Todd Taranaki Limited
Mangahewa-C Hydraulic Fracturing Groundwater Monitoring Programme Report 2011-2013

Technical Report 2013–15

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Executive summary

The Mangahewa-C wellsite is located off Tikorangi Road East, Tikorangi. The site was established by Todd Taranaki Limited (the Company) in 2006. The resource consents currently held by the Company permit the drilling of up to eight wells from the wellsite.

As of 30 June 2013, 4 wells have been drilled from the Mangahewa-C wellsite since its establishment. As part of the on-going well development programme at the wellsite, the Mangahewa-11 and Mangahewa-09 wells were hydraulically fractured following their completion. In order to stimulate production from the Manghahewa-11 well, a total of 5 distinct producing zones were fractured between 30 April 2012 and 8 May 2012. The fractured intervals were located within the Mangahewa Formation, ranging in depth from 4,103 to 4,280 metres below ground level (total vertical depth). A single zone was also fractured via the Mangahewa-09 well on 20 May 2013. The fractured interval was also located within the Mangahewa Formation, from 4,082 to 4,086 metres below ground level (total vertical depth).

The discharges to land associated with the hydraulic fracturing of the Mangahewa-11 and Mangahewa-09 wells were permitted under resource consent 7971-1. The consent includes a number of special conditions, including specific conditions relating to the protection of local groundwater resources and groundwater sampling and analysis requirements. The Council was contracted by the Company to undertake the sampling and analysis of groundwater required by the conditions of the exercised consent.

The following report describes the groundwater monitoring programme implemented by the Taranaki Regional Council (the Council) to assess the potential effects of hydraulic fracturing activities at the Mangahewa-C wellsite on groundwater resources in the area surrounding the site. The results of the monitoring undertaken allow for an assessment of the Company's environmental performance to be made in relation to hydraulic fracturing activities and whether compliance with the conditions of consent 7971-1, relating specifically to the monitoring and protection of groundwater resources, has been achieved. The report covers the monitoring period 1 July 2011 to 30 June 2013.

The monitoring programme implemented by the Council included the sampling and analysis of groundwater samples taken from 5 private water supply wells/bores in the area surrounding the Mangahewa-C wellsite. Groundwater samples were submitted to Hills Laboratory for comprehensive physicochemical analysis. Additional samples were also obtained for carbon isotope analysis from sampling sites identified as containing dissolved methane. Groundwater samples were obtained from the private water supplies prior to hydraulic fracturing (baseline) and at intervals of 1 week, 3 months and 12 months post hydraulic fracturing. Samples of hydraulic fracturing fluid and formation fluids produced immediately following hydraulic fracturing were also obtained for analysis. In total, 25 samples were obtained for analysis during the period under review.

The results of the analyses carried out on samples taken from private water supplies show that the concentrations of each parameter analysed for remained consistent across the sampling period, with no significant changes detected post hydraulic fracturing.

There is no evidence to suggest that the hydraulic fracturing of the Mangahewa-11 well has resulted in any adverse effects on shallow groundwater in the vicinity of the Mangahewa-C wellsite. A final assessment on any effects associated with the hydraulic fracturing of the

Mangahewa-09 well will be made in the forthcoming monitoring period (2013/2014) after post fracturing groundwater samples are obtained in August 2013.

The Company has demonstrated a high level of environmental performance and compliance with regard to relevant conditions of resource consent 7971-1.

This report includes recommendations concerning the nature of on-going groundwater monitoring in the vicinity of the Mangahewa-C wellsite.

A separate report (Todd Taranaki Limited, Mangahewa-C Exploration Wellsite Monitoring Programme Report, Technical Report 2012-84, Taranaki Regional Council, September 2013) outlines all other wellsite activities carried out during the period September 2011 to May 2012 and the monitoring of these activities undertaken by the Council.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act (1991)

1.1.1 Introduction

The following report describes the groundwater monitoring programme implemented by the Taranaki Regional (the Council) in relation to hydraulic fracturing activities undertaken by Todd Taranaki Limited (the Company) at their Mangahewa-C wellsite, Tikorangi Road East, Tikorangi. The report also outlines and assesses the results of the monitoring carried out, and provides an assessment of Company performance with regard to consent compliance. The report encompasses the monitoring period 1 July 2011 to 30 June 2013.

As of 30 June 2013, 4 wells have been drilled from the Mangahewa-C wellsite since its establishment. As part of the on-going well development programme at the wellsite, the Mangahewa-11 and Mangahewa-09 wells were hydraulically fractured following their completion. In order to stimulate production from the Manghahewa-11 well, a total of 5 distinct producing zones were fractured between April 30 2012 and May 8 2012. The fractured intervals were located within the Mangahewa Formation, ranging in depth from 4,103 to 4,280 metres below ground level (total vertical depth - mTVD). A single zone was also fractured via the Mangahewa-09 well on 20 May 2013. The fractured interval was also located within the Mangahewa Formation, at a depth of 4,082 to 4,086 mTVD.

The discharges to land associated with hydraulic fracturing were permitted under resource consent 7971-1. The consent includes a number of special conditions, including specific conditions relating to the protection of local groundwater resources and groundwater sampling and analysis requirements. The Council was contracted by the Company to undertake the sampling and analysis of groundwater required by the conditions of the exercised consent.

The overall record of consent compliance and environmental performance at the Mangahewa-C wellsite is set out in the Council's exploration wellsite monitoring report for the site[1]. This report has been prepared by the Taranaki Regional Council to address specific monitoring investigations into the potential effects of hydraulic fracturing on groundwater resources in the vicinity of the Mangahewa-C wellsite.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the Resource Management Act and the Council's obligations and general approach to monitoring sites through monitoring programmes. Section 1 also describes the environment in which the Mangahewa-A wellsite is located, the process of hydraulic fracturing, details the resource consent held by the Company for hydraulic fracturing at the Mangahewa-A wellsite, outlines hydraulic fracturing activities carried out at the site during the period under review, and the nature of the monitoring programme implemented by the Council.

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[1] See bibliography

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

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

Section 4 presents recommendations regarding the on-going monitoring of groundwater in the vicinity of the site.

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

1.1.3 The Resource Management Act (1991) and monitoring

The Resource Management Act (the Act) 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 a discharger, and may include cultural and socio-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 (eg, recreational, cultural, or aesthetic);
(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 discharge source. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the Act to assess the effects of the exercise of consents. In accordance with section 35 of the Act, the Council undertakes compliance monitoring for consents and rules in regional plans; and maintains an overview of performance of resource users against regional plans and consents. Compliance monitoring, (covering both activity and impact), also enables the Council to continuously assess its own performance in resource management as well as that of resource users, particularly consent holders. It also enables the Council to continually re-evaluate its approach to resource management, and ultimately, through the refinement of methods, and considered responsible resource utilisation, to move closer to achieving sustainable development of the regions resources.

1.1.4 Evaluation of environmental performance

Besides discussing the various details of the performance and extent of compliance by the Company during the period under review, this report also assigns an overall environmental performance rating. The categories used by the Council, and their interpretation, are as follows:

- a **high** level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions.

- a **good** level of environmental performance and compliance indicates that adverse environmental effects of activities during the monitoring period were negligible or minor at most, or, the Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices, or, there were perhaps some items noted on inspection notices for attention but these items were not urgent nor critical, and follow-up inspections showed they have been dealt with, and inconsequential non compliances with conditions were resolved positively, co-operatively, and quickly.

- **improvement desirable** indicates that the Council may have been obliged to record a verified unauthorised incident involving measurable environmental impacts, or, there were measurable environmental effects arising from activities and intervention by Council staff was required, and there were matters that required urgent intervention, took some time to resolve, or remained unresolved at end of the period under review, and/or abatement notices may have been issued.

- **poor performance** indicates that the Council may have been obliged to record a verified unauthorised incident involving significant environmental impacts, or, there were adverse environmental effects arising from activities and there were grounds for prosecution or an infringement notice.

1.2 Existing environment

1.2.1 Site location

The Mangahewa-C wellsite is located off Tikorangi Road East, Tikorangi (Figure 1). Prior to the establishment of the wellsite, the land on which it is situated was used for livestock farming. The Mangahewa-C wellsite lies in an active petrochemical exploration and production area, which operates alongside rural and farming operations. The area consists of predominantly low density housing due to its rural location.

1.2.2 Geology

The hydraulically fractured intervals are located within the Mangahewa Formation. The intervals targeted for stimulation via the Mangahewa-11 well were located over an approximate depth range of 4,103 to 4,735 mTVD. The interval targeted for stimulation via the Mangahewa-09 well was located at an approximate depth of 4,082 to 4,086 mTVD.

The fractured intervals are isolated by the overlying Turi and Otaraoa Formations. These formations are comprised of highly impermeable shale and siltstone, which have restricted the vertical migration of gas and fluids over geologic time scales, resulting in the formation of the underlying hydrocarbon reservoir. The pressure within the reservoir is known to exceed hydrostatic pressure, confirming that it is confined from overlying formations.

In addition, hundreds of metres of low permeability strata overlie the Turi and Otaraoa Formations, further reducing the potential for any migration of formation fluids or hydrocarbons from the producing zones. The geological formations underlying the site are summarised below in Table 1.

There is no evidence of any active modern day faulting in the vicinity of the Mangahewa-C wellsite.

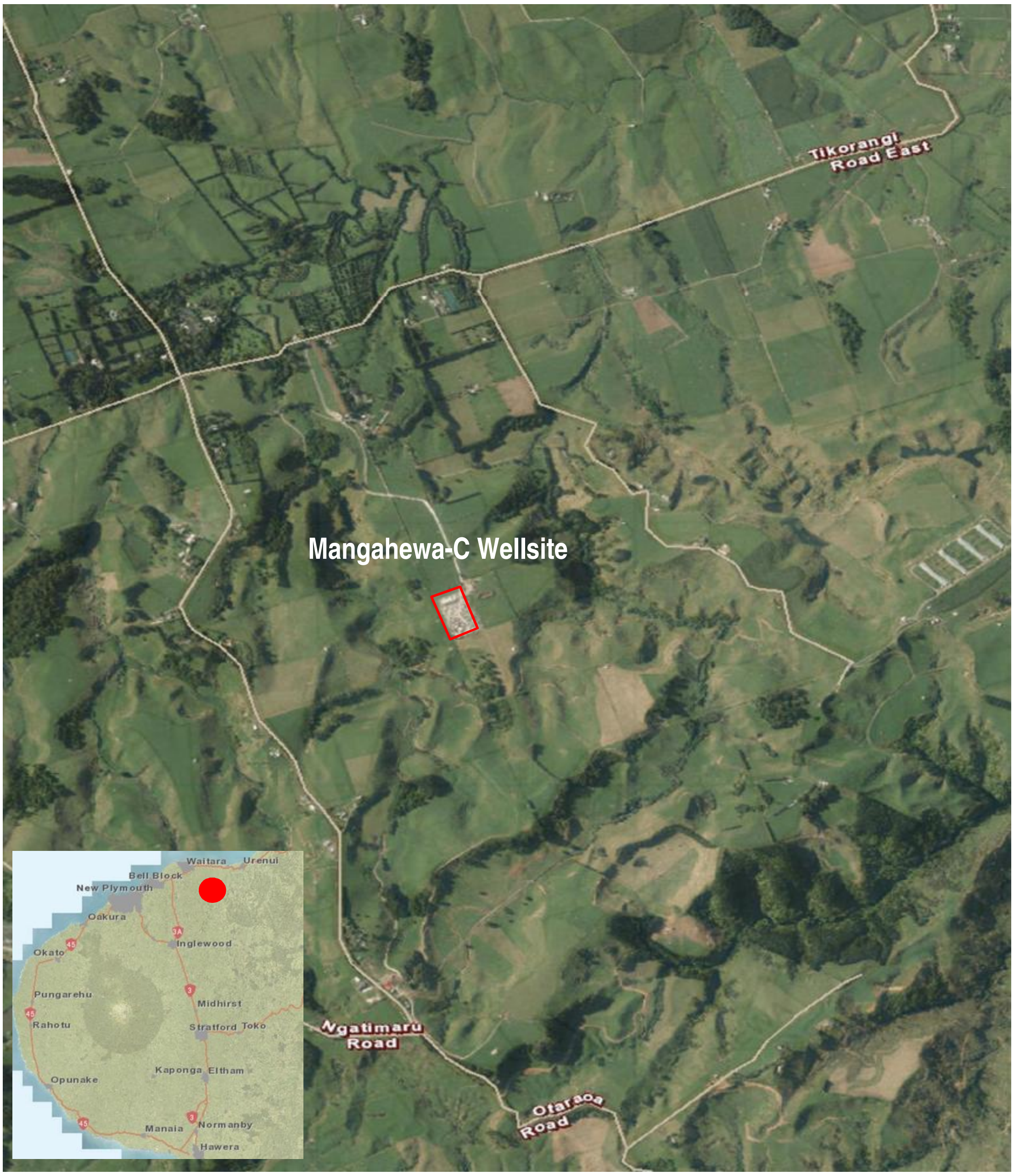

Figure 1 Location of Mangahewa-C wellsite

Table 1 Summary of geological formations underlying the Mangahewa-C wellsite

Formation	Description	Depth (mTVDSS)[2]
Taranaki Volcanics	Volcanics ashes and gravel	0 to +90
Matemateaonga	Sandy siltstones and silty claystones	+90 to -350
Urenui	Calcareous claystone with interbedded siltstone and sandstone	-350 to -825
Mount Messenger	Claystone with very fine and fine sandstone beds	-825 to -1,400
Manganui	Claystone with minor sandstone, siltstone and limestone beds	-1,400 to -2,925
Taimana	Calcareous claystone grading into argillaceous limestone	-2,925 to -3,075
Tikorangi	Arcillaceous limestone	-3,075 to -3,125
Otaraoa	Calcareous silty claystone with minor calcareous siltstones	-3,125 to -3,320
Turi	Argillaceous, carbonaceous shale and siltstone	-3,320 to -3,400

1.2.3 Hydrogeology

The shallow water bearing geological deposits underlying the Mangahewa-C wellsite include the Taranaki Volcanic and Matemateaonga Formations.

Approximately 80% of all groundwater used within Taranaki is extracted from aquifers contained in volcanic deposits. Most of this is used for agricultural purposes (Taylor & Evans, 1999). Thicknesses of up to 170 m have been encountered near Stratford. However, in general the formation thins concentrically away from the volcanic source (Mount Taranaki/Egmont). The volcanic deposits comprise both coarse material (sands, breccia, agglomerates) and fine material (clay, tuff and ash), resulting in irregular lithologies and anisotropic hydrogeologic conditions (Taylor & Evans, 1999). This produces a complex groundwater system of multiple perched and partially confined aquifers. Typically the unconfined groundwater level (water table) on the ring plain is encountered at depths of 1 to 10 m below ground level; these are the aquifers that are most used in Taranaki for domestic and farm purposes. The deeper aquifers in the volcanics are usually confined, whereas the shallower aquifers are usually unconfined. In addition, perched water tables are found above various impermeable layers throughout the volcanic deposits. These are caused by localised iron pans and mudstones, and have been found at almost any depth from a few metres down to about 230 m. Groundwater levels in wells drilled in volcanic deposits on the ring plain are generally close to the surface (Taylor and Evans, 1999). Recharge of the Volcanics Formation aquifers is primarily from rainfall infiltration.

The Matemateaonga Formation comprises alternating Tertiary sandstone, conglomeratic shell and mudstone beds. The formation extends across almost the entire region, except north of Urenui (Taylor & Evans, 1999). In a hydrocarbon exploration bore near Stratford the formation was encountered from 170 to 1,086 m

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[2] mTVDSS: the true vertical depth sub sea level

below ground level. It is exposed throughout large areas of the eastern hill country in central and south Taranaki. The formation contains a greater proportion of sands towards south Taranaki, and is more fine-grained in the north. The upper Matemateaonga aquifers in North Taranaki are largely unconfined. Elsewhere in the region, the aquifers are either confined or partially confined. Flowing artesian conditions exist at a number of localities, particularly in a band of incised hill country bordering the ring plain from Toko south to Ohangai. The Tertiary sediments that make up the inland hill country in the east of the region also underlie the volcanics deposits of the ring plain. The principal Tertiary water bearing formation is the Matemateaonga, where generally extensive aquifers are developed within sand and shellbeds between relatively impermeable mudstone layers (Allis et al, 1997).

