbrooke	Recovery	Analysis Date: 3/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
GPE066	5.99×10^2	2.00×10^2	0.13	
GPE010	6.14×10^2	2.05×10^2	190.0	
GPE030	5.76×10^2	1.92×10^2	365.0	
GPE065	5.99×10^2	2.00×10^2	22.0	
Average	5.97×10^2	1.99×10^2		

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

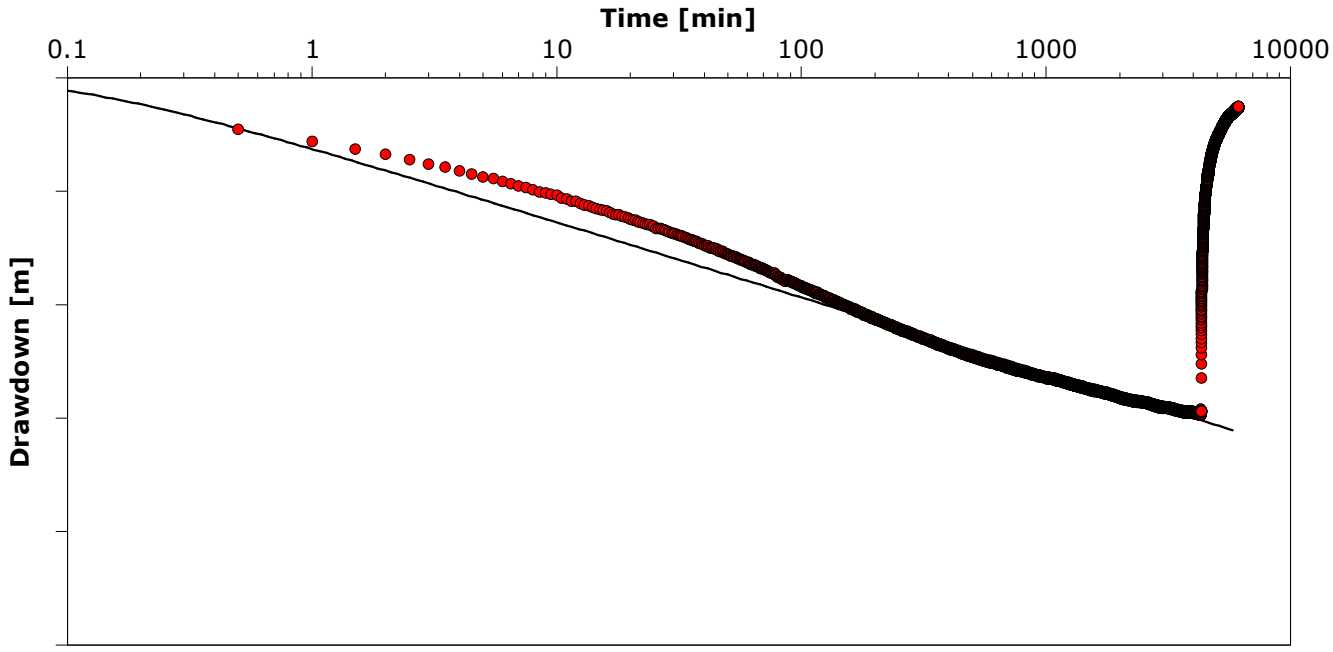
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by: C Houlbrooke	GPE065 Drawdown	Analysis Date: 17/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
GPE065	7.75×10^{2}	2.58×10^{2}	3.03×10^{-4}	22.0	

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

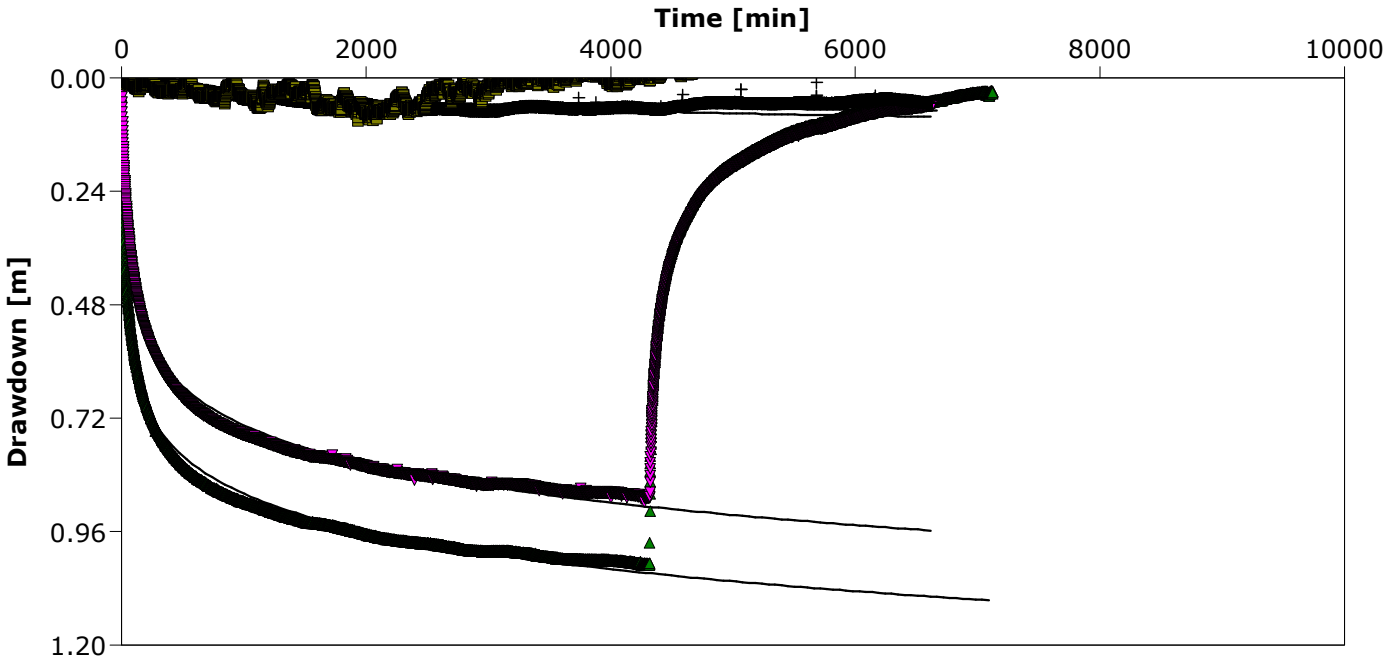
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by: C Houlbrooke	Obs bores drawdown	Analysis Date: 16/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
GPE010	7.76×10^{2}	2.59×10^{2}	1.62×10^{-5}	190.0	
GPE030	7.57×10^{2}	2.52×10^{2}	1.76×10^{-5}	365.0	
GPE105	3.53×10^{3}	1.18×10^{3}	1.01×10^{-3}	1204.0	
GPE012	5.12×10^{3}	1.71×10^{3}	9.52×10^{-4}	1026.0	
Average	2.54×10^{3}	8.48×10^{2}	4.99×10^{-4}		

Golder Associates (NZ) Limited
Level 2, Nielsen Centre
129 Hurstmere Road
Takapuna, Auckland 0622
New Zealand

