Greymouth Petroleum Limited Turangi-B Hydraulic Fracturing Monitoring Programme Report 2013-2015

Technical Report 2014-115

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Executive summary

Greymouth Petroleum Limited (Greymouth) operates the Turangi-B wellsite, located at Turangi Road, Motunui. The wellsite lies within the Parahaki catchment and contains a hydrocarbon producing well and associated infrastructure.

Greymouth hold resource consent 7952-1, authorising the discharge of contaminants associated with hydraulic fracturing activities into land at depths greater than 3,410 m TVD beneath the Turangi-B wellsite. The consent was issued by Taranaki Regional Council (the Council) on 8 November 2011 and contains a total of 13 special conditions which set out the requirements that Greymouth must satisfy.

The following report for the period July 2013 to January 2015 outlines and discusses the results of the monitoring programme implemented by the Council in relation to the programme of hydraulic fracturing undertaken by Greymouth, within their Turangi-B wellsite. The report also assesses Greymouth's level of environmental performance and compliance with the resource consent held in relation to the activity.

During the monitoring period being reported, Greymouth demonstrated a high level of environmental performance.

The programme of hydraulic fracturing undertaken by Greymouth at the Turangi-B wellsite was that of the Turangi-4 well which took place between November 2011 and March 2012.

The programme of monitoring implemented by the Council in relation to fracturing activities commenced in the 2011-2012 monitoring year. The results of monitoring undertaken between November 2011 and September 2012 were presented in the 2011-2013 annual report (Taranaki Regional Council, 2013). The results of monitoring undertaken between December 2012 and January 2015 are presented in this report. Monitoring included groundwater sampling at 11 sites and analysis of samples for a range of chemical and isotopic analysis.

The results of the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Greymouth have had no adverse effects on local groundwater resources. There were no Unauthorised Incidents recording non-compliance in respect of the resource consent, or provisions in regional plans, during the period under review.

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

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

This report includes recommendations for the 2015-2016 year.

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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 outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Greymouth Petroleum Limited (Greymouth) at their Turangi-B wellsite, Turangi Road, Motunui over the period July 2013 – January 2015. The wellsite is located in the Parahaki catchment. The report also assesses Greymouth's level of environmental performance and compliance with the resource consents held in relation to the activity.

The programme of hydraulic fracturing undertaken by Greymouth at the Turangi-B wellsite included the fracturing of one well, Turangi-4. The monitoring programme implemented by the Council commenced during the 2011-2012 period. The programme has consisted of groundwater monitoring components. Surface water monitoring in relation to hydraulic fracturing events was not in practice by the Council when this well as fractured.

A report was completed in July 2013 which outlined and discussed the results of the monitoring carried out during the 2011-2012 and 2012-2013 monitoring periods. The following report provides an update on the results of further monitoring carried out since the initial report was issued.

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 1991 (RMA) and the Council's obligations and general approach to monitoring sites though annual programmes, the resource consents held by Greymouth for discharges into land associated with hydraulic fracturing in the Waiau catchment, a description of the activities undertaken under these consents, and the nature of the monitoring programme in place for the period under review.

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

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

Section 4 presents recommendations to be implemented in the 2015-2016 monitoring year.

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

1.1.3 The Resource Management Act 1991 and monitoring

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

(a) the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
(b) physical effects on the locality, including landscape, amenity and visual effects;
(c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
(d) natural and physical resources having special significance (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 activity. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and, ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder/s during the period under review, this report also assigns a rating as to each Company's environmental and administrative performance.

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

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

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

Environmental Performance

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

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

  For example:

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

- **Improvement required** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

- **Poor** Likely or actual adverse effects of activities on the receiving environment were significant. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative compliance

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

- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however these are addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided

for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

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

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

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

1.2 Process description

1.2.1 Hydraulic fracturing

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

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 fractures. Once fractures have been initiated, pumping continues in order to force the fluid and proppant into the fractures created. The proppant is designed to keep the fractures open when the pumping is stopped. The placement of proppant into the fractures 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 fluids and hydrocarbons are drawn to the surface.

1.2.2 Turangi-B wellsite history

The Turangi-B wellsite has been in operation since 2011. Surrounding land uses are predominantly agricultural, however a number of wellsites and pipelines associated with hydrocarbon exploration, production and processing are located within a 10 km radius of the site, including the Turangi-A wellsite, the Turangi production station, the methanol plant at Motunui and the Pohokura production station. The topography of the site is flat countryside. The Parahaki Stream is located to the west of the wellsite. The wellhead is located approximately 300 metres upgradient of an unnamed tributary of the Parahaki Stream.

The Turangi-4 well was drilled in 2011 and hydraulic fracturing occurred between 15 November 2011 and 7 March 2012 (Table 1). The location of the wellsite is illustrated in Figure 1. A well construction schematic for the Turangi-4 well is included in Appendix I.

Table 1 Summary of hydraulic fracturing activity at the Turangi-B wellsite.

Well	Wellsite	Consent	Date		Injection zone (m TVDss)	Formation
			Start	End		
Turangi-4	Turangi-B	7952-1	15/11/11	7/3/12	3,400 to 4,000	Kapuni

A report was completed in July 2013 (Greymouth Petroleum Limited, 2013) which outlined and discussed the results of the monitoring carried out during the 2011-2012 and 2012-2013 monitoring periods. The following report provides an update on the results of further monitoring carried out since the report was issued.

1.3 Resource consent

1.3.1 Discharges onto and into land

Sections 15(1)(b) of the RMA stipulate that no person may discharge any contaminant onto or into land, which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

Greymouth holds resource consent **7952-1**, authorising the discharge of contaminants into land at the Turangi-B wellsite. The consent was issued by the Council on 8 November 2011, under Section 87(e) of the RMA. This is the consent under which Turangi-4 was fractured. Consent 7952-1 contains a total of 13 special conditions which set out the requirements that Greymouth must satisfy. The conditions are summarised below.

Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur.

Condition 2 stipulates the distance horizontally from the wellsite past which discharge may not occur.

Condition 3 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater aquifers.

Conditions 4, 5 and 6 relate to fresh water monitoring requirements, to allow compliance with condition 3 to be assessed.

Condition 7 is a notification requirement.

Condition 8 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme.

Condition 9 stipulates how the report required by conditions 8 is to be submitted.

Condition 10 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained.

Condition 11 requires the consent holder to adopt best practicable options.