The Council's Wells Database indicates that there are 9 private groundwater abstractions within a 2.5 kilometre (km) radius of the Mangahewa-C wellsite. The specific details of each abstraction are included below in Table 2. The groundwater abstractions registered in the vicinity of the Mangahewa-C wellsite range in depth from 4 metres (m) to 56.3 m, and include a spring discharge. The majority of abstractions are utilised as stock water rather than for consumptive purposes. The abstractions listed below all draw their water from the superficial Taranaki Volcanics Formation.

The salinity of groundwater beneath the site increases with depth. The freshwater to saline water interface is a gradational feature, above which there is potential for freshwater to occur. The salinity of groundwater can be assessed by analysing resistivity survey logs. Based on resistivity data available for surrounding wells, and their correlation with the stratigraphic sequence of the Mangahewa-C wells, the freshwater/saline water interface below the Mangahewa-C wellsite has been estimated to occur within the lower Matemateaonga Formation, at a depth of 275 m below sea level. The Mangahewa-C wellsite is elevated approximately 135 m above sea level, therefore it is estimated that potentially useable groundwater will be encountered to depth of approximately 400 m below the wellsite.

Table 2 Summary of groundwater abstractions within 2.5 km radius of Mangahewa-C wellsite

Site Code	Easting (NZTM)	Northing (NZTM)	Classification	Distance from Wellsite (m)	Total Depth (m)	Static Water Level (m)	Formation/ Aquifer
GND0437	1712309	5678461	Bore	2,169	56.3	16.40	Taranaki Volcanics
GND1081	1714040	5674772	Well	1,968	4.9	0.25	Taranaki Volcanics
GND2254	1712606	5677572	Bore	1,249	37	Artesian	Taranaki Volcanics
GND2255	1713472	5677892	Well	1,265	4	0.69	Taranaki Volcanics
GND2256	1713212	5677276	Well	677	3.3	0.67	Taranaki Volcanics
GND2257	1712437	5676917	Well	1,000	5	NR*	Taranaki Volcanics
GND2258	1713501	5675128	Well	1,522	5	2.04	Taranaki Volcanics
GND2263	1714326	5674780	Well	2,064	4.3	2.78	Taranaki Volcanics
GND2320	1711494	5677890	Spring	2,301	N/A	N/A	Taranaki Volcanics

NR* - Not recorded as no historical records available and no access to bore for manual measurement

1.3 Resource consents and Regional Fresh Water Plan

1.3.1 Discharge permits

Sections 15(1)(b) and (d) of the Act, stipulate that no person may discharge any contaminant onto or into 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 discharge of contaminants associated with hydraulic fracturing, onto and into land where contaminants may reach water, is a discretionary activity under Rule 44 of the Regional Freshwater Plan for Taranaki (RFWP).

The rule is set out below:

> *Discharge of contaminants onto or into land restricted by s15(1)(b) [where contaminants may reach water] and s15(1)(d) [where the discharge is from industrial or trade premises] of the Act which is not expressly provided for in Rules 21-42 or which is provided for but does not meet the standards, terms or conditions and any other discharge of contaminants to land which is provided for in Rules 21-42 but which does not meet the standards, terms or conditions of those rules [irrespective of whether the discharges are from industrial or trade premises or are likely to reach water].*

1.3.2 Relevant resource consent held by the Company

Resource consent 7971-1, "*to discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,425 mTVD beneath the Mangahewa-C wellsite,*" was granted to the Company on 20 January 2012, under Section 87(e) of the Act.

Consent conditions were imposed to ensure that any potential adverse environmental effects associated with the proposed activity were avoided. A summary of the conditions attached to the consent are as follows:

- Condition 1 requires the injection of fluids to be below 3,425 mTVD;
- Condition 2 requires that no discharge occur more than 500 m horizontally from the wellsite;
- Condition 3 requires that the exercise of the consent does not contaminate or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir;
- Conditions 4 and 5 relate to groundwater monitoring requirements;
- Condition 6 is a notification requirement;
- Condition 7 requires the consent holder to submit a "Pre-fracturing Discharge Report" at least 10 days prior to the second and any subsequent hydraulic fracturing discharges;
- Condition 8 requires the consent holder to submit a "Post-fracturing Discharge Report" within 30 days of the discharge ceasing;
- Condition 9 details the address and format for information submission;
- Condition 10 requires the consent holder to provide access for Council staff to obtain fluid samples;
- Condition 11 requires the best practicable option to be adopted for injection;

- Condition 12 stipulates that no hydrocarbon based fracturing fluids are to be used; and
- Condition 13 is a review condition.

The consent conditions provide the Council with an option to review the conditions of the consent at specified intervals. Optional reviews are provided for on an annual basis for the duration of the consent.

The permit is due to expire on 1 June 2014.

At the request of the Company, the Council was contracted to undertake the groundwater monitoring required by conditions 4 and 5 of the consent.

A copy of consent 7971-1 is included in Appendix I of this report.

1.4 Process description

1.4.1 Hydraulic fracturing

Hydraulic fracturing is a reservoir stimulation technique used to increase the flow of hydrocarbon fluids to the surface. The primary objective of hydraulic fracturing is to increase the area of the target reservoir that is exposed to the wellbore and which, therefore, may contribute to fluid or gas flow, once the hydraulic fracturing operation has been completed.

The process of hydraulic fracturing involves the pumping of fluids (consisting of freshwater and a small volume of chemicals) 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 artificial fractures in the receiving formation. 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 subsequently stopped. The placement of proppant into the fractures is assisted by the use of cross-linked gels. These are solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become gels that transport the proppant into the formation. Once in the formation these gels 'break' back with time and temperature to a liquid state and are flowed back to surface without disturbing the proppant wedge. With continued flow, fluids pumped as part of hydraulic fracturing process, formation hydrocarbon fluids, and gases are drawn to the surface.

1.4.2 Well design

The Mangahewa-11 and Mangahewa-09 wells are constructed using steel casing, held in place with cement, installed as a succession of tubular sections. The annular space between the casing string and the surrounding geological formations is filled with cement. The cement provides foundation stability as well as isolating the wellbore and its contents from the surrounding formations and freshwater aquifers. Both the design of the well and materials used in its construction were selected based on their ability to withstand the pressure exerted during hydraulic fracturing, and were thoroughly tested and evaluated prior to the hydraulic fracturing programme commencing. The Mangahewa-11 and Mangahewa-09 are perforated between approximately 4,103 to 4,280 mTVD and 4,082 to 4,086 mTVD; respectively.

1.5 Hydraulic fracturing programme

During the period under review, hydraulic fracturing activities at the Mangahewa-C wellsite included the fracturing of the Mangahewa-11 well, between April 30 2012 and May 8 2012, and the Manngahewa-09 well, on 20 May 2013. Details of the hydraulic fracturing programme for each well are listed below in Table 3.

Table 3 Summary of hydraulic fracturing operations at the Mangahewa-C wellsite (2011 - 2013)

Fracturing Event	Date	Well	Formation	Depth (mTVD)
1	30 April 2012	Mangahewa-11	Mangahewa	4,265 – 4,280 4,233 – 4,245
2	04 May 2012	Mangahewa-11	Mangahewa	4,175 – 4,178 4,188 – 4,191
3	08 May 2012	Mangahewa-11	Mangahewa	4,103 – 4,117
4	20 May 2013	Mangahewa-09	Mangahewa	4,082 – 4,086

1.6 Post-fracturing discharge reports

As required by the conditions of the consent 7971-1, the Company provided a Post-fracturing Discharge Report following the completion of the Mangahewa-11 fracturing programme and an additional report following the completion of the Mangahewa-09 programme.

The conclusions from each of the reports submitted are summarised as follows:

Mangahewa-11 - Fracture Event 1:

- The fracture interval was below 3,425 mTVD. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 280 cubic metres (m^3) with total proppant of 53 tons.
- The total duration of treatment was 83 minutes;
- In total, 313 m^3 of fluid was recovered from the well post fracturing, in excess of 100% of the volume discharged. Returned fluids were trucked off-site for disposal via either deep well injection (47% of waste) or landfarming (53% of waste);
- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 98 m in length (max. each side of the well) and 88 m in height (max.);
- The maximum wellhead pressure during the treatment was 7,100 pounds per square inch (psi). Maximum downhole pressure (at perforations) was 13,200 psi; and
- Pressure testing of the well annulus indicates that well integrity was maintained throughout the fracture treatment.

Mangahewa-11 - Fracture Event 2:

- The fracture interval was below 3,425 mTVD. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 301 m^3 with total proppant of 53 tons.
- The total duration of treatment was 84 minutes;
- In total, 334 m^3 of fluid was recovered from the well post fracturing, in excess of 100% of the volume discharged. Returned fluids were trucked off-site for disposal via either deep well injection (47% of waste) or landfarming (53% of waste);
- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 100 m in length (max. each side of the well) and 69 m in height (max.);
- The maximum wellhead pressure during the treatment was 6,000 psi. Maximum downhole pressure (at perforations) was 11,600 psi; and
- Pressure monitoring and testing within the A and B annuli of the Mangahewa-11 well indicate that well integrity was maintained throughout the fracture treatment.

Mangahewa-11 - Fracture Event 3:

- The fracture interval was below 3,425 mTVD. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 362 m^3 with total proppant of 57 tons.
- The total duration of treatment was 90 minutes;
- In total, 367 m^3 of fluid was recovered from the well post fracturing, in excess of 100% of the volume discharged. Returned fluids were trucked off-site for disposal via either deep well injection (47% of waste) or landfarming (53% of waste);
- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 138 m in length (max. each side of the well) and 25 m in height (max.);
- The maximum wellhead pressure during the treatment was 6,400 psi. Maximum downhole pressure (at perforations) was 11,100 psi; and
- Pressure monitoring and testing within the A and B annuli of the Mangahewa-11 well indicate that well integrity was maintained throughout the fracture treatment.

Mangahewa-09 - Fracture Event 1:

- The fracture interval was below 3,425 mTVD. Post job simulation indicates that the fractures were contained, and did not extend beyond this point;
- The fracturing fluid used was water based;
- The volume of fluid pumped into the formation (discharge) was 377 m^3 with total proppant of 62 tons.
- The total duration of treatment was 113 minutes;
- In total, 226 m^3 of fluid was recovered from the well post fracturing, leaving 191 m^3 within the reservoir at the conclusion of the initial hydraulic fracturing flow back. Additional fracturing fluids will be returned to the surface as the well is produced. Returned fluids were trucked off-site for disposal via either deep well

injection (90% of waste),land application (9% of waste) or landfarming (1% of waste);

- Post fracturing modelling indicates that the total injected sand and fluids creating a propped fracture network in the reservoir 180 m in length (max. each side of the well) and 15 m in height (max.);
- The maximum wellhead pressure during the treatment was 7,506 psi. Maximum downhole pressure (at perforations) was 12,386 psi; and
- Pressure monitoring and testing within the A and B annuli of the Mangahewa-09 well indicate that well integrity was maintained throughout the fracture treatment.

1.7 Monitoring programme

1.7.1 Introduction

Section 35 of the Act sets obligations upon the Council to gather information, monitor, and conduct research on the effects arising from consented activities within the Taranaki region and report upon these.

To perform its statutory obligations, the Council may be required to take 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. In addition, the Council was contracted by the Company to carry out the sampling and analysis of local groundwater resources required by the conditions of consent 7971-1. The monitoring programme implemented by the Council in relation to the hydraulic fracturing activities at the Mangahewa-C wellsite, consisted of three main components:

- Programme design, liaison and management;
- Physicochemical sampling; and
- Carbon isotope analysis;

Each component of the monitoring programme is discussed in further detail below.

1.7.2 Programme design, liaison and management

A significant amount of time was spent in the scoping and design stage of the project. Further time was spent in discussion with the Company regarding consent conditions and their interpretation and application, monitoring requirements, providing advice and guidance on the Council's environmental management strategies, the content of regional plans, and consultation on associated matters.

1.7.3 Physicochemical sampling

In order to select suitable sites for sampling, a survey of water abstraction sites within a 2.5 km radius of the Mangahewa-C wellsite was carried out. Initially, a desktop review of data held by the Council, including a search of the Council ‘wells’ database, was conducted. The desktop review indicated that the Council held records of several groundwater abstractions in the area of investigation (Table 2). Following the desktop review, a field survey was undertaken on 4 April 2012 to confirm the location of known abstraction sites, to assess their suitability for sampling and to identify any additional groundwater abstraction sites that may not have been registered with the Council.

During the field survey, some of the sites identified within the 2.5 km radius of the wellsite during the desktop review were found to be no longer in use, inaccessible or had been abandoned. In total, 5 private groundwater abstraction sites were selected for inclusion in the monitoring programme. In addition, 2 other sites identified within 2.5 km search radius (GND1081 and GND2263) are being sampled, and will be reported on, as part of the separate Mangahewa-A hydraulic fracturing groundwater monitoring programme. Samples of hydraulic return fluids were also obtained from each well hydraulically fractured during the period under review. A sample of hydraulic fracturing fluid used in the treatment of the Mangahewa-09 well was also obtained for analysis.

Details of the sites selected for inclusion in the monitoring programme are listed below in Table 4. The locations of the sampling points are illustrated below in Figure 2.

Table 4 Summary of sampling sites selected for inclusion in the monitoring programme

Site Code	Classification	Distance from Wellsite (m)	Casing Depth (m)	Total Depth (m)	High Static Water Level (m)	Aquifer	Comment
GND2254	Bore	1,249	NR*	37	Artesian	Taranaki Volcanics	Downgradient of Mangahewa-C wellsite
GND2255	Well	1,265	Dug/lined	4	0.69	Taranaki Volcanics	Downgradient of Mangahewa-C wellsite
GND2256	Well	677	Dug/lined	3.3	0.67	Taranaki Volcanics	Downgradient of Mangahewa-C wellsite
GND2257	Well	1,000	Dug/lined	5	NR*	Taranaki Volcanics	Downgradient of Mangahewa-C wellsite
GND2258	Well	1,522	Dug/lined	7	2.04	Taranaki Volcanics	Upgradient of Mangahewa-C wellsite

NR* - Not recorded as no historical records available and no access to bore for manual measurement

Samples were obtained from each site following standard groundwater sampling methodologies and generally in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand (2006). Bore samples were obtained via existing pumps installed in each bore, either at the wellhead if a sample tap was installed, from a pressure tank, or outlet supply pipework. Samples from wells and springs were obtained directly from source using a bailer.

All samples were sent to Hills Laboratory (IANZ accredited) and transported using chain of custody procedures. All samples were analysed in the laboratory for wide range of chemical parameters, including general groundwater characterisation parameters, compounds associated with hydrocarbon reservoirs, deep formation waters and fluids used in the hydraulic fracturing process. Testing parameters were selected in consultation with GNS Science (the Institute of Geological and Nuclear Science).

The parameters included:

- Conventional groundwater characterisation parameters;
- Trace metals;

- Compounds commonly used in hydraulic fracturing fluid such as methanol, glycols and formaldehyde;
- Total petroleum hydrocarbons;
- The "BTEX" range of compounds – benzene, toluene, ethyl benzene and xylene; and
- Dissolved natural gas.

Samples were obtained from each of the 5 sampling sites included in the programme at the following frequencies:

- Pre hydraulic fracturing;
- 1 week post hydraulic fracturing;
- 1 month post hydraulic fracturing;
- 3 months post hydraulic fracturing; and
- 1 year post hydraulic fracturing.

As required by the conditions of consent 7971-1, the details of the Monitoring Programme to be implemented and a Sampling and Analysis Plan were compiled and submitted for approval by the Chief Executive, Taranaki Regional Council, prior to the fracturing of the Mangahewa-11 well (see Appendix II).

In addition to the Mangahewa-11, the Mangahewa-09 well was also hydraulically fractured during the monitoring period. The sampling carried out in relation to the Mangahewa-11 fracturing event will be used to provide baseline water quality data for the assessment of potential effects related to the Manghaewa-09 fracturing event. Further sampling will be carried out in the forthcoming monitoring period for comparison with baseline results.