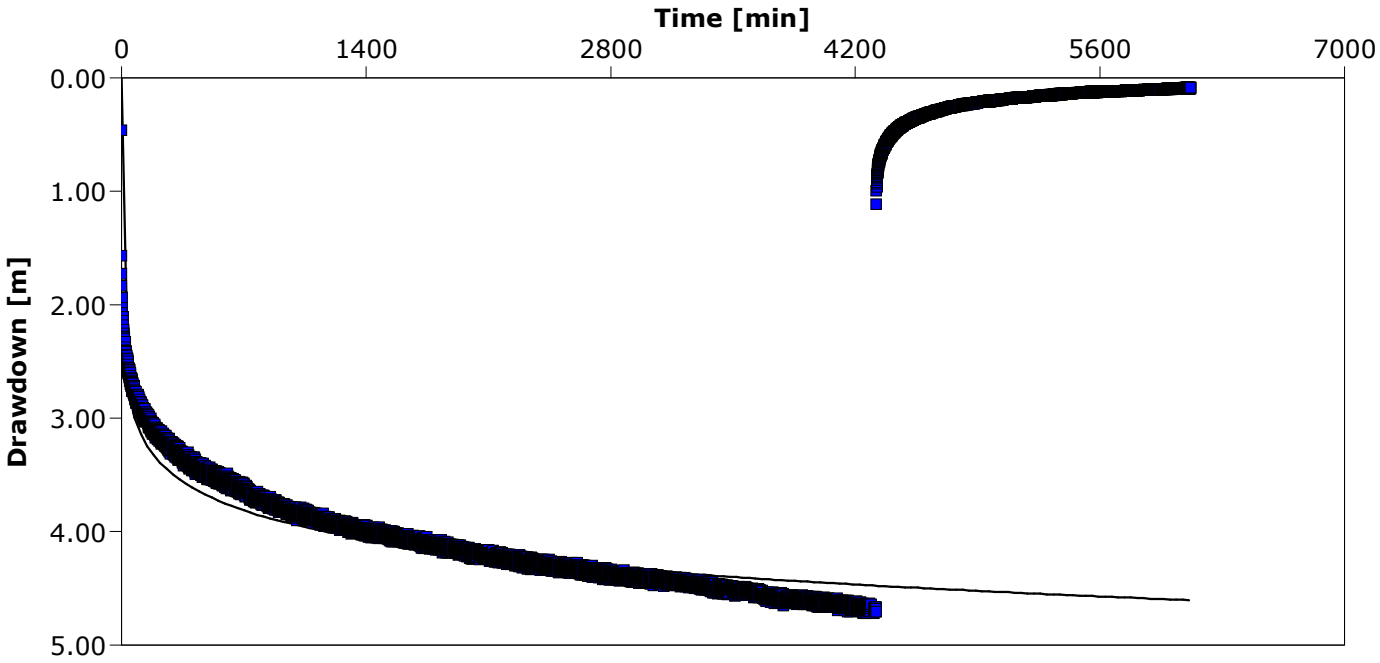
Pumping Test Analysis Report

Project: Makauri MAR Trial

Number: 1415771

Client: GDC

Location: Kaiaponi, Gisborne	Pumping Test: Constant Rate test	Pumping Well: GPE066
Test Conducted by: Honnors/GDC/Golder		Test Date: 5/05/2017
Analysis Performed by:	Drawdown pumped bore	Analysis Date: 17/05/2017
Aquifer Thickness: 3.00 m	Discharge: variable, average rate 13 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
GPE066	2.45×10^{2}	8.16×10^{1}	5.00×10^{-1}	0.13	

APPENDIX C

Aquifer Geochemistry Analysis Sheets.

Watercare Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170509-082

Attention:	Hilltop Sampler	*Final Report:*	**228731-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**31-May-2017**
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**09-May-2017**
Client Reference:	**MAR**	*Sampled By:*	**Peter Hancock**
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**

Sample Details	WATERS
Lab Sample ID:	**170509-082-1**
Client Sample ID:	20172081
Sample Date/Time:	08/05/2017 08:53
Description:	598 Bushmere Rd - MAR injection bore GPE066

Chemistry Detailed

Anions by Ion Chromatography (0.45 µm Filtered)

Chloride	mg/L	120
Nitrate (as N)	mg/L	0.0048
Nitrite (as N)	mg/L	0.0060
Sulphate	mg/L	<0.04
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.011 *

Ion Balance (Anions/Cations) by Calculation

Anion Total	meq/L	15 *
Cation Total	meq/L	15 *
meq/L Difference	meq/L	0.25 *
Percent Difference	%	0.85 *
Sum of Anions + Cations	meq/L	29 *

General Testing

Ammoniacal Nitrogen (as N)	mg/L	2.0
Ammoniacal Nitrogen (as NH4)	mg/L	2.6 *
Bicarbonate Alkalinity (as HCO3) by Calc	mg/L	690 *
Bicarbonate Alkalinity (as HCO3)	mg/L	680
Carbonate Alkalinity (as CO3)	mg/L	<0.6 *
Carbonate Alkalinity (as CO3)	mg/L	<3.3
Hydroxide Alkalinity (as CaCO3)	mg/L	<3.3
Nitrate (as NO3)	mg/L	0.021 *
Nitrite (as NO2)	mg/L	0.020 *
pH (at room temp c. 20 °C)	pH unit	7.1
Sulfide	mg/L	<0.1 *
Total Alkalinity (as CaCO3)	mg/L	560
Total Chlorine (as Cl2)	mg/L	0.09
Total Dissolved Solids	mg/L	780
Total Nitrogen (as N)	mg/L	2.0
Total Phosphorus (as P)	mg/L	0.43
Total Suspended Solids	mg/L	13
Turbidity	NTU	37

Metals

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

Arsenic (Dissolved)	mg/L	0.011
Calcium (Dissolved)	mg/L	170
Iron (Dissolved)	mg/L	5.1

Sample Details (continued)

WATERS

Lab Sample ID:	**170509-082-1**
Client Sample ID:	20172081
Sample Date/Time:	08/05/2017 08:53
Description:	598 Bushmere Rd - MAR injection bore GPE066

Metals

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

Magnesium (Dissolved)	mg/L	20
Manganese (Dissolved)	mg/L	0.96
Potassium (Dissolved)	mg/L	8.4
Sodium (Dissolved)	mg/L	88

Total Metals by ICP-MS—Trace (Default Digest)

Arsenic (Total)	mg/L	0.011
Calcium (Total)	mg/L	170
Iron (Total)	mg/L	5.1
Magnesium (Total)	mg/L	19
Manganese (Total)	mg/L	0.94
Potassium (Total)	mg/L	8.2
Sodium (Total)	mg/L	86
Total Hardness (as CaCO3)	mg/L	520

Organics

Total Organic Carbon by Non-dispersive infrared detection

Total Organic Carbon	mg/L	5.2

Microbiology

Escherichia coli by Membrane Filtration

Escherichia coli	cfu/100 mL	<1.6

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

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

Reference Methods

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

Analyte	Method Reference	MDL	Samples	Location
Chemistry Detailed				
Anions by Ion Chromatography (0.45 µm Filtered)				
Chloride	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Nitrate (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Nitrite (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Sulphate	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Calculation	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Ion Balance (Anions/Cations) by Calculation				
Anion Total	APHA (online edition) 1030 E	meq/L	All	Auckland
Cation Total	APHA (online edition) 1030 E	meq/L	All	Auckland
meq/L Difference	APHA (online edition) 1030 E	meq/L	All	Auckland
Percent Difference	APHA (online edition) 1030 E		All	Auckland
Sum of Anions + Cations	APHA (online edition) 1030 E		All	Auckland
General Testing				
Ammoniacal Nitrogen (as N) by Colorimetry/Discrete Analyser	HMSO (1981) ISBN 0117516139	0.005 mg/L	All	Auckland
Ammoniacal Nitrogen (as NH4) by Calculation	Calculation from Ammonia (as N)	0.006 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Calculation	APHA (online edition) 4500-CO2 D	1 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Calculation	APHA (online edition) 4500-CO2 D	1 mg/L	All	Auckland
Hydroxide Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Nitrate (as NO3) by Calculation	Calculation	0.009 mg/L	All	Auckland
Nitrite (as NO2) by Calculation	Calculation	0.007 mg/L	All	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland

General Testing				
Sulfide by Colour Comparison (Methylene Blue Method)	APHA (online edition) 4500-S2 D	0.1 mg/L	All	Auckland
Total Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Chlorine (as Cl2) by Spectrophotometry according to APHA (2005) 4500-Cl G	APHA (online edition) 4500-Cl G	0.02 mg/L	All	Auckland
Total Dissolved Solids by Gravimetry	APHA (online edition) 2540 C (Modified: Dried at 103 - 105 °C)	15 mg/L	All	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J (modified), 4500-NO3 I	0.010 mg/L	All	Auckland
Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/Discrete Analyser	APHA (online edition) 4500-P J (modified)	0.004 mg/L	All	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	All	Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	All	Auckland
Metals				
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Arsenic (Dissolved)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Dissolved)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Dissolved)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.02 mg/L	All	Auckland
Sodium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Metals by ICP-MS—Trace (Default Digest)				
Arsenic (Total)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Total)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Total)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Total)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Total)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Total)	In House based on EPA 200.8 by ICPMS	0.05 mg/L	All	Auckland
Sodium (Total)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Hardness (as CaCO3)	In House based on EPA 200.8 by ICPMS	0.03 mg/L	All	Auckland
Organics				
Total Organic Carbon by Non-dispersive infrared detection				
Total Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	All	Auckland
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland
Preparations				
Digest for Total Metals in Liquids	APHA (online edition) 3030 E (modified, 4:1 Nitric:Hydrochloric Acid)		All	Auckland
Glass Fibre Filtration (1.2 µm)	APHA (online edition) 2540 C (Filtration)		All	Auckland
Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)		All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Operations Manager.

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

Watercare Laboratory Services is a division of Watercare Services Limited .

ilac-MRA IANZ ACCREDITED LABORATORY

Report Signatory 31/05/2017

Anel Du Preez
KTP Signatory

Watercare Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170505-086

Attention:	Hilltop Sampler	*Final Report:*	**228730-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**31-May-2017**
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**05-May-2017**
Client Reference:	**MAR**	*Sampled By:*	**Daniel Williams**
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**

No client filtered sample bottle received for sample ID 20172080 (590 Matawai rd GPF159). Logged as lab filtered dissolved metal test instead and was subsampled from the bulk as requested by the client.

Sample Details		WATERS	WATERS	WATERS	WATERS
Lab Sample ID:		**170505-086-1**	**170505-086-2**	**170505-086-3**	**170505-086-4**
Client Sample ID:		20172070	20172071	20172072	20172080
Sample Date/Time:		04/05/2017 09:20	04/05/2017 10:05	04/05/2017 11:05	04/05/2017 13:00
Description:		Mc Intyre 409 Matawai Rd (SH2) GPD116	Patterson 54 Bolitho Rd GPD115	Stuart 370 Bushmere Rd	590 Matawai Rd
Chemistry Detailed					
Anions by Ion Chromatography (0.45 µm Filtered)					
Chloride	mg/L	65	130	320	27
Nitrate (as N)	mg/L	0.0080	0.0094	0.0050	0.0054
Nitrite (as N)	mg/L	<0.002	<0.002	<0.002	<0.002
Sulphate	mg/L	<0.04	<0.04	<0.04	0.68
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.0080 *	0.0094 *	0.0050 *	0.0054 *
Ion Balance (Anions/Cations) by Calculation					
Anion Total	meq/L	16 *	14 *	22 *	8.9 *
Cation Total	meq/L	16 *	14 *	22 *	8.5 *
meq/L Difference	meq/L	0.78 *	0.25 *	0.021 *	0.40 *
Percent Difference	%	2.4 *	0.88 *	0.046 *	2.3 *
Sum of Anions + Cations	meq/L	32 *	28 *	45 *	17 *
General Testing					
Ammoniacal Nitrogen (as N)	mg/L	1.4	4.1	2.0	0.42
Ammoniacal Nitrogen (as NH4)	mg/L	2.0 *	5.5 *	2.6 *	0.53 *
Bicarbonate Alkalinity (as HCO3) by Calc	mg/L	840 *	630 *	810 *	490 *
Bicarbonate Alkalinity (as HCO3)	mg/L	840	630	810	500
Carbonate Alkalinity (as CO3)	mg/L	0.6 *	<0.6 *	0.6 *	<0.6 *
Carbonate Alkalinity (as CO3)	mg/L	<3.3	<4.0	<3.3	<2.0
Hydroxide Alkalinity (as CaCO3)	mg/L	<3.3	<4.0	<3.3	<2.0
Nitrate (as NO3)	mg/L	0.035 *	0.042 *	0.022 *	0.024 *
Nitrite (as NO2)	mg/L	<0.007 *	<0.007 *	<0.007 *	<0.007 *
pH (at room temp c. 20 °C)	pH unit	7.2	7.0	7.2	7.2
Sulfide	mg/L	<0.1 *	<0.1 *	<0.1 *	-
Total Alkalinity (as CaCO3)	mg/L	690	520	660	410
Total Chlorine (as Cl2)	mg/L	0.07	0.06	0.09	0.03
Total Dissolved Solids	mg/L	850	780	1200	530
Total Nitrogen (as N)	mg/L	1.2	3.8	1.8	0.42
Total Phosphorus (as P)	mg/L	0.31	0.15	0.33	0.13
Total Suspended Solids	mg/L	200	30	220	2.0
Turbidity	NTU	310	150	110	12
Metals					
Dissolved Metals by ICP-MS—Trace					
Arsenic (Dissolved)	mg/L	-	-	-	0.0020
Calcium (Dissolved)	mg/L	-	-	-	100

Sample Details (continued)		WATERS	WATERS	WATERS	WATERS
Lab Sample ID:		**170505-086-1**	**170505-086-2**	**170505-086-3**	**170505-086-4**
Client Sample ID:		20172070	20172071	20172072	20172080
Sample Date/Time:		04/05/2017 09:20	04/05/2017 10:05	04/05/2017 11:05	04/05/2017 13:00
Description:		Mc Intyre 409 Matawai Rd (SH2) GPD116	Patterson 54 Bolitho Rd GPD115	Stuart 370 Bushmere Rd	590 Matawai Rd
Metals					
Dissolved Metals by ICP-MS—Trace					
Iron (Dissolved)	mg/L	-	-	-	0.0025
Magnesium (Dissolved)	mg/L	-	-	-	11
Manganese (Dissolved)	mg/L	-	-	-	0.31
Potassium (Dissolved)	mg/L	-	-	-	5.2
Sodium (Dissolved)	mg/L	-	-	-	52
Dissolved Metals by ICP-MS—Trace (Received Filtered)					
Arsenic (Dissolved)	mg/L	0.0043	0.0053	0.0076	-
Calcium (Dissolved)	mg/L	190	160	220	-
Iron (Dissolved)	mg/L	10	8.9	4.9	-
Magnesium (Dissolved)	mg/L	24	19	34	-
Manganese (Dissolved)	mg/L	1.5	0.70	1.4	-
Potassium (Dissolved)	mg/L	6.4	9.0	7.6	-
Sodium (Dissolved)	mg/L	100	89	180	-
Total Metals by ICP-MS—Trace (Default Digest)					
Arsenic (Total)	mg/L	0.0051	0.0051	0.0094	0.0022
Calcium (Total)	mg/L	190	160	230	110
Iron (Total)	mg/L	28	10	10	1.0
Magnesium (Total)	mg/L	25	19	37	11
Manganese (Total)	mg/L	1.6	0.68	1.5	0.32
Potassium (Total)	mg/L	7.5	9.0	8.6	5.8
Sodium (Total)	mg/L	98	89	190	54
Total Hardness (as CaCO3)	mg/L	570	480	730	320
Organics					
Total Organic Carbon by Non-dispersive infrared detection					
Total Organic Carbon	mg/L	4.1	3.3	4.7	2.5
Microbiology					
Escherichia coli by Membrane Filtration					
Escherichia coli	cfu/100 mL	<1.6	<1.6	<1.6	<1.6

