Todd Energy Ltd
Mangahewa-G Hydraulic Fracturing

Monitoring Programme

2018-2021

Technical Report 21-04

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Taranaki Regional Council

Taranaki Regional Council
Private Bag 713
Stratford

ISSN: 1178-1467 (Online)
Document: 2640397 (Word)
Document: 2778039 (Pdf)
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Executive summary

Todd Energy Ltd (Todd) operates the Mangahewa-G hydrocarbon exploration site located on Otaraoa Road, Tikorangi. This report outlines and discusses the results of the monitoring programme implemented by the Council in relation to hydraulic fracturing activities conducted by Todd at the wellsite over the period 24 April 2019 to 2 October 2019. The report also details the results of the monitoring undertaken and assesses the environmental effects of the Company's activities.

During the monitoring period, Todd demonstrated an overall high level of environmental performance.

The programme of hydraulic fracturing undertaken by Todd at the Mangahewa-G wellsite included the hydraulic fracturing of six wells. The wells targeted for stimulation were the Mangahewa-25, Mangahewa 26, Mangahewa 27, Mangahewa 28, Mangahewa 29 and Mangahewa 30 wells.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2018-2019, 2019-2020 and 2020-2021 monitoring years. Monitoring included pre and post discharge groundwater sampling. Samples of hydraulic fracturing fluids, and fluids returning to the wellhead post fracturing, were also obtained for physicochemical analysis in order to characterise the discharges and to determine compliance with consent conditions.

This is the first monitoring report produced by the Council in relation to the hydraulic fracturing activities at the Mangahewa-G wellsite.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Todd had no significant adverse effects on local groundwater or surface water resources. There were no unauthorised incidents recording non-compliance in respect of the resource consent held by Todd in relation to these activities or provisions in regional plans, during the period under review.

Todd demonstrated a high level of environmental and administrative performance and compliance with the resource consents over the reporting period.

For reference, in the 2020-2021 year, consent holders were found to achieve a high level of environmental performance and compliance for 86% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 11% of the consents, a good level of environmental performance and compliance was achieved

This report includes recommendations for the future monitoring of any hydraulic fracturing activities at the Mangahewa-G wellsite.

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1 Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Todd Energy Ltd (Todd) at the Mangahewa-G wellsite, over the period 24 April 2019 to 2 October 2019. The report also assesses Todd's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by Todd at the Mangahewa-G wellsite included the hydraulic fracturing of six wells. The wells targeted for stimulation were the Mangahewa-25, Mangahewa 26, Mangahewa 27, Mangahewa 28, Mangahewa 29 and Mangahewa 30 wells.

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2018-2019, 2019-2020 and 2020-2021 monitoring years. Monitoring included a mixture of groundwater, surface water and discharge monitoring components. This is the first monitoring report produced by the Council in relation to hydraulic fracturing activities at the Mangahewa-G wellsite.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about:

- the nature of the monitoring programme in place for the period under review; and
- a description of the activities and operations conducted at Mangahewa-G.

Section 2 presents the results of monitoring during the period under review, including scientific and technical data.

Section 3 discusses the results, their interpretations, and their significance for the environment.

Section 4 presents recommendations to be implemented for the future monitoring of any hydraulic fracturing activities at the Mangahewa-G wellsite.

A glossary of common abbreviations and scientific terms, and a bibliography, are presented at the end of the report.

1.1.3 The Resource Management Act 1991 and monitoring

The Resource Management Act 1991 (RMA) primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

a. the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;

b. physical effects on the locality, including landscape, amenity and visual effects;

c. ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;

d. natural and physical resources having special significance (for example recreational, cultural, or aesthetic); and

e. risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each activity. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with Section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and, ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and administrative performance

Besides discussing the various details of the performance and extent of compliance by the Company, this report also assigns them a rating for their environmental and administrative performance during the period under review.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year. Administrative performance is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (that is a defence under the provisions of the RMA can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

High: No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment. The Council did not record any verified unauthorised incidents involving environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

Good: Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

For example:

- High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
- Strong odour beyond boundary but no residential properties or other recipient nearby.

Improvement required: Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party. Cumulative

adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

Poor: Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or during investigations of incidents reported to the Council by a third party. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative performance

High: The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

Good: Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

Improvement required: Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

Poor: Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 2020-2021 year, consent holders were found to achieve a high level of environmental performance and compliance for 86% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 11% of the consents, a good level of environmental performance and compliance was achieved.

1.2 Process description

1.2.1 Hydraulic fracturing

Hydraulic fracturing is a reservoir stimulation technique used to increase the flow of hydrocarbons to the surface. The primary objective of hydraulic fracturing is to increase the permeability of the target reservoir by creating numerous small, interconnected fractures, thus increasing the flow of hydrocarbons from the formation to a given well. The process of hydraulic fracturing has enabled companies to produce hydrocarbons at economically viable rates from extremely low permeability reservoirs and those that have become depleted using conventional production techniques.

The process of hydraulic fracturing involves the pumping of fluids and a proppant (medium-grained sand or small ceramic pellets) down a well, through a perforated section of the well casing, and into the target reservoir. The fluid mixture is pumped at a pressure that exceeds the fracture strength of the reservoir rock in order to create fractures. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the pumping is stopped. The placement of proppant into the fractures can be assisted by the use of cross-linked gels (gel fracturing), turbulent flow (slick-water fracturing), or the use of nitrogen gas.

1.2.1.1 Gel fracturing

Gel fracturing utilises cross-linked gel solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become viscous gels. These gels are used to transport the proppant into the

formation. Once in the formation they 'break' back with time, temperature and the aid of gel breaking chemicals into a liquid state and are flowed back to surface, without disturbing the proppant which remains in place and enhances the flow of hydrocarbons back to the surface.

1.2.1.2 Slick water fracturing

Slick water fracturing utilises water based fracturing fluids with friction-reducing additives. The addition of the friction reducers allows the fracturing fluids and proppant to be pumped to the target zone at higher rates and reduced pressures, than when using water alone. The higher rate creates turbulence within the fluid column holding the proppant and enabling its placement into the open fractures and enhancing the flow of hydrocarbons back to the surface.

1.2.1.3 Nitrogen gas fracturing

Nitrogen gas assisted fracturing involves replacing some of the fluid used in the fracturing process with nitrogen gas, which can fracture rock at high pressures much like water. While nitrogen (N_2) is a gas at room temperature, it can be maintained in a liquid state through cooling and pressurisation. Nitrogen assisted fracturing can be beneficial from a production standpoint as inevitably during the fracturing process some of the water pumped down the well remains underground in the rock formation, which can block some of the small pores inhibiting hydrocarbon recovery. The use of nitrogen gas reduces the amount of water required for each fracturing event. This also reduces the total concentration of chemical additives required and the volume of water returning to the surface that requires subsequent disposal.

1.2.2 The Mangahewa-G wellsite and hydraulic fracturing activities

The Mangahewa-G wellsite is located on Otaraoa Road, Tikorangi and lies within the Waitara catchment. The area surrounding the site is rural in nature and farming and forestry activities co-exist with active petroleum exploration and production operations. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by Todd at the Mangahewa-G wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

Well	Bore id.	Date range	Mid-point injection intervals (m TVDss)	Formation
Mangahewa-25	GND3019	26/04/2019-26/05/2019	3,467.2-4,013.7	Mangahewa
Mangahewa-26	GND3020	23/04/2019-01/06/2019	3,599.5-4,049.5	Mangahewa
Mangahewa-27	GND3058	12/07/2019-06/08/2019	3,466.5-4,054.5	Mangahewa
Mangahewa-28	GND3059	16/07/2019-13/08/2019	3,571.7-4,038.7	Mangahewa
Mangahewa-29	GND3066	11/09/2019-09/10/2019	3,445.3-4,117.3	Mangahewa
Mangahewa-30	GND3067	15/09/2019-02/10/2019	3,458.8-4,066.7	Mangahewa

Figure 1 Location map

1.3 Resource consents

1.3.1 Discharges of wastes to land

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

The Company holds one resource consent the details of which are summarised in Table 2 below. The consent renewed early and varied on two occasions during the reported period. Summaries of the conditions attached to the permit are set out in Section 3 of this report.

A summary of the various consent types issued by the Council is included Appendix I, as is a copy of the permit held by the Company during the period under review.

Table 2 resource consent held by the Company during the period under review

Consent number	Purpose of consent	Granted	Next review	Expires
10025-1	To discharge water based hydraulic fracturing fluids into land at depths greater than 3,200 m TVDss beneath the Mangahewa-G wellsite	03 March 2015	N/A	varied
10025-1.1		03 March 2015	N/A	renewed
10025-2.0		19 March 2019	N/A	varied
10025-2.1		19 March 2019	June 2021	01/06/2033

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor and conduct research on the exercise of resource consents within the Taranaki region. The Council is also required to assess the effects arising from the exercising of these consents and report upon them.

The Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations and seek information from consent holders.

The monitoring programme for the Mangahewa-G wellsite consisted of four primary components.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Council in:

- ongoing liaison with resource consent holders over consent conditions and their interpretation and application;
- in discussion over monitoring requirements;
- preparation for any consent reviews, renewals or new consent applications;
- advice on the Council's environmental management strategies and content of regional plans; and
- consultation on associated matters.

1.4.3 Assessment of data submitted by the consent holder

As required by the conditions of consent 10025-2.1, Todd submitted pre and post fracturing discharge reports to the Council for the well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post fracturing reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the consent.

1.4.4 Physiochemical sampling

1.4.4.1 Groundwater

As a general principle, all existing bores or wells within a 1 km radius of a hydraulic fracturing activity are assessed for their suitability for sampling (or otherwise) and included in the monitoring programme for the wellsite.

The survey of existing sites resulted in a total of eight potential monitoring sites being identified within the 1 km radius of the site. Upon further analysis four of the eight sites were found to be oil wells and the remaining four sites were unsuitable due to either their proximity to the wellsite (greater than 500 m away and/or up-gradient) or depth (too shallow). As there were no suitable monitoring sites located consent conditions required Todd install a site specific monitoring bore. The new bore installed by Todd is the sole groundwater monitoring site included in the monitoring programme. A summary of bore details are included in Table 3 below.

Table 3 Details of groundwater sites included in the monitoring programme

Monitoring site	Easting (NZTM)	Northing (NZTM)	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND2823	17114395	5674073	On-site	32	26-32	Marine terraces north

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition and a further two rounds of sampling were carried out following completion of the activities.

1.4.4.2 Hydraulic fracturing and return fluids

In addition to the sampling of local groundwater, representative samples of the hydraulic fracturing fluid and reservoir fluids produced back to the wellhead immediately following each fracturing event (return fluids) were obtained for analysis.

Samples of return fluids were collected at regular intervals during the flow-back period. Return fluids are comprised of a mixture of hydraulic fracturing fluids and formation fluids produced from the target reservoir, following the completion of the hydraulic fracturing process. The relative concentrations of each contributing fluid type change as the volume of fluid produced from the well increases. Immediately following the opening of the well post fracturing, a high proportion of the fluid returning to the wellhead is fluid injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces in relation to formation fluids. The individual samples of return fluid are generally combined in a composite sample for laboratory analysis. Composites are designed to provide a representative sample of fluids returning to the wellhead over the entire flow-back period.

All samples were transported to Hill Laboratories Ltd (Hills) for analysis following standard chain of custody procedures.

1.4.5 Surface water quality monitoring

One ephemeral unnamed tributary of the Mangahewa Stream is located to the north of the Mangahewa-G wellsite. (Figure 1). Following a survey of the area no suitable monitoring sites were identified down-gradient of the site and the estimated location of groundwater/subsurface drainage from the discharge area. Therefore no surface water monitoring is required for inclusion in the monitoring programme.

2 Results

2.1 Consent holder submitted data

The conclusions from the Mangahewa-G post fracturing discharge reports are summarised as follows:

2.1.1 Mangahewa-25 post fracturing discharge report

- A total of seven intra-zonal units were fractured over the period 26 April 2019 to 26 May 2019 at mid-point depths between 3,467 to 4,014 m TVDss.
- A total of 8,768 bbls (1,394 m^3) of liquid was discharged across the seven fractured units. The total proppant weight was 130.1 tonnes (286,917 lbs).
- All fluid injected was returned from the well over the flow-back period.
- A total of 115.3 tonnes (254,243 lbs) of proppant was estimated to have remained within the formation following flow-back.
- Two screen outs occurred during hydraulic fracturing of the Mangahewa-25 well. One during the fracturing of the MaA3 zone and the other during the fracturing of MaA6 zone. All fluids remained within their respective injection intervals.
- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-25 fracturing operations was pumped to the Mangahewa and McKee production station (MMPS) and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.1.2 Mangahewa-26 post fracturing discharge report

- A total of six intra-zonal units were fractured over the period 23 April 2019 to 01 June 2019 at mid-point depths between 3,599 to 4,050 m TVDss.
- A total of 13,317 bbls (2,117 m^3) of liquid was discharged across the six fractured zones. The total proppant weight was 260.1 tonnes (578,395 lbs).
- All fluid injected was returned from the well over the flow-back period.
- A total of 168.2 tonnes (370,852 lbs) of proppant was estimated to have remained within the formation following flow-back.
- One screen out occurred in the MaD2L interval during hydraulic fracturing of the Mangahewa-26 well. All fluids remained within the injection interval.
- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-26 fracturing operations was pumped to the MMPS and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.1.3 Mangahewa-27 post fracturing discharge report

- A total of 11 intra-zonal units were fractured over the period 01 June 2019 to 06 August 2019 at mid-point depths between 3,466 to 4,055 m TVDss.
- A total of 21,362 bbls (3,396 m^3) of liquid was discharged across the 11 fractured zones. The total proppant weight was 254 tonnes (560,042 lbs).
- All fluid injected was returned from the well over the flow-back period.
- A total of 252.7 tonnes (557,042 lbs) of proppant was estimated to have remained within the formation following flow-back.
- No screen outs occurred during hydraulic fracturing of the Mangahewa-27 well.
- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-27 fracturing operations was pumped to the MMPS and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.1.4 Mangahewa-28 post fracturing discharge report

- A total of 11 intra-zonal units were fractured over the period 16 July 2019 to 13 August 2019 at mid-point depths between 3,571 to 4,039 m TVDss.
- A total of 36,265 bbls (5,765 m^3) of liquid was discharged across the 11 fractured zones. The total proppant weight was 286 tonnes (630,801 lbs).
- In total 44,158 bbls (7,020 m^3) of fluid was returned from the well over the flow-back period.
- A total of 282.6 tonnes (623,018 lbs) of proppant was estimated to have remained within the formation following flow-back.
- No screen outs occurred during hydraulic fracturing of the Mangahewa-28 well.
- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-28 fracturing operations was pumped to the MMPS and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.1.5 Mangahewa-29 post fracturing discharge report

- A total of 12 intra-zonal units were fractured over the period 11 September 2019 to 9 October 2019 at mid-point depths between 3,445 to 4,118 m TVDss.
- A total of 21,068 bbls (3,350 m^3) of liquid was discharged across the 12 fractured zones. The total proppant weight was 331.9 tonnes (731,760 lbs).
- All fluid injected was returned from the well over the flow-back period.
- A total of 327.9 tonnes (722,997 lbs) of proppant was estimated to have remained within the formation following flow-back.
- No screen outs occurred during hydraulic fracturing of the Mangahewa-29 well.

- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-29 fracturing operations was pumped to the MMPS and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.1.6 Mangahewa-30 post fracturing discharge report

- A total of eight intra-zonal units were fractured over the period 15 September 2019 to 2 October 2019 at mid-point depths between 3,458 to 4,067 m TVDss.
- A total of 18,338 bbls (2,916 m^3) of liquid was discharged across the six fractured zones. The total proppant weight was 271.3 tonnes (598,112 lbs).
- All fluid injected was returned from the well over the flow-back period.
- A total of 268.5 tonnes (591,935 lbs) of proppant was estimated to have remained within the formation following flow-back.
- No screen outs occurred during hydraulic fracturing of the Mangahewa-30 well.
- The Company monitored the Geonet seismic network throughout the duration of the programme and there were no events recorded in proximity to the wellsite.
- All return fluid from the Mangahewa-30 fracturing operations was pumped to the MMPS and disposed of by deep well injection under the Company's deep well injection consents.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.

2.2 Physiochemical sampling

2.2.1 Groundwater

Hydraulic fracturing activities commenced at the Mangahewa-G wellsite on 26 April 2019 and continued until 2 October 2019. A pre-fracturing baseline sample was collected on 22 January 2019 following installation of the site specific monitoring bore. Post fracturing samples were collected at various intervals following commencement of the activities which spanned several months. Samples were collected on 5 July 2019, 26 November 2019 and 4 September 2020.

A low concentration of methanol was recorded in the groundwater sample collected on 4 September 2020 and the Company were contacted to provide an explanation. The Company reported that there was no inventory of methanol onsite and there were no site processes that required the use of methanol. There had also been no incidents at the site that had the potential for any offsite impacts. The laboratory were also contacted and the sample re-analysed which returned the same result.