Condition 12 relates to the composition of the fracturing fluid.

Condition 13 is a review provision

Figure 1 Location of Turangi-B wellsite

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets obligations upon the Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki region and report upon these.

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

The monitoring programme implemented in relation to the hydraulic fracturing of the Turangi-4 well consisted of four primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Review of consent holder submitted data

As required by the conditions of consent 7952-1, Greymouth submitted a post-fracturing discharge report to the Council following the completion of the Turangi-4 fracturing programme. Post-fracturing reports confirm details of the fracturing activities that occurred. The specific range of information required in the report is stipulated in the conditions of the resource consent. The post-fracturing discharge report is discussed in detail in the 2011-2013 annual report (Taranaki Regional Council, 2013).

1.4.4 Chemical sampling

The groundwater monitoring programme over the period in question included the sampling of eleven wells, a combination of five specially installed monitoring wells and six existing groundwater supplies in the vicinity of the wellsite at which hydraulic fracturing took place, and the analysis of the results.

The details of each site are included in Table 2 and their proximity to the Turangi-B wellsite is illustrated in Figure 2.

Table 2 Details of groundwater sites included in the monitoring programme

Hydraulically fractured well	Monitoring site	Distance from bottom hole location (m)	Total depth (m)	Screened interval (m)	Aquifer
Turangi-4 (GND2244)	GND1125	791	25.7	19 - 25	Marine Terraces
	GND1673	843	42	26-42	Marine Terraces
	GND2229	936	NR*	NR*	Unknown
	GND2230	356	4	NA**	Marine Terraces
	GND2231	336	4	NA**	Marine Terraces
	GND2239	543	3.9	NA**	Marine Terraces
	GND2234	89	5	2.5	Marine Terraces
	GND2235	152	5	2.5	Marine Terraces

Hydraulically fractured well	Monitoring site	Distance from bottom hole location (m)	Total depth (m)	Screened interval (m)	Aquifer
	GND2236	149	5	2.5	Marine Terraces
	GND2237	125	5	2.5	Marine Terraces
	GND2238	88	5	2.5	Marine Terraces

*Bore not accessible to obtain measurements

** Well not screened

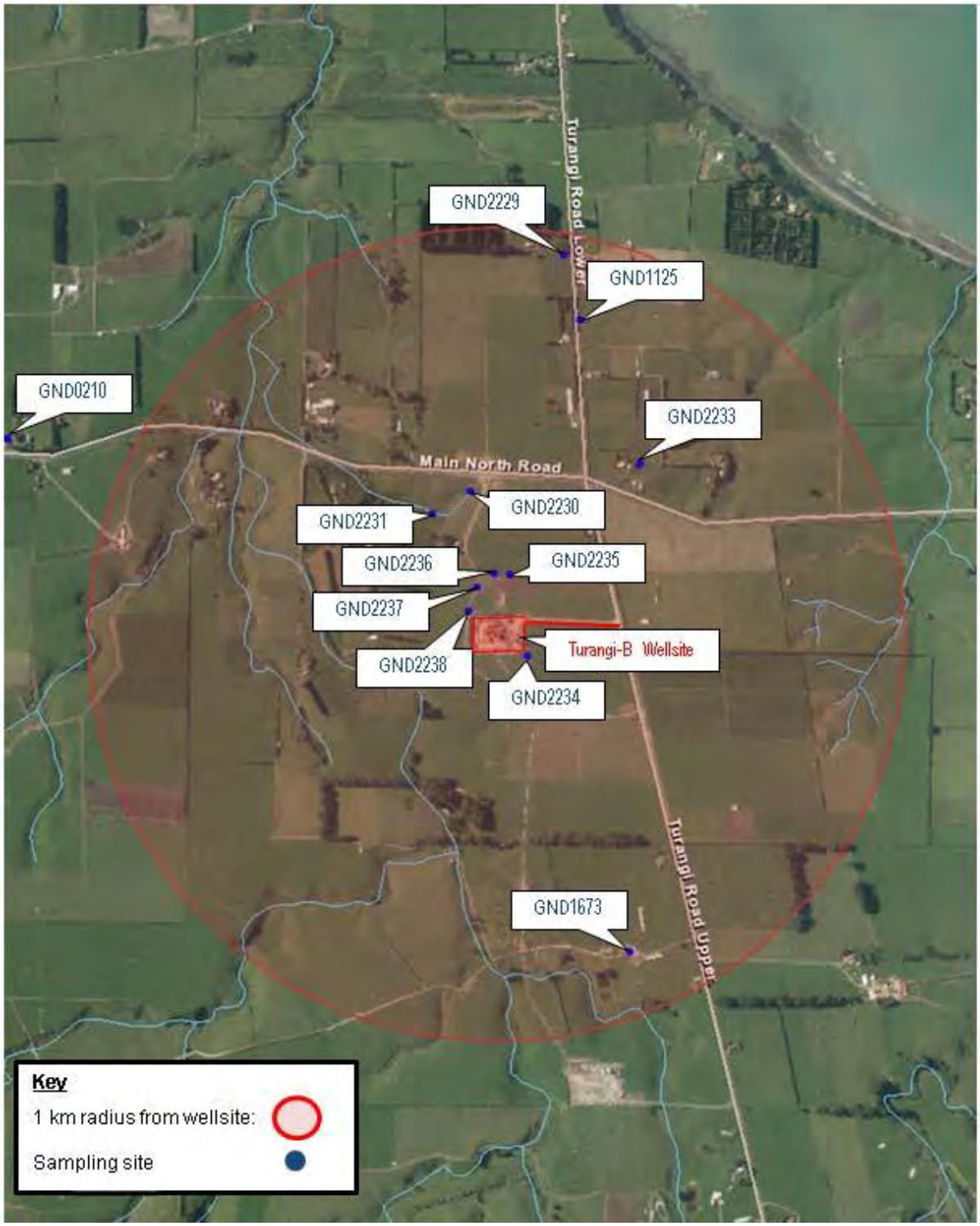

Figure 2 Location of groundwater sampling sites in relation to the Turangi-B wellsite

Samples of groundwater were obtained before fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out post-fracturing for comparison with baseline results.

Seven rounds of groundwater sampling occurred between November 2011 and November 2012. The results of these sampling rounds are outlined in the 2011-2013 biennial report (Taranaki Regional Council, 2013).