1.8 Carbon isotope analysis

A carbon isotope analysis was carried out on samples from bores in which dissolved methane was present in initial groundwater samples analysed. The analysis of carbon isotopes is used to determine the isotopic signature of methane gas present in groundwater as an indicator of its origin. Shallow methane gas, derived from the breakdown of organic material close to the surface (e.g. swamps), is termed biogenic. Alternatively, thermogenic methane is normally produced in deep hydrocarbon reservoirs. Compositionally, shallow biogenic gas is easily recognisable from thermogenic gas, as the former is nearly 100% methane, while thermogenic methane usually occurs in the company of the related gases, ethane, propane, butane and pentane, derived from thermal decomposition (King, 2012). They can also be discriminated on the basis of their common stable (non-radioactive) carbon isotopes, ^{12}Carbon (^{12}C has 6 neutrons) and ^{13}Carbon (^{13}C has 7 neutrons). Biogenic methane contains more ^{12}Carbon while thermogenic methane contains more of the ^{13}C carbon isotope. By analysing the isotope composition of dissolved methane present in groundwater, it can be determined whether the methane present has been generated by the breakdown of organic material in the shallow subsurface, or may be due to migration or leakage from a hydrocarbon reservoir. There are areas within the Taranaki region where thermogenic methane is present in shallow groundwater, including areas where there is no history of hydraulic fracturing. In such cases, changes in the concentration of gas can be used as an indicator of hydraulic fracturing induced gas migration.

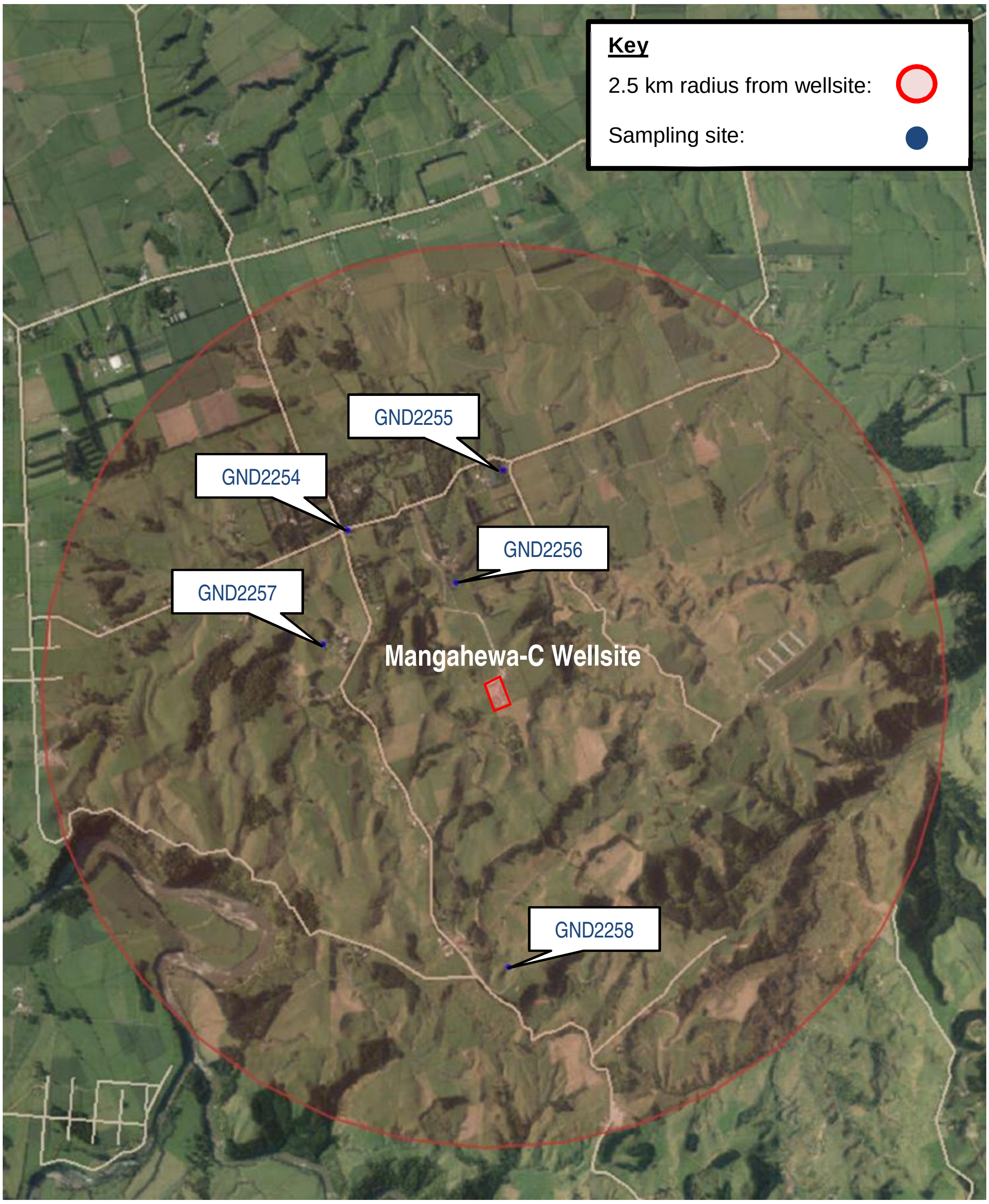

Figure 2 Location of groundwater sampling sites

2. Results

2.1 Physicochemical monitoring

The monitoring programme incorporated a total of 10 sampling events, which took place between 17 April 2012 and 25 May 2013. A summary of each sampling event is included below in Table 5.

Table 5 Sampling event summary

Date	Sampling event	Sites sampled	Sampling comments
17 April 2012	Pre hydraulic fracturing	GND2254 GND2255 GND2256 GND2257 GND2258	Private water supplies
11 May 2012	Mangahewa-11 return fluid sampling	GND2271	Sample from production well post fracturing
16 May 2012	1 week post hydraulic fracturing	GND2254 GND2255 GND2256 GND2257 GND2258	Private water supplies
26 July 2012	3 month post hydraulic fracturing	GND2254 GND2255 GND2256 GND2257 GND2258	Private water supplies
20 September 2012	Carbon isotope sampling	GND2224	Only sites containing dissolved methane used for isotope sampling
03 May 2013	Mangahewa-09 fracturing fluid	GND2358	Sample of hydraulic fracturing fluid pre-pumping
10 May 2013	1 year post hydraulic fracturing	GND2254 GND2255 GND2256 GND2257 GND2258	Private water supplies
15 May 2013	Mangahewa-09 return fluid sampling	GND2358	Sample from production well post fracturing
20 May 2013	Mangahewa-09 fracturing fluid	GND2358	Sample of hydraulic fracturing fluid pre-pumping
25 May 2013	Mangahewa-09 return fluid sampling	GND2358	Sample from production well post fracturing

2.1.1 Hydraulic fracturing and return fluid analysis

Two samples of the hydraulic fracturing fluid used in the stimulation of the Mangahewa-09 well were obtained for analysis. In addition, samples of the fluid returning to the surface following the completion of both the Mangahewa-09 and Manghaewa-11 hydraulic fracturing treatments were also obtained.

The results of the analyses carried out on the hydraulic fracturing fluid used in the treatment of the Mangahewa-09 well are summarised below in Table 6. Due to the viscosity of the sample obtained, the range of analyses that were able to be performed on the sample were limited. The sample taken was gel like in composition, as opposed to a liquid. While the fracturing fluid is predominantly comprised of water (97% by fluid volume), specialised additives are used to increase the viscosity of the fluid in order to suspend the proppant prior to injection (see

Section 1.4.1). The results of the analyses undertaken on the hydraulic fracturing fluid indicate the presence of relatively low concentration of glycols, common ingredients in hydraulic fracturing fluids. The results also indicate that the hydraulic fracturing fluid used contained low levels of hydrocarbon additives. Due to the volume of water used in the fracturing fluid mixture, all additives included in the mixture are highly dilute (i.e. present only at parts per million or sub-parts per million levels).

Table 6 Results of hydraulic fracturing fluid analysis

Analyte	Units	Mangahewa-09 (03/05/2013)	Mangahewa-09 (20/05/2013)
Ethylene glycol	g/m^3	23	188
Propylene glycol	g/m^3	13	52
Methanol	g/m^3	<2	<20
Benzene	g/m^3	0.21	0.0025
Toluene	g/m^3	0.74	0.047
Ethylbenzene	g/m^3	0.072	0.0071
m&p-Xylene	g/m^3	0.014	0.025
o-Xylene	g/m^3	0.155	0.0121
C7 - C9	g/m^3	1.2	0.8
C10 - C14	g/m^3	9.4	64
C15 - C36	g/m^3	20	120
Total hydrocarbons (C7 - C36)	g/m^3	30	185

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Mangahewa-11 and Mangahewa 09 wells are summarised below in Table 7. 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 following fracturing, a high proportion of the fluid returning to the wellhead is those injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, return fluids begin to contain less hydraulic fracturing fluid and an increasing proportion of formation fluids.

Each return fluid sample submitted for analysis was a composite sample comprising equal proportions of sample taken at various stages post fracturing. In the case of the Mangahewa-11 sample, the composite was made up of a number of samples taken within the first 2 hours of well flowback commencing. As such, the sample contains a significant proportion of fracturing fluid. This can be seen in the elevated concentrations of fracturing fluid additives such as glycols and methanol.

The first Mangahewa-09 return fluid sample submitted for analysis (15 May 2013) was a composite sample, containing equal volumes of sample taken immediately following the commencement of flowback and a sample taken 5 days later.

The combination of these samples resulted in a composite sample containing both the additives associated with hydraulic fracturing fluids and also high salinity and hydrocarbon concentrations associated with hydrocarbon reservoir fluids.

The second Mangahewa-09 return fluid sample submitted for analysis (25 May 2013) was also a composite sample, containing equal volumes of sample taken immediately following the commencement of flowback and an additional sample taken 6 hours later. The combination of these samples resulted in a composite sample containing a higher proportion of fracturing fluid than formation fluids, with elevated concentrations of fracturing fluid additives such as propylene glycol, and relatively low levels of salinity. The high concentrations of hydrocarbons within the sample indicate that it may have been taken prior to going through the separator system.

Table 7 Results of return fluid analysis

Analyte	**Units**	**Mangahewa-11 (11/05/2012)**	**Mangahewa-09 (15/05/2013)**	**Mangahewa-09 (25/05/2013)**
pH	pH Units	7.1	6.4	7.3
Total Alkalinity	g/m^3 as $CaCO_3$	2,300	1,320	1,890
Total Hardness	g/m^3 as $CaCO_3$	186	32,000	650
Conductivity (EC)	mS/m	1,700	7,110	1,395
Dissolved Barium	g/m^3	28	50	6.5
Dissolved Calcium	g/m^3	64	12,700	250
Dissolved Copper	g/m^3	0.0108	< 0.005	0.005
Dissolved Iron	g/m^3	6.3	0.14	2.5
Dissolved Magnesium	g/m^3	6.6	84	7
Dissolved Manganese	g/m^3	5.1	3.2	1.37
Dissolved Mercury	g/m^3	-	<0.011	< 0.011
Dissolved Nickel	g/m^3	0.024	0.28	0.03
Dissolved Potassium	g/m^3	600	460	1,020
Dissolved Sodium	g/m^3	3,500	6,100	2,200
Dissolved Sulphur		19	19	45
Dissolved Zinc	g/m^3	0.064	0.14	< 0.02
Bromide	g/m^3		35	6.7
Chloride	g/m^3	4,300	27,000	3,400
Nitrite-N	g/m^3	0.004	0.3	1.8
Nitrate-N	g/m^3	2.8	560	1.9
Nitrate	g/m^3	12.3	2,500	8.2
Nitrate-N + Nitrite-N	g/m^3	2.8	560	3.7
Sulphate	g/m^3	55	56	136
Ethylene glycol	g/m^3	121	230	< 4

Analyte	Units	Mangahewa-11 (11/05/2012)	Mangahewa-09 (15/05/2013)	Mangahewa-09 (25/05/2013)
Propylene glycol	g/m^3	<4	< 4	630
Methanol	g/m^3	480	< 2	< 2
Benzene	g/m^3	4.4	19.6	63
Toluene	g/m^3	1.95	15.5	230
Ethylbenzene	g/m^3	0.046	0.7	22
m&p-Xylene	g/m^3	0.19	4.5	134
o-Xylene	g/m^3	0.124	1.59	40
Formaldehyde	g/m^3	1.83	0.11	0.09
C7 - C9	g/m^3	1.46	21	250
C10 - C14	g/m^3	3.1	22	350
C15 - C36	g/m^3	5.5	17.4	410
Total hydrocarbons (C7 - C36)	g/m^3	10.1	60	1,000
Ethane	g/m^3	0.37	1.22	1.28
Ethylene	g/m^3	<0.004	< 0.007	< 0.003
Methane	g/m^3	2.5	1.71	3.2

2.1.2 Groundwater analysis

In terms of an assessing any possible effects of hydraulic fracturing upon local aquifers, several key parameters, and the relative changes in their concentration can be used as indicators of potential contamination. Inorganic indicator parameters include pH, electrical conductivity, total dissolved solids and chloride. Changes in the concentration of these parameters may indicate the migration of deep formation water, which is highly saline in composition (Table 7). Potential migration pathways include fractures or conduits created by the hydraulic fracturing process, leakage from the wellbore due to integrity issues, or the mishandling of fluids at the surface. The results of the pH, electrical conductivity, total dissolved solid and chloride analyses carried out on the samples from private water supplies are plotted below in Figure 3, Figure 4, Figure 5 and Figure 6; respectively. The results indicate that the relative concentration of each of the indicator parameters remained consistent across the sampling period.

The presence of hydrocarbons, the BTEX group of chemicals in any groundwater samples obtained, may indicate the leakage or migration of deep formation or reservoir fluids. No hydrocarbons or BTEX were detected in any of the groundwater samples analysed.

There were no traces of any ethylene glycol, propylene glycol, methanol, and/or formaldehyde (combinations of which are typically used in fracturing fluids), in any of the groundwater samples analysed.