In response to the laboratories confirmation the Company undertook additional hydrocarbon and methanol sampling on 28 September 2020. The results showed that methanol and hydrocarbon concentrations were below detection limits. To provide additional assurance that the result was anomalous a follow up sample was also taken by the Council on 10 November 2020. The analysis included an extensive suite of parameters and the results confirmed methanol concentrations remained below the detection limit and all other analyte concentrations were similar to those previously reported for the site (Table 4).

Trace C15-C36 hydrocarbons were detected in the interim sampling undertaken in November 2019. The trace hydrocarbon detection was not accompanied by other potential indicators of contamination are not considered significant. The measured concentration was within the measured error range of the lab detection limit.

Overall, samples demonstrate relatively narrow ranges in analyte concentrations over time. The subtle variation in analyte concentrations are a result of natural seasonal fluctuation and sampling variability. The results of the laboratory analysis indicate there have been no significant changes in groundwater composition over the period monitored.

A summary of the results for groundwater samples taken in relation to the hydraulic fracturing activities compared to baseline is included in Table 4. The certificates of analysis for the review period are included in Appendix II.

Table 4 Results of groundwater sampling carried out in relation to the Mangahewa-G fracturing event

		Pre-fracturing	3 mth post fracturing	Interim	1 year post fracturing	1 year re-sample
Sample date	**Unit**	**22/01/2019**	**05/07/2019**	**26/11/2019**	**04/09/2020**	**03/11/2020**
Sample time	**-**	**13:00**	**12:50**	**13:15**	**12:45**	**11:30**
Sample id. TRC	**-**	**TRC190293**	**TRC19257**	**TRC194234**	**TRC202697**	**TRC203764**
pH	pH	7.4	7.1	7.3	6.8	7.2
Temperature	°C	24.4	11.2	20.3	16	17.1
Total alkalinity	g/m^3 $CaCO_3$	50	19.6	41	37	18.3
Bicarbonate	g/m^3 HCO_3	61	24	50	46	22
Total hardness	g/m^3 $CaCO_3$	48	11.7	43	35	12.6
Electrical conductivity	mS/m	16.8	4.3	12.8	10.2	4.8
Total dissolved solids	g/m^3	120	47	86	95	48
Dissolved calcium	g/m^3	14.1	3.6	12.7	10.4	3.9
Chloride	g/m^3	5.9	1.1	9.6	7.3	3.3
Dissolved magnesium	g/m^3	3.2	0.66	2.6	2.1	0.67
Dissolved potassium	g/m^3	1.92	1.11	1.85	1.53	1.17
Dissolved sodium	g/m^3	15.1	3.4	8.8	7.3	3.9
Nitrite	g/m^3 N	0.005	0.005	< 0.002	< 0.002	<0.002
Nitrate	g/m^3 N	0.27	0.24	0.33	0.087	0.141
Nitrate & nitrite	g/m^3 N	0.27	0.25	0.33	0.088	0.141
Sulphate	g/m^3	19	1.6	8.2	5.5	5.2
Dissolved barium	g/m^3	0.013	0.007	0.031	0.019	0.010
Bromide	g/m^3	< 0.05	< 0.05	< 0.05	0.05	0.05
Dissolved copper	g/m^3	0.003	0.0083	0.0047	0.002	0.0041
Dissolved iron	g/m^3	0.02	0.04	< 0.02	< 0.02	0.04
Dissolved manganese	g/m^3	0.038	0.0037	0.031	0.0103	0.0042
Dissolved mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	<0.0008
Dissolved Nickel	mg/kg	0.0006	< 0.0005	< 0.0005	< 0.0005	<0.0005
Dissolved zinc	g/m^3	0.023	0.026	0.135	0.099	0.048
Ethylene glycol	g/m^3	< 4	< 4	< 4	< 4	<4
Propylene glycol	g/m^3	< 4	< 4	< 4	< 4	<4
Methanol	g/m^3	< 2	< 2	< 2	17	<2
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010
m-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	<0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	<0.0010
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	<0.02
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	<0.003
Ethylene	g/m^3	< 0.004	< 0.003	< 0.004	< 0.003	<0.004
Methane	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	<0.002
C7-C9 hydrocarbons*	g/m^3	< 0.06	< 0.06	< 0.10	< 0.10	<0.10
C10-C14 hydrocarbons*	g/m^3	< 0.5	< 0.2	< 0.2	< 0.2	<0.2
C15-C36 hydrocarbons	g/m^3	< 1.0	< 0.4	0.5	< 0.4	<0.4
Total hydrocarbons*	g/m^3	< 1.6	< 0.7	< 0.7	< 0.7	<0.7

Note higher detection limits are a result of the matrix requiring dilution prior to analysis*

2.2.2 Hydraulic fracturing and return fluids

The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the Mangahewa-25, Mangahewa 26 and Mangahewa 27 wells are shown below in Table 5. The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the Mangahewa-28, Mangahewa 29 and Mangahewa 30 wells are shown below in Table 6. The certificates of analysis are included in Appendix III.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Mangahewa-25 and Mangahewa-26 wells are summarised below in Table 7. The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Mangahewa-27, Mangahewa 28, Mangahewa 29 and Mangahewa-30 wells are summarised below in Table 8. The certificates of analysis are included in Appendix III. The results demonstrate the variability of groundwater composition and hydrocarbon concentrations during flow-back. The relatively high levels of chloride, sodium and hydrocarbons in each sample indicate that the composite samples prepared contained a greater proportion of reservoir fluids than hydraulic fracturing fluids introduced during the fracturing activities, which are comprised predominantly of freshwater.

Table 5 Results of hydraulic fracturing fluid sampling

Parameter	Site code	GND3019	GND3020	GND3058	
	Todd id.	MHW25	MHW26	MHW27	
Sample id.	Unit	TRC192379	TRC192384	TRC192891	TRC193381
Ethylene glycol	g/m^3	5	<4	<400	<400
Propylene glycol	g/m^3	<4	<4	<400	<400
Methanol	g/m^3	<5	<5	<200	<300
Benzene	g/m^3	0.0115	<0.010	<0.010	<0.010
Toluene	g/m^3	0.022	<0.010	<0.010	<0.010
Ethylbenzene	g/m^3	0.017	<0.010	<0.010	<0.010
m-Xylene	g/m^3	0.08	<0.02	<0.02	<0.02
o-Xylene	g/m^3	0.002	<0.010	<0.010	<0.010
C7-C9 hydrocarbons	g/m^3	0.24	<0.6	<0.6	<0.6
C10-C14 hydrocarbons	g/m^3	360	28	360	14.4
C15-C36 hydrocarbons	g/m^3	53	42	49	43
Total hydrocarbons	g/m^3	420	69	410	58

Table 6 Results of hydraulic fracturing fluid sampling

Parameter	Site code	GND3059		GND3066		GND3067
	Todd id.	MHW28		MHW29		MHW30
Sample id.	Unit	TRC192893	TRC193383	TRC193385	TRC193386	TRC193387
Ethylene glycol	g/m^3	<400	<400	<400	<400	<400
Propylene glycol	g/m^3	<400	<400	<400	<400	<400
Methanol	g/m^3	<200	<300	<300	<300	<300
Benzene	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010
Toluene	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010
Ethylbenzene	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010
m-Xylene	g/m^3	<0.02	<0.02	<0.02	<0.02	<0.02

Parameter	Site code	GND3059		GND3066		GND3067
	Todd id.	MHW28		MHW29		MHW30
Sample id.	Unit	TRC192893	TRC193383	TRC193385	TRC193386	TRC193387
o-Xylene	g/m^3	<0.010	<0.010	<0.010	<0.010	<0.010
C7-C9 hydrocarbons	g/m^3	<0.6	<0.6	<0.6	<0.6	<0.6
C10-C14 hydrocarbons	g/m^3	2.4	400	52	4.3	90
C15-C36 hydrocarbons	g/m^3	16	62	43	25	52
Total hydrocarbons	g/m^3	19	460	95	30	142

*Note * Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limits.*

Table 7 Results of hydraulic fracturing return fluid sampling

Parameter	Site code	GND3019			GND3020		
	Todd id.	MHW25			MHW26		
Sample id.	unit	TRC192376	TRC192377	TRC192378	TRC192380	TRC192381	TRC192382
pH	pH	6.9	6.8	7	6.7	6.3	7.0
Total alkalinity	g/m^3 $CaCO_3$	790	880	1,900	1,400	1,300	2,700
Bicarbonate	g/m^3 HCO_3	790	516	1,381	957	877	2,190
Total hardness	g/m^3 $CaCO_3$	250	270	300	260	360	300
Electrical conductivity	mS/m	4,610	4,190	3,220	3,090	3,520	3,830
Total dissolved solids	g/m^3	30,000	28,000	21,000	19,600	22,000	25,000
Total barium	g/m^3	14.9	13.2	78	49	13	135
Bromide	g/m^3	25	11	19	21	11	9
Total calcium	g/m^3	82	90	92	61	86	89
Total copper	g/m^3	0.075	0.125	<0.0053	0.0112	<0.0053	0.0096
Total iron	g/m^3	41	5.2	2.9	10.5	8.4	4.4
Total magnesium	g/m^3	11.9	10.1	16.7	26	35	18
Total manganese	g/m^3	2.1	0.96	1.48	0.72	2.5	5.2
Total mercury	g/m^3	<0.0021	<0.0021	0.0024	<0.0021	<0.0021	<0.0021

Parameter	Site code	GND3019			GND3020		
	Todd id.	MHW25			MHW26		
Sample id.	unit	TRC192376	TRC192377	TRC192378	TRC192380	TRC192381	TRC192382
Total Nickel	g/m^3	0.168	0.117	<0.032	0.035	0.073	0.075
Total potassium	g/m^3	11,300	7,500	1,970	2,200	6,300	6,300
Total sodium	g/m^3	2,400	3,800	6,300	5,600	3,400	4,800
Total sulphur	g/m^3	230	210	20	30	149	141
Total zinc	g/m^3	0.98	0.31	0.11	0.028	0.076	0.230
Chloride	g/m^3	17,100	6,600	5,500	7,600	7,800	7,900
Nitrite nitrogen	g/m^3 N	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate nitrogen	g/m^3 N	0.7	<0.5	<0.5	<0.5	<0.5	<0.10
Nitrate & nitrite nitrogen	g/m^3 N	0.16	<0.10	<0.10	<0.10	<0.10	<0.10
Sulphate	g/m^3	680	640	58	90	450	420
Ethylene glycol*	g/m^3	<4	91	6	230	190	41
Propylene glycol*	g/m^3	<4	<4	<4	<4	<4	<4
Methanol	g/m^3	4,800	81	5	<5	<5	8
Benzene	g/m^3	5.1	48	8.2	9.1	10.6	6.7
Toluene	g/m^3	5.4	157	2.1	6.4	7.7	4.9
Ethylbenzene	g/m^3	0.83	37	<0.010	0.39	0.41	0.32
m-Xylene	g/m^3	4.2	250	0.38	2.2	2.4	1.82
o-Xylene	g/m^3	1.98	78	0.25	0.99	1.02	0.86
Formaldehyde	g/m^3	<1.5	<1.5	<0.15	<0.15	<1.5	0.78
C7-C9 hydrocarbons	g/m^3	87	1,010	4.3	25	17	19.7
C10-C14 hydrocarbons	g/m^3	1,410	7,000	14.2	102	100	109
C15-C36 hydrocarbons	g/m^3	540	4,900	17	129	149	123
Total hydrocarbons	g/m^3	2,000	12,900	36	260	270	250

Table 8 Results of hydraulic fracturing return fluid sampling

Parameter	Site code	GND3058		GND3059		GND3066	GND3067
	Todd id.	MHW27		MHW28		MHW29	MHW30
Sample id.	unit	TRC192892	TRC193382	TRC192894	TRC193384	TRC194229	TRC194230
pH	pH	6.9	8.0	6.8	7.6	7	7.6
Total alkalinity	g/m^3 $CaCO_3$	1,300	3,900	700	1,670	1,260	3,100
Bicarbonate	g/m^3 HCO_3	1,049	4,270	668	1,540	1,273	3,440
Total hardness	g/m^3 $CaCO_3$	520	260	630	410	560	410
Electrical conductivity	mS/m	3,980	3,420	4,440	3,750	3,840	3,570
Total dissolved solids	g/m^3	>25,000	25,000	>25,000	29,000	26,000	24,000
Total barium	g/m^3	50	127	102	130	149	210
Bromide	g/m^3	25	29	21	21		
Total calcium	g/m^3	174	77	230	132	188	143
Total copper	g/m^3	0.0153	<0.0053	0.0076	<0.0053	<0.0053	<0.0053
Total iron	g/m^3	8.8	1.6	5.8	9.1	5	3.1
Total magnesium	g/m^3	20	16	17.2	9.1	21	13.4
Total manganese	g/m^3	1.21	0.8	1.43	1.35	2.1	3.3
Total mercury	g/m^3	0.00011	<0.00008	0.00012	0.00051	0.0001	<0.00008
Total Nickel	g/m^3	<0.032	<0.032	<0.032	<0.032	<0.032	<0.032
Total potassium	g/m^3	5,000	2,600	5,900	4,900	5,100	3,600
Total sodium	g/m^3	4,600	6,700	4,300	5,300	5,200	5,900
Total sulphur	g/m^3	133	61	123	100	112	87
Total zinc	g/m^3	0.049	0.026	0.125	0.127	0.056	0.091
Chloride	g/m^3	12,400	10,100	14,200	11,100	11,900	8,900
Nitrite nitrogen	g/m^3 N	<0.10	0.011	<0.10	0.015	<0.010	<0.010
Nitrate nitrogen	g/m^3 N	<0.10	<0.010	0.29	0.113	<0.010	0.115
Nitrate & nitrite nitrogen	g/m^3 N	<0.10	0.015	0.29	0.128	<0.010	0.118
Sulphate	g/m^3	400	181	370	300	340	260
Ethylene glycol*	g/m^3	<400	<400	<400	<400	<400	<400
Propylene glycol*	g/m^3	<400	<400	<400	<400	<400	<400

Parameter	Site code	GND3058		GND3059		GND3066	GND3067
	Todd id.	MHW27		MHW28		MHW29	MHW30
Sample id.	unit	TRC192892	TRC193382	TRC192894	TRC193384	TRC194229	TRC194230
Methanol	g/m^3	<200	<300	<200	<300	<200	<200
Benzene	g/m^3	13.8	3.6	10	4.4	2.9	1.34
Toluene	g/m^3	17.8	1.32	6.8	6.7	0.15	0.66
Ethylbenzene	g/m^3	1.52	0.037	0.3	0.77	0.069	0.0185
m-Xylene	g/m^3	8.3	0.18	1.48	4.5	0.51	0.115
o-Xylene	g/m^3	3.1	0.124	0.72	1.8	0.27	0.07
Formaldehyde	g/m^3	<1.5	<0.15	<1.5	<1.5	0.58	0.49
C7-C9 hydrocarbons	g/m^3	94	1.9	13	40	4	1
C10-C14 hydrocarbons	g/m^3	240	11.7	1	83	22	9
C15-C36 hydrocarbons	g/m^3	181	15	4	89	26	13
Total hydrocarbons	g/m^3	520	29	18	210	52	23

*Note * Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in higher detection limit.*

2.3 Investigations, interventions, and incidents

The monitoring programme for the year was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with Todd. During the year matters may arise which require additional activity by the Council, for example provision of advice and information, or investigation of potential or actual causes of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

The Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The incident register includes events where the consent holder concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

During the period under review, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with Todd's conditions in resource consents or provisions in Regional Plans.

3 Discussion

3.1 Environmental effects of exercise of consents

Six wells (Mangahewa-25 to Mangahewa-30) were stimulated by hydraulic fracturing at the Mangahewa-G wellsite during the period 24 April 2019 to 2 October 2019.

The monitoring programme carried out by the Council in relation to the fracturing events undertaken included pre and post fracturing sampling at one groundwater monitoring site in the vicinity of the Mangahewa-G wellsite. The results of post fracturing groundwater sampling carried out generally showed only very minor variations in water composition in comparison to baseline results. The minor variations in analytes are a result of natural variations in water composition. Methanol was detected in one of the samples and is discussed above. Follow up sampling showed there were no long-term impacts. All subsequent samples confirmed that methanol concentrations were below detection limits.

There was no surface water monitoring undertaken in relation to the wellsite as there are no nearby surface waters suitable for monitoring.

In summary, the monitoring carried out by the Council during the period being reported indicated that the hydraulic fracturing activities undertaken by Todd at the Mangahewa-G wellsite has had no significant adverse effects on local groundwater or surface water resources.

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 9 and Table 10.