Where access to the bore was available, samples were obtained using a pneumatic bladder or peristaltic pump, using a low-flow sampling methodology. Where access to the bore was not available, samples were obtained at a point in the water distribution network as close to the wellhead as practicable. Samples taken from wide diameter wells were taken directly from the well. All samples were transported to Hill Laboratories Limited for analysis following standard chain of custody procedures.

2. Results

2.1 Groundwater sampling

A total of eleven sites were sampled between April 2013 and January 2015 to monitor the effects of the hydraulic fracturing of the Turangi-4 well on local groundwater resources.

As a continuation of the 2011–2013 biennial report, key indicator parameters pH, electrical conductivity and chloride are plotted against time (Figures 3, 4 and 6). Changes in the concentration of these parameters may indicate the migration of deep formation water, which is highly saline in composition, via 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 monitoring carried out indicate that the pH concentrations in all the private water supplies sampled remained consistent across the sampling period. Electrical conductivity values were consistent across most sites, but varied at GND2229, where they dropped throughout the monitoring period. There were some minor variations in chloride concentrations at the private water supplies. The changes in the concentrations of these analytes are a result of natural variations in water composition and are unrelated to fracturing activities.

In the 2011-2013 report, a slight increase in chloride concentration was detected in samples obtained from the wellsite monitoring wells, GND2237 and GND2238. As Figure 6 shows, chloride concentrations in these wells have fallen considerably since the last round of sampling.