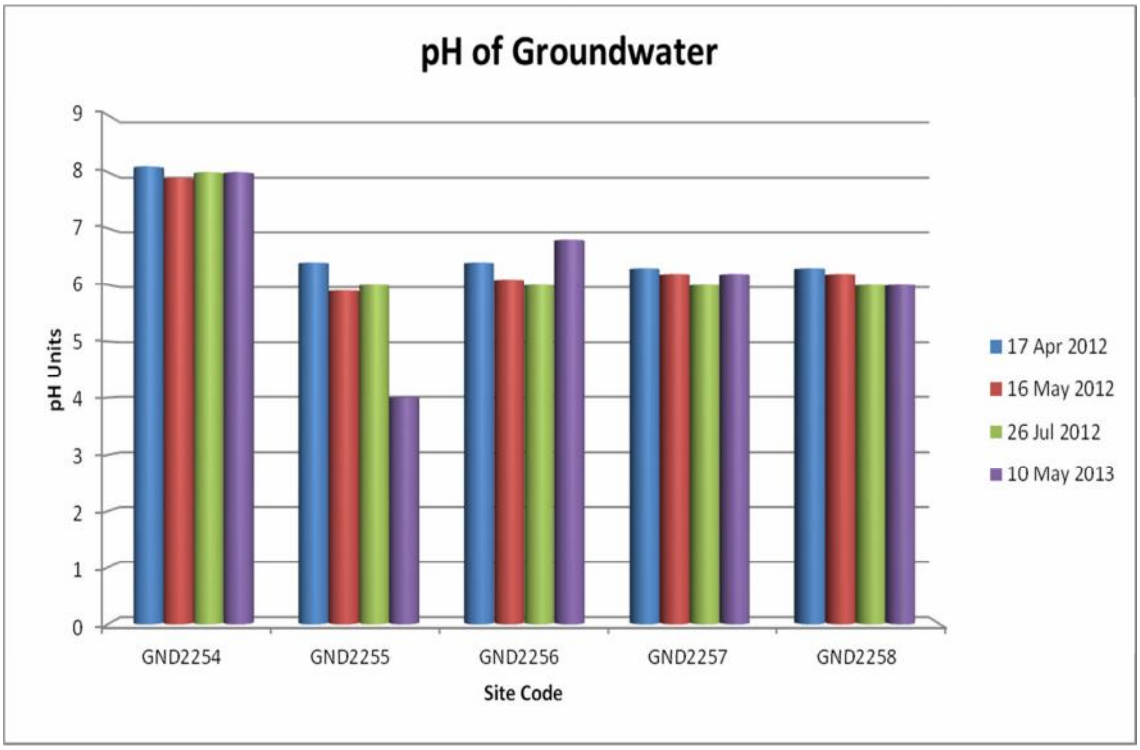

Figure 3 Results of pH analyses

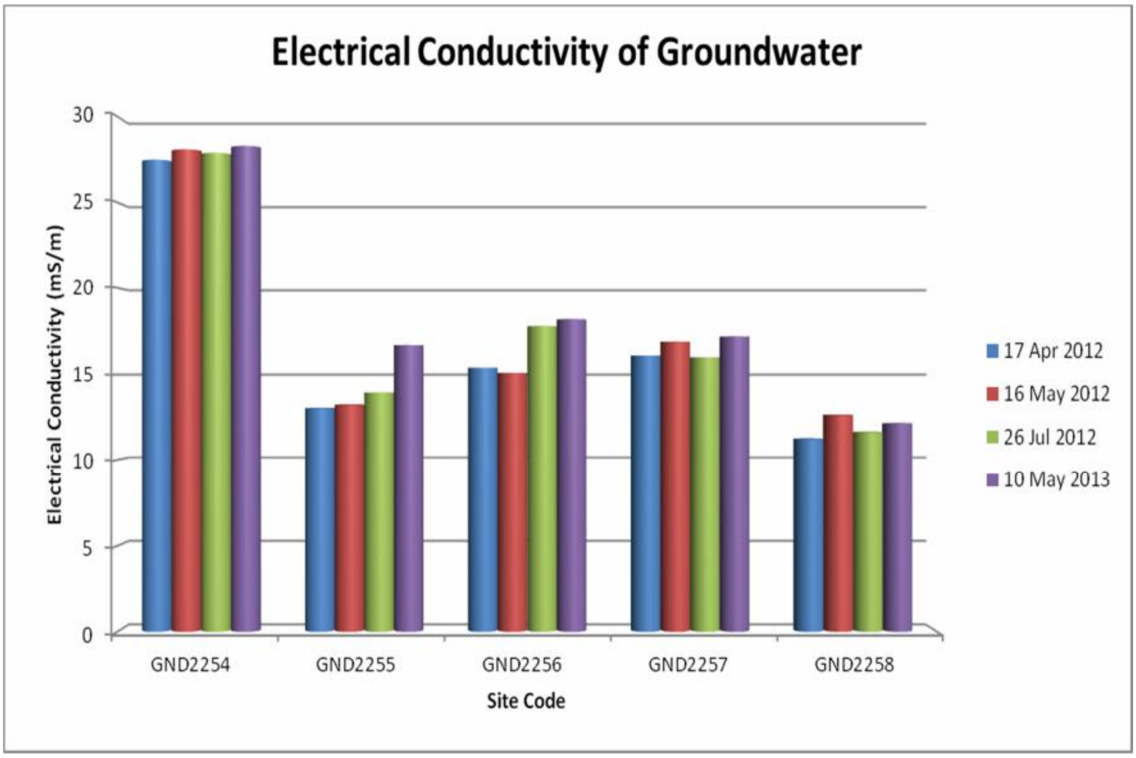

Figure 4 Results of electrical conductivity analyses

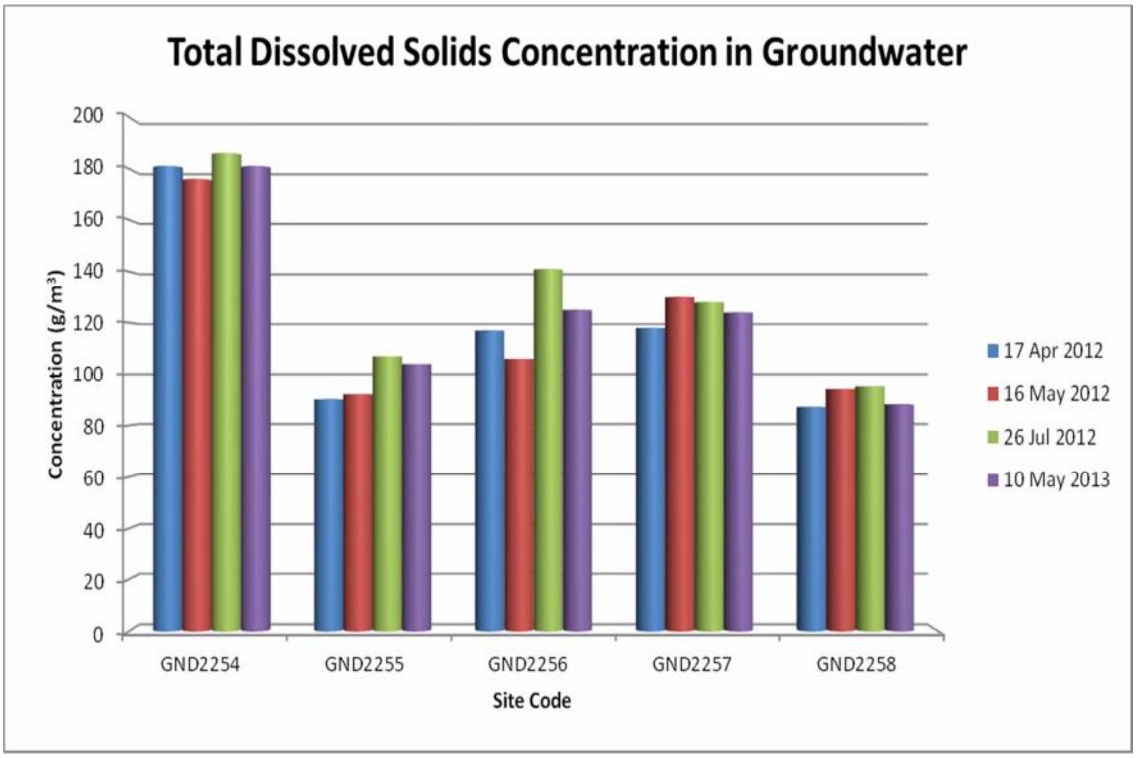

Figure 5 Results of total dissolved solids analyses

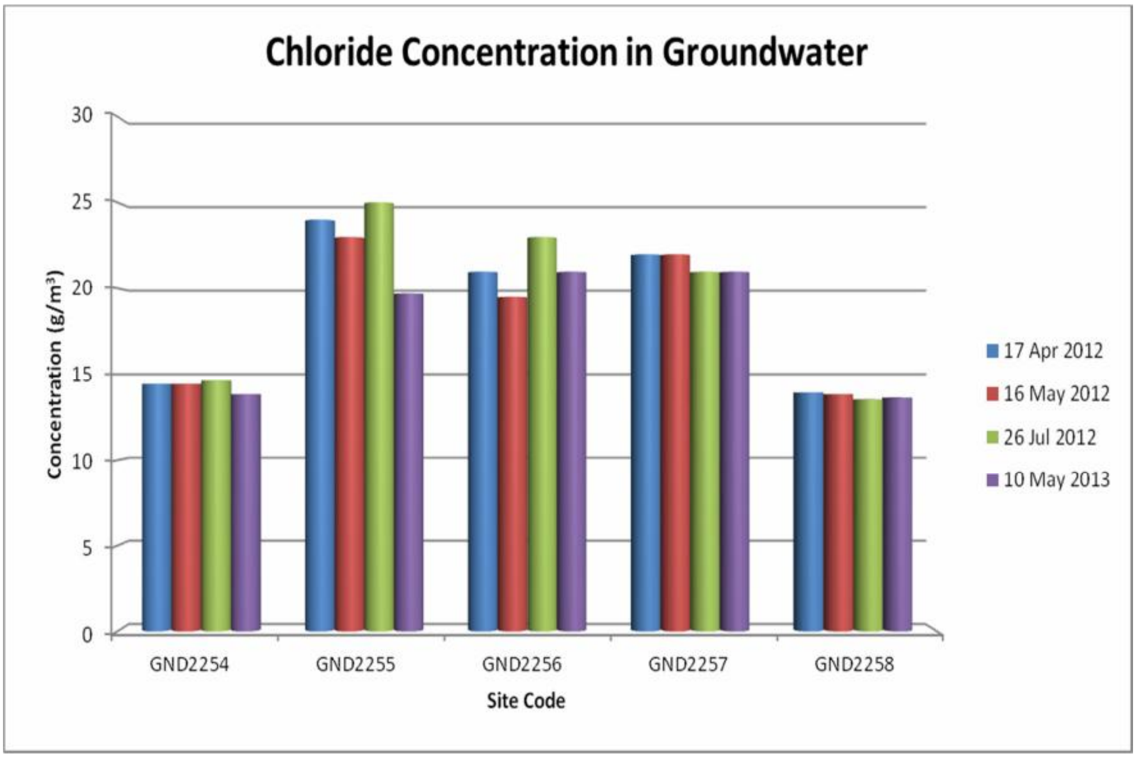

Figure 6 Results of chloride analyses

If the hydraulic fracturing process had created fractures or conduits within the geological seals overlying the reservoir, it would also be expected that hydrocarbon gases would be present in groundwater. It should be noted however, methane gas can be found naturally occurring in groundwater, in areas where organic material has decomposed within groundwater bearing zones. A low concentration of methane gas was detected in samples obtained from GND2254, the deepest sampling location included in the monitoring programme. Traces of methane gas (parts per billion) were detected in both GND2256 and GND2258 during the second round of sampling. Methane was not detected in samples from these sites during later sampling rounds. The methane concentrations measured in GND2254 remained stable across the sampling period (Figure 7). The concentration of methane found within bore GND2254 was within the typical range encountered in other bores within the Taranaki region, including localities where no hydraulic fracturing has ever taken place.

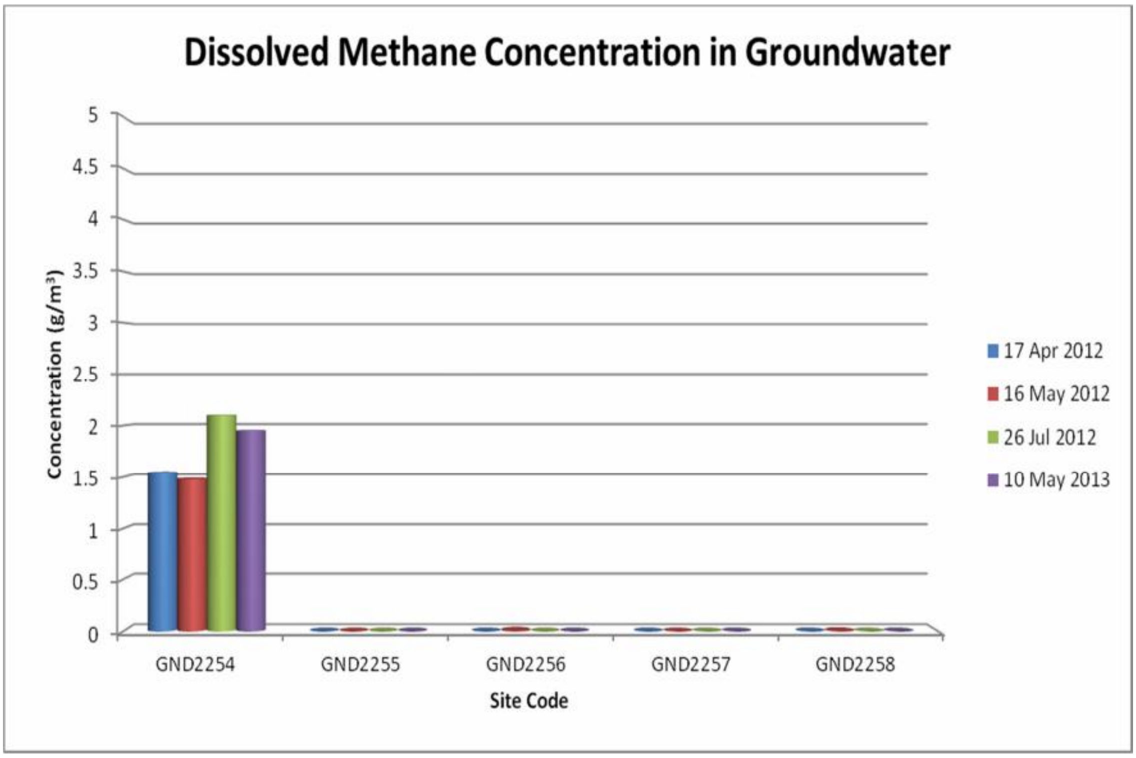

Figure 7 Results of dissolved methane analyses

A full table of analytical results is included in Appendix III of this report. Laboratory Analysis Reports are included in Appendix IV.

2.2 Carbon isotope analysis

GND2254 was identified as containing dissolved methane following the baseline physicochemical sampling round. In order to establish the origin of the methane gas detected, a sample was obtained from the bore for carbon isotope analysis on 20 September 2012. The sample was obtained with assistance from GNS Science, who would also be undertaking the analysis in their National Isotope Centre. The isotopic analysis is used to calculate a delta carbon13 ($\delta^{13}C$) value for a given sample, which is then used to determine the origin of the gas. Generally, a $\delta^{13}C$ value that exceeds -50‰ indicates biogenic methane, and a $\delta^{13}C$ value less than-50‰ indicates thermogenic methane. The higher or lower the $\delta^{13}C$ values, the stronger the isotopic signature. A $\delta^{13}C$ value in the vicinity of -50‰ can indicate a mixture of both biogenic and thermogenic methane. The isotopic analyses carried out the sample obtained from GND2254 returned a $\delta^{13}C$ result of -78.4 ‰. The results indicate that the methane gas present in GND2254 is strongly biogenic.

3. Discussion

3.1 Environmental effects of hydraulic fracturing on shallow groundwater

A total of 5 private groundwater supplies were selected for inclusion in the groundwater monitoring programme implemented by Council. Samples from each site were obtained pre hydraulic fracturing (baseline sampling) and at intervals of 1 week, 1 month, 3 months and 12 months post fracturing.

The selection of sampling sites was designed to provide a sample set representative of groundwater abstractions and usage in the investigation area. Other criteria assessed were the distance of each potential sampling site from the Mangahewa-C wellsite, and whether the site was upgradient or downgradient of the wellsite, based on the inferred groundwater flow direction in the area of investigation.

The results of the physicochemical analyses carried out on samples taken from private water supplies show very little compositional variation across the sampling period. The concentration of all parameters analysed for during post fracturing sampling events remained consistent with pre hydraulic fracturing baseline values.

The results of the physicochemical analyses undertaken show that to date, the hydraulic fracturing activities carried out at the Mangahewa-C wellsite have had no adverse effects on groundwater resources in the area surrounding the site. In order to confirm this assessment, and to assess the effects of any future hydraulic fracturing activities at the site, further sampling of all sites included in the monitoring programme is proposed for the forthcoming monitoring period.

A single private water supply included in the monitoring programme (GND2254), was identified as containing dissolved methane following the baseline physicochemical sampling round. The results indicate that the methane gas present in GND2254 is strongly biogenic. The carbon isotope analysis carried out indicates that hydraulic fracturing activities at the Mangahewa-C wellsite have not resulted in the migration of thermogenic methane gas into shallow groundwater aquifers. Following any future fracturing events, further samples will be obtained and analysed to assess any changes in the isotopic signature of the methane gas present within the bore.

3.2 Evaluation of performance

The assessment of the Company’s compliance performance for the period under review is based on the monitoring work carried out and the assessment of the results. A tabular summary of the Company’s compliance record, with specific regard to the groundwater related conditions, of consent 7971-1 is set out below in Table 8.

The consent holder has achieved a high level of environmental performance and compliance in respect of the resource consent exercised. The criteria associated with a “high” level of environmental performance are outlined in Section 1.1.4 as follows:

> “a high level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about,

> and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions."

The results of the monitoring programme implemented show no evidence of any adverse effects on groundwater due to hydraulic fracturing activities at the Mangahewa-C wellsite.