Table 9 Summary of performance for consent 10025-2.1

Purpose: ***To discharge water based hydraulic fracturing fluids into land at depths greater than 3,200 metres true vertical depth subsea (TVDss) beneath the Mangahewa-G wellsite***		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Any discharge shall occur below 3,200 m TVDss	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2028	Assessment of consent holder submitted data	N/A
3. Undertake micro seismic monitoring for events within 1 km of the Inglewood fault	Notification and post fracturing report	N/A
4. Monitoring and reporting of seismic events within 5 km of any discharge location	Notification and post fracturing report	Yes
5. Actions to be taken following the occurrence of any event described in condition 3 and 4	Notification under condition 3 and 4	N/A
6. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
7. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes

Purpose: *To discharge water based hydraulic fracturing fluids into land at depths greater than 3,200 metres true vertical depth subsea (TVDss) beneath the Mangahewa-G wellsite*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
8. If no suitable bores exist within 500 m of the wellsite, a monitoring bore may need to be installed	Inspection of bores	Yes
9. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a monitoring programme and assessment of results	Yes
10. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan	Development and certification of a Sampling and Analysis Plan	Yes
11. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
12. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
13. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
14. A post fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post fracturing discharge report received	Yes
15. For programs including multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required	Reports received via email	Yes
16. A review of the seismic monitoring data to be provided to the Council within 6 months of the commencement of any hydraulic fracturing	Seismic monitoring report received	Yes
17. The reports outlined in conditions 12, 14 and 15 must be emailed to consents@trc.govt.nz	Report received by email	Yes
18. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers	Access provided	Yes
19. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
20. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes

Purpose: *To discharge water based hydraulic fracturing fluids into land at depths greater than 3,200 metres true vertical depth subsea (TVDss) beneath the Mangahewa-G wellsite*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
21. Lapse clause	Receive notice of exercise of consent	Yes
22. Review condition	N/A	N/A
Overall assessment of environmental performance and compliance in respect of this consent		**High**
Overall assessment of administrative performance and compliance in respect of this consent		**High**

N/A = not applicable

During the monitoring period, Todd demonstrated a high level of environmental and high level of administrative performance with the resource consent as defined in Section 1.1.4.

3.3 Alterations to monitoring programmes of future hydraulic fracturing events

In designing and implementing the monitoring programmes for air/water discharges in the region, the Council has taken into account:

- the extent of information already made available through monitoring or other means to date;
- its relevance under the RMA;
- the Council's obligations to monitor consented activities and their effects under the RMA;
- the record of administrative and environmental performances of the consent holder; and
- reporting to the regional community.

The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki exercising resource consents.

It is proposed that the range of monitoring carried out in relation to the hydraulic fracturing activities undertaken by Todd be replicated for any future fracturing events at the Mangahewa-G wellsite.

Recommendations to this effect are included in Section 4 of this report.

It should be noted that the proposed programme represents a reasonable and risk-based level of monitoring for the site in question. The Council reserves the right to subsequently adjust the programme from that initially prepared, should the need arise if potential or actual non-compliance is determined at any time during future monitoring periods.

3.4 Exercise of optional review of consent

Resource consent 10025-2.1 provides for an optional review of the consent in June 2021. Condition 22 allows the Council to review the consent, for the purpose of:

a. ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

b. further specifying the best practicable option as required by condition 19; and/or

c. ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Based on the results of monitoring in the year under review, it is considered that there are no grounds that require a review to be pursued or grounds to exercise the review option.

4 Recommendations

1. THAT in the first instance, the range of monitoring carried out during the reporting period in relation to Todd's hydraulic fracturing activities be replicated for any future fracturing events at the Mangahewa-G wellsite.
2. THAT should there be issues with environmental or administrative performance in future periods, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.
3. THAT the option for a review of resource consents in June 2021, as set out in condition 22 of the consent not be exercised.

Glossary of common terms and abbreviations

The following abbreviations and terms may be used within this report:

Biomonitoring	Assessing the health of the environment using aquatic organisms.
bbls	Barrel. Unit of measure used in the oil and gas industry (equivalent to approximately 159 L).
Conductivity	An indication of the level of dissolved salts in a sample, usually measured at 25°C and expressed in µS/cm.
DO	Dissolved oxygen.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
EPT	Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) which are macroinvertebrates sensitive to pollution.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
L/s	Litres per second.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
masl	Metres above sea level.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 L).
NZTM	New Zealand Transverse Mercator coordinates.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	Resource Management Act 1991 and including all subsequent amendments.

Screen Out	A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure.
SQMCI	Semi quantitative macroinvertebrate community index.
TVDss	True vertical depth sub-sea.
µS/cm	Microsiemens per centimetre.
Workover	The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons.

For further information on analytical methods, contact a Science Services Manager.

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Todd Energy Ltd (2019) Sampling and analysis plan - Mangahewa-G groundwater monitoring programme April 2019. Frodo number #2041345.

Appendix I

Resource consent held by Todd Energy Ltd

(For a copy of the signed resource consent
please contact the TRC Consents department)

Water abstraction permits

Section 14 of the RMA stipulates that no person may take, use, dam or divert any water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or it falls within some particular categories set out in Section 14. Permits authorising the abstraction of water are issued by the Council under Section 87(d) of the RMA.

Water discharge permits

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations. Permits authorising discharges to water are issued by the Council under Section 87(e) of the RMA.

Air discharge permits

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising discharges to air are issued by the Council under Section 87(e) of the RMA.

Discharges of wastes to land

Sections 15(1)(b) and (d) of the RMA stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Permits authorising the discharge of wastes to land are issued by the Council under Section 87(e) of the RMA.

Land use permits

Section 13(1)(a) of the RMA stipulates that no person may in relation to the bed of any lake or river use, erect, reconstruct, place, alter, extend, remove, or demolish any structure or part of any structure in, on, under, or over the bed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Land use permits are issued by the Council under Section 87(a) of the RMA.

Coastal permits

Section 12(1)(b) of the RMA stipulates that no person may erect, reconstruct, place, alter, extend, remove, or demolish any structure that is fixed in, on, under, or over any foreshore or seabed, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations. Coastal permits are issued by the Council under Section 87(c) of the RMA.

Discharge Permit

Pursuant to the Resource Management Act 1991
a resource consent is hereby granted by the
Taranaki Regional Council

Name of Consent Holder:	Todd Energy Limited PO Box 802 New Plymouth 4340	
Decision Date (Change):	8 May 2019	
Commencement Date (Change):	8 May 2019	(Granted Date: 19 March 2019)

Conditions of Consent

Consent Granted:	To discharge water-based hydraulic fracturing fluids into land at depths greater than 3,200 mTVDss beneath the Mangahewa-G wellsite
Expiry Date:	1 June 2033
Review Date(s):	June 2021, June 2027
Site Location:	Mangahewa-G wellsite, 1067 Otaraoa Road, Tikorangi
Grid Reference (NZTM)	1714303E-5674058N
Catchment:	Onaero
Tributary:	Mangahewa

For General, Standard and Special conditions
pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance with section 36 of the Resource Management Act 1991.

Special conditions

1. The discharge point shall be deeper than 3,200 mTVDss.

   Note: mTVDss = metres true vertical depth subsea, i.e. the true vertical depth in metres below mean sea level

2. There shall be no discharge of hydraulic fracturing fluids after 1 June 2028.

3. The consent holder shall undertake micro-seismic monitoring during any hydraulic fracturing activities occurring within 1,000 metres of the subsurface mapped position of the Inglewood fault. If the micro-seismic monitoring records a seismic event higher than a Modified Mercalli intensity of magnitude 1 hydraulic fracturing shall cease.

4. If the GeoNet seismic monitoring network records a seismic event higher than a Modified Mercalli intensity of magnitude 3 within 5 km of the geographical position of any hydraulic fracturing discharge, then:
   (a) if a hydraulic fracturing discharge is currently being undertaken it shall cease immediately and not recommence; or
   (b) if a hydraulic fracturing discharge has occurred within the previous 72 hours no further hydraulic fracturing discharges shall occur.

5. Following the occurrence of any seismic event described in special condition 3 or 4 the consent holder shall cease discharges and investigate and report to the Chief Executive, Taranaki Regional Council on the likelihood of the seismic event being induced by the exercise of this consent. Hydraulic fracturing discharges may only then continue once the Chief Executive, Taranaki Regional Council has considered the report and concluded that the environmental risk of recommencing hydraulic fracturing is acceptable and has advised the consent holder accordingly.

6. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1,000 mg/l.

7. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 6 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:
   (a) the location of the discharge point(s);
   (b) the location of sampling sites; and
   (c) sampling frequency with reference to a hydraulic fracturing programme.

8. Representative groundwater sampling is required to be undertaken at a minimum of one suitable site within 500 metres of the wellsite. If no suitable groundwater monitoring sites can be identified it will be necessary to install at least one monitoring bore of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council and installed in accordance with NZS 4411:2001.

9. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:

   (a) pH;
   (b) conductivity;
   (c) total dissolved solids;
   (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
   (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
   (f) total petroleum hydrocarbons;
   (g) formaldehyde;
   (h) dissolved methane and ethane gas;
   (i) methanol;
   (j) glycols;
   (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
   (l) carbon-13 composition of any dissolved methane gas discovered ($^{13}C\text{-}CH_4$).

   Note: The samples required, under conditions 7 and 9 could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.

10. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive, Taranaki Regional Council for review and certification before the first sampling is undertaken. The plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 6.

    Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 7.

11. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.

12. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing Discharge Report' to the Chief Executive, Taranaki Regional Council. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:

    (a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
    (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
    (c) the total volume of fracture fluid planned to be pumped down the well, including mini-fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
    (d) the monitoring techniques to be used to determine the fate of discharged material;
    (e) the results of the reviews required by condition 19;
    (f) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
    (g) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 6;
    (h) the extent and permeability characteristics of the geology above the discharge point to the surface;
    (i) an annotated seismic profile showing the locations of any interpreted faults (active or inactive) within 2 km if available of the subsurface discharge location, and a discussion regarding the potential for adverse environmental effects due to the presence of any identified faults;
    (j) an assessment of the integrity of the well;
    (k) the burst pressure of the well casing and the anticipated maximum well and discharge pressures and the duration of the pressures;
    (l) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
    (m) details why the contaminants in the discharge and the monitoring techniques used comply with condition 19.

    Note; If seismic data is not available within 2 km of the subsurface discharge location the pre-fracturing report should include a seismic profile to the distance that data is available and a map showing any identified faults within the modelled fracture length plus a margin of 50%.

    Note: For further information regarding the level of detail required to adequately comply with the requirements of the pre-fracturing report contact Taranaki Regional Council.

13. The consent holder shall notify the Taranaki Regional Council of the date that each discharge is intended to commence by emailing worknotification@trc.govt.nz, unless the Chief Executive, Taranaki Regional Council advises that an alternative electronic method of service is required. Notification also shall identify the 'Pre-fracturing Discharge Report', required by condition 12, which details the discharge and be given no less than 3 days before the intended discharge date. If any discharge occurs more than 30 days after the notification date, additional notification as specified in this condition is required.

14. Subject to condition 15, within 90 days of any commencement date as advised under condition 13, the consent holder shall submit a comprehensive 'Post-fracturing Discharge Report' to the Chief Executive, Taranaki Regional Council. The report shall, as a minimum, contain:

    (a) date and time of discharge;
    (b) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e., depth and lateral position) of the discharge point for each fracture interval;
    (c) the contaminant volumes and composition of fluid discharged into each fracture interval;
    (d) the volume of return fluids from each fracture interval;
    (e) an analysis for the constituents set out in conditions 9(a) to 9(l), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
    (f) an estimate of the volume of fluids (and proppant) remaining underground;
    (g) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 30 days after the programme is completed or after that period of production;
    (h) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
    (i) The results of the seismic monitoring required by conditions 3 and 4;
    (j) the results of pressure testing required by condition 11 and the top-hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottom hole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
    (k) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
    (l) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 6;
    (m) results of the monitoring referred to in condition 12(d); and
    (n) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

    Note: Further information regarding the level of detail required to adequately comply with the requirements of the post-fracturing report can be found on the Taranaki Regional Council website.

15. For programs including multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the specified 90-day deadline from each commencement date. In these situations the consent holder shall submit a subsequent 'Post-fracturing Discharge Report' to the Chief Executive, Taranaki Regional Council within 90 days of the previous report submitted.

16. Within 6 months of any commencement date as advised under condition 13, the consent holder shall submit a review of the GeoNet seismic monitoring network data and any monitoring undertaken in accordance with condition 3 on the likelihood of any seismic events occurring as the result of the exercise of this consent, extending for a period of 3 months past the last hydraulic fracture.

17. The reports described in conditions 12, 14 and 15 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

18. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

19. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:

    (a) the discharge is contained within the fracture interval;
    (b) regular reviews of monitoring techniques used to ensure the discharge does not cause adverse environmental effects are undertaken;
    (c) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
    (d) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.

20. The fracture fluid shall be comprised of no less than 95% water, nitrogen and proppant by volume.

21. This consent shall lapse on 31 March 2024, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

22. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review:

    a) during the month of June each year, and/or
    b) within 30 days of receiving any investigation and report in accordance with special condition 5 above;

    for the purposes of:

    (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
    (b) further specifying the best practicable option as required by condition 19; and/or
    (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 8 May 2019

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management

Appendix II

Certificates of analysis (groundwater)

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2470970 SPv1
Contact:	Jane Harvey	**Date Received:**	11-Nov-2020
	C/- Taranaki Regional Council	**Date Reported:**	19-Nov-2020
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	72831
		Client Reference:	#6353 - Mangahewa-G Re-sample/Pre-frac GW
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

		Sample Name:	TRC203764 (GND2823) 10-Nov-2020 11:30 am				
		Lab Number:	2470970.1				
Individual Tests							
Sum of Anions	meq/L		0.58	-	-	-	-
Sum of Cations	meq/L		0.45	-	-	-	-
pH	pH Units		7.2	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$		18.3	-	-	-	-
Bicarbonate	g/m³ at 25°C		22	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$		12.6	-	-	-	-
Electrical Conductivity (EC)	mS/m		4.8	-	-	-	-
Total Dissolved Solids (TDS)	g/m³		48	-	-	-	-
Sample Temperature*†	°C		17.1	-	-	-	-
Dissolved Barium	g/m³		0.010	-	-	-	-
Dissolved Calcium	g/m³		3.9	-	-	-	-
Dissolved Copper	g/m³		0.0041	-	-	-	-
Dissolved Iron	g/m³		0.04	-	-	-	-
Dissolved Magnesium	g/m³		0.67	-	-	-	-
Dissolved Manganese	g/m³		0.0042	-	-	-	-
Dissolved Mercury	g/m³		< 0.00008	-	-	-	-
Dissolved Nickel	g/m³		< 0.0005	-	-	-	-
Dissolved Potassium	g/m³		1.17	-	-	-	-
Dissolved Sodium	g/m³		3.9	-	-	-	-
Dissolved Zinc	g/m³		0.048	-	-	-	-
Bromide	g/m³		0.05	-	-	-	-
Chloride	g/m³		3.3	-	-	-	-
Nitrite-N	g/m³		< 0.002	-	-	-	-
Nitrate-N	g/m³		0.141	-	-	-	-
Nitrate-N + Nitrite-N	g/m³		0.141	-	-	-	-
Sulphate	g/m³		5.2	-	-	-	-
Ethylene Glycol in Water*							
Ethylene glycol*	g/m³		< 4	-	-	-	-
Propylene Glycol in Water*							
Propylene glycol*	g/m³		< 4	-	-	-	-
Methanol in Water - Aqueous Solvents*							
Methanol*	g/m³		< 2	-	-	-	-

Sample Type: Aqueous						
Sample Name:		TRC203764 (GND2823) 10-Nov-2020 11:30 am				
Lab Number:		2470970.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.004	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

Analyst's Comments

† Customer supplied data. Please note: Hill Laboratories cannot be held responsible for the validity of this customer supplied data, or any subsequent calculations that rely on this information.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	10 g/m³	1
Sample Temperature*	Temperature of the sample at the time of sampling, supplied by customer.	0.1 °C	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Ethylene Glycol in Water*	Direct injection, dual column GC-FID.	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID.	4 g/m³	1
Methanol in Water - Aqueous Solvents*	GC-FID analysis. In-house.	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis. In-house based on US EPA 8260 and 5021.	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	Derivatisation, SPE extraction, LC-MS/MS analysis. In-house based on US EPA 8315A.	0.02 g/m³	1
Gases in groundwater	Headspace GC-FID analysis. In-house.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water			
C7 - C9	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.10 g/m³	1
C10 - C14	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.2 g/m³	1
C15 - C36	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.4 g/m³	1
Total hydrocarbons (C7 - C36)	Calculation: Sum of carbon bands from C7 to C36. In-house based on US EPA 8015.	0.7 g/m³	1

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

Testing was completed between 11-Nov-2020 and 19-Nov-2020. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
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Private Bag 3205
Hamilton 3240 New Zealand

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T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2431942 SPv1
Contact:	Jane Harvey	**Date Received:**	05-Sep-2020
	C/- Taranaki Regional Council	**Date Reported:**	15-Sep-2020
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	72831
		Client Reference:	#6074 - Mangahewa-G 1 year PF GW
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