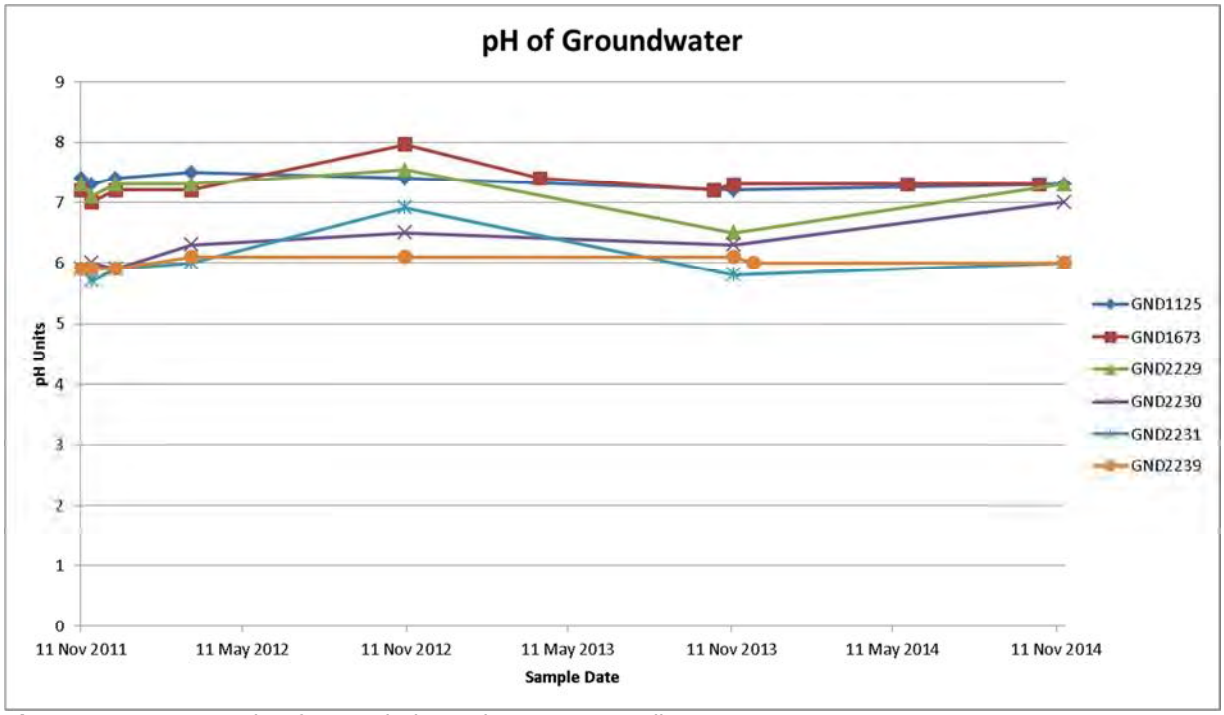

Figure 3 Results of pH analysis at private water supplies

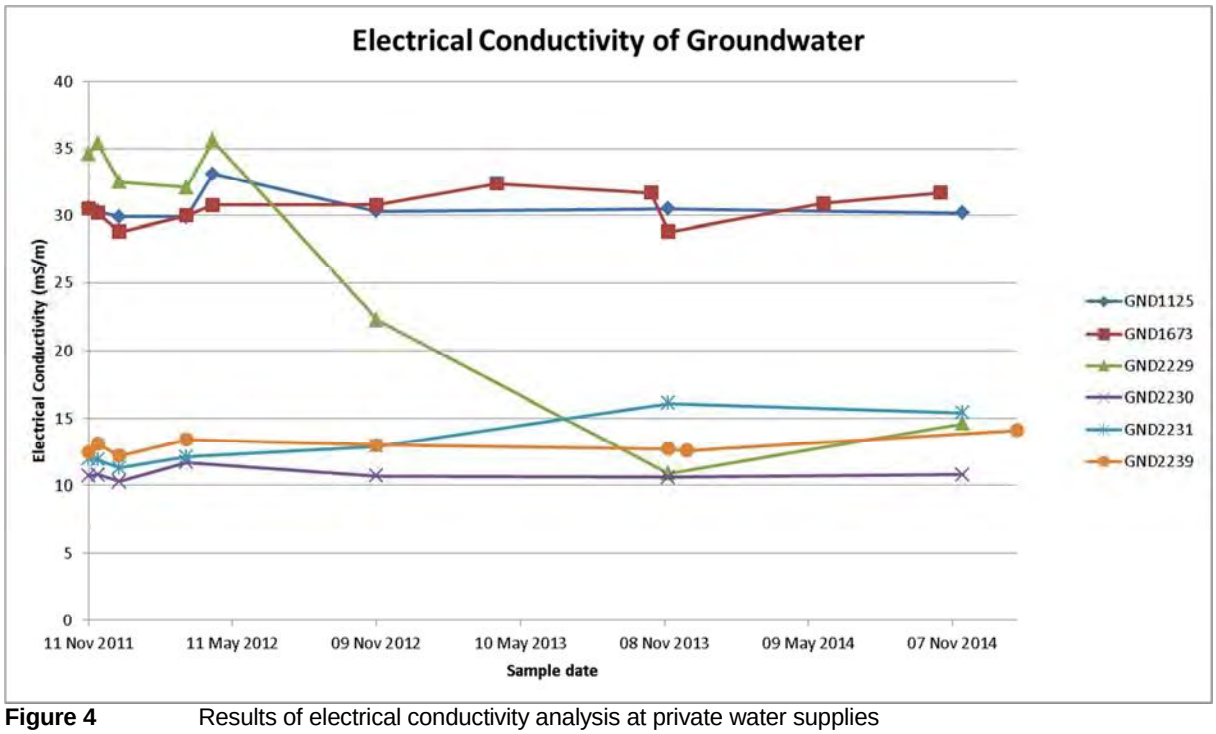

Figure 4 Results of electrical conductivity analysis at private water supplies

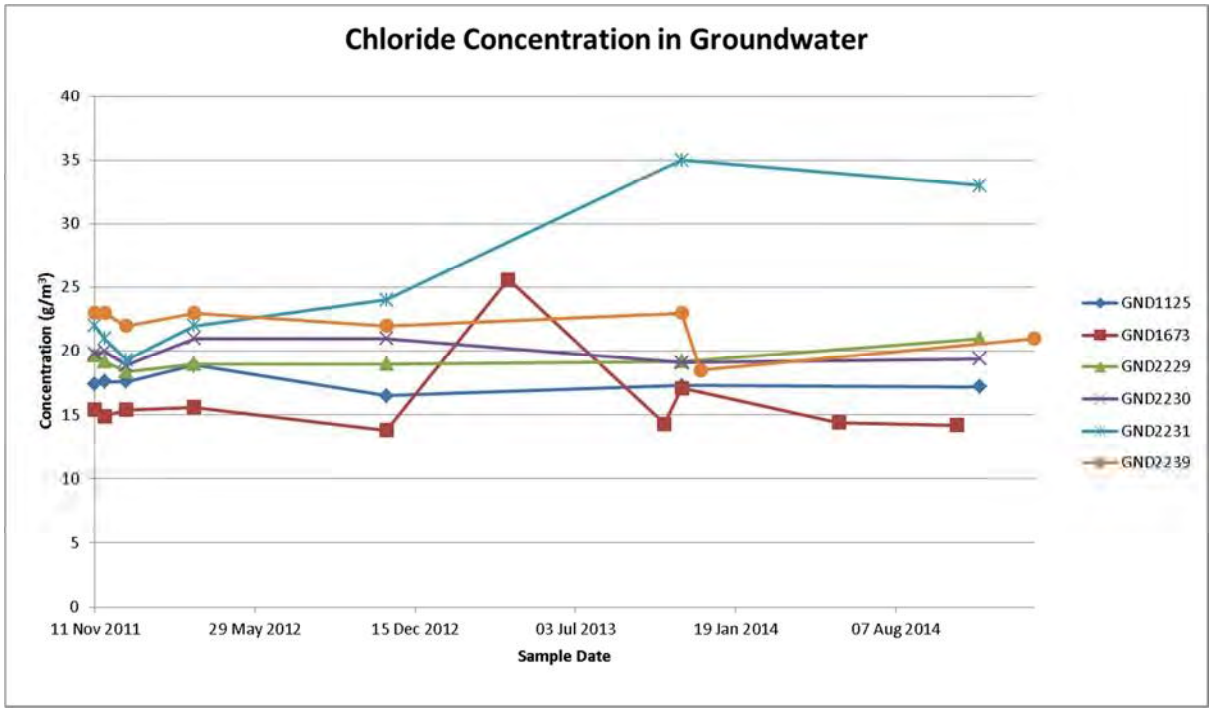

Figure 5 Results of chloride analysis at private water supplies

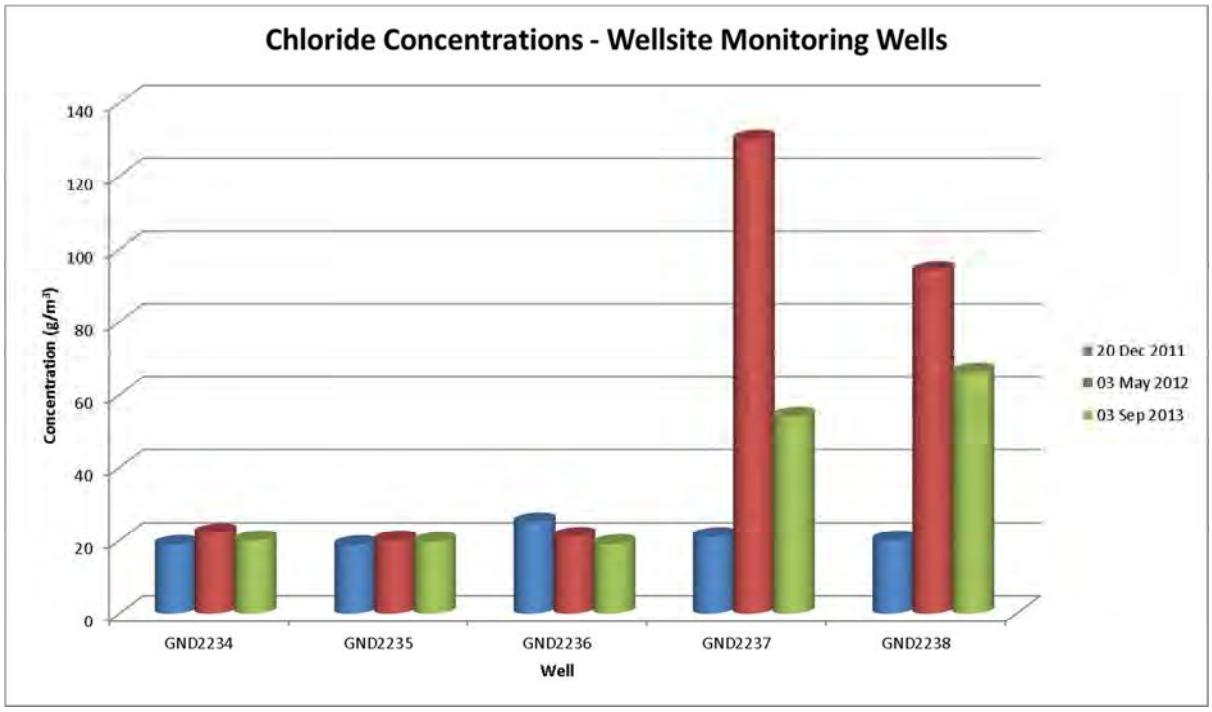

Figure 6 Results of electrical conductivity analysis at wellsite monitoring wells

There were no traces of any substance associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities, in any of the post-fracturing samples obtained from the private water supply wells during the monitoring period. Methane was detected at all private groundwater supply sites sampled. Concentrations were generally low and within the expected ranges typically seen in shallow groundwater across Taranaki.