Figure 8 Evaluation of compliance performance

Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
Consent 7971-1: To discharge contaminants associatied with hydraulic fracturing activities into land at depths greater than 3,425 mTVD beneath the Mangahewa-C wellsite		
3. The consent holder shall ensure that the exercise of this consent does not contaminate or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir.	Assessment of groundwater sampling results	Yes
4. The consent holder shall undertake a programme of sampling and testing that, to the satisfaction of the Chief Executive, Taranaki Regional Council, monitor the effects of the exercise of this consent on groundwater users within 2.5 km of the Mangahewa-C wellsite. Any groundwater samples shall be taken in accordance with recognized field procedures and analysed for: (a) pH; (b) Conductivity; (c) Total dissolved solids; (d) Total suspended solids; (e) Major ions (Ca, Mg, K, Na, total alkalinity, chloride, nitrate-nitrogen, and sulfate); (f) Trace metals (cadmium, copper, iron, manganese, nickel, and zinc); (g) Total organic carbon; (h) Formaldehyde; (i) Dissolved methane and ethane gas; (j) Carbon-13 composition of dissolved methane gas ($^{13}C-CH_4$); and (k) Benzene, toluene, ethylbenzene, and xylenes (BTEX).	Implementation of approved groundwater monitoring programme and assessment of sampling results	Yes
5. 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 (CE) for review and certification before the first sampling is undertaken. This Plan shall specify the use of standard protocols recognized to constitute good professional practice including quality control and assurance. A properly accredited laboratory shall be used for all sample analysis. Results shall	Details of Sampling and Analysis Plan certified by the Chief Executive, receipt and assessment of sampling results	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
be provided to the CE within 30 calendar days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 3.		
Overall assessment of compliance and environmental performance in relation to groundwater monitoring conditions		**High**

3.3 Alterations to monitoring programmes for 2013/2014 period

In designing and implementing the monitoring programmes for discharges to land and water in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring discharges and effects, and subsequently reporting to the regional community, 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 discharging to the environment.

It is proposed that the frequency of groundwater sampling in the vicinity of the Mangahewa-C wellsite be reduced to a minimum of one annual sampling event per monitoring year. If further hydraulic fracturing is carried out at the wellsite, the existing data gathered during the period under review will be used as a baseline to assess any potential adverse effects on groundwater. Samples will be obtained from each private water supply site included in the monitoring programme 3 months following any future hydraulic fracturing event. It is also proposed that that a follow up round of carbon isotope sampling and analysis be carried out in the forthcoming monitoring period.

It is also proposed that the groundwater abstraction bore recently drilled at the Mangahewa-C wellsite (GND2360) be included in the groundwater monitoring programme for the site. GND2360 will provide a unique opportunity to analyse deep groundwater quality in close proximity to the wellsite.

Recommendations to this effect are attached to this report.

4. Recommendations

1. THAT this report be forwarded to the Company, and to any interested parties upon request;

2. THAT for the forthcoming 2013/2014 monitoring period, the sampling of private water supplies in the vicinity of the Mangahewa-C wellsite be reduced to a frequency of one annual sampling event;

3. THAT if further hydraulic fracturing is carried out at the Mangahewa-C wellsite, a sample be obtained from each private water supply 3 months following the hydraulic fracturing event;

4. THAT during the 2013/2014 monitoring period, a further round of carbon isotope sampling and analysis is carried out; and

5. THAT bore GND2360 is included as an additional sampling site during any future monitoring of hydraulic fracturing activities at the Mangahewa-C wellsite.

Glossary of common terms and abbreviations

The following abbreviations and terms are commonly used within Council reports:

Al*	aluminium
As*	arsenic
Biomonitoring	assessing the health of the environment using aquatic organisms
BOD	biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate
BODF	biochemical oxygen demand of a filtered sample
Bore	a hole drilled into the ground and completed for the abstraction of water or hydrocarbons to a depth of greater than 20 metres below the ground surface
Bund	a wall around a tank to contain its contents in the case of a leak
CBOD	carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate
cfu	colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample
COD	chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction
Condy	conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m
Cu*	copper
Cumec	A volumetric measure of flow- 1 cubic metre per second (1 m^3s^{-1})
DO	dissolved oxygen
DRP	dissolved reactive phosphorus
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
Ent	enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample
F	fluoride
FC	faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample
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
GV	Guideline value (Drinking-water Standards for New Zealand 2008)
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 what were the circumstances/events surrounding an incident including any allegations of an incident
l/s	litres per second
MAV	Maximum acceptable value (Drinking-water Standards for New Zealand 2008)
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
Mixing zone	the zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point
NH_4	ammonium, normally expressed in terms of the mass of nitrogen (N)
NH_3	unionised ammonia, normally expressed in terms of the mass of nitrogen (N)
NO_3	nitrate, normally expressed in terms of the mass of nitrogen (N)
NTU	Nephelometric Turbidity Unit, a measure of the turbidity of water
O&G	oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons)
Pb*	lead
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. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5
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
PM_{10}	relatively fine airborne particles (less than 10 micrometre diameter)
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
SS	suspended solids
SQMCI	semi quantitative macroinvertebrate community index;
Temp	temperature, measured in °C (degrees Celsius)
Turb	turbidity, expressed in NTU
UI	Unauthorised Incident
UIR	Unauthorised Incident Register – contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan
Well	a hole dug, augured or drilled, tapping the water table or springs, to a depth of less than 20 metres below the ground surface
Zn*	zinc

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form.

For further information on analytical methods, contact the Council's laboratory.

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Appendix I

Resource consent 7971-1

Consent 7971-1

TARANAKI
REGIONAL
COUNCIL

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on all correspondence

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 Taranaki Limited P O Box 802 Taranaki Mail Centre NEW PLYMOUTH 4340
Decision Date:	20 January 2012
Commencement Date:	20 January 2012

Conditions of Consent

Consent Granted:	To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3425mTVD beneath the Mangahewa-C wellsite at or about (NZTM) 1713435E-5676634N
Expiry Date:	1 June 2014
Review Date(s):	June 2013
Site Location:	Mangahewa-C wellsite, Tikorangi Road East, Waitara [Property owners: PG & BM Bourke]
Legal Description:	Lot 9 DP 408656 (Discharge source & site)
Catchment:	Waiau

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 to section 36 of the Resource Management Act.

Special conditions

1. Any discharge shall occur below 3425 mTVD.

   Note: mTVD = metres true vertical depth, i.e. the true vertical depth in metres below the surface.

2. No discharge shall occur more than 500 metres horizontally from each wellbore on the Mangahewa-C wellsite.

3. The consent holder shall ensure that the exercise of this consent does not contaminate or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir.

4. The consent holder shall undertake a programme of sampling and testing that, to the satisfaction of the Chief Executive, Taranaki Regional Council, monitor the effects of the exercise of this consent on groundwater users within 2.5 km of the Mangahewa-C wellsite. Any groundwater samples shall be taken in accordance with recognized field procedures and analysed for:

   (a) pH;
   (b) Conductivity;
   (c) Total dissolved solids;
   (d) Total suspended solids;
   (e) Major ions (Ca, Mg, K, Na, total alkalinity, chloride, nitrate-nitrogen, and sulfate);
   (f) Trace metals (cadmium, copper, iron, manganese, nickel, and zinc);
   (g) Total organic carbon;
   (h) Formaldehyde;
   (i) Dissolved methane and ethane gas;
   (j) Carbon-13 composition of dissolved methane gas ($^{13}C-CH_4$); and
   (k) Benzene, toluene, ethylbenzene, and xylenes (BTEX).

5. 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 (CE) for review and certification before the first sampling is undertaken. This Plan shall specify the use of standard protocols recognized to constitute good professional practice including quality control and assurance. A properly accredited laboratory shall be used for all sample analysis. Results shall be provided to the CE within 30 calendar days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 3.

   Note: The samples required, under condition 4, could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.

6. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing of the date that the discharges are expected to commence. Notification shall occur by email to worknotification@trc.govt.nz, where practicable and reasonable one working day prior to the exercise of the consent, but in any event 24 hours notice shall be given. Notification shall include the consent number and a brief description of the activity consented.

7. The second and subsequent discharges 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 10 working days before the discharge commences and, as a minimum, shall contain:

   (a) The intended fracturing intervals and the co-ordinates of the fracture initiation point for each fracture interval;
   (b) The total volume of material planned to be pumped down the well and its composition, including a list of the chemicals or additives to be used;
   (c) The mitigation measures that are in place to ensure the discharge does not cause adverse environmental effects;
   (d) The results of pressure testing the well;
   (e) The extent and characteristics of the geological seals in place above the discharge zone;
   (f) The anticipated well and discharge zone pressures and the duration the pressures;
   (g) The anticipated extent of fractures; and
   (h) Details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

8. At the conclusion of any discharge, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive, Taranaki Regional Council. The report shall be provided within 30 working days after the discharge ceases and, as a minimum, shall contain:

   (a) Confirmation of the interval where fracturing occurred;
   (b) Confirmation of volumes and fluid compositions discharged;
   (c) The volume of returned fluids and an estimate of the proportion of fluids and proppant remaining in the reservoir;
   (d) The results of modeling the discharge, including a proppant concentration diagram or a similar diagram, showing the likely extent of the fractures generated by the discharge;
   (e) Well and discharge zone pressure durations and the maximum pressure reached;
   (f) Details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
   (g) An assessment of the effectiveness of the mitigation measures in place with specific reference to those described in application 6949.

9. The reports described in conditions 7 and 8 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

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

11. 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 on the environment; in particular, ensuring that the discharge is contained within the discharge zone.

12. No hydrocarbon based fraccing fluid shall be discharged.

13. That the Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of 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.

Signed at Stratford on 20 January 2012

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Sampling and Analysis Plan

Sampling and Analysis Plan

Mangahewa-C Groundwater Monitoring Programme
2011/2012

Resource Consent(s) / Consent Holder(s)

7971-1 / Todd Taranaki Limited

Project Description:

Design and implement a Sampling and Analysis Plan that will provide for the assessment of the existing chemical characteristics of groundwater in the vicinity of the Mangahewa-C wellsite and for the identification of any changes in local groundwater quality following planned hydraulic fracturing activities at the Mangahewa-C wellsite. By implementing the proposed Sampling and Analysis Plan, the consent holder (Todd Taranaki Ltd.) will be deemed to be in compliance with *Conditions 4 & 5* of Consent 7971-1. The data provided by the monitoring programme will allow the Taranaki Regional Council (TRC) to assess whether the consent holder has ensured that the exercise of their consent has not contaminated or put at risk actual or potential usable freshwater aquifers above the hydrocarbon reservoir, as specified under *Condition 3* of Consent 7971-1.

Sampling Locations:

A survey of groundwater abstractions within the vicinity of the Mangahewa-C wellsite carried out on the 4th of April 2012. Following the survey, a total of five (5) groundwater abstraction sites have been selected for inclusion in the monitoring programme. The sampling sites have been selected based on their proximity to the Mangahewa-C wellsite and their individual construction and usage characteristics. The site selection is designed to provide a sample set representative of groundwater abstractions in the area surrounding the site.

The details of the sites selected for inclusion in the programme are listed below in *Table 1*.

***Table 1*:** Sampling Site Details

Site No.	Owner/Occupier	Location	Type	Depth (m)	Easting (m)	Northing (m)
GND2254	Mark & Abbie Jury	589 Otaraoa Rd.	Bore	37	1712606	5677572
GND2255	Per Sorensen	282 Tikorangi Rd.	Well	4	1713472	5677892
GND2256	Paul Bourke	Tikorangi Rd.	Well	5	1713212	5677276
GND2257	Keith Chamberlain	686 Otaraoa Rd.	Well	5	1712473	5676917
GND2258	Simon Payne	Otaraoa Rd.	Well	7	1713501	5675128

Sampling Frequency:

The monitoring programme provides for an initial 12 months of groundwater sampling. Groundwater samples will be obtained from the sampling sites listed in *Table 1* at the following specified intervals:

- Pre hydraulic fracturing (baseline sample)
- 1 week following initial hydraulic fracturing event
- 3 months after initial hydraulic fracturing event
- 12 months after initial hydraulic fracturing event.

During the initial hydraulic fracturing event, a sample of the fracturing fluids used and fluids returning to the well head will also be obtained and analysed for the same parameters as the groundwater samples.

Chemical Analysis:

Samples will be obtained following the protocols for groundwater sampling in New Zealand issued by the Ministry for the Environment (2006). Once collected, samples will be transported using chain of custody procedures. Samples will be submitted to Hill Laboratories, accredited to NZS/ISO/IEC 17025:2005, for analysis. Samples will be analysed for the following parameters, as specified under *Condition 4* of Consent 7971-1:

(a) pH;
(b) Conductivity;
(c) Total dissolved solids;
(d) Total suspended solids;
(e) Major ions (Ca, Mg, K, Na, total alkalinity, chloride, nitrate-nitrogen, and sulfate);
(f) Trace metals (cadmium, copper, iron, manganese, nickel, and zinc);
(g) Total organic carbon;
(h) Formaldehyde;
(i) Dissolved methane and ethane gas;
(j) Carbon-13 composition of dissolved methane gas (^{13}C-CH_4); and
(k) Benzene, toluene, ethylbenzene, and xylenes (BTEX).

Note: ^{13}C-CH_4 analysis to be undertaken on samples if dissolved methane gas is detected in the initial groundwater sampling run. Samples will be obtained according to established sampling procedures for this analysis.

Data Submission:

As set out in *Condition 5* of Consent 7971-1, the results of each sampling round shall be provided to the Chief Executive (TRC) within 30 calendar days of sampling and shall include supporting quality control and assurance information as set out above.

Appendix III

Results of physicochemical analyses

Site	Date	Sample Number	pH	Temperature (ºC)	Conductivity (EC)	Total Alkalinity (g/m^3 as $CaCO_3$)	Bicarbonate (g/m^3 at 25 °C)	Total Hardness (g/m^3 as CaCO3)	Total Dissolved Solids (g/m^3)	Barium (g/m^3)	Bromide (g/m^3)	Dissolved Calcium (g/m^3)	Dissolved Copper (g/m^3)	Dissolved Iron (g/m^3)	Dissolved Magnesium (g/m^3)	Dissolved Manganese (g/m^3)	Dissolved Nickel (g/m^3)	Dissolved Potassium (g/m^3)	Dissolved Sodium (g/m^3)	Dissolved Zinc (g/m^3)	Chloride (g/m^3)	Nitrite (g/m^3)
Private Water Supplies																						
GND2254	17 Apr 2012	TRC121416	8.1	15.2	27.5	132	161.04	104	181	0.0146	0.07	25	<0.0005	0.32	10.5	0.024	<0.0005	2.3	21	0.0012	14.4	0.003
	16 May 2012	TRC121516	7.9	15.1	28.1	126	153.72	107	176	0.015	0.05	24	<0.0005	0.29	11.1	0.024	<0.0005	2.1	16.3	0.0017	14.4	<0.002
	26 Jul 2012	TRC122574	8	14.8	27.9	131	158	98	186	0.0148	<0.05	23	<0.0005	0.31	9.8	0.024	<0.0005	2.3	21	0.002	14.6	<0.002
	10 May 2012	TRC136044	8		28.3	130	157	102	181	0.0168	0.07	24	<0.0005	0.31	10.3	0.026	<0.0005	2.3	23	0.0087	13.8	0.002
GND2255	17 Apr 2012	TRC121417	6.4	15	13	20	24.4	31	90	0.043	0.1	6.5	0.0072	<0.02	3.7	0.0029	<0.0005	3.5	12.6	0.0112	24	0.003
	16 May 2012	TRC121517	5.9	14.5	13.2	19	23.18	107	92	0.042	0.08	6	0.0194	<0.02	3.4	0.0021	<0.0005	3	11.3	0.0115	23	<0.002
	26 Jul 2012	TRC122575	6	14.9	13.9	19.6	24	28	107	0.047	0.11	6	0.033	0.03	3.1	0.0019	<0.0005	3.5	12.9	0.028	25	0.005
	10 May 2012	TRC136046	4		16.7	<1	<1	28	104	0.048	0.09	5.8	0.027	0.03	3.2	0.0028	<0.0005	3.2	11	0.194	19.7	<0.002
GND2256	17 Apr 2012	TRC121418	6.4	15.8	15.4	20	24.4	39	117	0.054	0.1	8.6	0.0007	<0.02	4.2	0.0023	<0.0005	4.9	12.7	0.0151	21	<0.002
	16 May 2012	TRC121518	6.1	15.6	15.1	22	26.84	37	106	0.051	0.08	7.9	0.0006	<0.02	<0.02	0.0057	<0.0005	4.5	10.5	0.0097	19.5	<0.002
	26 Jul 2012	TRC122576	6	15.5	17.8	19.7	24	45	141	0.075	0.12	10.1	0.0006	<0.02	4.9	0.0013	<0.0005	6	12.7	0.0091	23	<0.002
	10 May 2012	TRC136045	6.8		18.2	32	39	48	125	0.077	0.11	11.5	0.0007	<0.02	4.7	0.014	<0.0005	7.1	12.6	0.051	21	<0.002
GND2257	17 Apr 2012	TRC121419	6.3	14.8	16.1	24	29.28	39	118	0.0143	0.1	8.1	0.0125	1.82	4.6	0.0199	<0.0005	2.2	15.5	0.047	22	0.005
	16 May 2012	TRC121519	6.2	12.2	16.9	24	29.28	39	130	0.0144	0.08	7.9	0.02	1.25	4.7	0.053	<0.00050	1.99	14.6	0.068	22	<0.002
	26 Jul 2012	TRC122577	6	12	16	22	26	38	128	0.021	0.1	8.3	0.0152	1.22	4.3	0.021	<0.0005	2.3	14.6	0.088	21	<0.002
	10 May 2012	TRC136047	6.2		17.2	27	33	42	124	0.0174	0.1	8.4	0.022	1	5.1	0.021	0.0006	2.7	15.6	0.33	21	0.003
GND2258	17 Apr 2012	TRC121420	6.3	15.2	11.2	18	21.96	30	87	0.08	0.08	6.3	<0.0005	<0.02	3.4	0.0014	<0.0005	3.8	8.3	0.0095	13.9	<0.002
	16 May 2012	TRC121520	6.2	14	12.6	25	30.5	34	94	0.076	0.06	7.5	0.0042	0.1	3.7	0.053	0.0006	3.8	7.7	0.028	13.8	<0.002
	26 Jul 2012	TRC122573	6	14.3	11.6	18	22	30	95	0.091	0.07	6.9	0.0007	<0.02	3.1	0.0011	<0.0005	3.7	7.5	0.0182	13.5	<0.002
	10 May 2012	TRC136048	6		12.1	19.1	23	32	88	0.095	0.1	6.9	0.0005	<0.02	3.6	0.001	<0.0005	3.9	8.2	0.0113	13.6	<0.002
Mangahewa-11 Hydraulic Fracturing Return Fluid																						
GND2271	11 May 2012	TRC121445	7.1		1,700	2,300		186		28		64	0.0108	6.3	6.6	5.1	0.024	600	3,500	0.064	4,300	0.004
Mangahewa-09 Hydraulic Fracturing Fluid																						
GND2358	03 May 2012	TRC135859																				
	20 May 2012	TRC136042																				
Mangahewa-09 Hydraulic Fracturing Return Fluid																						
GND2358	15 May 2012	TRC136043	6.4		7,110	1320	1,610	32,000		50	35	12,700	<0.005	0.14	84	3.2	0.28	460	6,100	0.14	27,000	0.3
	25 May 2012	TRC136078	7.3		1,395	1890		650		6.5	6.7	250	0.005	2.5	7	1.37	0.03	1,020	2,200	<0.02	3400	1.8