		Sample Name:	TRC202697 (GND2823) 04-Sep-2020 12:45 pm				
		Lab Number:	2431942.1				
Individual Tests							
Sum of Anions	meq/L		1.07	-	-	-	-
Sum of Cations	meq/L		1.06	-	-	-	-
pH	pH Units		6.8	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$		37	-	-	-	-
Bicarbonate	g/m³ at 25°C		46	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$		35	-	-	-	-
Electrical Conductivity (EC)	mS/m		10.2	-	-	-	-
Total Dissolved Solids (TDS)	g/m³		95	-	-	-	-
Sample Temperature*†	°C		16.0	-	-	-	-
Dissolved Barium	g/m³		0.019	-	-	-	-
Dissolved Calcium	g/m³		10.4	-	-	-	-
Dissolved Copper	g/m³		0.0020	-	-	-	-
Dissolved Iron	g/m³		< 0.02	-	-	-	-
Dissolved Magnesium	g/m³		2.1	-	-	-	-
Dissolved Manganese	g/m³		0.0103	-	-	-	-
Dissolved Mercury	g/m³		< 0.00008	-	-	-	-
Dissolved Nickel	g/m³		< 0.0005	-	-	-	-
Dissolved Potassium	g/m³		1.53	-	-	-	-
Dissolved Sodium	g/m³		7.3	-	-	-	-
Dissolved Zinc	g/m³		0.099	-	-	-	-
Bromide	g/m³		0.05	-	-	-	-
Chloride	g/m³		7.3	-	-	-	-
Nitrite-N	g/m³		< 0.002	-	-	-	-
Nitrate-N	g/m³		0.087	-	-	-	-
Nitrate-N + Nitrite-N	g/m³		0.088	-	-	-	-
Sulphate	g/m³		5.5	-	-	-	-
Ethylene Glycol in Water*							
Ethylene glycol*	g/m³		< 4	-	-	-	-
Propylene Glycol in Water*							
Propylene glycol*	g/m³		< 4	-	-	-	-
Methanol in Water - Aqueous Solvents*							
Methanol*	g/m³		17	-	-	-	-

Sample Type: Aqueous						
Sample Name:		TRC202697 (GND2823) 04-Sep-2020 12:45 pm				
Lab Number:		2431942.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

Analyst's Comments

† Customer supplied data. Please note: Hill Laboratories cannot be held responsible for the validity of this customer supplied data, or any subsequent calculations that rely on this information.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	10 g/m³	1
Sample Temperature*	Temperature of the sample at the time of sampling, supplied by customer.	0.1 °C	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Ethylene Glycol in Water*	Direct injection, dual column GC-FID.	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID.	4 g/m³	1
Methanol in Water - Aqueous Solvents*	GC-FID analysis. In-house.	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis. In-house based on US EPA 8260 and 5021.	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	Derivatisation, SPE extraction, LC-MS/MS analysis. In-house based on US EPA 8315A.	0.02 g/m³	1
Gases in groundwater	Headspace GC-FID analysis. In-house.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water			
C7 - C9	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.10 g/m³	1
C10 - C14	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.2 g/m³	1
C15 - C36	Solvent extraction, GC-FID analysis. In-house based on US EPA 8015.	0.4 g/m³	1
Total hydrocarbons (C7 - C36)	Calculation: Sum of carbon bands from C7 to C36. In-house based on US EPA 8015.	0.7 g/m³	1

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

Testing was completed between 07-Sep-2020 and 15-Sep-2020. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Martin Cowell - BSc
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2112606 SPv1
Contact:	Jane Harvey	**Date Received:**	23-Jan-2019
	C/- Taranaki Regional Council	**Date Reported:**	01-Feb-2019
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	72831
		Client Reference:	#4812 - Todd MHW G HF Pre-frac GW
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

		Sample Name:	TRC190293 (GND2823) 22-Jan-2019 1:00 pm				
		Lab Number:	2112606.1				
Individual Tests							
Sum of Anions	meq/L		1.58	-	-	-	-
Sum of Cations	meq/L		1.68	-	-	-	-
pH	pH Units		7.4	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$		50	-	-	-	-
Bicarbonate	g/m³ at 25°C		61	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$		48	-	-	-	-
Electrical Conductivity (EC)	mS/m		16.8	-	-	-	-
Total Dissolved Solids (TDS)	g/m³		120	-	-	-	-
Sample Temperature*	°C		24.4	-	-	-	-
Dissolved Barium	g/m³		0.013	-	-	-	-
Dissolved Calcium	g/m³		14.1	-	-	-	-
Dissolved Copper	g/m³		0.0030	-	-	-	-
Dissolved Iron	g/m³		0.02	-	-	-	-
Dissolved Magnesium	g/m³		3.2	-	-	-	-
Dissolved Manganese	g/m³		0.038	-	-	-	-
Dissolved Mercury	g/m³		< 0.00008	-	-	-	-
Dissolved Nickel	g/m³		0.0006	-	-	-	-
Dissolved Potassium	g/m³		1.92	-	-	-	-
Dissolved Sodium	g/m³		15.1	-	-	-	-
Dissolved Zinc	g/m³		0.023	-	-	-	-
Bromide	g/m³		< 0.05	-	-	-	-
Chloride	g/m³		5.9	-	-	-	-
Nitrite-N	g/m³		0.005	-	-	-	-
Nitrate-N	g/m³		0.27	-	-	-	-
Nitrate-N + Nitrite-N	g/m³		0.27	-	-	-	-
Sulphate	g/m³		19.0	-	-	-	-
Ethylene Glycol in Water							
Ethylene glycol*	g/m³		< 4	-	-	-	-
Propylene Glycol in Water							
Propylene glycol*	g/m³		< 4	-	-	-	-
Methanol in Water - Aqueous Solvents							
Methanol*	g/m³		< 2	-	-	-	-

Sample Type: Aqueous						
Sample Name:		TRC190293 (GND2823) 22-Jan-2019 1:00 pm				
Lab Number:		2112606.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.004	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.06	-	-	-	-
C10 - C14	g/m³	< 0.5	-	-	-	-
C15 - C36	g/m³	< 1.0	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 1.6	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	10 g/m³	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	1

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

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

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

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Certificate of Analysis

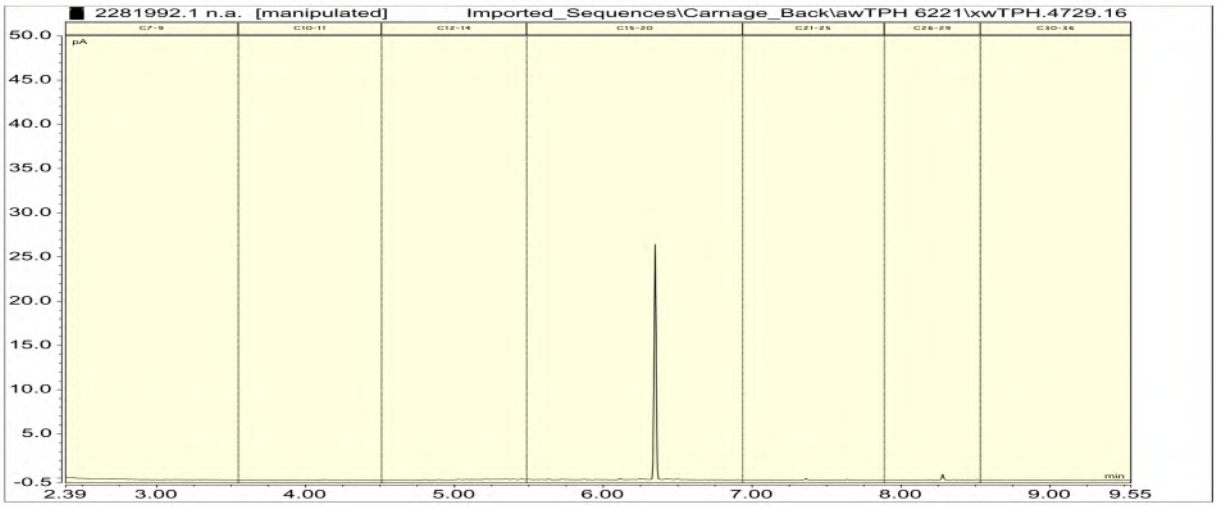
Client:	Taranaki Regional Council	**Lab No:**	2281992 SPv1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	**Date Received:**	27-Nov-2019
		Date Reported:	04-Dec-2019
		Quote No:	47915
		Order No:	72831
		Client Reference:	#5514 - Todd MHW-G 3 month PF GW Nov 2019
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

Sample Name:		TRC194234 (GND2823) 26-Nov-2019 1:15 pm				
Lab Number:		2281992.1				
Individual Tests						
Sum of Anions	meq/L	1.28	-	-	-	-
Sum of Cations	meq/L	1.29	-	-	-	-
pH	pH Units	7.3	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	41	-	-	-	-
Bicarbonate	g/m³ at 25°C	50	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$	43	-	-	-	-
Electrical Conductivity (EC)	mS/m	12.8	-	-	-	-
Total Dissolved Solids (TDS)	g/m³	86	-	-	-	-
Sample Temperature*	°C	20.3	-	-	-	-
Dissolved Barium	g/m³	0.031	-	-	-	-
Dissolved Calcium	g/m³	12.7	-	-	-	-
Dissolved Copper	g/m³	0.0047	-	-	-	-
Dissolved Iron	g/m³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m³	2.6	-	-	-	-
Dissolved Manganese	g/m³	0.031	-	-	-	-
Dissolved Mercury	g/m³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m³	1.85	-	-	-	-
Dissolved Sodium	g/m³	8.8	-	-	-	-
Dissolved Zinc	g/m³	0.135	-	-	-	-
Bromide	g/m³	< 0.05	-	-	-	-
Chloride	g/m³	9.6	-	-	-	-
Nitrite-N	g/m³	< 0.002	-	-	-	-
Nitrate-N	g/m³	0.33	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.33	-	-	-	-
Sulphate	g/m³	8.2	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-

Sample Type: Aqueous						
Sample Name:		TRC194234 (GND2823) 26-Nov-2019 1:15 pm				
Lab Number:		2281992.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.004	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	0.5	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

2281992.1
TRC194234 (GND2823) 26-Nov-2019 1:15 pm
Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B / MfE Petroleum Industry Guidelines	0.10 - 0.7 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	10 g/m³	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1

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

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

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
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Private Bag 3205
Hamilton 3240 New Zealand

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E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2204407 SPv1
Contact:	Jane Harvey	**Date Received:**	06-Jul-2019
	C/- Taranaki Regional Council	**Date Reported:**	15-Jul-2019
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5160 - Todd MHW G pre frac GW July 2019
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

		Sample Name:	TRC192597 - GND2823 05-Jul-2019 12:50 pm				
		Lab Number:	2204407.1				
Individual Tests							
Sum of Anions	meq/L		0.47	-	-	-	-
Sum of Cations	meq/L		0.41	-	-	-	-
pH	pH Units		7.1	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$		19.6	-	-	-	-
Bicarbonate	g/m³ at 25°C		24	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$		11.7	-	-	-	-
Electrical Conductivity (EC)	mS/m		4.3	-	-	-	-
Total Dissolved Solids (TDS)	g/m³		47	-	-	-	-
Sample Temperature*	°C		11.2	-	-	-	-
Dissolved Barium	g/m³		0.007	-	-	-	-
Dissolved Calcium	g/m³		3.6	-	-	-	-
Dissolved Copper	g/m³		0.0083	-	-	-	-
Dissolved Iron	g/m³		0.04	-	-	-	-
Dissolved Magnesium	g/m³		0.66	-	-	-	-
Dissolved Manganese	g/m³		0.0037	-	-	-	-
Dissolved Mercury	g/m³		< 0.00008	-	-	-	-
Dissolved Nickel	g/m³		< 0.0005	-	-	-	-
Dissolved Potassium	g/m³		1.11	-	-	-	-
Dissolved Sodium	g/m³		3.4	-	-	-	-
Dissolved Zinc	g/m³		0.026	-	-	-	-
Bromide	g/m³		< 0.05	-	-	-	-
Chloride	g/m³		1.1	-	-	-	-
Nitrite-N	g/m³		0.005	-	-	-	-
Nitrate-N	g/m³		0.24	-	-	-	-
Nitrate-N + Nitrite-N	g/m³		0.25	-	-	-	-
Sulphate	g/m³		1.6	-	-	-	-
Ethylene Glycol in Water							
Ethylene glycol*	g/m³		< 4	-	-	-	-
Propylene Glycol in Water							
Propylene glycol*	g/m³		< 4	-	-	-	-
Methanol in Water - Aqueous Solvents							
Methanol*	g/m³		< 2	-	-	-	-

Sample Type: Aqueous						
Sample Name:		TRC192597 - GND2823 05-Jul-2019 12:50 pm				
Lab Number:		2204407.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.06	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	10 g/m³	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	1

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

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

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

Appendix III

Certificates of analysis
(hydraulic fracturing fluids)

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

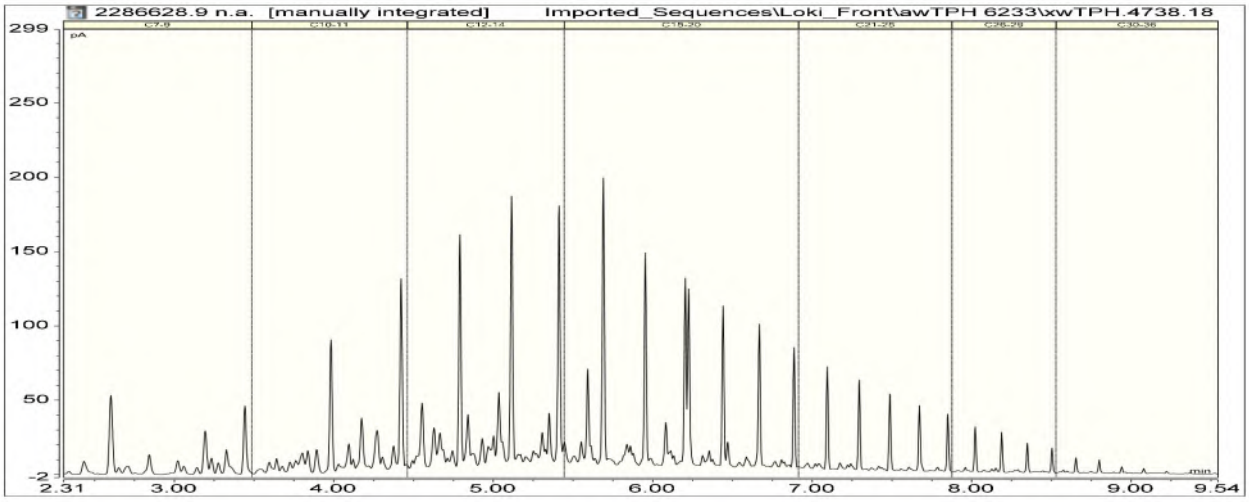
Client:	Taranaki Regional Council	**Lab No:**	2286628 SPv1
Contact:	Jane Harvey	**Date Received:**	04-Dec-2019
	C/- Taranaki Regional Council	**Date Reported:**	16-Dec-2019
	Private Bag 713	**Quote No:**	71307
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5531 - MHW G Return Fluid MHW-29 and MWH-30
		Submitted By:	Sarah Larkin