The full results of the groundwater monitoring carried out during the period under review are included in Appendix IV.

2.2 Carbon isotope analysis

During the period being reported, three groundwater samples were sent to GNS Science for carbon isotope 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. Results of analyses undertaken in the period being reported are compared with previous results in Table 3 below.

Table 3 Results of carbon isotope analysis at private water supplies

GND1125		GND1673		GND2229	
26/09/12	20/11/14	16/04/12	5/11/14	16/04/12	20/11/14
-87‰	-86‰	-63‰	-74‰	-49‰	-92‰

Table 3 shows that the methane gas present in GND1125 and GND1673 is strongly biogenic. The result from the most recent carbon isotope analysis in GND2229 indicates that the methane present is more biogenic in origin than that tested in 2012.

It is important to note that the results were issued from the analysing laboratory with an uncertainty of measurement of ±10‰

2.3 Investigations, interventions, and incidents

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

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

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

During the period under review, there was no requirement for the Council to undertake any significant additional investigations and/or interventions, or record incidents, in association with the conditions in Greymouth's resource consent for hydraulic fracturing at the Turangi-B wellsite or provisions in Regional Plans.

3. Discussion

3.1 Environmental effects of hydraulic fracturing on useable freshwater resources

This is a report regarding on-going monitoring of hydraulic fracturing that occurred in the 2011-2012 period.

To assess the level of environmental performance and compliance by Greymouth during the period being reported, the monitoring programme implemented by the Council included both groundwater and surface water monitoring components. The groundwater monitoring component of the programme included the sampling of groundwater at selected sites in the vicinity of the hydraulically fractured well. The groundwater system was surveyed prior to any hydraulic fracturing occurring to determine baseline conditions, allowing comparisons to be made with post-fracturing results.

The results of post-fracturing groundwater sampling carried out in the vicinity of the Turangi-4 well showed only very minor variations in water composition in comparison to baseline results. The minor variations in some analytes are a result of natural variations in water composition and unrelated to fracturing activities.

Methane was detected in low concentrations in all of the private water supply wells. Concentrations were within the expected range for shallow groundwater in Taranaki. Carbon isotope analysis carried out in 2012 and 2014 indicates that the methane gas present in GND1125 and GND1673 is strongly biogenic in origin. The origin of the methane gas in GND2229 is more variable, with the 2014 analysis indicating a strong biogenic origin and the 2012 analysis indicating neither a strongly biogenic or thermogenic origin. GND2229 also has a highly variable methane concentration, which may be affecting results or indicating natural fluxes in gas flow. No traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities were present in the groundwater.

In summary, the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Greymouth during the period being reported had no adverse effects on local groundwater resources.

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 4.

Table 4 Summary of performance for Consent 7952-1:
To discharge contaminants in association with hydraulic fracturing activities into land at depths greater than 3,410 mTVD beneath the Turangi-B wellsite.

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,410 mTVD	Assessment of consent holder submitted data	Yes
2. No discharge shall occur more than 500 m horizontally from the wellsite	Assessment of consent holder submitted data	Yes
3. Exercise of consent shall not result in any contaminants reaching any useable freshwater aquifers	Results of groundwater monitoring	Yes
4. Consent holder shall undertake sampling programme	Development and certification of a Monitoring Programme	Yes
5. Sampling required by condition 4 shall be undertaken at certain periods before and after the exercise of the consent.	Assessment of consent holder submitted data	Yes
6. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan.	Development and certification of a Sampling and Analysis Plan	Yes
7. Consent holder shall notify the Council of hydraulic fracturing discharge.	Notification received	Yes
8. A post-fracturing discharge report is to be provided to the Council within 30 working days after the discharge ceases.	Post-fracturing discharge report received	Yes
9. The reports outlined in conditions 8 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
10. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers	Access provided	Yes
11. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
12. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
13. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance and compliance in respect of this consent		High

During the 2012-2015 monitoring period, Greymouth demonstrated a high level of environmental and a high level of administrative performance and compliance with its resource consents as defined in Section 1.1.4.

3.3 Alterations to monitoring programmes for 2015-2016

In designing and implementing the monitoring programmes for air/water discharges in the region, the Council has taken into account the extent of information made available by previous authorities, its relevance under the RMA the obligations of the RMA in terms of monitoring emissions/discharges and effects, and subsequently reporting to the regional community. The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that for 2015-2016 year no further monitoring be carried out in relation to previously undertaken hydraulic fracturing events at the Turangi-B wellsite. Monitoring should recommence however if any further fracturing is undertaken at the site.

3.4 Exercise of optional review of consent

Resource consent 7952-1 provides for an optional review of the consent an annual basis, with the next optional review date being November 2015. Condition 13 of this consent allows the Council to review consent conditions to ensure they 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. The Council can also review the consent in order to further specify the best practicable option and/or to ensure that hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Following an assessment of the current consent conditions and the results of monitoring undertaken over the period under review, it is considered that there are no grounds that require a review to be pursued or grounds to exercise the review option.

4. Recommendations

1. THAT no further monitoring be carried out in relation to previously undertaken hydraulic fracturing events at the Turangi-B wellsite. Monitoring should recommence however if any further fracturing is undertaken at the site.

2. THAT the option for a review of the resource consent in November 2015, as set out in condition 13 of consent 7952-1, is not exercised, on the grounds that the current conditions of the consents are adequate to ensure that any significant adverse effects on the environment are avoided.

Glossary of common terms and abbreviations

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

Biomonitoring	Assessing the health of the environment using aquatic organisms.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
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.
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.

Bibliography and references

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 1)

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 2)

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 2 re-fracture)

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 3)

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 4)

Greymouth Petroleum Limited (2011) Turangi 4 Post Fracturing Discharge Report (Zone 5)

Taranaki Regional Council (2013) Turangi-B Hydraulic Fracturing Groundwater Monitoring Programme Report 2011-2013. Technical Report 2013-14.