Site	Date	Sample Number	Nitrate (g/m^3)	Nitrate + Nitrite (g/m^3)	Sulphate (g/m^3)	Ethylene Glycol (g/m^3)	Methanol (g/m^3)	Formaldehyde (g/m^3)	Ethane (g/m^3)	Ethylene (g/m^3)	Methane (g/m^3)	Total Petroleum Hydrocarbons (g/m^3)	Benzene (g/m^3)	Toluene (g/m^3)	Ethylbenzene (g/m^3)	Xylene-M&P (g/m^3)	Xylene-O (g/m^3)
Private Water Supplies																	
GND2254	17 Apr 2012	TRC121416	<0.002	0.005	<0.5	<4	<2	<0.02	<0.003	<0.004	1.54	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	16 May 2012	TRC121516	<0.002	<0.002	<0.5	<4	<2	<0.02	<0.003	<0.004	1.48	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	26 Jul 2012	TRC122574	<0.002	<0.002	0.7	<4	<2	<0.02	<0.003	<0.004	2.1	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	10 May 2012	TRC136044	<0.002	0.002	<0.5	<4	<2	<0.02	<0.003	<0.004	1.95	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
GND2255	17 Apr 2012	TRC121417	1.22	1.22	3.1	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	16 May 2012	TRC121517	1.19	1.19	3	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	26 Jul 2012	TRC122575	1.75	1.75	3.3	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	10 May 2012	TRC136046	0.94	0.94	24	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
GND2256	17 Apr 2012	TRC121418	4.8	4.8	4.1	<4	<2	<0.02	<0.003	<0.0010	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	16 May 2012	TRC121518	3.7	3.7	4.1	<4	<2	<0.02	<0.003	<0.004	0.007	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	26 Jul 2012	TRC122576	7	7	4.5	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	10 May 2012	TRC136045	3.8	3.8	5.3	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
GND2257	17 Apr 2012	TRC121419	4.5	4.5	4.4	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	16 May 2012	TRC121519	4.8	4.8	4.6	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	26 Jul 2012	TRC122577	4.9	4.9	4.9	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	10 May 2012	TRC136047	4.3	4.3	5	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
GND2258	17 Apr 2012	TRC121420	2.8	2.8	4.2	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	16 May 2012	TRC121520	2.4	2.4	3.9	<4	<2	<0.02	<0.003	<0.004	0.003	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	26 Jul 2012	TRC122573	3.1	3.1	4.2	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
	10 May 2012	TRC136048	3	3	4	<4	<2	<0.02	<0.003	<0.004	<0.002	<0.7	<0.0010	<0.0010	<0.0010	<0.002	<0.0010
Mangahewa-05 Hydraulic Fracturing Return Fluid																	
GND2271	11 May 2012	TRC121445	2.8	2.8	55	121	480	1.83	0.37	<0.004	2.5	10.1	4.4	1.95	0.046	0.19	0.124
Mangahewa-05 Hydraulic Fracturing Fluid																	
GND2358	03 May 2012	TRC135859				23	<2					30	0.21	0.74	0.072	0.014	0.155
	20 May 2012	TRC136042				188	<2					185	0.0025	0.047	0.0071	0.025	0.0121
Mangahewa-05 Hydraulic Fracturing Return Fluid																	
GND2358	15 May 2012	TRC136043	560	560	56	230	<2	0.11	1.22	<0.007	1.71	60	19.6	15.5	0.7	4.5	1.59
	25 May 2012	TRC136078	1.9	3.7	136	<4	<2	0.09	1.28	<0.003	3.2	1,000	63	230	22	134	40

Appendix IV

Laboratory Analysis Reports

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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

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

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	998928 SPv1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	**Date Registered:**	18-Apr-2012
		Date Reported:	26-Apr-2012
		Quote No:	47915
		Order No:	32190
		Client Reference:	Mangahewa GW Sampling
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2254 17-Apr-2012 9:00 am	GND2255 17-Apr-2012 9:45 am	GND2256 17-Apr-2012 10:20 am	GND2257 17-Apr-2012 10:50 am	GND2258 17-Apr-2012 11:45 am
Lab Number:		998928.1	998928.2	998928.3	998928.4	998928.5
Individual Tests						
Sum of Anions	meq/L	3.0	1.21	1.43	1.51	1.03
Sum of Cations	meq/L	3.1	1.26	1.46	1.58	1.05
pH	pH Units	8.1	6.4	6.4	6.3	6.3
Total Alkalinity	g/m^3 as $CaCO_3$	132	19.8	20	24	17.8
Bicarbonate	g/m^3 at 25°C	158	24	25	29	22
Total Hardness	g/m^3 as $CaCO_3$	104	31	39	39	30
Electrical Conductivity (EC)	mS/m	27.5	13.0	15.4	16.1	11.2
Total Dissolved Solids (TDS)	g/m^3	181	90	117	118	87
Dissolved Barium	g/m^3	0.0146	0.043	0.054	0.0143	0.080
Dissolved Calcium	g/m^3	25	6.5	8.6	8.1	6.3
Dissolved Copper	g/m^3	< 0.0005	0.0072	0.0007	0.0125	< 0.0005
Dissolved Iron	g/m^3	0.32	< 0.02	< 0.02	1.82	< 0.02
Dissolved Magnesium	g/m^3	10.5	3.7	4.2	4.6	3.4
Dissolved Manganese	g/m^3	0.024	0.0029	0.0023	0.0199	0.0014
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Potassium	g/m^3	2.3	3.5	4.9	2.2	3.8
Dissolved Sodium	g/m^3	21	12.6	12.7	15.5	8.3
Dissolved Zinc	g/m^3	0.0012	0.0112	0.0151	0.047	0.0095
Bromide	g/m^3	0.07	0.10	0.10	0.10	0.08
Chloride	g/m^3	14.4	24	21	22	13.9
Nitrite-N	g/m^3	0.003	0.003	< 0.002	0.005	< 0.002
Nitrate-N	g/m^3	< 0.002	1.22	4.8	4.5	2.8
Nitrate-N + Nitrite-N	g/m^3	0.005	1.22	4.8	4.5	2.8
Sulphate	g/m^3	< 0.5	3.1	4.1	4.4	4.2
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
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&p-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

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous

Sample Name:		GND2254 17-Apr-2012 9:00 am	GND2255 17-Apr-2012 9:45 am	GND2256 17-Apr-2012 10:20 am	GND2257 17-Apr-2012 10:50 am	GND2258 17-Apr-2012 11:45 am
Lab Number:		998928.1	998928.2	998928.3	998928.4	998928.5
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Ethylene	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Methane	g/m^3	1.54	< 0.002	< 0.002	< 0.002	< 0.002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 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.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H$^+$ B 21st ed. 2005.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
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 21st ed. 2005.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-5
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) 21st ed. 2005.	10 g/m^3	1-5
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21st ed. 2005.	-	3, 5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-5
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-5

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

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

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

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1007479 SPv2
Contact:	Regan Phipps	**Date Registered:**	15-May-2012
	C/- Taranaki Regional Council	**Date Reported:**	23-May-2012
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	32696
		Client Reference:	
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2271 11-May-2012 12:00 pm				
Lab Number:		1007479.3				
Individual Tests						
pH*	pH Units	7.1	-	-	-	-
Total Alkalinity*	g/m^3 as CaCO$_3$	2,300	-	-	-	-
Total Hardness*	g/m^3 as CaCO$_3$	186	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,700	-	-	-	-
Dissolved Barium*	g/m^3	28	-	-	-	-
Dissolved Calcium*	g/m^3	64	-	-	-	-
Dissolved Copper*	g/m^3	0.0108	-	-	-	-
Dissolved Iron*	g/m^3	6.3	-	-	-	-
Dissolved Magnesium*	g/m^3	6.6	-	-	-	-
Dissolved Manganese*	g/m^3	5.1	-	-	-	-
Dissolved Nickel*	g/m^3	0.024	-	-	-	-
Dissolved Potassium*	g/m^3	600	-	-	-	-
Dissolved Sodium*	g/m^3	3,500	-	-	-	-
Dissolved Sulphur	g/m^3	19	-	-	-	-
Dissolved Zinc*	g/m^3	0.064	-	-	-	-
Chloride*	g/m^3	4,300	-	-	-	-
Nitrite-N*	g/m^3	0.004	-	-	-	-
Nitrate-N*	g/m^3	2.8	-	-	-	-
Nitrate*	g/m^3	12.3	-	-	-	-
Nitrate-N + Nitrite-N*	g/m^3	2.8	-	-	-	-
Sulphate	g/m^3	55	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	121	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	480	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	4.4	-	-	-	-
Toluene	g/m^3	1.95	-	-	-	-
Ethylbenzene	g/m^3	0.046	-	-	-	-
m&p-Xylene	g/m^3	0.19	-	-	-	-
o-Xylene	g/m^3	0.124	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	1.83	-	-	-	-
Gases in groundwater						

Sample Type: Aqueous

Sample Name:		GND2271 11-May-2012 12:00 pm				
Lab Number:		1007479.3				
Gases in groundwater						
Ethane	g/m^3	0.37	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	2.5	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	1.46	-	-	-	-
C10 - C14	g/m^3	3.1	-	-	-	-
C15 - C36	g/m^3	5.5	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	10.1	-	-	-	-

Analyst's Comments

Supplement to test report 1007479v1 issued on 23/5/12.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	3
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	3
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	3
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	3
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	3
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	3
pH*	Saline water, pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	3
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	3
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	3
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.10 mS/m	3
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.0006 g/m^3	3
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	3
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	3
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	3
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	3
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	3
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.006 g/m^3	3
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	3
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	3
Dissolved Sulphur	Filtered sample, ICP-OES.	0.10 g/m^3	3
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	3

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	3
Nitrite-N*	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	3
Nitrate-N*	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	3
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	3
Nitrate-N + Nitrite-N*	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	3
Soluble Sulphate	Calculation: from dissolved sulphur.	2 g/m^3	3

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

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

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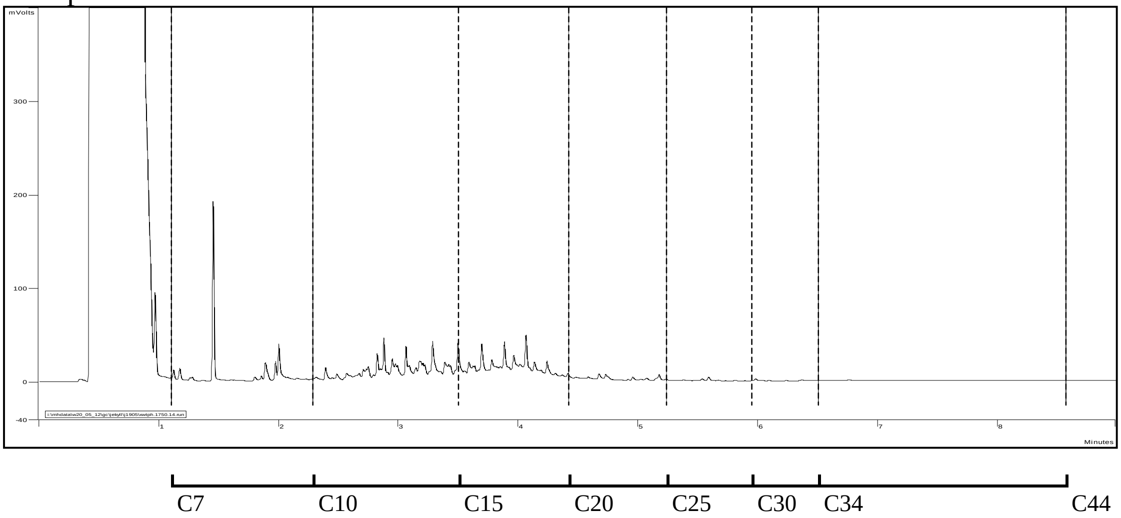
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 1007479.3



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1009096 SPv1
Contact:	Regan Phipps	**Date Registered:**	19-May-2012
	C/- Taranaki Regional Council	**Date Reported:**	25-May-2012
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	
		Client Reference:	Groundwater
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2254 16-May-2012 9:10 am	GND2255 16-May-2012 10:40 am	GND2256 16-May-2012 11:15 am	GND2257 16-May-2012 12:00 pm	GND2258 16-May-2012 12:50 pm
Lab Number:		1009096.1	1009096.2	1009096.3	1009096.4	1009096.5
Individual Tests						
Sum of Anions	meq/L	2.9	1.19	1.33	1.54	1.15
Sum of Cations	meq/L	2.9	1.14	1.31	1.51	1.12
pH	pH Units	7.9	5.9	6.1	6.2	6.2
Total Alkalinity	g/m^3 as $CaCO_3$	126	19.4	22	24	25
Bicarbonate	g/m^3 at 25°C	152	24	26	29	31
Total Hardness	g/m^3 as $CaCO_3$	107	29	37	39	34
Electrical Conductivity (EC)	mS/m	28.1	13.2	15.1	16.9	12.6
Total Dissolved Solids (TDS)	g/m^3	176	92	106	130	94
Dissolved Barium	g/m^3	0.0150	0.042	0.051	0.0144	0.076
Dissolved Calcium	g/m^3	24	6.0	7.9	7.9	7.5
Dissolved Copper	g/m^3	< 0.0005	0.0194	0.0006	0.020	0.0042
Dissolved Iron	g/m^3	0.29	< 0.02	< 0.02	1.25	0.10
Dissolved Magnesium	g/m^3	11.1	3.4	4.1	4.7	3.7
Dissolved Manganese	g/m^3	0.024	0.0021	0.0057	0.0158	0.053
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0006
Dissolved Potassium	g/m^3	2.1	3.0	4.5	1.99	3.8
Dissolved Sodium	g/m^3	16.3	11.3	10.5	14.6	7.7
Dissolved Zinc	g/m^3	0.0017	0.0115	0.0097	0.068	0.028
Bromide	g/m^3	0.05	0.08	0.08	0.08	0.06
Chloride	g/m^3	14.4	23	19.5	22	13.8
Nitrite-N	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m^3	< 0.002	1.19	3.7	4.8	2.4
Nitrate-N + Nitrite-N	g/m^3	< 0.002	1.19	3.7	4.8	2.4
Sulphate	g/m^3	< 0.5	3.0	4.1	4.6	3.9
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
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&p-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