Sample Type: Saline

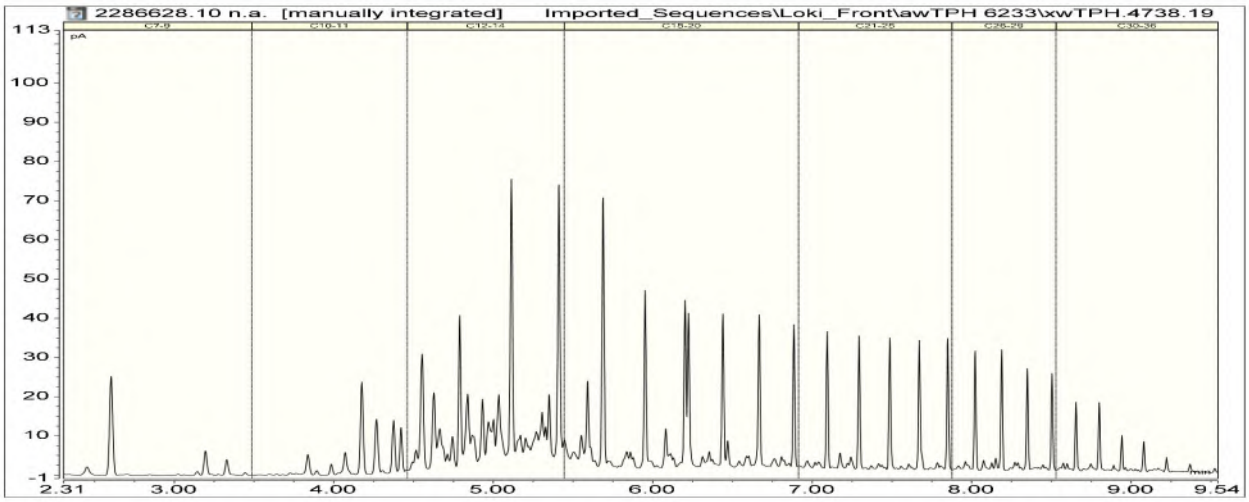
Sample Name:		Composite of TRC194229 (GND3066) 1-4	Composite of TRC194300 (GND3067) 1-4			
Lab Number:		2286628.9	2286628.10			
Individual Tests						
pH*	pH Units	7.0	7.6	-	-	-
Total Alkalinity*	g/m³ as $CaCO_3$	1,260	3,100	-	-	-
Analysis Temperature for Bicarbonate	°C	20	21	-	-	-
Bicarbonate	g/m³ at Analysis Temperature	1,273	3,440	-	-	-
Total Hardness*	g/m³ as $CaCO_3$	560	410	-	-	-
Electrical Conductivity (EC)*	mS/m	3,840	3,570	-	-	-
Total Dissolved Solids (TDS)*	g/m³	26,000	24,000	-	-	-
Total Barium	g/m³	149	210	-	-	-
Total Calcium	g/m³	188	143	-	-	-
Total Copper	g/m³	< 0.0053	< 0.0053	-	-	-
Total Iron	g/m³	5.0	3.1	-	-	-
Total Magnesium	g/m³	21	13.4	-	-	-
Total Manganese	g/m³	2.1	3.3	-	-	-
Total Mercury*	g/m³	0.00010	< 0.00008	-	-	-
Total Nickel	g/m³	< 0.032	< 0.032	-	-	-
Total Potassium	g/m³	5,100	3,600	-	-	-
Total Sodium	g/m³	5,200	5,900	-	-	-
Total Sulphur*	g/m³	112	87	-	-	-
Total Zinc	g/m³	0.056	0.091	-	-	-
Bromide*	g/m³	22 #1	19 #1	-	-	-
Chloride*	g/m³	11,900	8,900	-	-	-
Nitrite-N	g/m³	< 0.010 #2	< 0.010 #2	-	-	-
Nitrate-N	g/m³	< 0.010	0.115	-	-	-
Nitrate*	g/m³	< 0.05	0.51	-	-	-
Nitrate-N + Nitrite-N	g/m³	< 0.010 #2	0.118 #2	-	-	-
Sulphate*	g/m³	340	260	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 400	< 400	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 400	< 400	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 200	< 200	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	2.9	1.34	-	-	-
Toluene*	g/m³	1.15	0.66	-	-	-
Ethylbenzene*	g/m³	0.069	0.0185	-	-	-
m&p-Xylene*	g/m³	0.51	0.115	-	-	-

Sample Type: Saline						
Sample Name:		Composite of TRC194229 (GND3066) 1-4	Composite of TRC194300 (GND3067) 1-4			
Lab Number:		2286628.9	2286628.10			
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m³	0.27	0.070	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.58	0.49	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m³	3.8	0.69	-	-	-
C10 - C14*	g/m³	22	8.5	-	-	-
C15 - C36*	g/m³	26	13.4	-	-	-
Total hydrocarbons (C7 - C36)*	g/m³	52	23	-	-	-

2286628.9
Composite of TRC194229 (GND3066) 1-4
Client Chromatogram for TPH by FID



2286628.10
Composite of TRC194300 (GND3067) 1-4
Client Chromatogram for TPH by FID



Analyst's Comments

#1 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the Br analysis.

#2 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2N, NO3N and NOxN analysis.

Appendix No.1 - GNS report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	9-10
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	9-10
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	9-10
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	9-10
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	9-10
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B / MfE Petroleum Industry Guidelines	0.10 - 0.7 g/m^3	9-10
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	9-10
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	9-10
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	9-10
pH*	Saline water, pH meter. APHA 4500-H$^+$ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	9-10
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	9-10
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	9-10
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	9-10
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	9-10
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.10 mS/m	9-10
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	50 g/m^3	9-10
Total Barium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.00063 g/m^3	9-10
Total Calcium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m^3	9-10
Total Copper	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m^3	9-10
Total Iron	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m^3	9-10
Total Magnesium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m^3	9-10
Total Manganese	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m^3	9-10
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	9-10
Total Nickel	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.0070 g/m^3	9-10
Total Potassium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m^3	9-10
Total Sodium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m^3	9-10

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23rd ed. 2017.	0.5 g/m³	9-10
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m³	9-10
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	9-10
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	9-10
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	9-10
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	9-10
Nitrate*	Calculation from Nitrate-N.	0.005 g/m³	9-10
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	9-10
Total Sulphate*	Calculation: from total sulphur.	2 g/m³	9-10

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

Dates of testing are available on request. Please contact the laboratory for more information.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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ANALYTICAL LABORATORY
Private Bag 2000, Taupo
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CERTIFICATE OF ANALYSIS

ENVSUBGNS_WAIRAKEI 99

Report No: 2019120606

Customer Ref:152967

Ara Heron
RJ Hill Laboratories (Hamilton)
Environmental Reports Officers
Private Bag 3205
Hamilton

GNS Lot No: 2019120606

GNS Sample No.	2019007437	2019007438
Collection Date		
Site ID	2286628.9	2286628.10
Field ID		

pH		7.13	7.70	-	-
Bicarbonate (Total)	mg/l	1273	3441	-	-
HCO_3 Analysis Temperature	°C	20	21	-	-
HCO_3 Analysis Date		11/12/2019	11/12/2019	-	-

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report.
The detection limits given below are those attainable in a relatively clean matrix.

Parameter	Method	*Detection Limit	
Bicarbonate (total)	HCO_3 Titration Method ASTM Standards D513-82 Vol.11.01 1988	20	mg/l
pH	Electrometric Method - APHA 4500-H+ B 23rd Edition 2017	-	-

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

M. K. Appleby

Moya Appleby
Senior Technician

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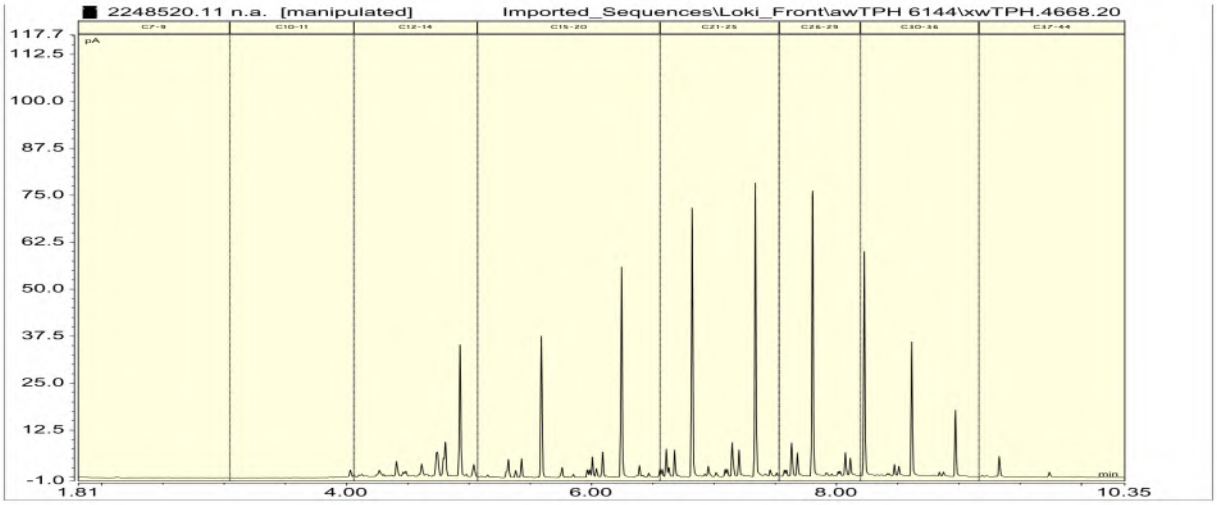
Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2248520 SPv1
Contact:	Jane Harvey	**Date Received:**	26-Sep-2019
	C/- Taranaki Regional Council	**Date Reported:**	08-Oct-2019
	Private Bag 713	**Quote No:**	50522
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5298 - Hydraulic Fracturing Mangahewa_G (MHW G)
		Submitted By:	Sarah Larkin

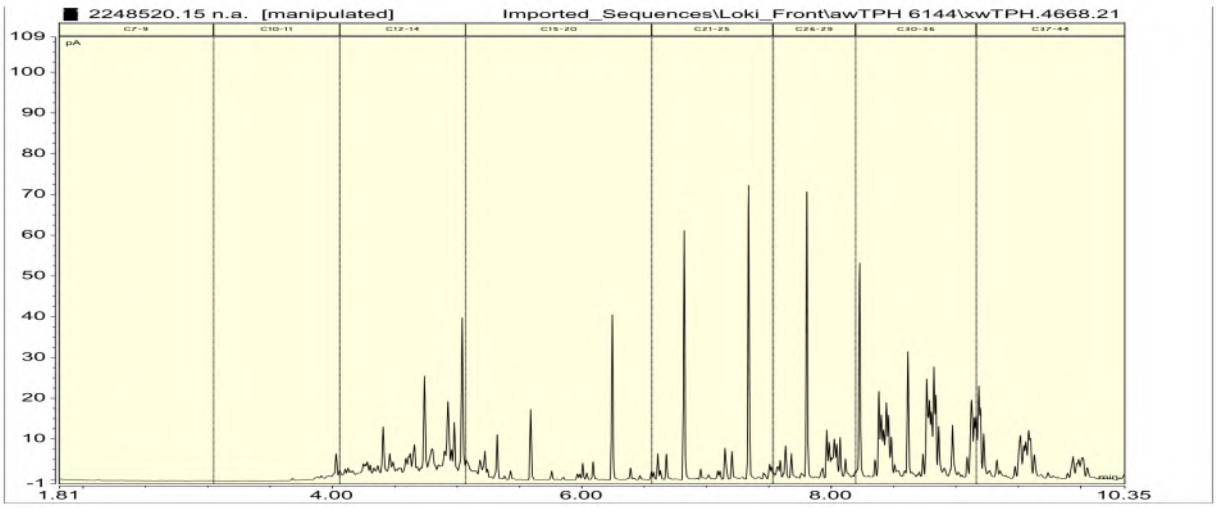
Sample Type: Aqueous

Sample Name:		TRC193386 (GND3066) MHW29 FF Slick 12-Sep-2019	Composite of TRC193381 (GND3058) MHW27 FF Gel Bottle 1, TRC193381 (GND3058) MHW27 FF Gel Bottle 2 & TRC193381 (GND3058) MHW27 FF Gel Bottle 3 25-Sep-2019	Composite of TRC193383 (GND3059) MHW28FF Gel Bottle 1, TRC193383 (GND3059) MHW28FF Gel Bottle 2, TRC193383 (GND3059) MHW28FF Gel Bottle 3 & TRC193383 (GND3059) MHW28FF Gel Bottle 4 25-Sep-2019	Composite of TRC193385 (GND3066) MHW29 FF Gel Bottle 1, TRC193385 (GND3066) MHW29 FF Gel Bottle 2 & TRC193385 (GND3066) MHW29 FF Gel Bottle 3 11-Sep-2019	Composite of TRC193387 (GND3067) MHW30 FF Gel Bottle 1, TRC193387 (GND3067) MHW30 FF Gel Bottle 2 & TRC193387 (GND3067) MHW30 FF Gel Bottle 3 25-Sep-2019
Lab Number:		2248520.11	2248520.15	2248520.16	2248520.17	2248520.18
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 400	< 400	< 400	< 400	< 400
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 400	< 400	< 400	< 400	< 400
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 300	< 300	< 300	< 300	< 300
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Toluene	g/m³	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ethylbenzene	g/m³	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
m&p-Xylene	g/m³	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
o-Xylene	g/m³	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
C10 - C14	g/m³	4.3	14.4	400	52	90
C15 - C36	g/m³	25	43	62	43	52
Total hydrocarbons (C7 - C36)	g/m³	30	58	460	95	142

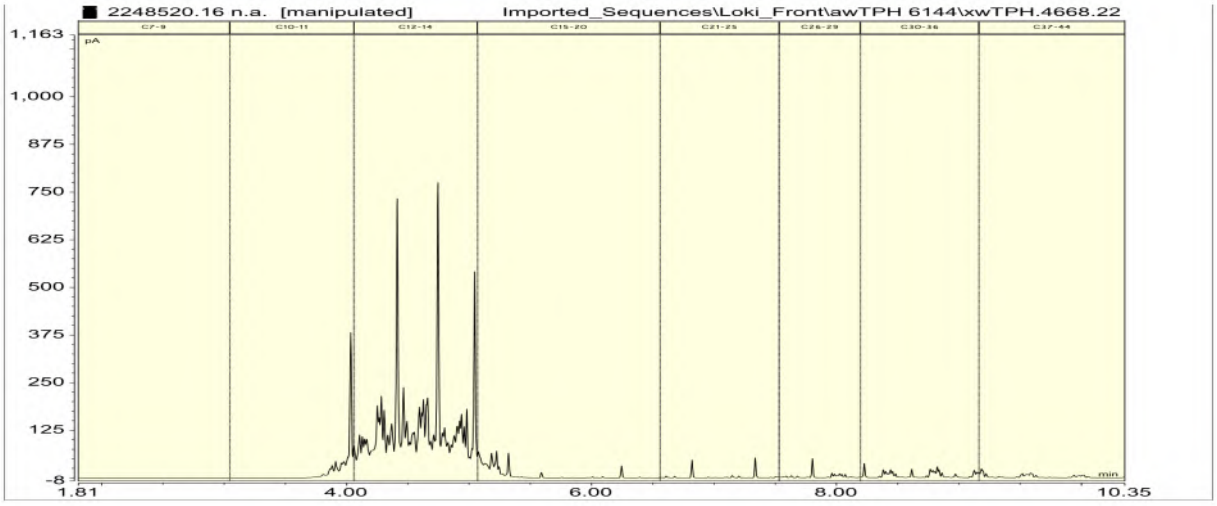
2248520.11
TRC193386 (GND3066) MHW29 FF Slick 12-Sep-2019
Client Chromatogram for TPH by FID



2248520.15
Composite of TRC193381 (GND3058) MHW27 FF Gel Bottle 1, TRC193381 (GND3058) MHW27 FF Gel Bottle 2 & TRC193381
Client Chromatogram for TPH by FID



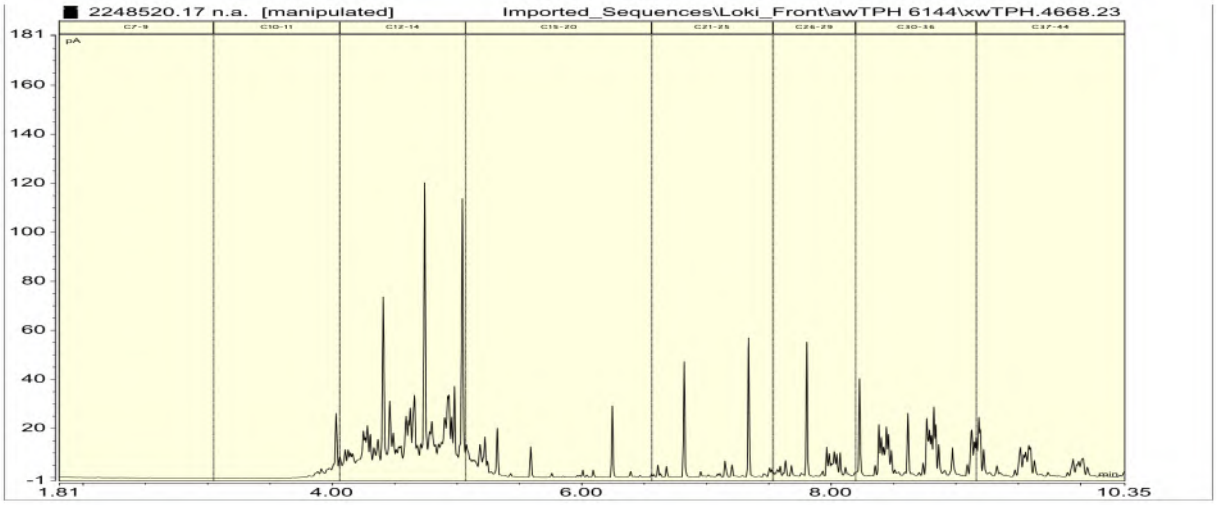
2248520.16
Composite of TRC193383 (GND3059) MHW28FF Gel Bottle 1, TRC193383 (GND3059) MHW28FF Gel Bottle 2, TRC193383 (GND3059)
Client Chromatogram for TPH by FID



2248520.17

Composite of TRC193385 (GND3066) MHW29 FF Gel Bottle 1, TRC193385 (GND3066) MHW29 FF Gel Bottle 2 & TRC193385