Sample Details		WATERS
Lab Sample ID:		**170505-086-5**
Client Sample ID:		20172074
Sample Date/Time:		05/05/2017 09:45
Description:		Harper Road
Chemistry Detailed		
Anions by Ion Chromatography (0.45 µm Filtered)		
Chloride	mg/L	29
Nitrate (as N)	mg/L	0.0028
Nitrite (as N)	mg/L	0.0037
Sulphate	mg/L	0.47
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.0065 *
Ion Balance (Anions/Cations) by Calculation		
Anion Total	meq/L	9.3 *
Cation Total	meq/L	9.5 *
meq/L Difference	meq/L	0.25 *
Percent Difference	%	1.3 *
Sum of Anions + Cations	meq/L	19 *
General Testing		
Ammoniacal Nitrogen (as N)	mg/L	0.27
Ammoniacal Nitrogen (as NH4)	mg/L	0.35 *
Bicarbonate Alkalinity (as HCO3) by Calc	mg/L	510 *
Bicarbonate Alkalinity (as HCO3)	mg/L	520

Sample Details (continued)	WATERS
Lab Sample ID:	**170505-086-5**
Client Sample ID:	20172074
Sample Date/Time:	05/05/2017 09:45
Description:	Harper Road

General Testing		
Carbonate Alkalinity (as CO3)	mg/L	<0.6 *
Carbonate Alkalinity (as CO3)	mg/L	<2.0
Hydroxide Alkalinity (as CaCO3)	mg/L	<2.0
Nitrate (as NO3)	mg/L	0.012 *
Nitrite (as NO2)	mg/L	0.012 *
pH (at room temp c. 20 °C)	pH unit	7.4
Sulfide	mg/L	<0.1 *
Total Alkalinity (as CaCO3)	mg/L	420
Total Chlorine (as Cl2)	mg/L	0.02
Total Dissolved Solids	mg/L	520
Total Nitrogen (as N)	mg/L	0.29
Total Phosphorus (as P)	mg/L	0.12
Total Suspended Solids	mg/L	4.8
Turbidity	NTU	17
Metals		
Dissolved Metals by ICP-MS—Trace (Received Filtered)		
Arsenic (Dissolved)	mg/L	0.0035
Calcium (Dissolved)	mg/L	130
Iron (Dissolved)	mg/L	1.6
Magnesium (Dissolved)	mg/L	13
Manganese (Dissolved)	mg/L	0.20
Potassium (Dissolved)	mg/L	4.2
Sodium (Dissolved)	mg/L	47
Total Metals by ICP-MS—Trace (Default Digest)		
Arsenic (Total)	mg/L	0.0033
Calcium (Total)	mg/L	130
Iron (Total)	mg/L	1.6
Magnesium (Total)	mg/L	13
Manganese (Total)	mg/L	0.20
Potassium (Total)	mg/L	5.2
Sodium (Total)	mg/L	46
Total Hardness (as CaCO3)	mg/L	360
Organics		
Total Organic Carbon by Non-dispersive infrared detection		
Total Organic Carbon	mg/L	5.8
Microbiology		
Escherichia coli by Membrane Filtration		
Escherichia coli	cfu/100 mL	<1.6

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

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

Reference Methods

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

Analyte	Method Reference	MDL	Samples	Location
Chemistry Detailed				
Anions by Ion Chromatography (0.45 µm Filtered)				
Chloride	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Nitrate (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Nitrite (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Sulphate	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Calculation	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Ion Balance (Anions/Cations) by Calculation				
Anion Total	APHA (online edition) 1030 E	meq/L	All	Auckland

Chemistry Detailed				
Ion Balance (Anions/Cations) by Calculation				
Cation Total	APHA (online edition) 1030 E	meq/L	All	Auckland
meq/L Difference	APHA (online edition) 1030 E	meq/L	All	Auckland
Percent Difference	APHA (online edition) 1030 E		All	Auckland
Sum of Anions + Cations	APHA (online edition) 1030 E		All	Auckland
General Testing				
Ammoniacal Nitrogen (as N) by Colorimetry/Discrete Analyser	HMSO (1981) ISBN 0117516139	0.005 mg/L	All	Auckland
Ammoniacal Nitrogen (as NH4) by Calculation	Calculation from Ammonia (as N)	0.006 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Calculation	APHA (online edition) 4500-CO2 D	1 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Calculation	APHA (online edition) 4500-CO2 D	1 mg/L	All	Auckland
Hydroxide Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Nitrate (as NO3) by Calculation	Calculation	0.009 mg/L	All	Auckland
Nitrite (as NO2) by Calculation	Calculation	0.007 mg/L	All	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland
Sulfide by Colour Comparison (Methylene Blue Method)	APHA (online edition) 4500-S2 D	0.1 mg/L	1, 2, 3, 5	Auckland
Total Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Chlorine (as Cl2) by Spectrophotometry according to APHA (2005) 4500-Cl G	APHA (online edition) 4500-Cl G	0.02 mg/L	All	Auckland
Total Dissolved Solids by Gravimetry	APHA (online edition) 2540 C (Modified: Dried at 103 - 105 ºC)	15 mg/L	All	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J (modified), 4500-NO3 I	0.010 mg/L	All	Auckland
Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/Discrete Analyser	APHA (online edition) 4500-P J (modified)	0.004 mg/L	All	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	All	Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	All	Auckland
Metals				
Dissolved Metals by ICP-MS—Trace				
Arsenic (Dissolved)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	4	Auckland
Calcium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	4	Auckland
Iron (Dissolved)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	4	Auckland
Magnesium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	4	Auckland
Manganese (Dissolved)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	4	Auckland
Potassium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.05 mg/L	4	Auckland
Sodium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	4	Auckland
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Arsenic (Dissolved)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	1, 2, 3, 5	Auckland
Calcium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	1, 2, 3, 5	Auckland
Iron (Dissolved)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	1, 2, 3, 5	Auckland
Magnesium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	1, 2, 3, 5	Auckland
Manganese (Dissolved)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	1, 2, 3, 5	Auckland
Potassium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.02 mg/L	1, 2, 3, 5	Auckland
Sodium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	1, 2, 3, 5	Auckland
Total Metals by ICP-MS—Trace (Default Digest)				
Arsenic (Total)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Total)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Total)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Total)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Total)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Total)	In House based on EPA 200.8 by ICPMS	0.05 mg/L	All	Auckland
Sodium (Total)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Hardness (as CaCO3)	In House based on EPA 200.8 by ICPMS	0.03 mg/L	All	Auckland
Organics				
Total Organic Carbon by Non-dispersive infrared detection				
Total Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	All	Auckland
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland
Preparations				
0.45 µm Filtration for Dissolved Metals	APHA (online edition) 3010B (modified)		4	Auckland

Preparations

Digest for Total Metals in Liquids	APHA (online edition) 3030 E (modified, 4:1 Nitric:Hydrochloric Acid)	All	Auckland
Glass Fibre Filtration (1.2 µm)	APHA (online edition) 2540 C (Filtration)	All	Auckland
Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)	All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Operations Manager.

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

Watercare Laboratory Services is a division of Watercare Services Limited .

ACCREDITED LABORATORY

Report Signatory 31/05/2017

Anel Du Preez
KTP Signatory

Watercare
Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Auckland, 2150
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
Queenstown, 9349
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170627-092

Attention:	Hilltop Sampler	*Final Report:*	**232646-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**29-Jun-2017**
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**27-Jun-2017**
Client Reference:	**MAR (Micro)**	*Sampled By:*	**Alice Trevelyan**
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**

Sample Details

WATERS

Lab Sample ID:	**170627-092-1**
Client Sample ID:	20172897
Sample Date/Time:	26/06/2017 09:20
Description:	598 Bushmere Rd - MAR injection bore GPE066

Microbiology

Escherichia coli by Membrane Filtration

Escherichia coli	cfu/100 mL	6.5

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

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

Reference Methods

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

Analyte	Method Reference	MDL	Samples	Location
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland

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

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

Watercare Laboratory Services is a division of Watercare Services Limited .