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous

Sample Name:		GND2254 16-May-2012 9:10 am	GND2255 16-May-2012 10:40 am	GND2256 16-May-2012 11:15 am	GND2257 16-May-2012 12:00 pm	GND2258 16-May-2012 12:50 pm
Lab Number:		1009096.1	1009096.2	1009096.3	1009096.4	1009096.5
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Ethylene	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Methane	g/m^3	1.48	< 0.002	0.007	< 0.002	0.003
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 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.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
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 21st ed. 2005.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-5
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) 21st ed. 2005.	10 g/m^3	1-5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-5
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-5

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

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

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1030257	SPv1
Contact:	Regan Phipps	**Date Registered:**	27-Jul-2012	
	C/- Taranaki Regional Council	**Date Reported:**	03-Aug-2012	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Groundwater	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:		GND2254 26-Jul-2012 10:45 am	GND2255 26-Jul-2012 11:15 am	GND2256 26-Jul-2012 11:45 am	GND2257 26-Jul-2012 12:20 pm	
Lab Number:		1030257.1	1030257.2	1030257.3	1030257.4	
Individual Tests						
Sum of Anions	meq/L	3.0	1.28	1.64	1.49	-
Sum of Cations	meq/L	2.9	1.20	1.61	1.51	-
pH	pH Units	8.0	6.0	6.0	6.0	-
Total Alkalinity	g/m^3 as $CaCO_3$	131	19.6	19.7	22	-
Bicarbonate	g/m^3 at 25°C	158	24	24	26	-
Total Hardness	g/m^3 as $CaCO_3$	98	28	45	38	-
Electrical Conductivity (EC)	mS/m	27.9	13.9	17.8	16.0	-
Total Dissolved Solids (TDS)	g/m^3	186	107	141	128	-
Dissolved Barium	g/m^3	0.0148	0.047	0.075	0.021	-
Dissolved Calcium	g/m^3	23	6.0	10.1	8.3	-
Dissolved Copper	g/m^3	< 0.0005	0.033	0.0006	0.0152	-
Dissolved Iron	g/m^3	0.31	0.03	< 0.02	1.22	-
Dissolved Magnesium	g/m^3	9.8	3.1	4.9	4.3	-
Dissolved Manganese	g/m^3	0.024	0.0019	0.0013	0.021	-
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m^3	2.3	3.5	6.0	2.3	-
Dissolved Sodium	g/m^3	21	12.9	12.7	14.6	-
Dissolved Zinc	g/m^3	0.0020	0.028	0.0091	0.088	-
Bromide	g/m^3	< 0.05	0.11	0.12	0.10	-
Chloride	g/m^3	14.6	25	23	21	-
Nitrite-N	g/m^3	< 0.002	0.005	< 0.002	< 0.002	-
Nitrate-N	g/m^3	< 0.002	1.75	7.0	4.9	-
Nitrate-N + Nitrite-N	g/m^3	< 0.002	1.75	7.0	4.9	-
Sulphate	g/m^3	0.7	3.3	4.5	4.9	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	-
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-

Sample Type: Aqueous

Sample Name:		GND2254 26-Jul-2012 10:45 am	GND2255 26-Jul-2012 11:15 am	GND2256 26-Jul-2012 11:45 am	GND2257 26-Jul-2012 12:20 pm	
Lab Number:		1030257.1	1030257.2	1030257.3	1030257.4	
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	-
Gases in groundwater						
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	-
Ethylene	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	-
Methane	g/m^3	2.1	< 0.002	< 0.002	< 0.002	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 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.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-4
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-4
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-4
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-4
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-4
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 21st ed. 2005.	1.0 g/m^3 at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-4
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) 21st ed. 2005.	10 g/m^3	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-4
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-4

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-4
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-4

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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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1030272 SPv1
Contact:	Regan Phipps	**Date Registered:**	27-Jul-2012
	C/- Taranaki Regional Council	**Date Reported:**	03-Aug-2012
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	
		Client Reference:	Groundwater
		Submitted By:	Regan Phipps

Sample Type: Aqueous

	Sample Name:	GND2258 26-Jul-2012 1:00 pm				
	Lab Number:	1030272.1				
Individual Tests						
Sum of Anions	meq/L	1.05	-	-	-	-
Sum of Cations	meq/L	1.02	-	-	-	-
pH	pH Units	6.0	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	18.0	-	-	-	-
Bicarbonate	g/m^3 at 25°C	22	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	30	-	-	-	-
Electrical Conductivity (EC)	mS/m	11.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	95	-	-	-	-
Dissolved Barium	g/m^3	0.091	-	-	-	-
Dissolved Calcium	g/m^3	6.9	-	-	-	-
Dissolved Copper	g/m^3	0.0007	-	-	-	-
Dissolved Iron	g/m^3	< 0.02	-	-	-	-
Dissolved Magnesium	g/m^3	3.1	-	-	-	-
Dissolved Manganese	g/m^3	0.0011	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	3.7	-	-	-	-
Dissolved Sodium	g/m^3	7.5	-	-	-	-
Dissolved Zinc	g/m^3	0.0182	-	-	-	-
Bromide	g/m^3	0.07	-	-	-	-
Chloride	g/m^3	13.5	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	3.1	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	3.1	-	-	-	-
Sulphate	g/m^3	4.2	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-

Sample Type: Aqueous

Sample Name:		GND2258 26-Jul-2012 1:00 pm				
Lab Number:		1030272.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	< 0.003	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	-	-	-	-
C10 - C14	g/m^3	< 0.2	-	-	-	-
C15 - C36	g/m^3	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	< 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.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	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.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 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 21st ed. 2005.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	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) 21st ed. 2005.	10 g/m^3	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I (Modified) 21st ed. 2005.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	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.

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1134070 SPv1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	**Date Registered:**	11-May-2013
		Date Reported:	21-May-2013
		Quote No:	47915
		Order No:	
		Client Reference:	Groundwater
		Submitted By:	Taranaki Regional Council

Sample Type: Aqueous

Sample Name:		GND2254 10-May-2013 9:01 am	GND2256 10-May-2013 10:00 am	GND2255 10-May-2013 11:00 am	GND 2257 10-May-2013 12:20 pm	GND 2258 10-May-2013 1:15 pm
Lab Number:		1134070.1	1134070.2	1134070.3	1134070.4	1134070.5
Individual Tests						
Sum of Anions	meq/L	3.0	1.63	1.13	1.54	1.06
Sum of Cations	meq/L	3.1	1.69	1.21	1.63	1.10
pH	pH Units	8.0	6.8	4.0	6.2	6.0
Total Alkalinity	g/m^3 as $CaCO_3$	130	32	< 1.0	27	19.1
Bicarbonate	g/m^3 at 25°C	157	39	< 1.0	33	23
Total Hardness	g/m^3 as $CaCO_3$	102	48	28	42	32
Electrical Conductivity (EC)	mS/m	28.3	18.2	16.7	17.2	12.1
Total Dissolved Solids (TDS)	g/m^3	181	125	104	124	88
Dissolved Barium	g/m^3	0.0168	0.077	0.048	0.0174	0.095
Dissolved Calcium	g/m^3	24	11.5	5.8	8.4	6.9
Dissolved Copper	g/m^3	< 0.0005	0.0007	0.027	0.022	0.0005
Dissolved Iron	g/m^3	0.31	< 0.02	0.03	1.00	< 0.02
Dissolved Magnesium	g/m^3	10.3	4.7	3.2	5.1	3.6
Dissolved Manganese	g/m^3	0.026	0.0140	0.0028	0.021	0.0010
Dissolved Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	0.0006	< 0.0005
Dissolved Potassium	g/m^3	2.3	7.1	3.2	2.7	3.9
Dissolved Sodium	g/m^3	23	12.6	11.0	15.6	8.2
Dissolved Zinc	g/m^3	0.0087	0.051	0.194	0.33	0.0113
Bromide	g/m^3	0.07	0.11	0.09	0.10	0.10
Chloride	g/m^3	13.8	21	19.7	21	13.6
Nitrite-N	g/m^3	0.002	< 0.002	< 0.002	0.003	< 0.002
Nitrate-N	g/m^3	< 0.002	3.8	0.94	4.3	3.0
Nitrate-N + Nitrite-N	g/m^3	0.002	3.8	0.94	4.3	3.0
Sulphate	g/m^3	< 0.5	5.3	24	5.0	4.0
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	< 4	< 4	< 4	< 4
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
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&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Sample Type: Aqueous

Sample Name:		GND2254 10-May-2013 9:01 am	GND2256 10-May-2013 10:00 am	GND2255 10-May-2013 11:00 am	GND 2257 10-May-2013 12:20 pm	GND 2258 10-May-2013 1:15 pm
Lab Number:		1134070.1	1134070.2	1134070.3	1134070.4	1134070.5
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m^3	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Ethylene	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Methane	g/m^3	1.95	< 0.002	< 0.002	< 0.002	< 0.002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 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.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-5
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-5
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-5
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-5
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-5
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-5
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-5
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-5
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
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 21st ed. 2005.	1.0 g/m^3 at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-5
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) 21st ed. 2005.	10 g/m^3	1-5
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00010 g/m^3	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-5
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 g/m^3	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m^3	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m^3	1-5
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-5
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-5
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-5

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

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

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Peter Robinson

Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1132196 SPv2
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	**Date Registered:**	07-May-2013
		Date Reported:	20-May-2013
		Quote No:	50522
		Order No:	
		Client Reference:	Hydraulic fracturing fluid testi
		Submitted By:	Regan Phipps

Amended Report

This report replaces an earlier report issued on the 20 May 2013 at 3:42 pm
GCMS TIC and LSR added by Peter/Ara

Sample Type: Aqueous

Sample Name:		GND2358 03-May-2013 12:30 am				
Lab Number:		1132196.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	23	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	13	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	0.21	-	-	-	-
Toluene	g/m^3	0.74	-	-	-	-
Ethylbenzene	g/m^3	0.072	-	-	-	-
m&p-Xylene	g/m^3	0.014	-	-	-	-
o-Xylene	g/m^3	0.155	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	1.2	-	-	-	-
C10 - C14	g/m^3	9.4	-	-	-	-
C15 - C36	g/m^3	20	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	30	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - 1132196.1 BTEX TIC

Appendix No.3 - 1132196.1 BTEX LSR

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1

Sample Type: Aqueous

Test	**Method Description**	**Default Detection Limit**	**Samples**
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	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.