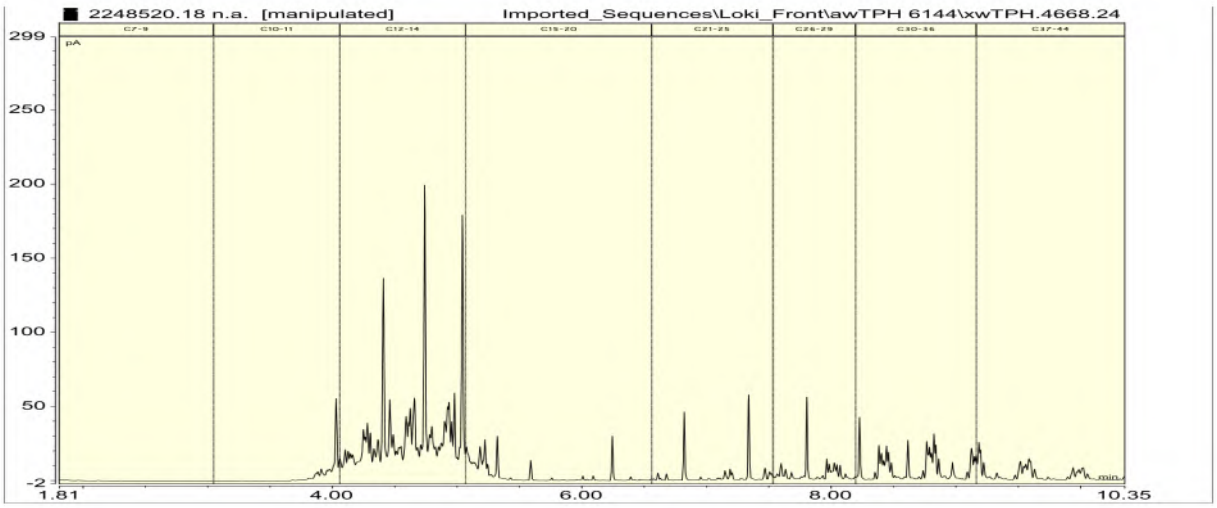
Client Chromatogram for TPH by FID



2248520.18

Composite of TRC193387 (GND3067) MHW30 FF Gel Bottle 1, TRC193387 (GND3067) MHW30 FF Gel Bottle 2 & TRC193387

Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	11, 15-18
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	11, 15-18
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	11, 15-18
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	11, 15-18
Total Petroleum Hydrocarbons in Water*	Solvent extraction, GC-FID analysis. Headspace GC-MS analysis for C7-C9 carbon band.	0.06 - 0.7 g/m^3	11, 15-18

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

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

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Martin Cowell - BSc
Client Services Manager - Environmental

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Certificate of Analysis

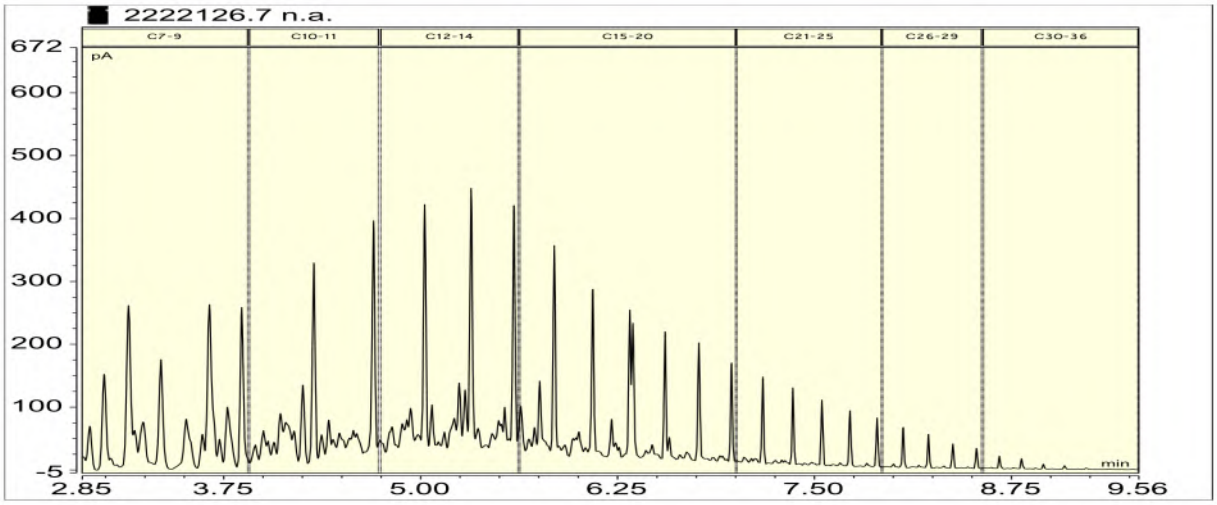
Client:	Taranaki Regional Council	**Lab No:**	2222126 SPv1
Contact:	Jane Harvey	**Date Received:**	09-Aug-2019
	C/- Taranaki Regional Council	**Date Reported:**	21-Aug-2019
	Private Bag 713	**Quote No:**	71307
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5201 - Hydraulic Fracturing Mangahewa-G (MHW G)
		Submitted By:	Sarah Larkin

Sample Type: Saline

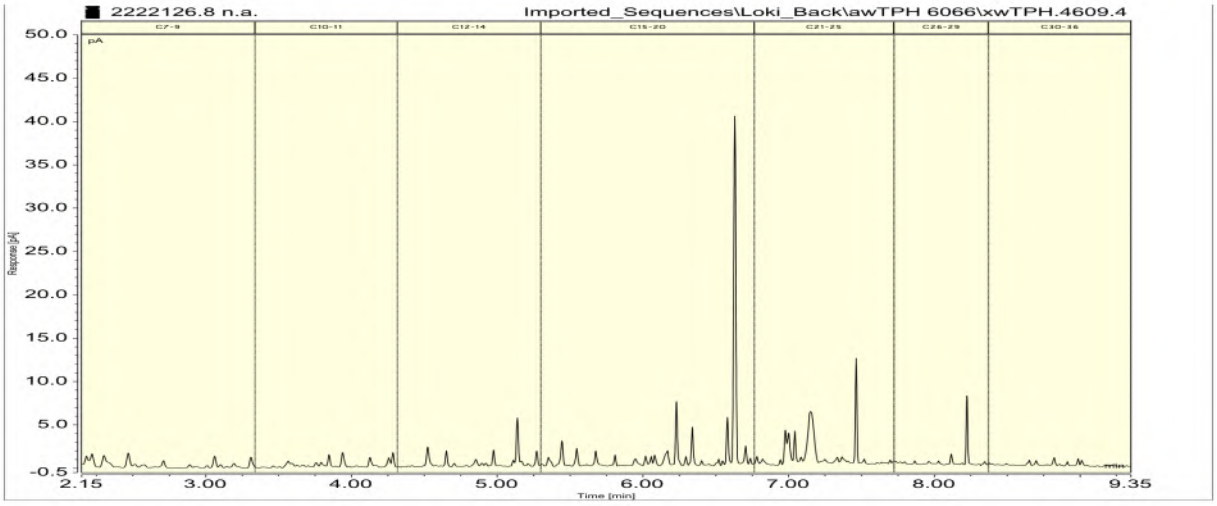
Sample Name:	Composite of TRC192892 (GND3058) A, TRC192892 (GND3058) B & TRC192892 (GND3058) C	Composite of TRC192894 (GND3059) A, TRC192894 (GND3059) B & TRC192894 (GND3059) C			
Lab Number:	2222126.7	2222126.8			
Individual Tests					
pH* pH Units	6.9	6.8	-	-	-
Total Alkalinity* g/m³ as $CaCO_3$	1,300	700	-	-	-
Analysis Temperature for Bicarbonate °C	21	22	-	-	-
Bicarbonate g/m³ at Analysis Temperature	1,049	668	-	-	-
Total Hardness* g/m³ as $CaCO_3$	520	630	-	-	-
Electrical Conductivity (EC)* mS/m	3,980	4,440	-	-	-
Total Dissolved Solids (TDS)* g/m³	> 25,000	> 25,000	-	-	-
Total Barium g/m³	50 #1	102	-	-	-
Total Calcium g/m³	174	230	-	-	-
Total Copper g/m³	0.0153	0.0076	-	-	-
Total Iron g/m³	8.8	5.8	-	-	-
Total Magnesium g/m³	20	17.2	-	-	-
Total Manganese g/m³	1.21	1.43	-	-	-
Total Mercury* g/m³	0.00011	0.00012	-	-	-
Total Nickel g/m³	< 0.032	< 0.032	-	-	-
Total Potassium g/m³	5,000	5,900	-	-	-
Total Sodium g/m³	4,600	4,300	-	-	-
Total Sulphur* g/m³	133	123	-	-	-
Total Zinc g/m³	0.049	0.125	-	-	-
Bromide* g/m³	24	21	-	-	-
Chloride* g/m³	12,400	14,200	-	-	-
Nitrite-N g/m³	< 0.10 #2	< 0.10 #3	-	-	-
Nitrate-N g/m³	< 0.10	0.29	-	-	-
Nitrate* g/m³	< 0.5	1.3	-	-	-
Nitrate-N + Nitrite-N g/m³	< 0.10 #2	0.29	-	-	-
Sulphate* g/m³	400	370	-	-	-
Ethylene Glycol in Water					
Ethylene glycol* g/m³	< 400	< 400	-	-	-
Propylene Glycol in Water					
Propylene glycol* g/m³	< 400	< 400	-	-	-

Sample Type: Saline						
Sample Name:		Composite of TRC192892 (GND3058) A, TRC192892 (GND3058) B & TRC192892 (GND3058) C	Composite of TRC192894 (GND3059) A, TRC192894 (GND3059) B & TRC192894 (GND3059) C			
Lab Number:		2222126.7	2222126.8			
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 200	< 200	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	13.8	10.0	-	-	-
Toluene*	g/m³	17.8	6.8	-	-	-
Ethylbenzene*	g/m³	1.52	0.30	-	-	-
m&p-Xylene*	g/m³	8.3	1.48	-	-	-
o-Xylene*	g/m³	3.1	0.72	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	< 1.5	< 1.5	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	94	13.2	-	-	-
C10 - C14*	g/m³	240	0.7	-	-	-
C15 - C36*	g/m³	181	4.1	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	520	18.0	-	-	-

2222126.7
Composite of TRC192892 (GND3058) A, TRC192892 (GND3058) B & TRC192892 (GND3058) C
Client Chromatogram for TPH by FID



2222126.8
Composite of TRC192894 (GND3059) A, TRC192894 (GND3059) B & TRC192894 (GND3059) C
Client Chromatogram for TPH by FID



Analyst's Comments

#1 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. The average of the results of the replicate analyses has been reported. Replicate 1 = 50mg/lg, replicate 2 = 43mg/L, replicate 3 = 57mg/L.

#2 Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NOxNsal /NO2Nsal analysis.

#3 Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal analysis.

Appendix No.1 - GNS report

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	7-8
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	7-8
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	7-8
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	7-8
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	7-8
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	7-8
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	7-8
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	7-8
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	7-8
pH*	Saline water, pH meter. APHA 4500-H$^+$ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	7-8
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	7-8

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	7-8
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m³ at Analysis Temperature	7-8
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	7-8
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.10 mS/m	7-8
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	50 g/m³	7-8
Total Barium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.00063 g/m³	7-8
Total Calcium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m³	7-8
Total Copper	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m³	7-8
Total Iron	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m³	7-8
Total Magnesium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m³	7-8
Total Manganese	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m³	7-8
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	7-8
Total Nickel	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.0070 g/m³	7-8
Total Potassium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m³	7-8
Total Sodium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m³	7-8
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23rd ed. 2017.	0.5 g/m³	7-8
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m³	7-8
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	7-8
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	7-8
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	7-8
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	7-8
Nitrate*	Calculation from Nitrate-N.	0.005 g/m³	7-8
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	7-8
Total Sulphate*	Calculation: from total sulphur.	2 g/m³	7-8
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	7-8

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

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

Helena Bertram BSc
Client Services Manager - Environmental

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CERTIFICATE OF ANALYSIS

ENVSUBGNS_WAIRAKEI 91

Report No: 2019081202

Customer Ref:152293

Ara Heron
RJ Hill Laboratories (Hamilton)
Environmental Reports Officers
Private Bag 3205
Hamilton

GNS Lot No: 2019081202

GNS Sample No.	2019004450	2019004451
Collection Date		
Site ID	2222126.7	2222126.8
Field ID		

pH		7.65	7.49	-	-
Bicarbonate (Total)	mg/l	1049	668	-	-
HCO_3 Analysis Temperature	°C	21	22	-	-
HCO_3 Analysis Date		16/08/2019	15/08/2019	-	-

SUMMARY OF METHODS AND DETECTION LIMITS

The following table gives a brief description of the methods used to conduct the analyses on this report.
The detection limits given below are those attainable in a relatively clean matrix.

Parameter	Method	*Detection Limit	
Bicarbonate (total)	HCO_3 Titration Method ASTM Standards D513-82 Vol.11.01 1988	20	mg/l
pH	Electrometric Method - APHA 4500-H+ B 23rd Edition 2017	-	-

*Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Notes: These samples were collected by yourselves (or your agent) and analysed as received at the laboratory. This report must not be reproduced, except in full, without the written consent of the signatory. Samples are held at the laboratory after reporting for a period of 2 to 6 months, dependent on sample type.

M. K. Appleby

Moya Appleby
Senior Technician

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W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2221737 SPv1
Contact:	Jane Harvey	**Date Received:**	09-Aug-2019
	C/- Taranaki Regional Council	**Date Reported:**	16-Aug-2019
	Private Bag 713	**Quote No:**	50522
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5201 - Hydraulic Fracturing Mangahewa-G (MHW G)
		Submitted By:	Sarah Larkin

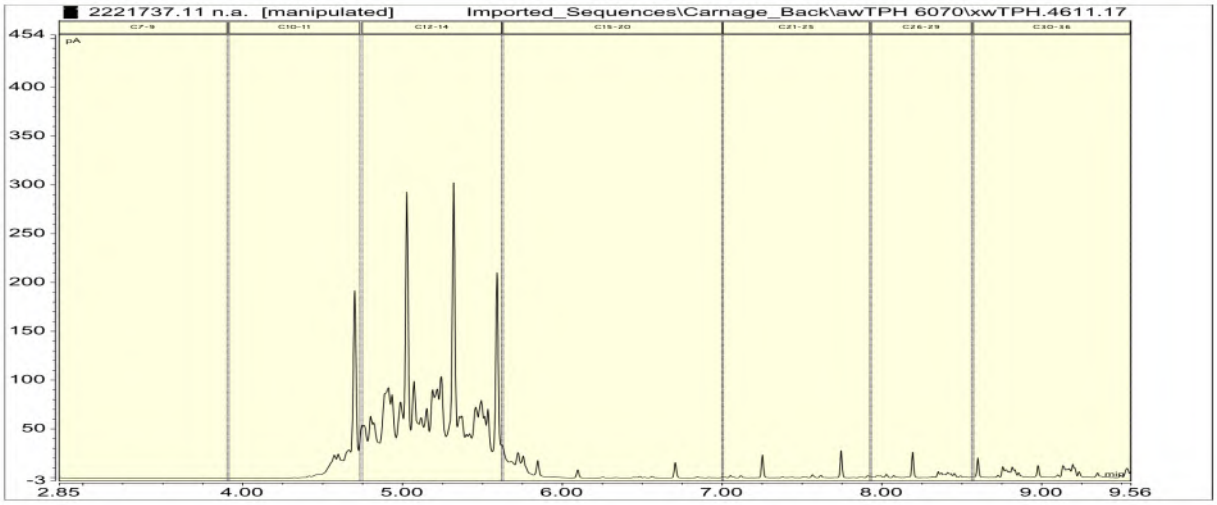
Sample Type: Aqueous

Sample Name:		Composite of TRC192891 (GND30508) A, TRC192891 (GND30508) B, TRC192891 (GND30508) C & TRC192891 (GND30508) D	Composite of TRC192893 (GND3059) A, TRC192893 (GND3059) B, TRC192893 (GND3059) C, TRC192893 (GND3059) D, TRC192893 (GND3059) E & TRC192893 (GND3059) F			
Lab Number:		2221737.11	2221737.12			
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 400	< 400	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 400	< 400	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 200	< 200	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.010	< 0.010	-	-	-
Toluene	g/m³	< 0.010	< 0.010	-	-	-
Ethylbenzene	g/m³	< 0.010	< 0.010	-	-	-
m&p-Xylene	g/m³	< 0.02	< 0.02	-	-	-
o-Xylene	g/m³	< 0.010	< 0.010	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.6	< 0.6	-	-	-
C10 - C14	g/m³	360	2.4	-	-	-
C15 - C36	g/m³	49	16	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	410	19	-	-	-

2221737.11

Composite of TRC192891 (GND30508) A, TRC192891 (GND30508) B, TRC192891 (GND30508) C & TRC192891 (GND30508) D