ACCREDITED LABORATORY

Report Signatory 29/06/2017

Marina Fisher
KTP Signatory

Watercare Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170624-052

Attention:	Hilltop Sampler	*Final Report:*	**232100-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**26-Jun-2017**
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**24-Jun-2017**
Client Reference:	**MAR (Micro)**	*Sampled By:*	**Alice Trevelyan**
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**

Sample Details		WATERS	WATERS
Lab Sample ID:		**170624-052-1**	**170624-052-2**
Client Sample ID:		20172875	20172878
Sample Date/Time:		23/06/2017 09:42	23/06/2017 10:49
Description:		599 Bushmere Road GPE010	598 Bushmere Road MAR Pilot Bore GPE 065
Microbiology			
Escherichia coli by Membrane Filtration			
Escherichia coli	cfu/100 mL	<1.6	6.6

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

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

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

Analyte	Method Reference	MDL	Samples	Location
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Operations Manager

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

Watercare Laboratory Services is a division of Watercare Services Limited .

ilac-MRA IANZ ACCREDITED LABORATORY

Report Signatory 26/06/2017

Qi Zhu
KTP Signatory

Watercare Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170607-106

Attention:	Hilltop Sampler	*Final Report:*	**231671-0**	*Replaces Report*	**230948-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**22-Jun-2017**		
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**07-Jun-2017**		
Client Reference:	**598 Bushmere Road MAR Injection Bore GPE066**	*Sampled By:*	**Mark Joblin**		
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**		

Sample Details	WATERS
Lab Sample ID:	**170607-106-1**
Client Sample ID:	20172586
Sample Date/Time:	06/06/2017 11:30
Description:	598 Bushmere Road MAR Injection Bore GPE066

Chemistry Detailed

Anions by Ion Chromatography (0.45 µm Filtered)

Chloride	mg/L	15
Nitrate (as N)	mg/L	0.0055
Nitrite (as N)	mg/L	<0.002
Sulphate	mg/L	76
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.0055 *

Ion Balance (Anions/Cations) by Calculation

Anion Total	meq/L	6.4 *
Cation Total	meq/L	6.5 *
meq/L Difference	meq/L	0.54e-1 *
Percent Difference	%	0.42 *
Sum of Anions + Cations	meq/L	13 *

General Testing

Ammoniacal Nitrogen (as N)	mg/L	0.55
Ammoniacal Nitrogen (as NH4)	mg/L	0.71 *
Bicarbonate Alkalinity (as HCO3)	mg/L	270
Carbonate Alkalinity (as CO3)	mg/L	<2.0
Conductivity (at 25 °C)	mS/m	60.6
Hydroxide Alkalinity (as CaCO3)	mg/L	<2.0
pH (at room temp c. 20 °C)	pH unit	7.6
Total Alkalinity (as CaCO3)	mg/L	220
Total Chlorine (as Cl2)	mg/L	0.04
Total Dissolved Solids	mg/L	460
Total Nitrogen (as N)	mg/L	1.1
Total Phosphorus (as P)	mg/L	0.018
Total Suspended Solids	mg/L	3.0
Turbidity	NTU	0.65

Metals

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

Arsenic (Dissolved)	mg/L	0.0027
Calcium (Dissolved)	mg/L	78
Iron (Dissolved)	mg/L	0.035
Magnesium (Dissolved)	mg/L	8.5
Manganese (Dissolved)	mg/L	0.21
Potassium (Dissolved)	mg/L	4.9
Sodium (Dissolved)	mg/L	39

Total Metals by ICP-MS—Trace (Default Digest)

Sample Details (continued)

WATERS

Lab Sample ID:	**170607-106-1**
Client Sample ID:	20172586
Sample Date/Time:	06/06/2017 11:30
Description:	598 Bushmere Road MAR Injection Bore GPE066

Metals

Total Metals by ICP-MS—Trace (Default Digest)

Arsenic (Total)	mg/L	0.0027
Iron (Total)	mg/L	0.063
Manganese (Total)	mg/L	0.20
Potassium (Total)	mg/L	4.9
Sodium (Total)	mg/L	35

Organics

Total Organic Carbon by Non-dispersive infrared detection

Total Organic Carbon	mg/L	3.7

Microbiology

Escherichia coli by Membrane Filtration

Escherichia coli	cfu/100 mL	1.6

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

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

Reference Methods

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

Analyte	Method Reference	MDL	Samples	Location
Chemistry Detailed				
Anions by Ion Chromatography (0.45 µm Filtered)				
Chloride	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Nitrate (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Nitrite (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Sulphate	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Calculation	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Ion Balance (Anions/Cations) by Calculation				
Anion Total	APHA (online edition) 1030 E	meq/L	All	Auckland
Cation Total	APHA (online edition) 1030 E	meq/L	All	Auckland
meq/L Difference	APHA (online edition) 1030 E	meq/L	All	Auckland
Percent Difference	APHA (online edition) 1030 E		All	Auckland
Sum of Anions + Cations	APHA (online edition) 1030 E		All	Auckland
General Testing				
Ammoniacal Nitrogen (as N) by Flow Analysis	APHA (online edition) 4500-NH3 H	0.005 mg/L	All	Auckland
Ammoniacal Nitrogen (as NH4) by Calculation	Calculation from Ammonia (as N)	0.006 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Conductivity (at 25 °C) by Electrode	APHA (online edition) 2510 B	0.5 mS/m	All	Auckland
Hydroxide Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland
Total Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Chlorine (as Cl2) by Spectrophotometry according to APHA (2005) 4500-Cl G	APHA (online edition) 4500-Cl G	0.02 mg/L	All	Auckland
Total Dissolved Solids by Gravimetry	APHA (online edition) 2540 C (Modified: Dried at 103 - 105 ºC)	15 mg/L	All	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J (modified), 4500-NO3 I	0.010 mg/L	All	Auckland
Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/Discrete Analyser	APHA (online edition) 4500-P J (modified)	0.004 mg/L	All	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	All	Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	All	Auckland
Metals				
Dissolved Metals by ICP-MS—Trace (Received Filtered)				

Metals				
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Arsenic (Dissolved)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Dissolved)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Dissolved)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.02 mg/L	All	Auckland
Sodium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Metals by ICP-MS—Trace (Default Digest)				
Arsenic (Total)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Iron (Total)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Manganese (Total)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Total)	In House based on EPA 200.8 by ICPMS	0.05 mg/L	All	Auckland
Sodium (Total)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Organics				
Total Organic Carbon by Non-dispersive infrared detection				
Total Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	All	Auckland
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland
Preparations				
Digest for Total Metals in Liquids	APHA (online edition) 3030 E (modified, 4:1 Nitric:Hydrochloric Acid)		All	Auckland
Glass Fibre Filtration (1.2 µm)	APHA (online edition) 2540 C (Filtration)		All	Auckland
Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)		All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Operations Manager.