Appendix II

Resource consent held by Greymouth

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE: 06-765 7127
FAX: 06-765 5097
www.trc.govt.nz
Please quote our file number 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:	Greymouth Petroleum Limited P O Box 3394 NEW PLYMOUTH 4341
Decision Date:	8 November 2011
Commencement Date:	8 November 2011

Conditions of Consent

Consent Granted:	To discharge contaminants in association with hydraulic fracturing activities into land at depths greater than 3,410 mTVD beneath the Turangi-B wellsite at or about (NZTM) 1713604E-5682493N
Expiry Date:	1 June 2016
Review Date(s):	November 2012, November 2013, November 2014, November 2015
Site Location:	Turangi-B wellsite, 650 Main North Road, Motunui [Property owner: RJ Topless]
Legal Description:	Pt Lot 2 DP 7153 Blk VI Waitara SD[Discharge source & site]
Catchment:	Parahaki

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 [the 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 3410 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 m horizontally from the 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 monitor the effects of the exercise of this consent by recording the water level and sampling all wells and bores that are used for water supply within a 1 km radius of the Turangi-B wellsite, along with two control sites. The 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. The sampling required by condition 4 shall be undertaken before this consent is exercised and 1 week, 1 month, 3 months and 1 year after the date that this consent is first exercised.

6. 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 Council or other contracted party on behalf of the consent holder.

7. 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.

8. At the conclusion of the 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 6922.

9. The reports described in condition 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 November each year, for the purposes of:

    (a) Requiring sampling times in addition to those specified in condition 5; and/or

    (b) 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 8 November 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix III

Certifcates of analysis

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:**	1175595 SPv1
Contact:	Regan Phipps	**Date Registered:**	04-Sep-2013
	C/- Taranaki Regional Council	**Date Reported:**	10-Sep-2013
	Private Bag 713	**Quote No:**	
	STRATFORD 4352	**Order No:**	
		Client Reference:	Turangi-B Groundwater
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2234 03-Sep-2013 11:25 am	GND2238 03-Sep-2013 11:40 am	GND2237 03-Sep-2013 12:10 pm	GND2236 03-Sep-2013 12:30 pm	GND2235 03-Sep-2013 12:45 pm
Lab Number:		1175595.1	1175595.2	1175595.3	1175595.4	1175595.5
Individual Tests						
Sum of Anions	meq/L	0.92	4.7	1.86	0.91	1.00
Sum of Cations	meq/L	0.89	4.6	1.85	0.89	0.99
pH	pH Units	7.1	6.2	6.2	6.2	6.2
Total Alkalinity	g/m³ as $CaCO_3$	11.8	12.3	10.5	13.8	16.8
Bicarbonate	g/m³ at 25°C	14.4	15.0	12.8	16.8	20
Total Hardness	g/m³ as $CaCO_3$	22	155	67	22	25
Electrical Conductivity (EC)	mS/m	10.6	57.0	22.8	10.4	11.3
Dissolved Calcium	g/m³	4.3	47	22	4.2	5.4
Dissolved Magnesium	g/m³	2.9	9.0	2.9	2.8	2.9
Dissolved Potassium	g/m³	1.20	11.1	4.6	1.05	1.42
Dissolved Sodium	g/m³	9.4	28	8.8	9.7	10.2
Chloride	g/m³	20	155	55	19.0	19.6
Nitrite-N	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m³	0.58	0.55	0.41	0.34	0.26
Nitrate-N + Nitrite-N	g/m³	0.58	0.55	0.41	0.34	0.26
Sulphate	g/m³	3.7	4.7	2.9	3.7	4.7
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m³	< 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
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Samples**
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/m³ 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/m³ at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m³ as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	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.	-	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m³	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m³	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m³	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m³	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/m³	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3- I 21st ed. 2005.	0.002 g/m³	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m³	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m³	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m³	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.

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

Hill Laboratories
BETTER TESTING BETTER RESULTS

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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:**	1175595 SPv1
Contact:	Regan Phipps	**Date Registered:**	04-Sep-2013
	C/- Taranaki Regional Council	**Date Reported:**	10-Sep-2013
	Private Bag 713	**Quote No:**	
	STRATFORD 4352	**Order No:**	
		Client Reference:	Turangi-B Groundwater
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND2234 03-Sep-2013 11:25 am	GND2238 03-Sep-2013 11:40 am	GND2237 03-Sep-2013 12:10 pm	GND2236 03-Sep-2013 12:30 pm	GND2235 03-Sep-2013 12:45 pm
Lab Number:		1175595.1	1175595.2	1175595.3	1175595.4	1175595.5
Individual Tests						
Sum of Anions	meq/L	0.92	4.7	1.86	0.91	1.00
Sum of Cations	meq/L	0.89	4.6	1.85	0.89	0.99
pH	pH Units	7.1	6.2	6.2	6.2	6.2
Total Alkalinity	g/m³ as $CaCO_3$	11.8	12.3	10.5	13.8	16.8
Bicarbonate	g/m³ at 25°C	14.4	15.0	12.8	16.8	20
Total Hardness	g/m³ as $CaCO_3$	22	155	67	22	25
Electrical Conductivity (EC)	mS/m	10.6	57.0	22.8	10.4	11.3
Dissolved Calcium	g/m³	4.3	47	22	4.2	5.4
Dissolved Magnesium	g/m³	2.9	9.0	2.9	2.8	2.9
Dissolved Potassium	g/m³	1.20	11.1	4.6	1.05	1.42
Dissolved Sodium	g/m³	9.4	28	8.8	9.7	10.2
Chloride	g/m³	20	155	55	19.0	19.6
Nitrite-N	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m³	0.58	0.55	0.41	0.34	0.26
Nitrate-N + Nitrite-N	g/m³	0.58	0.55	0.41	0.34	0.26
Sulphate	g/m³	3.7	4.7	2.9	3.7	4.7
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m³	< 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
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-5

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Samples**
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/m³ 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/m³ at 25°C	1-5
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21st ed. 2005.	1.0 g/m³ as $CaCO_3$	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	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.	-	1-5
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m³	1-5
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m³	1-5
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.05 g/m³	1-5
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.02 g/m³	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/m³	1-5
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3- I 21st ed. 2005.	0.002 g/m³	1-5
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.002 g/m³	1-5
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 21st ed. 2005.	0.002 g/m³	1-5
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m³	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.