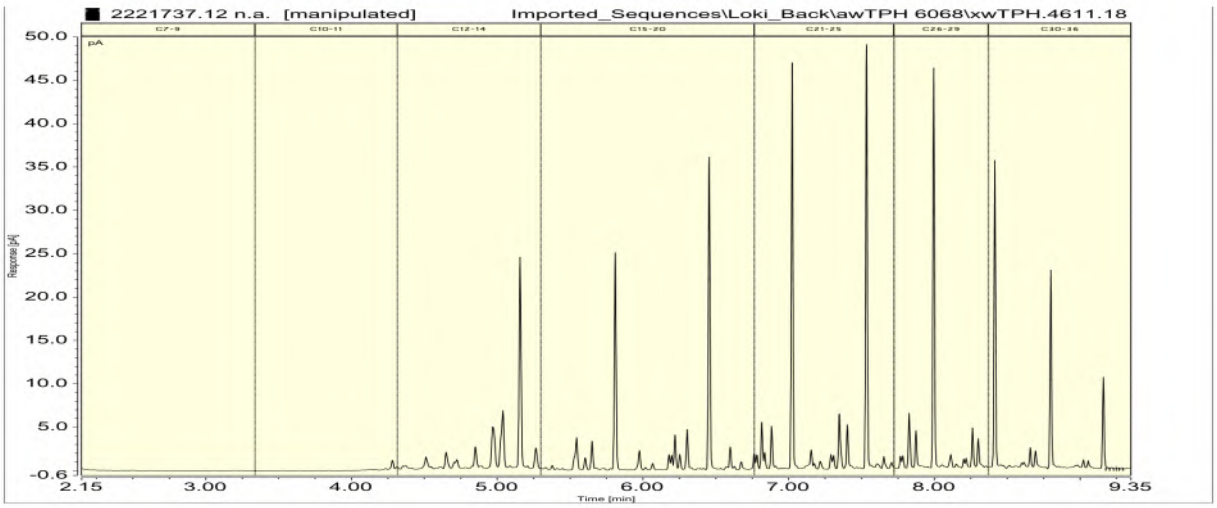
Client Chromatogram for TPH by FID



2221737.12

Composite of TRC192893 (GND3059) A, TRC192893 (GND3059) B, TRC192893 (GND3059) C, TRC192893 (GND3059) D, TRC192893

Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	11-12
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	11-12
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	11-12
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	11-12
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	11-12
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	11-12

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

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

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

Martin Cowell - BSc
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Hamilton 3240 New Zealand

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E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2196104 SPv1
Contact:	Jane Harvey	**Date Received:**	20-Jun-2019
	C/- Taranaki Regional Council	**Date Reported:**	04-Jul-2019
	Private Bag 713	**Quote No:**	50522
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5117 - Hydraulic Fracturing Monitoring Programme - Discharge -O
		Submitted By:	Jane Harvey

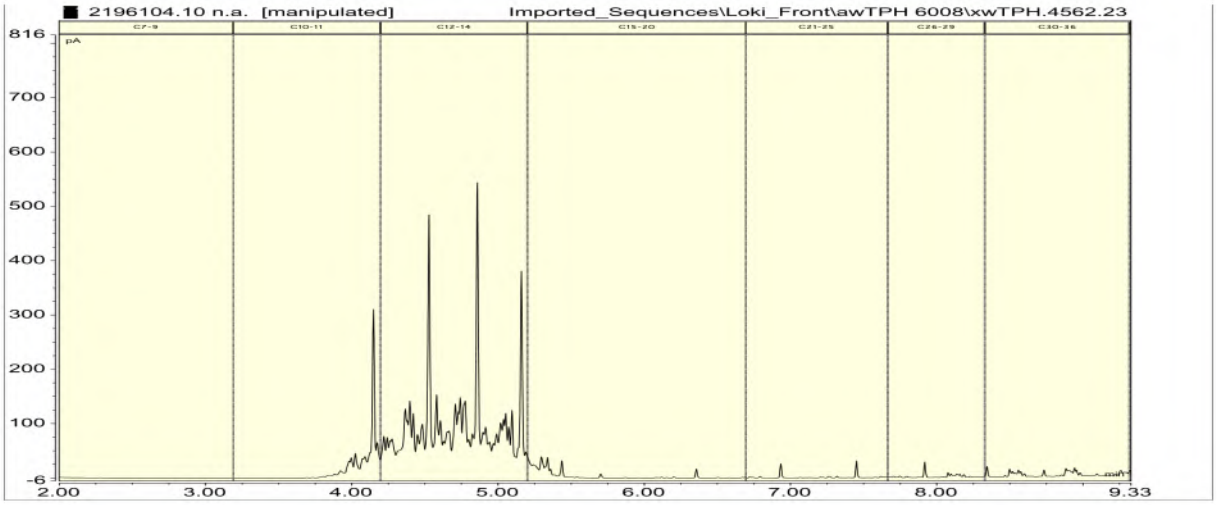
Sample Type: Aqueous

Sample Name:		Composite of TRC192379 (GND3019) [A], TRC192379 (GND3019) [B], TRC192379 (GND3019) [C] & TRC192379 (GND3019) [D]	Composite of TRC192384 (GND3020) [A], TRC192384 (GND3020) [B], TRC192384 (GND3020) [C], TRC192384 (GND3020) [D] & TRC192384 (GND3020) [E]			
Lab Number:		2196104.10	2196104.11			
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	5	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 5	< 5	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0115	< 0.010	-	-	-
Toluene	g/m³	0.022	< 0.010	-	-	-
Ethylbenzene	g/m³	0.0017	< 0.010	-	-	-
m&p-Xylene	g/m³	0.008	< 0.02	-	-	-
o-Xylene	g/m³	0.0020	< 0.010	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.24	< 0.6	-	-	-
C10 - C14	g/m³	360	28	-	-	-
C15 - C36	g/m³	53	42	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	420	69	-	-	-

2196104.10

Composite of TRC192379 (GND3019) [A], TRC192379 (GND3019) [B], TRC192379 (GND3019) [C] & TRC192379 (GND3019) [D]

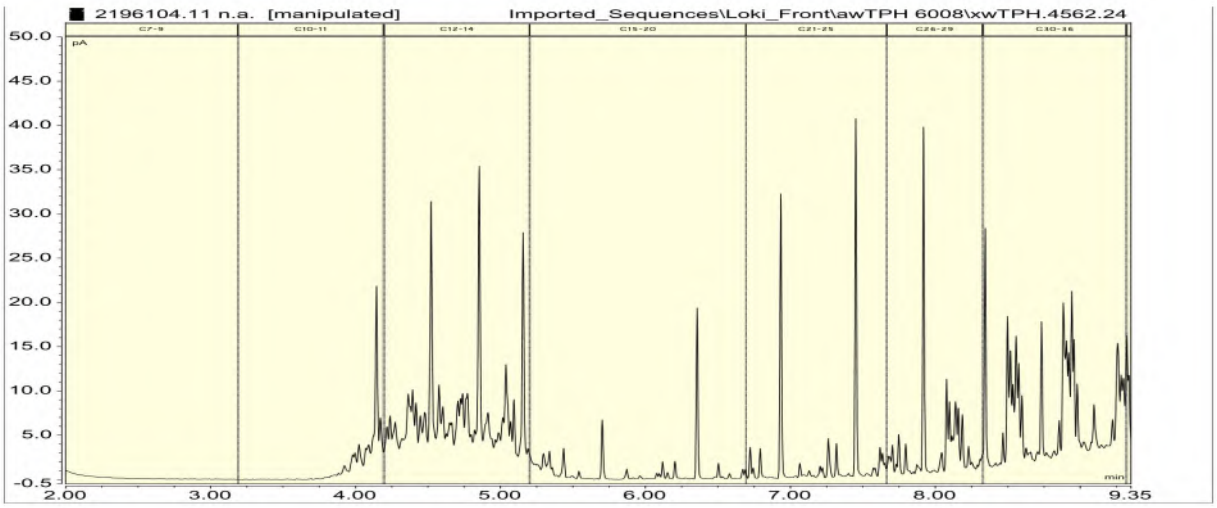
Client Chromatogram for TPH by FID



2196104.11

Composite of TRC192384 (GND3020) [A], TRC192384 (GND3020) [B], TRC192384 (GND3020) [C], TRC192384 (GND3020) [D] &

Client Chromatogram for TPH by FID



Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	10-11
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	10-11
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	10-11
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	10-11
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	10-11
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	10-11

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

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

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2195711 SPv1
Contact:	Jane Harvey	**Date Received:**	20-Jun-2019
	C/- Taranaki Regional Council	**Date Reported:**	04-Jul-2019
	Private Bag 713	**Quote No:**	71307
	Stratford 4352	**Order No:**	72831
		Client Reference:	#5117 - Hydraulic Fracturing Monitoring Programme - Discharge -O
		Submitted By:	Jane Harvey

Sample Type: Saline

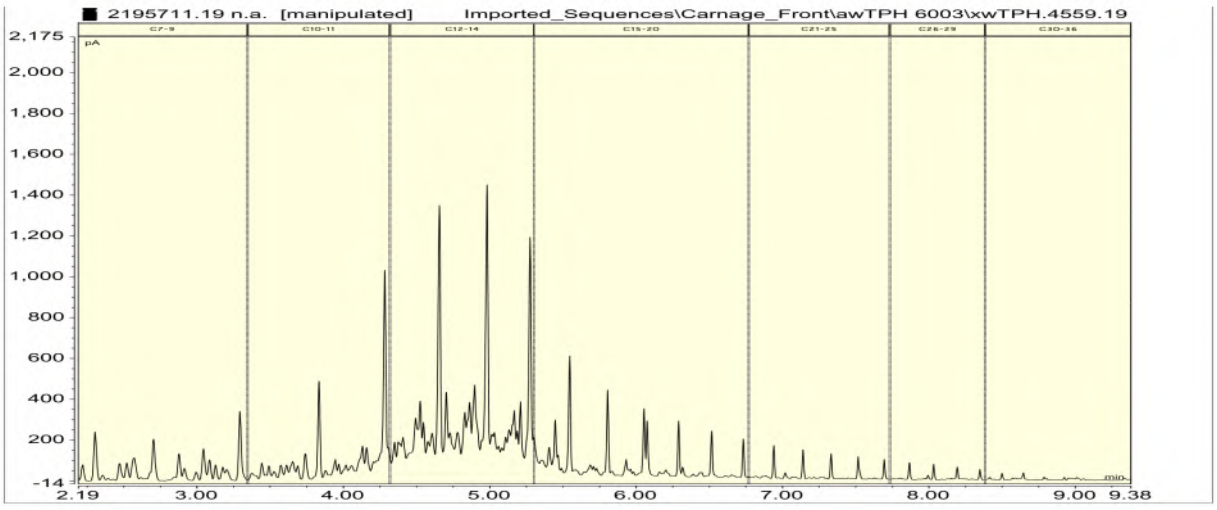
Sample Name:	Composite of TRC192376 (GND3019) [A], TRC192376 (GND3019) [B] & TRC192376 (GND3019) [C]	Composite of TRC192377 (GND3019) [A], TRC192377 (GND3019) [B] & TRC192377 (GND3019) [C]	Composite of TRC192378 (GND3019) [A], TRC192378 (GND3019) [B] & TRC192378 (GND3019) [C]	Composite of TRC192380 (GND3020) [A], TRC192380 (GND3020) [B] & TRC192380 (GND3020) [C]	Composite of TRC192381 (GND3020) [A], TRC192381 (GND3020) [B] & TRC192381 (GND3020) [C]
Lab Number:	2195711.19	2195711.20	2195711.21	2195711.22	2195711.23
Individual Tests					
pH* pH Units	6.9	6.8	7.0	6.7	6.3
Total Alkalinity* g/m³ as $CaCO_3$	790	880	1,900	1,400	1,300
Analysis Temperature for Bicarbonate °C	22	22	22	22	21
Bicarbonate g/m³ at Analysis Temperature	790	516	1,381	957	877
Total Hardness* g/m³ as $CaCO_3$	250	270	300	260	360
Electrical Conductivity (EC)* mS/m	4,610	4,190	3,220	3,090	3,520
Total Dissolved Solids (TDS)* g/m³	30,000	28,000	21,000	19,600	22,000
Total Barium g/m³	14.9 #1	13.2 #1	78	49	13.0
Total Calcium g/m³	82	90	92	61	86
Total Copper g/m³	0.075	0.125	< 0.0053	0.0112	< 0.0053
Total Iron g/m³	41	5.2	2.9	10.5	8.4
Total Magnesium g/m³	11.9	10.1	16.7	26	35
Total Manganese g/m³	2.1	0.96	1.48	0.72	2.5
Total Mercury g/m³	< 0.0021	< 0.0021	0.0024	< 0.0021	< 0.0021
Total Nickel g/m³	0.168	0.117	< 0.032	0.035	0.073
Total Potassium g/m³	11,300	7,500	1,970	2,200	6,300
Total Sodium g/m³	2,400	3,800	6,300	5,600	3,400
Total Sulphur* g/m³	230	210	20	30	149
Total Zinc g/m³	0.98	0.31	0.110	0.028	0.076
Bromide* g/m³	25	11	19	21	11
Chloride* g/m³	17,100	6,600	5,500	7,600	7,800
Nitrite-N g/m³	< 0.10 #2	< 0.10 #2	< 0.10 #2	< 0.10 #2	< 0.10 #2
Nitrate-N g/m³	0.15	< 0.10	< 0.10	< 0.10	< 0.10
Nitrate* g/m³	0.7	< 0.5	< 0.5	< 0.5	< 0.5
Nitrate-N + Nitrite-N g/m³	0.16 #2	< 0.10 #2	< 0.10 #2	< 0.10 #2	< 0.10 #2
Sulphate* g/m³	680	640	58	90	450
Ethylene Glycol in Water					
Ethylene glycol* g/m³	< 4	91	6	230	190
Propylene Glycol in Water					
Propylene glycol* g/m³	< 4	< 4	< 4	< 4	< 4

Sample Type: Saline						
Sample Name:		Composite of TRC192376 (GND3019) [A], TRC192376 (GND3019) [B] & TRC192376 (GND3019) [C]	Composite of TRC192377 (GND3019) [A], TRC192377 (GND3019) [B] & TRC192377 (GND3019) [C]	Composite of TRC192378 (GND3019) [A], TRC192378 (GND3019) [B] & TRC192378 (GND3019) [C]	Composite of TRC192380 (GND3020) [A], TRC192380 (GND3020) [B] & TRC192380 (GND3020) [C]	Composite of TRC192381 (GND3020) [A], TRC192381 (GND3020) [B] & TRC192381 (GND3020) [C]
Lab Number:		2195711.19	2195711.20	2195711.21	2195711.22	2195711.23
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	4,800	81	5	< 5	< 5
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	5.1	48	8.2	9.1	10.6
Toluene*	g/m³	5.4	157	2.1	6.4	7.7
Ethylbenzene*	g/m³	0.83	37	< 0.010	0.39	0.41
m&p-Xylene*	g/m³	4.2	250	0.38	2.2	2.4
o-Xylene*	g/m³	1.98	78	0.25	0.99	1.02
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	< 1.5	< 1.5	< 0.15	< 0.15	< 1.5
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	87	1,010	4.3	25	16.5
C10 - C14*	g/m³	1,410	7,000	14.2	102	100
C15 - C36*	g/m³	540	4,900	17	129	149
Total hydrocarbons (C7 - C36)	g/m³	2,000	12,900	36	260	270