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

Watercare Laboratory Services is a division of Watercare Services Limited .

ilac-MRA IANZ ACCREDITED LABORATORY

Report Signatory 22/06/2017

Carol Taylor
KTP Signatory

Watercare
Laboratory Services

Auckland
52 Aintree Ave,
PO Box 107028,
Auckland Airport,
Tel: (09) 539 7614
Fax: (09) 539 7601

Invercargill
142 Esk Street,
PO Box 747,
Invercargill, 9840
(03) 214 4040
(03) 214 4041

Queenstown
74 Glenda Drive,
PO Box 2614,
Wakatipu,
(03) 409 0559

www.watercarelabs.co.nz
clientsupport@water.co.nz

Certificate of Analysis
Laboratory Reference:170518-076

Attention:	Hilltop Sampler	*Final Report:*	**229077-0**
Client:	**GISBORNE DISTRICT COUNCIL**	*Report Issue Date:*	**04-Jun-2017**
Address:	**PO Box 747, Gisborne, 4040**	*Received Date:*	**18-May-2017**
Client Reference:	**MAR**	*Sampled By:*	**Peter Hancock**
Purchase Order:	**37/00/01/2104**	*Quote Reference :*	**5880**

Sample Details		WATERS	WATERS
Lab Sample ID:		**170518-076-1**	**170518-076-2**
Client Sample ID:		20172234	20172235
Sample Date/Time:		17/05/2017 12:14	17/05/2017 14:02
Description:		598 Bushmere Rd MAR Pilot Bore GPE 065	599 Bushmere Rd GPE010
Chemistry Detailed			
Anions by Ion Chromatography (0.45 µm Filtered)			
Chloride	mg/L	120	140
Nitrate (as N)	mg/L	0.0071	0.0072
Nitrite (as N)	mg/L	0.013	0.011
Sulphate	mg/L	0.11	<0.02
Total Oxidised Nitrogen (as N) by Calculation	mg/L	0.020 *	0.018 *
Ion Balance (Anions/Cations) by Calculation			
Anion Total	meq/L	15 *	16 *
Cation Total	meq/L	15 *	16 *
meq/L Difference	meq/L	0.063 *	0.38 *
Percent Difference	%	0.21 *	1.2 *
Sum of Anions + Cations	meq/L	30 *	32 *
General Testing			
Ammoniacal Nitrogen (as N)	mg/L	2.0	2.5
Ammoniacal Nitrogen (as NH4)	mg/L	2.5 *	3.2 *
Bicarbonate Alkalinity (as HCO3)	mg/L	700	710
Carbonate Alkalinity (as CO3)	mg/L	<4.0	<4.0
Hydroxide Alkalinity (as CaCO3)	mg/L	<4.0	<4.0
Nitrate (as NO3)	mg/L	0.031 *	0.032 *
Nitrite (as NO2)	mg/L	0.043 *	0.036 *
pH (at room temp c. 20 °C)	pH unit	7.1	7.2
Total Alkalinity (as CaCO3)	mg/L	580	580
Total Chlorine (as Cl2)	mg/L	0.07	0.04
Total Dissolved Solids	mg/L	850	860
Total Nitrogen (as N)	mg/L	1.9	2.3
Total Phosphorus (as P)	mg/L	0.39	0.33
Total Suspended Solids	mg/L	69	42
Turbidity	NTU	65	160
Metals			
Dissolved Metals by ICP-MS—Trace (Received Filtered)			
Arsenic (Dissolved)	mg/L	0.0080	0.0068
Calcium (Dissolved)	mg/L	180	200
Iron (Dissolved)	mg/L	5.5	15
Magnesium (Dissolved)	mg/L	20	22
Manganese (Dissolved)	mg/L	0.92	1.0
Potassium (Dissolved)	mg/L	10	9.6
Sodium (Dissolved)	mg/L	87	79

Sample Details (continued)		WATERS	WATERS
Lab Sample ID:		**170518-076-1**	**170518-076-2**
Client Sample ID:		20172234	20172235
Sample Date/Time:		17/05/2017 12:14	17/05/2017 14:02
Description:		598 Bushmere Rd MAR Pilot Bore GPE 065	599 Bushmere Rd GPE010
Metals			
Total Metals by ICP-MS—Trace (Default Digest)			
Arsenic (Total)	mg/L	0.0095	0.0072
Calcium (Total)	mg/L	180	180
Iron (Total)	mg/L	8.3	16
Magnesium (Total)	mg/L	22	24
Manganese (Total)	mg/L	0.95	1.0
Potassium (Total)	mg/L	9.0	8.9
Sodium (Total)	mg/L	90	82
Total Hardness (as CaCO3)	mg/L	550	560
Organics			
Total Organic Carbon by Non-dispersive infrared detection			
Total Organic Carbon	mg/L	5.4	3.7
Microbiology			
Escherichia coli by Membrane Filtration			
Escherichia coli	cfu/100 mL	<1.6	<1.6

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

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

Reference Methods

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

Analyte	Method Reference	MDL	Samples	Location
Chemistry Detailed				
Anions by Ion Chromatography (0.45 µm Filtered)				
Chloride	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Nitrate (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Nitrite (as N)	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Sulphate	In House based on APHA (online edition) 4110 B and EPA 300.0	0.02 mg/L	All	Auckland
Total Oxidised Nitrogen (as N) by Calculation	In House based on APHA (online edition) 4110 B and EPA 300.0	0.002 mg/L	All	Auckland
Ion Balance (Anions/Cations) by Calculation				
Anion Total	APHA (online edition) 1030 E	meq/L	All	Auckland
Cation Total	APHA (online edition) 1030 E	meq/L	All	Auckland
meq/L Difference	APHA (online edition) 1030 E	meq/L	All	Auckland
Percent Difference	APHA (online edition) 1030 E		All	Auckland
Sum of Anions + Cations	APHA (online edition) 1030 E		All	Auckland
General Testing				
Ammoniacal Nitrogen (as N) by Colorimetry/Discrete Analyser	HMSO (1981) ISBN 0117516139	0.005 mg/L	All	Auckland
Ammoniacal Nitrogen (as NH4) by Calculation	Calculation from Ammonia (as N)	0.006 mg/L	All	Auckland
Bicarbonate Alkalinity (as HCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Carbonate Alkalinity (as CO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Hydroxide Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Nitrate (as NO3) by Calculation	Calculation	0.009 mg/L	All	Auckland
Nitrite (as NO2) by Calculation	Calculation	0.007 mg/L	All	Auckland
pH (at room temp c. 20 °C) by Electrode	APHA (online edition) 4500-H B	0.1 pH unit	All	Auckland
Total Alkalinity (as CaCO3) by Titration	APHA (online edition) 2320 B	1 mg/L	All	Auckland
Total Chlorine (as Cl2) by Spectrophotometry according to APHA (2005) 4500-Cl G	APHA (online edition) 4500-Cl G	0.02 mg/L	All	Auckland
Total Dissolved Solids by Gravimetry	APHA (online edition) 2540 C (Modified: Dried at 103 - 105 °C)	15 mg/L	All	Auckland
Total Nitrogen (as N) by Persulphate Digestion and Flow Analysis	APHA (online edition) 4500-P J (modified), 4500-NO3 I	0.010 mg/L	All	Auckland

General Testing				
Total Phosphorus (as P) by Persulphate Digestion and Colorimetry/Discrete Analyser	APHA (online edition) 4500-P J (modified)	0.004 mg/L	All	Auckland
Total Suspended Solids by Gravimetry	APHA (online edition) 2540 D	0.2 mg/L	All	Auckland
Turbidity by Nephelometry	APHA (online edition) 2130 B (modified)	0.05 NTU	All	Auckland
Metals				
Dissolved Metals by ICP-MS—Trace (Received Filtered)				
Arsenic (Dissolved)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Dissolved)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Dissolved)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.02 mg/L	All	Auckland
Sodium (Dissolved)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Metals by ICP-MS—Trace (Default Digest)				
Arsenic (Total)	In House based on EPA 200.8 by ICPMS	0.00010 mg/L	All	Auckland
Calcium (Total)	In House based on EPA 200.8 by ICPMS	0.010 mg/L	All	Auckland
Iron (Total)	In House based on EPA 200.8 by ICPMS	0.002 mg/L	All	Auckland
Magnesium (Total)	In House based on EPA 200.8 by ICPMS	0.001 mg/L	All	Auckland
Manganese (Total)	In House based on EPA 200.8 by ICPMS	0.0005 mg/L	All	Auckland
Potassium (Total)	In House based on EPA 200.8 by ICPMS	0.05 mg/L	All	Auckland
Sodium (Total)	In House based on EPA 200.8 by ICPMS	0.1 mg/L	All	Auckland
Total Hardness (as CaCO3)	In House based on EPA 200.8 by ICPMS	0.03 mg/L	All	Auckland
Organics				
Total Organic Carbon by Non-dispersive infrared detection				
Total Organic Carbon	APHA (online edition) 5310 B	0.1 mg/L	All	Auckland
Microbiology				
Escherichia coli by Membrane Filtration				
Escherichia coli	USEPA Method 1603	2 cfu/100 mL	All	Auckland
Preparations				
Digest for Total Metals in Liquids	APHA (online edition) 3030 E (modified, 4:1 Nitric:Hydrochloric Acid)		All	Auckland
Glass Fibre Filtration (1.2 µm)	APHA (online edition) 2540 C (Filtration)		All	Auckland
Membrane Filtration (0.45 µm)	APHA (online edition) 4500-P B (preliminary filtration)		All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Operations Manager.