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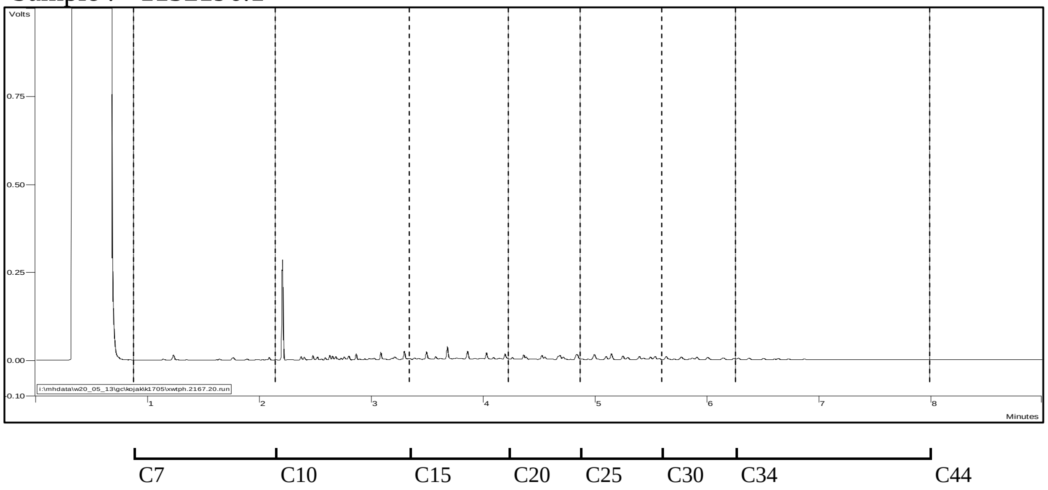
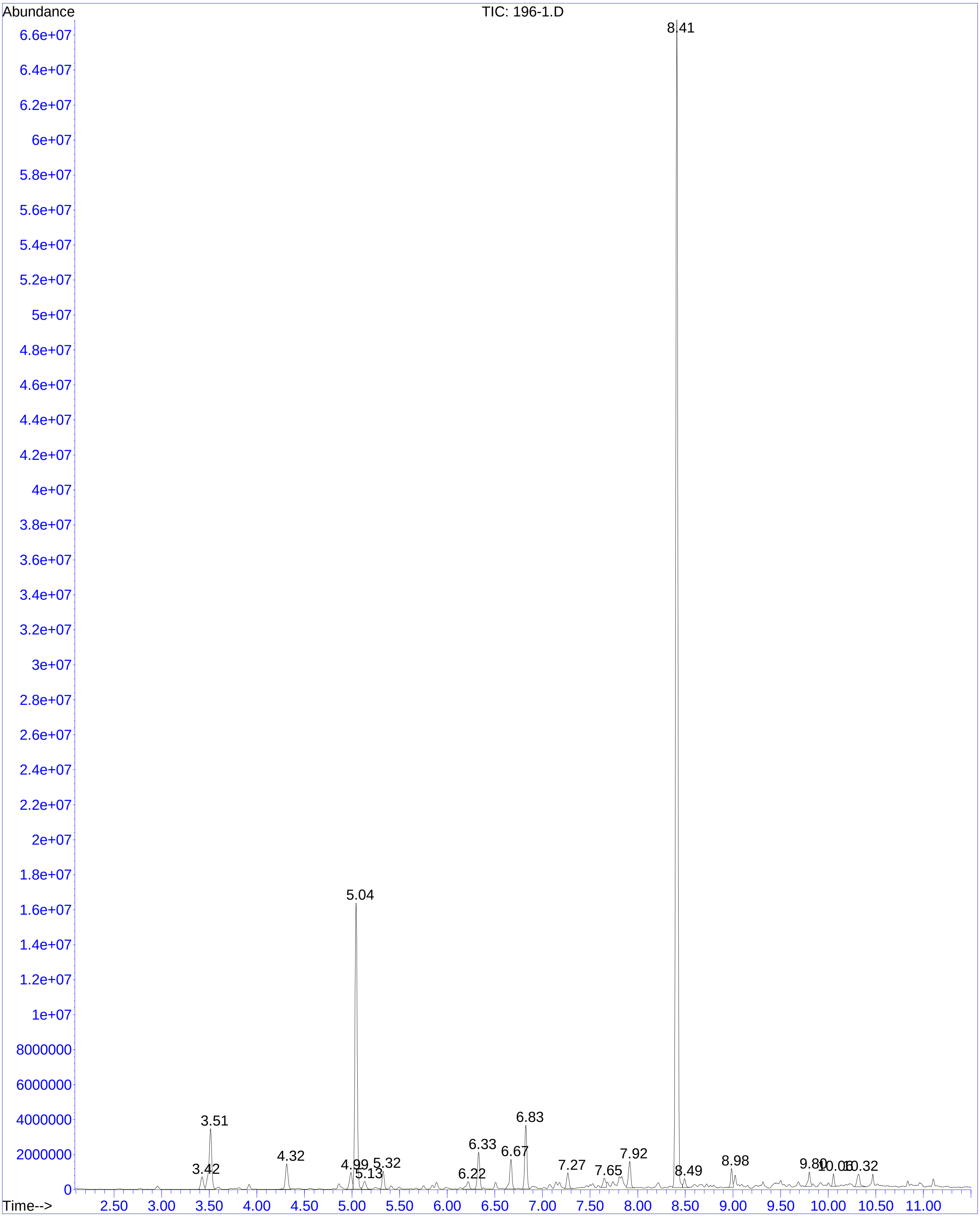
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1132196.1



```
File        : I:\MHDATA\W19_05_13\GCMSF\H0905\196-1.D
Operator    : Jonny
Acquired    :  9 May 2013   6:28 pm using AcqMethod BTEX_H2
Instrument  :   Harry The
Sample Name: aphsv.3514.7
Misc Info   :
Vial Number: 7
```



```
File       : I:\MHDATA\W19_05_13\GCMSF\H0905\196-1.D
Operator   : Jonny
Acquired   :  9 May 2013   6:28 pm using AcqMethod BTEX_H2
Sample Name: aphsv.3514.7
Misc Info  :
Vial Number: 7


Search Libraries:   O:\DATABASE\NIST05A.L            Minimum Quality:  45

Unknown Spectrum:   Apex
Integration Params: rteint.p (RTEINT used)

Pk#  RT    Area%          Library/ID                 Ref#     CAS#   Qual
----------------------------------------------------------------------------------------------
  1   3.42  0.83 O:\DATABASE\NIST05A.L
                 Cyclohexane                          1430 000110-82-7 91
                 Cyclohexane                          1432 000110-82-7 91
                 Cyclohexane                          1431 000110-82-7 90

  2   3.51  4.22 O:\DATABASE\NIST05A.L
                 Benzene                              1001 000071-43-2 95
                 Benzene                              1002 000071-43-2 91
                 Benzene                              1000 000071-43-2 91

  3   4.32  1.59 O:\DATABASE\NIST05A.L
                 Cyclohexane, methyl-                 3269 000108-87-2 96
                 Cyclohexane, methyl-                 3273 000108-87-2 95
                 Cyclohexane, methyl-                 3271 000108-87-2 95

  4   4.99  1.07 O:\DATABASE\NIST05A.L
                 Toluene-D8                           3882 002037-26-5 95
                 Toluene-D8                           3883 002037-26-5 80
                 1,2-Cyclopentanedione                3030 003008-40-0 47

  5   5.04 15.52 O:\DATABASE\NIST05A.L
                 Toluene                              2395 000108-88-3 95
                 Toluene                              2400 000108-88-3 93
                 Toluene                              2396 000108-88-3 91

  6   5.13  0.55 O:\DATABASE\NIST05A.L
                 Cyclohexane, 1,4-dimethyl-, trans-   6637 002207-04-7 94
                 Cyclohexane, 1,4-dimethyl-, trans-   6640 002207-04-7 94
                 Cyclohexane, 1,3-dimethyl-, cis-     6632 000638-04-0 91

  7   5.32  0.92 O:\DATABASE\NIST05A.L
                 Octane                               7419 000111-65-9 94
                 Octane                               7421 000111-65-9 87
                 Oxalic acid, isohexyl pentyl ester  87736 1000309-32-8 83

  8   6.22  0.59 O:\DATABASE\NIST05A.L
                 Octane, 2-methyl-                   12277 003221-61-2 87
                 Oxalic acid, 6-ethyloct-3-yl propy 106740 1000309-34-0 59
                 Octane                               7420 000111-65-9 59

  9   6.33  2.05 O:\DATABASE\NIST05A.L
                 Ethylbenzene                         4955 000100-41-4 93
                 Ethylbenzene                         4956 000100-41-4 87
                 Ethylbenzene                         4957 000100-41-4 87

 10   6.67  1.68 O:\DATABASE\NIST05A.L
                 Nonane                              12267 000111-84-2 94
                 Nonane                              12269 000111-84-2 90
                 1-Octanol, 2-butyl-                 47457 003913-02-8 72

 11   6.83  3.37 O:\DATABASE\NIST05A.L
                 o-Xylene                             4953 000095-47-6 97
                 p-Xylene                             4950 000106-42-3 97
                 Benzene, 1,3-dimethyl-               4970 000108-38-3 97

 12   7.27  0.89 O:\DATABASE\NIST05A.L
                 1R-.alpha.-Pinene                   15188 007785-70-8 95
                 Bicyclo[3.1.1]hept-2-ene, 2,6,6-tr  15376 002437-95-8 95
                 1S-.alpha.-Pinene                   15185 007785-26-4 94

 13   7.65  0.60 O:\DATABASE\NIST05A.L
                 Cyclotetrasiloxane, octamethyl-    122480 000556-67-2 81
                 Cyclotetrasiloxane, octamethyl-    122479 000556-67-2 80
                 7H-Dibenzo[b,g]carbazole, 7-methyl 112705 003557-49-1 50
```

```
                                 /ID                 Ref#     CAS#   Qual
 14   7.92  1.51 O:\DATABASE\NIST05A.L
                 Decane                              18488 000124-18-5 95
                 Decane                              18486 000124-18-5 93
                 Decane                              18487 000124-18-5 93

 15   8.41 61.03 O:\DATABASE\NIST05A.L
                 D-Limonene                          15162 005989-27-5 94
                 Limonene                            15153 000138-86-3 91
                 Limonene                            15154 000138-86-3 91

 16   8.49  0.46 O:\DATABASE\NIST05A.L
                 Benzene, 1,2,3-trimethyl-            9115 000526-73-8 97
                 Benzene, 1,2,4-trimethyl-            9128 000095-63-6 95
                 Benzene, 1,3,5-trimethyl-            9124 000108-67-8 95

 17   8.98  0.85 O:\DATABASE\NIST05A.L
                 Undecane                            27236 001120-21-4 94
                 Undecane                            27237 001120-21-4 94
                 Tetradecane                         55974 000629-59-4 86

 18   9.80  0.79 O:\DATABASE\NIST05A.L
                 Dodecane                            36431 000112-40-3 96
                 Hexadecane                          76092 000544-76-3 95
                 Pentadecane                         66067 000629-62-9 90

 19  10.06  0.53 O:\DATABASE\NIST05A.L
                 Naphthalene                         11577 000091-20-3 95
                 Naphthalene                         11575 000091-20-3 95
                 Azulene                             11571 000275-51-4 95

 20  10.32  0.94 O:\DATABASE\NIST05A.L
                 Hexadecane                          76093 000544-76-3 94
                 Hexadecane                          76088 000544-76-3 94
                 Hexadecane                          76090 000544-76-3 93
```

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1137820 SPv1
Contact:	Regan Phipps	**Date Registered:**	22-May-2013
	C/- Taranaki Regional Council	**Date Reported:**	30-May-2013
	Private Bag 713	**Quote No:**	
	STRATFORD 4352	**Order No:**	
		Client Reference:	Hydraulic fracturing fluid testi
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2358 20-May-2013 3:40 pm				
Lab Number:		1137820.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	188	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	52	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	0.0025	-	-	-	-
Toluene	g/m^3	0.047	-	-	-	-
Ethylbenzene	g/m^3	0.0071	-	-	-	-
m&p-Xylene	g/m^3	0.025	-	-	-	-
o-Xylene	g/m^3	0.0121	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	0.8	-	-	-	-
C10 - C14	g/m^3	64	-	-	-	-
C15 - C36	g/m^3	120	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	185	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1

ilac-MRA 823 365 IANZ laboratory

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The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

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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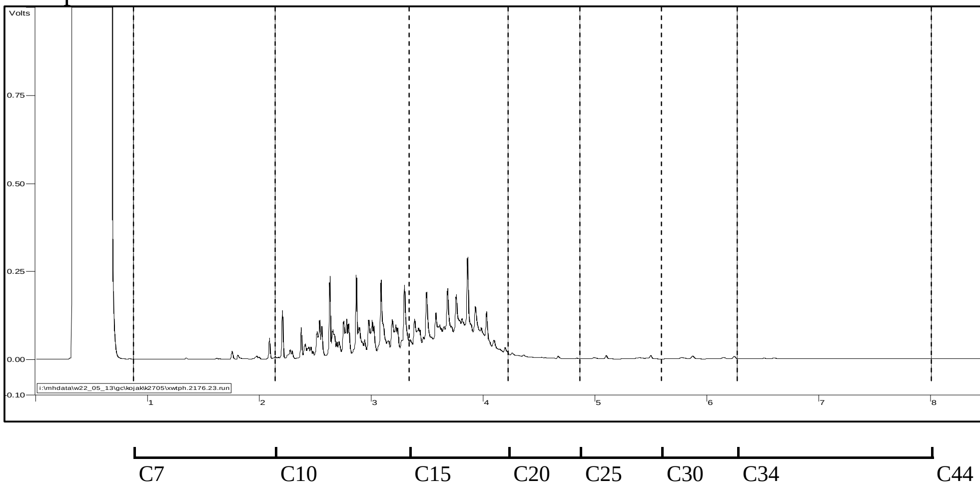
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1137820.1



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1136424 SPv1
Contact:	Regan Phipps	**Date Registered:**	17-May-2013
	C/- Taranaki Regional Council	**Date Reported:**	30-May-2013
	Private Bag 713	**Quote No:**	49265
	STRATFORD 4352	**Order No:**	
		Client Reference:	High Salinity Produced Wate
		Submitted By:	Regan Phipps

Sample Type: Saline

	Sample Name:	GND 2358 15-May-2013 12:00 pm				
	Lab Number:	1136424.1				
Individual Tests						
pH*	pH Units	6.4	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,320	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	32,000	-	-	-	-
Electrical Conductivity (EC)*	mS/m	7,110	-	-	-	-
Dissolved Barium*	g/m^3	50	-	-	-	-
Dissolved Calcium*	g/m^3	12,700	-	-	-	-
Dissolved Copper*	g/m^3	< 0.005	-	-	-	-
Dissolved Iron*	g/m^3	0.14	-	-	-	-
Dissolved Magnesium*	g/m^3	84	-	-	-	-
Dissolved Manganese*	g/m^3	3.2	-	-	-	-
Dissolved Nickel*	g/m^3	0.28	-	-	-	-
Dissolved Potassium*	g/m^3	460	-	-	-	-
Dissolved Sodium*	g/m^3	6,100	-	-	-	-
Dissolved Sulphur*	g/m^3	19	-	-	-	-
Dissolved Zinc*	g/m^3	0.14	-	-	-	-
Bromide*	g/m^3	35	-	-	-	-
Chloride*	g/m^3	27,000	-	-	-	-
Nitrite-N	g/m^3	0.3	-	-	-	-
Nitrate-N	g/m^3	560	-	-	-	-
Nitrate*	g/m^3	2,500	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	560	-	-	-	-
Sulphate*	g/m^3	56	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	230	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	19.6	-	-	-	-
Toluene*	g/m^3	15.5	-	-	-	-
Ethylbenzene*	g/m^3	0.70	-	-	-	-
m&p-Xylene*	g/m^3	4.5	-	-	-	-
o-Xylene*	g/m^3	1.59	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	0.11	-	-	-	-

Sample Type: Saline

Sample Name:		GND 2358 15-May-2013 12:00 pm				
Lab Number:		1136424.1				
Gases in groundwater						
Ethane*	g/m^3	1.22	-	-	-	-
Ethylene*	g/m^3	< 0.007	-	-	-	-
Methane*	g/m^3	1.71	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m^3	21	-	-	-	-
C10 - C14*	g/m^3	22	-	-	-	-
C15 - C36*	g/m^3	17.4	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m^3	60	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Saline

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater*	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1
pH*	Saline water, pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.10 mS/m	1
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21st ed. 2005.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.0006 g/m^3	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.006 g/m^3	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m^3	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1

Sample Type: Saline

Test	Method Description	Default Detection Limit	Samples
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	1
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m^3	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m^3	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.

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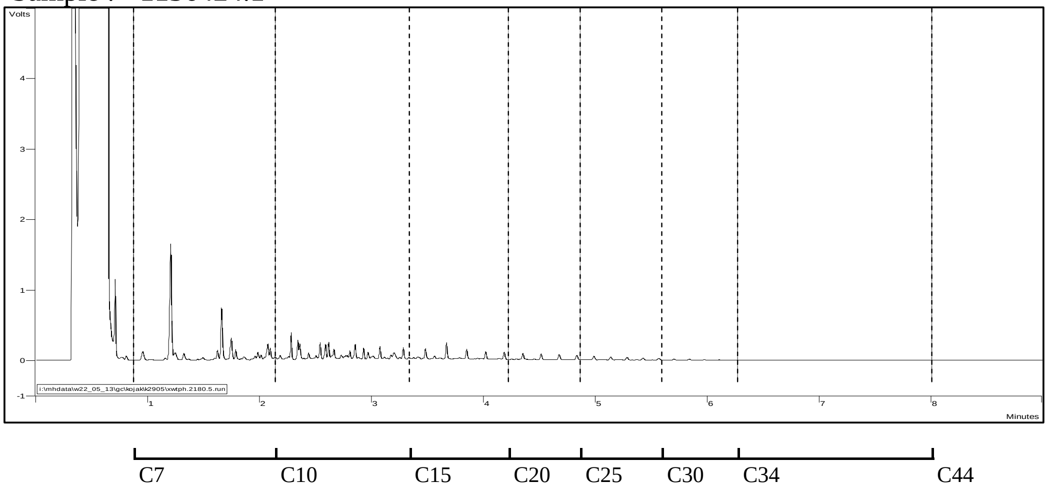
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1136424.1



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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1139732 SPv1
Contact:	Regan Phipps	**Date Registered:**	28-May-2013
	C/- Taranaki Regional Council	**Date Reported:**	18-Jun-2013
	Private Bag 713	**Quote No:**	49265
	STRATFORD 4352	**Order No:**	
		Client Reference:	Mangahewa C - Return Fluid
		Submitted By:	Regan Phipps

Sample Type: Saline

Sample Name:		GND2358 25-May-2013 12:55 pm				
Lab Number:		1139732.1				
Individual Tests						
pH*	pH Units	7.3	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,890	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	650	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,395	-	-	-	-
Dissolved Barium*	g/m^3	6.5	-	-	-	-
Dissolved Calcium*	g/m^3	250	-	-	-	-
Dissolved Copper*	g/m^3	0.005	-	-	-	-
Dissolved Iron*	g/m^3	2.5	-	-	-	-
Dissolved Magnesium*	g/m^3	7	-	-	-	-
Dissolved Manganese*	g/m^3	1.37	-	-	-	-
Dissolved Nickel*	g/m^3	0.03	-	-	-	-
Dissolved Potassium*	g/m^3	1,020	-	-	-	-
Dissolved Sodium*	g/m^3	2,200	-	-	-	-
Dissolved Sulphur*	g/m^3	45	-	-	-	-
Dissolved Zinc*	g/m^3	< 0.02	-	-	-	-
Bromide*	g/m^3	6.7	-	-	-	-
Chloride*	g/m^3	3,400	-	-	-	-
Nitrite-N	g/m^3	1.8	-	-	-	-
Nitrate-N	g/m^3	1.9	-	-	-	-
Nitrate*	g/m^3	8.2	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	3.7	-	-	-	-
Sulphate*	g/m^3	136	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	630	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	63	-	-	-	-
Toluene*	g/m^3	230	-	-	-	-
Ethylbenzene*	g/m^3	22	-	-	-	-
m&p-Xylene*	g/m^3	134	-	-	-	-
o-Xylene*	g/m^3	40	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	0.09	-	-	-	-

Sample Type: Saline

Sample Name:		GND2358 25-May-2013 12:55 pm				
Lab Number:		1139732.1				
Gases in groundwater						
Ethane*	g/m^3	1.28	-	-	-	-
Ethylene*	g/m^3	< 0.003	-	-	-	-
Methane*	g/m^3	3.2	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m^3	250	-	-	-	-
C10 - C14*	g/m^3	350	-	-	-	-
C15 - C36*	g/m^3	410	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m^3	1,000	-	-	-	-

Sample Type: Aqueous

Sample Name:		GND2358 [Mercury Testing] 25-May-2013 12:55 pm				
Lab Number:		1139732.2				
Individual Tests						
Total Mercury	g/m^3	< 0.011	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

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

Sample Type: Saline

Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater*	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water*	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1
pH*	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as CaCO$_3$	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m^3 as CaCO$_3$	1
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21st ed. 2005.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.0006 g/m^3	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.006 g/m^3	1

Sample Type: Saline

Test	Method Description	Default Detection Limit	Samples
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.0 g/m^3	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.4 g/m^3	1
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m^3	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m^3	1
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	1
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m^3	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m^3	1

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	2
Total Mercury	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.0021 g/m^3	2

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

Sample : 1139732.1