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

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BETTER TESTING BETTER RESULTS

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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:**	1202894 SPv1
Contact:	Regan Phipps	**Date Registered:**	14-Nov-2013
	C/- Taranaki Regional Council	**Date Reported:**	21-Nov-2013
	Private Bag 713	**Quote No:**	47915
	STRATFORD 4352	**Order No:**	
		Client Reference:	Turangi B-Post HF GW
		Submitted By:	Regan Phipps

Sample Type: Aqueous

Sample Name:		GND 2229 13-Nov-2013 10:00 am	GND 1125 13-Nov-2013 10:45 am	GND 2239 13-Nov-2013 11:15 am	GND 1673 13-Nov-2013 12:20 pm	GND 2230 13-Nov-2013 12:45 pm
Lab Number:		1202894.1	1202894.2	1202894.3	1202894.4	1202894.5
Individual Tests						
Sum of Anions	meq/L	0.97	3.2	1.12	3.0	0.94
Sum of Cations	meq/L	0.96	3.2	1.17	3.2	1.19
pH	pH Units	6.5	7.2	6.1	7.3	6.3
Total Alkalinity	g/m³ as $CaCO_3$	15.3	120	14.8	125	14.2
Bicarbonate	g/m³ at 25°C	18.6	146	18.0	152	17.3
Total Hardness	g/m³ as $CaCO_3$	24	95	26	82	25
Electrical Conductivity (EC)	mS/m	10.9	30.5	12.7	28.8	10.6
Total Dissolved Solids (TDS)	g/m³	91	240	105	230	91
Dissolved Barium	g/m³	0.0159	0.020	0.023	0.027	0.0189
Dissolved Bromine*	g/m³	0.077	0.057	0.084	0.065	0.082
Dissolved Calcium	g/m³	4.5	21	4.8	17.2	4.6
Dissolved Copper	g/m³	0.0052	0.0007	0.0009	< 0.0005	0.0022
Dissolved Iron	g/m³	0.19	5.0	< 0.02	7.1	0.10
Dissolved Magnesium	g/m³	3.1	10.2	3.4	9.4	3.2
Dissolved Manganese	g/m³	0.038	0.163	0.0036	0.169	0.021
Dissolved Mercury	g/m³	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved Nickel	g/m³	0.0008	< 0.0005	< 0.0005	0.0006	< 0.0005
Dissolved Potassium	g/m³	2.1	6.9	3.3	4.7	10.5
Dissolved Sodium	g/m³	9.6	22	13.0	26	9.7
Dissolved Zinc	g/m³	0.030	0.052	0.0122	0.0110	0.031
Chloride	g/m³	19.2	17.3	23	17.1	19.1
Nitrite-N	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m³	0.37	0.003	1.00	0.28	0.31
Nitrate-N + Nitrite-N	g/m³	0.37	0.004	1.00	0.28	0.31
Sulphate	g/m³	4.9	13.9	5.7	1.1	4.8
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	< 4	16	4	< 4
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	25	6	< 4
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	< 2	< 2	< 2	< 2
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Sample Type: Aqueous						
Sample Name:		GND 2229 13-Nov-2013 10:00 am	GND 1125 13-Nov-2013 10:45 am	GND 2239 13-Nov-2013 11:15 am	GND 1673 13-Nov-2013 12:20 pm	GND 2230 13-Nov-2013 12:45 pm
Lab Number:		1202894.1	1202894.2	1202894.3	1202894.4	1202894.5
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Gases in groundwater						
Ethane	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Ethylene	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Methane	g/m³	0.011	0.96	< 0.002	2.8	0.013
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	0.4
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Sample Name:		GND 2231 13-Nov-2013 1:30 pm				
Lab Number:		1202894.6				
Individual Tests						
Sum of Anions	meq/L	1.39	-	-	-	-
Sum of Cations	meq/L	1.37	-	-	-	-
pH	pH Units	5.8	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	13.5	-	-	-	-
Bicarbonate	g/m³ at 25°C	16.5	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$	38	-	-	-	-
Electrical Conductivity (EC)	mS/m	16.1	-	-	-	-
Total Dissolved Solids (TDS)	g/m³	142	-	-	-	-
Dissolved Barium	g/m³	0.021	-	-	-	-
Dissolved Bromine*	g/m³	0.094	-	-	-	-
Dissolved Calcium	g/m³	7.4	-	-	-	-
Dissolved Copper	g/m³	< 0.0005	-	-	-	-
Dissolved Iron	g/m³	0.04	-	-	-	-
Dissolved Magnesium	g/m³	4.7	-	-	-	-
Dissolved Manganese	g/m³	0.021	-	-	-	-
Dissolved Mercury	g/m³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m³	3.2	-	-	-	-
Dissolved Sodium	g/m³	12.1	-	-	-	-
Dissolved Zinc	g/m³	0.0048	-	-	-	-
Chloride	g/m³	35	-	-	-	-
Nitrite-N	g/m³	< 0.002	-	-	-	-
Nitrate-N	g/m³	0.24	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.24	-	-	-	-
Sulphate	g/m³	6.0	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-

Sample Type: Aqueous						
Sample Name:		GND 2231 13-Nov-2013 1:30 pm				
Lab Number:		1202894.6				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	0.003	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-6
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-6
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-6
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-6
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-6
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-6
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-6
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-6
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1-6
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1-6
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012.	0.1 pH Units	1-6
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-6
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 22nd ed. 2012.	1.0 g/m³ at 25°C	1-6
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-6
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-6
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) 22nd ed. 2012.	10 g/m³	1-6
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1-6
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-6
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-6
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-6
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-6
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-6
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-6

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-6
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1-6
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-6
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-6
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-6
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-6
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-6
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N.	0.0010 g/m^3	1-6
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m^3	1-6
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-6

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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Client Services Manager - Environmental Division