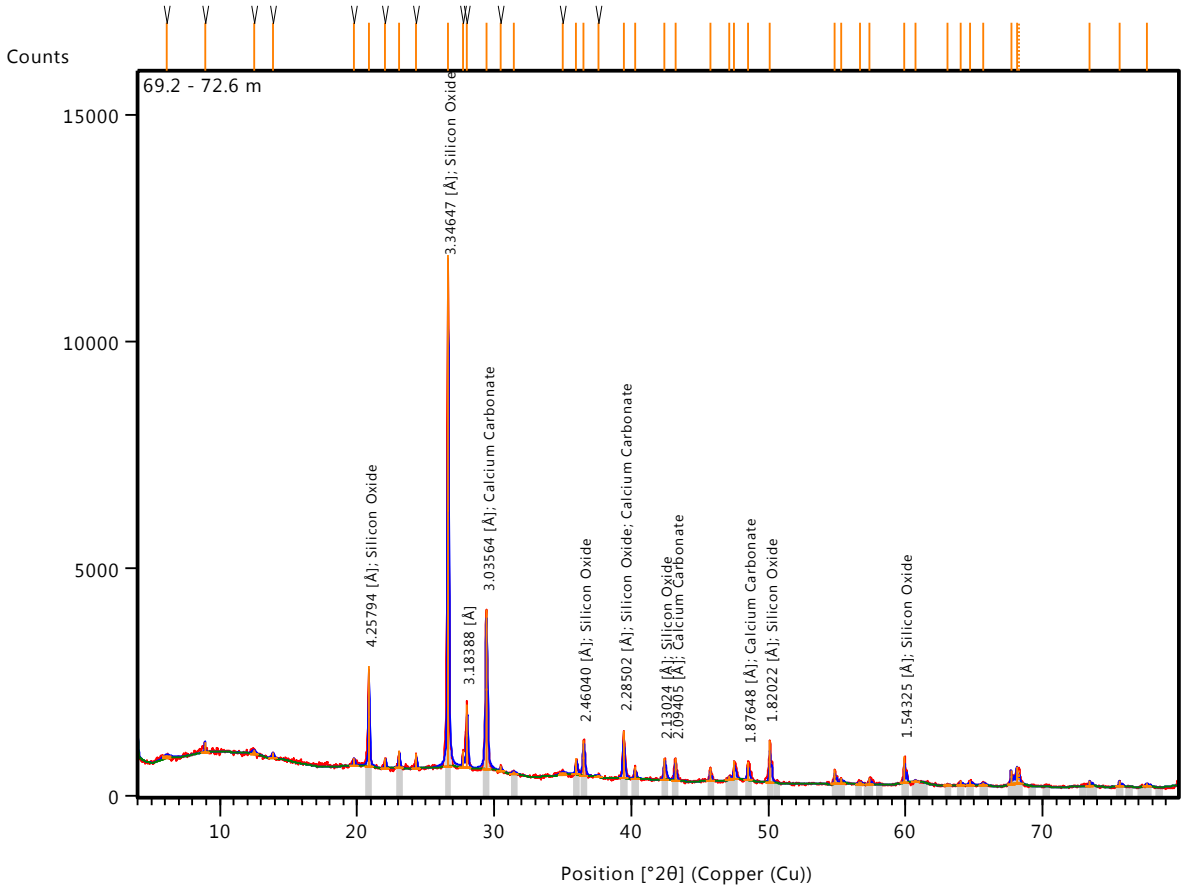
Samples, with suitable preservation and stability of analytes, will be held by the laboratory for a period of two weeks after results have been reported, unless otherwise advised by the submitter.

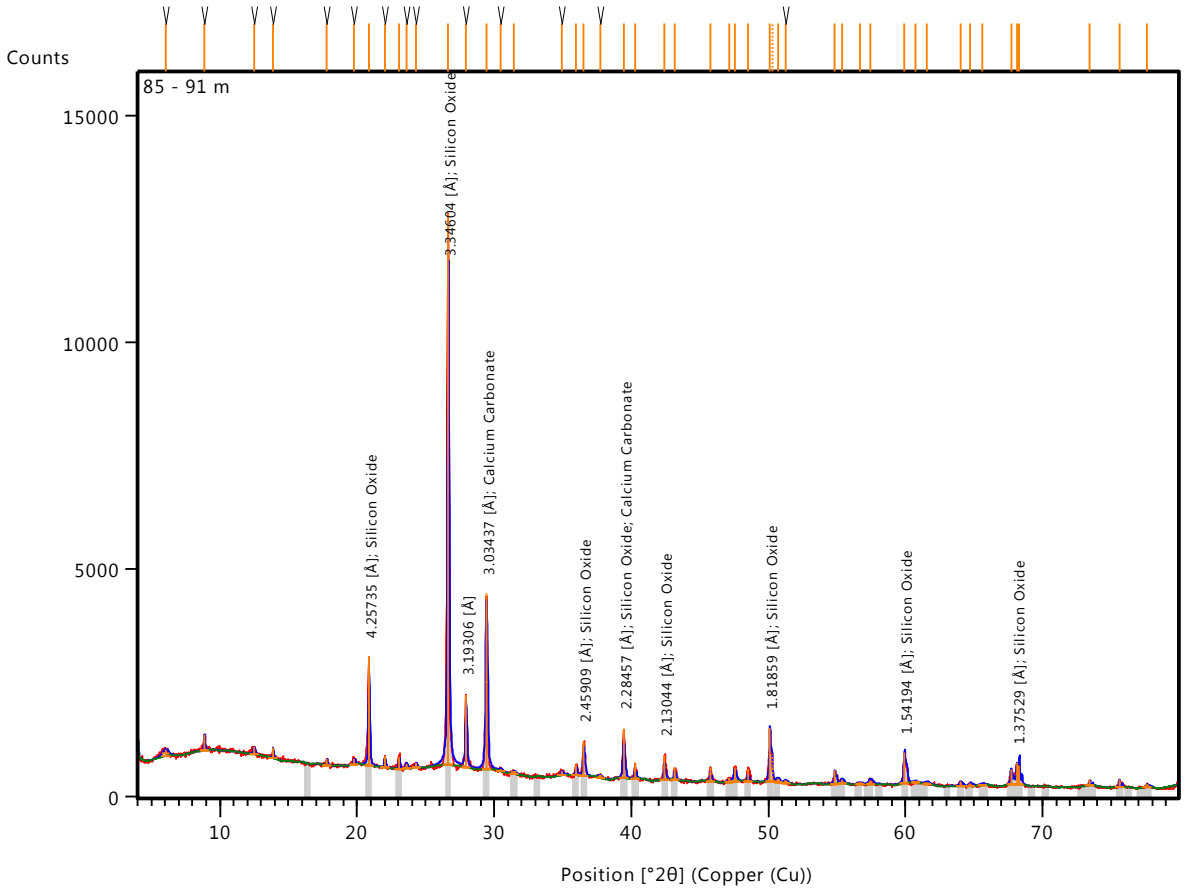
Watercare Laboratory Services is a division of Watercare Services Limited .