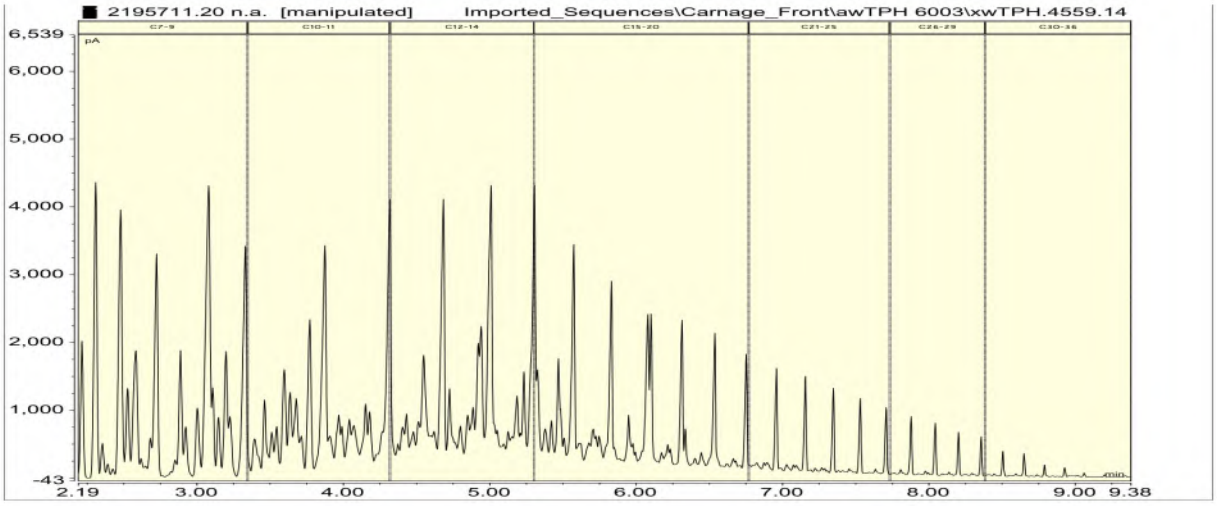
Sample Name:		Composite of TRC192382 (GND3020) [A], TRC192382 (GND3020) [B] & TRC192382 (GND3020) [C]				
Lab Number:		2195711.24				
Individual Tests						
pH*	pH Units	7.0	-	-	-	-
Total Alkalinity*	g/m³ as $CaCO_3$	2,700	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m³ at Analysis Temperature	2,190	-	-	-	-
Total Hardness*	g/m³ as $CaCO_3$	300	-	-	-	-
Electrical Conductivity (EC)*	mS/m	3,830	-	-	-	-
Total Dissolved Solids (TDS)*	g/m³	25,000	-	-	-	-
Total Barium	g/m³	135	-	-	-	-
Total Calcium	g/m³	89	-	-	-	-
Total Copper	g/m³	0.0096	-	-	-	-
Total Iron	g/m³	4.4	-	-	-	-
Total Magnesium	g/m³	18.3	-	-	-	-
Total Manganese	g/m³	5.2	-	-	-	-
Total Mercury	g/m³	< 0.0021	-	-	-	-
Total Nickel	g/m³	0.075	-	-	-	-
Total Potassium	g/m³	6,300	-	-	-	-
Total Sodium	g/m³	4,800	-	-	-	-
Total Sulphur*	g/m³	141	-	-	-	-
Total Zinc	g/m³	0.23	-	-	-	-
Bromide*	g/m³	9	-	-	-	-
Chloride*	g/m³	7,900	-	-	-	-
Nitrite-N	g/m³	< 0.10 #2	-	-	-	-
Nitrate-N	g/m³	< 0.10	-	-	-	-
Nitrate*	g/m³	< 0.5	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	< 0.10 #2	-	-	-	-
Sulphate*	g/m³	420	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	41	-	-	-	-

Sample Type: Saline						
Sample Name:	Composite of TRC192382 (GND3020) [A], TRC192382 (GND3020) [B] & TRC192382 (GND3020) [C]					
Lab Number:	2195711.24					
Propylene Glycol in Water						
Propylene glycol* g/m³	< 4	-	-	-	-	
Methanol in Water - Aqueous Solvents						
Methanol* g/m³	8	-	-	-	-	
BTEX in Water by Headspace GC-MS						
Benzene* g/m³	6.7	-	-	-	-	
Toluene* g/m³	4.9	-	-	-	-	
Ethylbenzene* g/m³	0.32	-	-	-	-	
m&p-Xylene* g/m³	1.82	-	-	-	-	
o-Xylene* g/m³	0.86	-	-	-	-	
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde* g/m³	0.78	-	-	-	-	
Total Petroleum Hydrocarbons in Water						
C7 - C9 g/m³	19.7	-	-	-	-	
C10 - C14* g/m³	109	-	-	-	-	
C15 - C36* g/m³	123	-	-	-	-	
Total hydrocarbons (C7 - C36) g/m³	250	-	-	-	-	

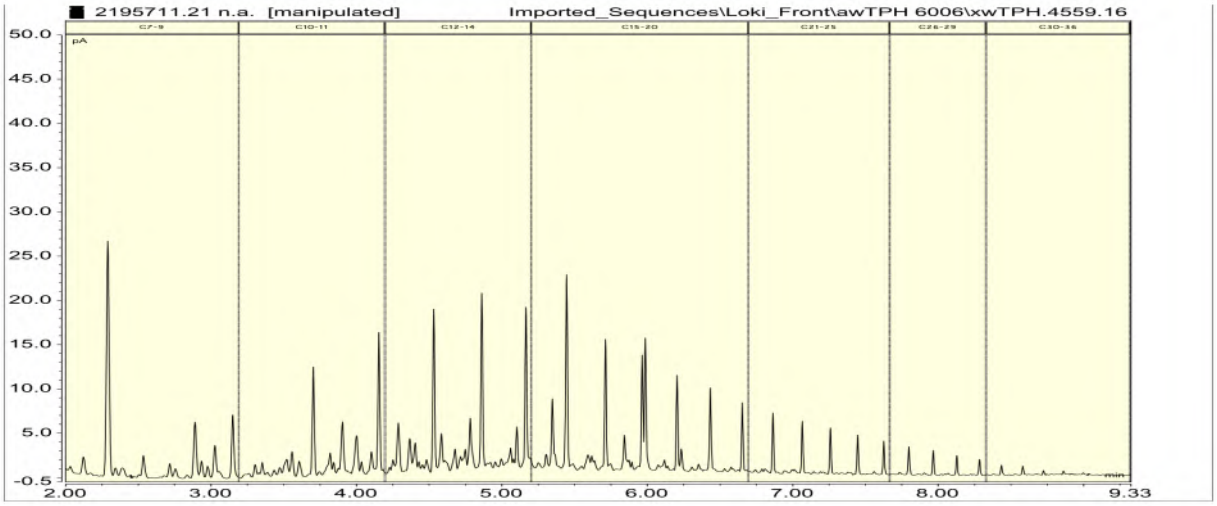
2195711.19
Composite of TRC192376 (GND3019) [A], TRC192376 (GND3019) [B] & TRC192376 (GND3019) [C]
Client Chromatogram for TPH by FID



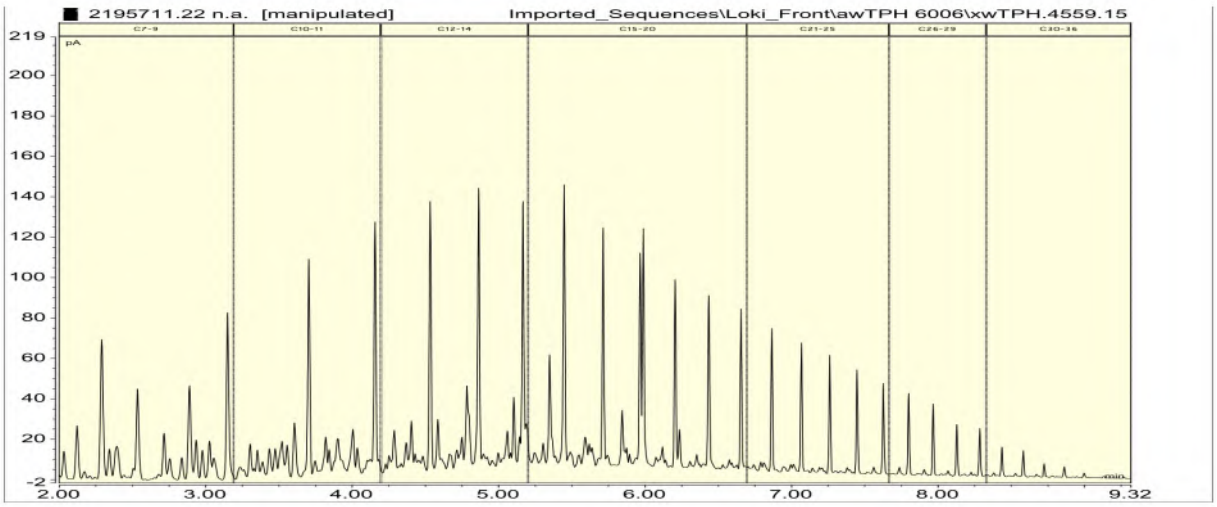
2195711.20
Composite of TRC192377 (GND3019) [A], TRC192377 (GND3019) [B] & TRC192377 (GND3019) [C]
Client Chromatogram for TPH by FID



2195711.21
Composite of TRC192378 (GND3019) [A], TRC192378 (GND3019) [B] & TRC192378 (GND3019) [C]
Client Chromatogram for TPH by FID



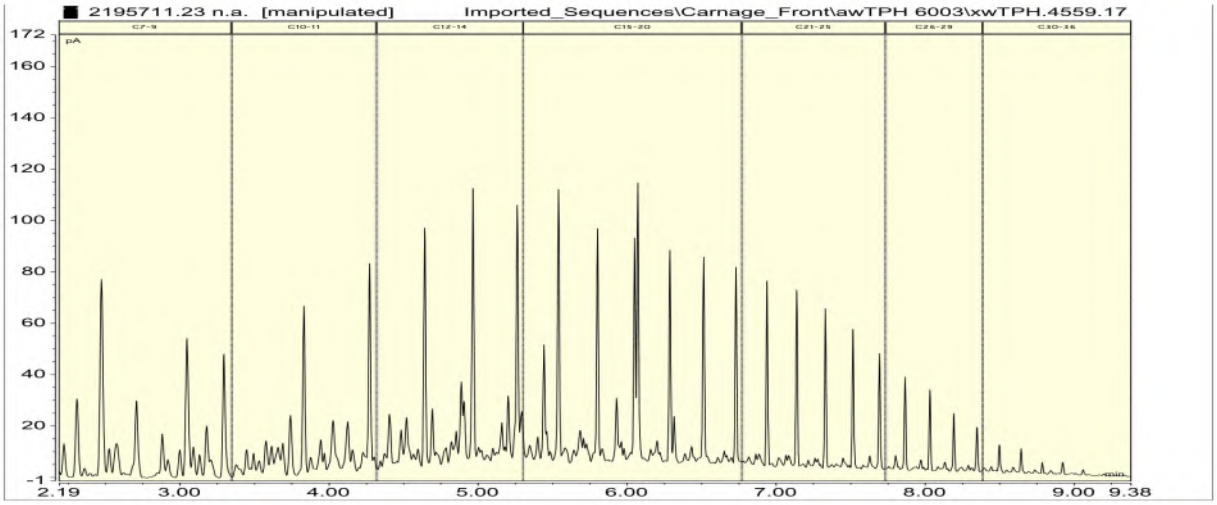
2195711.22
Composite of TRC192380 (GND3020) [A], TRC192380 (GND3020) [B] & TRC192380 (GND3020) [C]
Client Chromatogram for TPH by FID



2195711.23

Composite of TRC192381 (GND3020) [A], TRC192381 (GND3020) [B] & TRC192381 (GND3020) [C]

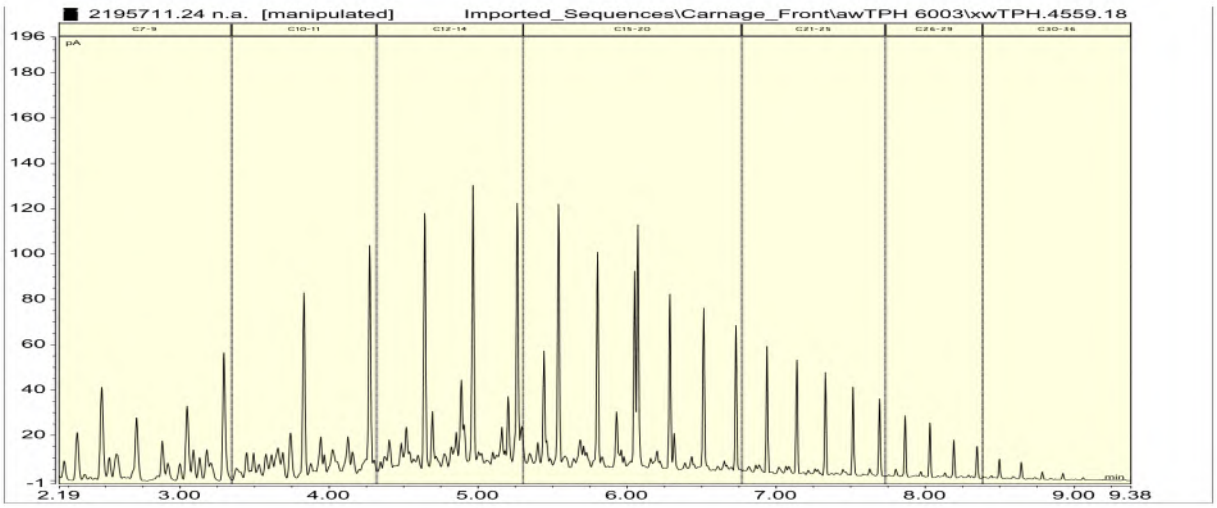
Client Chromatogram for TPH by FID



2195711.24

Composite of TRC192382 (GND3020) [A], TRC192382 (GND3020) [B] & TRC192382 (GND3020) [C]

Client Chromatogram for TPH by FID



Analyst's Comments

The toluene and C7-C9 TPH results for sample 2195711.10 have been reported from the re-analysis using a smaller volume. Therefore the result maybe underestimated due to volatile loss. It is noted that the original results were well out of calibration range.

#1 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

#2 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2N, NO3N and NOxN analysis.

Appendix No.1 - Chain of Custody

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	19-24
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	19-24
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	19-24

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	19-24
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	19-24
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	19-24
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	19-24
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	19-24
Total Digestion with HCl	Nitric/hydrochloric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	19-24
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	19-24
pH*	pH meter. APHA 4500-H$^+$ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	19-20, 22, 24
pH*	Saline water, pH meter. APHA 4500-H$^+$ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	21, 23
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	19-24
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	19-24
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	19-24
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m^3 as $CaCO_3$	19-24
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.10 mS/m	21, 23
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	19-20, 22, 24
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 23rd ed. 2017.	50 g/m^3	19-24
Total Barium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.00063 g/m^3	19-24
Total Calcium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m^3	19-24
Total Copper	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m^3	19-24
Total Iron	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m^3	19-24
Total Magnesium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m^3	19-24
Total Manganese	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0011 g/m^3	19-24
Total Mercury	Acid digestion, ICP-MS, screen level. APHA 3125 B 23rd ed. 2017.	0.0021 g/m^3	19-24
Total Nickel	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.0070 g/m^3	19-24
Total Potassium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	1.1 g/m^3	19-24
Total Sodium	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.42 g/m^3	19-24
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 B 23rd ed. 2017.	0.5 g/m^3	19-24
Total Zinc	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 23rd ed. 2017.	0.0042 g/m^3	19-24

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.05 g/m³	19-24
Chloride*	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	19-24
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	19-24
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	19-24
Nitrate*	Calculation from Nitrate-N.	0.005 g/m³	19-24
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.0010 g/m³	19-24
Total Sulphate*	Calculation: from total sulphur.	2 g/m³	19-24
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	19-24

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

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

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

ANALYSIS REQUEST

R J Hill Laboratories Limited
28 Duke Street, Hamilton 3204
Private Bag 3205
Hamilton 3240, New Zealand

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T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Job No: **219 5711**
Date Recv: 20-Jun-19 05:44
Received by: Simon Argent

3121957114

Quote No 71307 + 50522.
Primary Contact Jane Harvey
Submitted By Jane Harvey
Client Name Taranaki Regional Council
Address Private Bag 713, Stratford 4352
Phone 06 765 7127 *Mobile*
Email
Charge To Taranaki Regional Council
Client Reference #5117 - Hydraulic Fracturing Monitoring Programme - Discharge -Other
Order No 72831
Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

[X] *Email Primary Contact* [ ] *Email Submitter* [ ] *Email Client*
[ ] *Email Other*
[X] *Other* Via FTP site as specified in contract

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories — Date & Time: 19/6/19 1600; Name: S Larkin; Signature:
[✓] Tick if you require COC to be emailed back
Received at Hill Laboratories — Date & Time:; Name:; Signature:
Condition [ ] Room Temp [ ] Chilled [ ] Frozen — Temp: 13.3
[ ] Sample and Analysis details checked
Signature:

ADDITIONAL INFORMATION

1/2

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

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 6 working days following day of receipt of the samples at the laboratory

Requested Reporting Date:

No	Hills #	Sample Name	Sample Date/Time	Temperature	Sample Type	Tests Required
1		TRC192376 (GND3019)	26/4/19 – 29/4/19		Water saline	Quote 71307 — 3x bottles to make 1x composite
2		TRC192377 (GND3019)	09/5/19 – 13/5/19		"	" — 3x bottles to make 1x composite
3		TRC192378 (GND3019)	21/5/19 – 5/6/19		"	" — 3x bottles to make 1x composite
4		TRC192379 (GND3019)	26/4/19 – 16/5/19		"	Quote 50522 — 4x bottles to make 1x composite
5		TRC192380 (GND3020)	6/6/19 – 9/6/19		"	Quote 71307 — 3x bottles to make 1x composite
6		TRC192381 (GND3020)	2/6/19 – 5/6/19		"	" — 3x bottles to make 1x composite
7		TRC192382 (GND3020)	21/5/19 – 30/5/19		"	" — 3x bottles to make 1x composite
8		TRC192383 (GND3020)				
9		TRC192384 (GND3020)	23/4/19 – 21/5/19		"	Quote 50522 — 5x bottles to make 1x composite

Return fluids and Fracking fluids