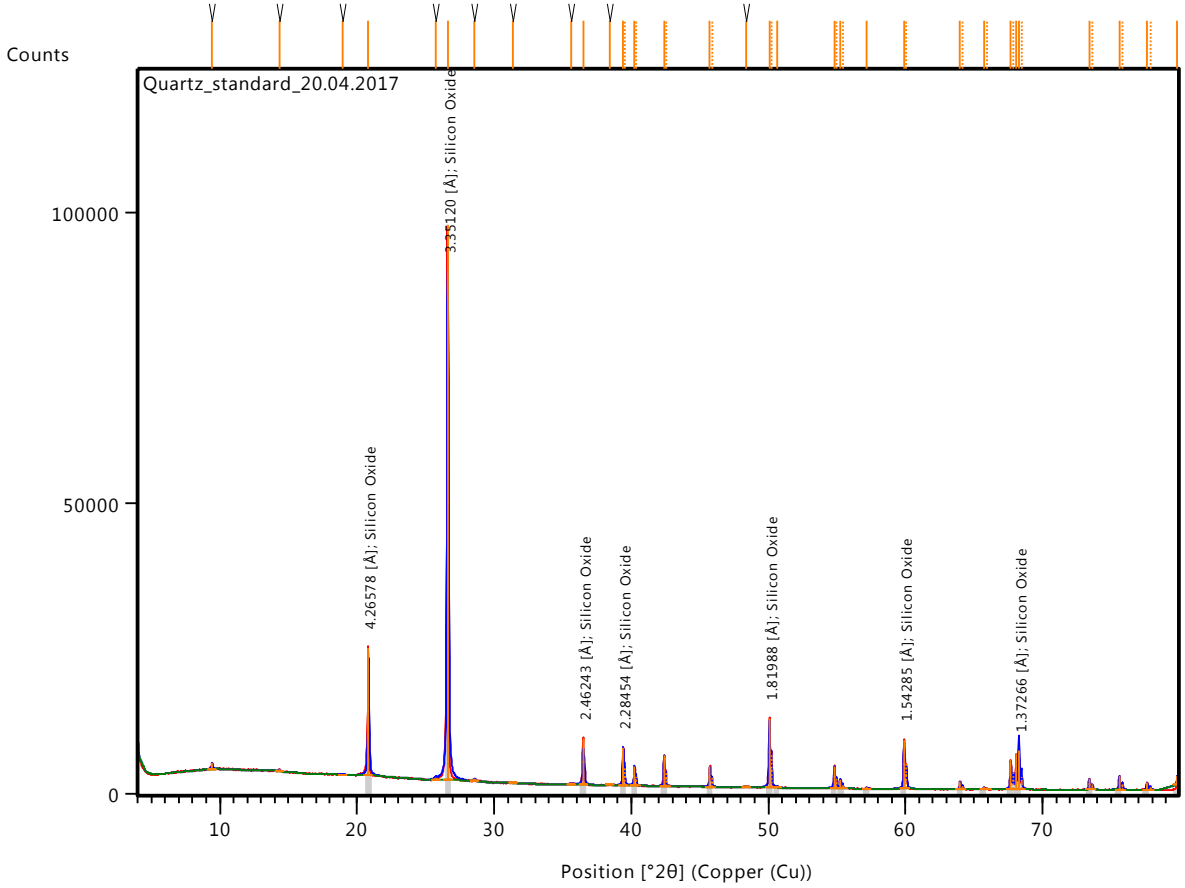
ilac-MRA IANZ ACCREDITED LABORATORY

Report Signatory 04/06/2017

Carol Taylor
KTP Signatory


Counts
69.2 - 72.6 m
15000
10000
5000
0
3.34647 [Å]; Silicon Oxide
4.25794 [Å]; Silicon Oxide
3.03564 [Å]; Calcium Carbonate
3.18388 [Å]
2.46040 [Å]; Silicon Oxide
2.28502 [Å]; Silicon Oxide; Calcium Carbonate
2.13024 [Å]; Silicon Oxide
2.09405 [Å]; Calcium Carbonate
1.87648 [Å]; Calcium Carbonate
1.82022 [Å]; Silicon Oxide
1.54325 [Å]; Silicon Oxide
10
20
30
40
50
60
70
Position [°2θ] (Copper (Cu))


Counts
85 - 91 m
15000
10000
5000
0
3.34604 [Å]; Silicon Oxide
4.25735 [Å]; Silicon Oxide
3.03437 [Å]; Calcium Carbonate
3.19306 [Å]
2.45909 [Å]; Silicon Oxide
2.28457 [Å]; Silicon Oxide; Calcium Carbonate
2.13044 [Å]; Silicon Oxide
1.81859 [Å]; Silicon Oxide
1.54194 [Å]; Silicon Oxide
1.37529 [Å]; Silicon Oxide
10
20
30
40
50
60
70
Position [°2θ] (Copper (Cu))


Counts
Quartz_standard_20.04.2017
100000
50000
0
4.26578 [Å]; Silicon Oxide
3.35120 [Å]; Silicon Oxide
2.46243 [Å]; Silicon Oxide
2.28454 [Å]; Silicon Oxide
1.81988 [Å]; Silicon Oxide
1.54285 [Å]; Silicon Oxide
1.37266 [Å]; Silicon Oxide
10
20
30
40
50
60
70
Position [°2θ] (Copper (Cu))

Report Limitations

This Report/Document has been provided by Golder Associates (NZ) Limited ("Golder") subject to the following limitations:

i) This Report/Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Report/Document, in whole or in part, in other contexts or for any other purpose.

ii) The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Report/Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

iii) Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Report/Document. Accordingly, if information in addition to that contained in this report is sought, additional studies and actions may be required.

iv) The passage of time affects the information and assessment provided in this Report/Document. Golder's opinions are based upon information that existed at the time of the production of the Report/Document. The Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

v) Any assessments, designs and advice made in this Report/Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Report/Document.

vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

vii) The Client acknowledges that Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. Golder will be fully responsible to the Client for the Services and work done by all of its subconsultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Golder and not Golder's affiliated companies. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any legal recourse, and waives any expense, loss, claim, demand, or cause of action, against Golder's affiliated companies, and their employees, officers and directors.

viii) This Report/Document is provided for sole use by the Client and is confidential to it. No responsibility whatsoever for the contents of this Report/Document will be accepted to any person other than the Client. Any use which a third party makes of this Report/Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Report/Document.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australia & NZ	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

AUCKLAND

Tel +64 9 486 8068
Fax +64 9 486 8072

Level 2
Nielsen Centre
129 Hurstmere Road
Takapuna
Auckland 0622

PO Box 33-849
Takapuna 0740

WELLINGTON

Tel +64 3 377 5696

Level 1
93 The Terrace
Wellington 6011

PO Box 5234
Wellington 6145

HAMILTON

Tel +64 7 859 2356
Fax +64 9 486 8072

Room 31 in the Homestead
Ruakura Research Centre
10 Bisley Road
Hamilton 3214

PO Box 19-479
Hamilton 3244

NELSON

Tel +64 3 548 1707
Fax +64 3 548 1727

Level 3
295 Trafalgar Street
Nelson 7010

PO Box 1724
Nelson 7040

CHRISTCHURCH

Tel +64 3 377 5696
Fax +64 3 377 9944

Level 1
214 Durham Street
Christchurch 8011

PO Box 2281
Christchurch 8140

DUNEDIN

Tel +64 3 479 0390
Fax +64 3 474 9642

Level 7B
John Wickliffe House
265 Princes Street
Dunedin 9016

PO Box 1087
Dunedin 9054

Golder Associates