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1212961	SPv3
Contact:	Regan Phipps	**Date Registered:**	07-Dec-2013	
	C/- Taranaki Regional Council	**Date Reported:**	13-Dec-2013	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Turangi B GW Sample	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:		GND2239 06-Dec-2013 1:00 pm				
Lab Number:		1212961.1				
Individual Tests						
Sum of Anions	meq/L	1.07	-	-	-	-
Sum of Cations	meq/L	1.28	-	-	-	-
pH	pH Units	6.0	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	15.5	-	-	-	-
Bicarbonate	g/m³ at 25°C	18.9	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$	26	-	-	-	-
Electrical Conductivity (EC)	mS/m	12.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m³	90	-	-	-	-
Dissolved Barium	g/m³	0.026	-	-	-	-
Dissolved Bromine*	g/m³	0.078	-	-	-	-
Dissolved Calcium	g/m³	5.0	-	-	-	-
Dissolved Copper	g/m³	0.0014	-	-	-	-
Dissolved Iron	g/m³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m³	3.2	-	-	-	-
Dissolved Manganese	g/m³	0.0054	-	-	-	-
Dissolved Mercury	g/m³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m³	11.0	-	-	-	-
Dissolved Sodium	g/m³	11.3	-	-	-	-
Dissolved Zinc	g/m³	0.034	-	-	-	-
Chloride	g/m³	18.5	-	-	-	-
Nitrite-N	g/m³	< 0.002	-	-	-	-
Nitrate-N	g/m³	1.39	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	1.39	-	-	-	-
Sulphate	g/m³	6.8	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-

Sample Type: Aqueous						
Sample Name:		GND2239 06-Dec-2013 1:00 pm				
Lab Number:		1212961.1				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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
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 22nd ed. 2012.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1

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

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

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1354080	SPv1
Contact:	Regan Phipps	**Date Registered:**	21-Nov-2014	
	C/- Taranaki Regional Council	**Date Reported:**	27-Nov-2014	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Turangi B - Post HF GW	
		Submitted By:	R McDonnell	

Sample Type: Aqueous

Sample Name:		GND2229 20-Nov-2014 8:40 am	GND1125 20-Nov-2014 9:15 am	GND2230 20-Nov-2014 10:43 am	GND2231 20-Nov-2014 11:45 am	
Lab Number:		1354080.1	1354080.2	1354080.3	1354080.4	
Individual Tests						
Sum of Anions	meq/L	1.37	3.1	0.95	1.33	-
Sum of Cations	meq/L	1.54	3.5	1.01	1.39	-
pH	pH Units	7.3	7.3	7.0	6.0	-
Total Alkalinity	g/m³ as $CaCO_3$	37	132	13.0	13.5	-
Bicarbonate	g/m³ at 25°C	45	160	15.8	16.5	-
Total Hardness	g/m³ as $CaCO_3$	39	99	26	37	-
Electrical Conductivity (EC)	mS/m	14.6	30.2	10.8	15.4	-
Total Dissolved Solids (TDS)	g/m³	71	210	74	108	-
Dissolved Barium	g/m³	0.0085	0.023	0.0160	0.021	-
Dissolved Bromine*	g/m³	0.082	0.057	0.077	0.092	-
Dissolved Calcium	g/m³	8.7	22	4.8	7.6	-
Dissolved Copper	g/m³	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Iron	g/m³	3.9	7.6	0.02	0.03	-
Dissolved Magnesium	g/m³	4.2	10.5	3.3	4.4	-
Dissolved Manganese	g/m³	0.27	0.169	0.0095	0.0180	-
Dissolved Mercury	g/m³	< 0.00008	< 0.00008	< 0.00008	< 0.00008	-
Dissolved Nickel	g/m³	0.0011	< 0.0005	< 0.0005	< 0.0005	-
Dissolved Potassium	g/m³	3.2	7.3	2.3	2.9	-
Dissolved Sodium	g/m³	12.0	24	10.2	13.1	-
Dissolved Zinc	g/m³	0.0086	0.40	0.0025	0.0023	-
Chloride	g/m³	21	17.2	19.4	33	-
Nitrite-N	g/m³	0.004	< 0.002	< 0.002	< 0.002	-
Nitrate-N	g/m³	< 0.002	< 0.002	0.35	0.24	-
Nitrate-N + Nitrite-N	g/m³	0.005	< 0.002	0.35	0.24	-
Sulphate	g/m³	1.2	< 0.5	5.7	6.3	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Toluene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Ethylbenzene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
m&p-Xylene	g/m³	< 0.002	< 0.002	< 0.002	< 0.002	-

Sample Type: Aqueous						
Sample Name:		GND2229 20-Nov-2014 8:40 am	GND1125 20-Nov-2014 9:15 am	GND2230 20-Nov-2014 10:43 am	GND2231 20-Nov-2014 11:45 am	
Lab Number:		1354080.1	1354080.2	1354080.3	1354080.4	
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	< 0.02	< 0.02	< 0.02	-
Gases in groundwater						
Ethane	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Ethylene	g/m³	< 0.003	< 0.003	< 0.003	< 0.003	-
Methane	g/m³	0.43	1.87	0.011	0.004	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	< 0.2	-
C15 - C36	g/m³	< 0.4	< 0.4	< 0.4	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m³	< 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**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1-4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1-4
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1-4
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1-4
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1-4
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	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 22nd ed. 2012.	0.1 pH Units	1-4
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ 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 22nd ed. 2012.	1.0 g/m³ at 25°C	1-4
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1-4
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m³	1-4
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1-4
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1-4
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1-4
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1-4
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1-4
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1-4
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1-4
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-4
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1-4
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	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:**	1377810	SPv1
Contact:	Regan Phipps	**Date Registered:**	28-Jan-2015	
	C/- Taranaki Regional Council	**Date Reported:**	11-Feb-2015	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Turangi B- Post HF	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:		GND 2239 27-Jan-2015 10:45 am				
Lab Number:		1377810.1				
Individual Tests						
Sum of Anions	meq/L	1.18	-	-	-	-
Sum of Cations	meq/L	1.17	-	-	-	-
pH	pH Units	6.0	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	14.5	-	-	-	-
Bicarbonate	g/m³ at 25°C	17.7	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$	28	-	-	-	-
Electrical Conductivity (EC)	mS/m	14.1	-	-	-	-
Total Dissolved Solids (TDS)	g/m³	94	-	-	-	-
Dissolved Barium	g/m³	0.029	-	-	-	-
Dissolved Bromine*	g/m³	0.100	-	-	-	-
Dissolved Calcium	g/m³	5.6	-	-	-	-
Dissolved Copper	g/m³	< 0.0005	-	-	-	-
Dissolved Iron	g/m³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m³	3.4	-	-	-	-
Dissolved Manganese	g/m³	0.0029	-	-	-	-
Dissolved Mercury	g/m³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m³	3.6	-	-	-	-
Dissolved Sodium	g/m³	11.8	-	-	-	-
Dissolved Zinc	g/m³	0.0062	-	-	-	-
Chloride	g/m³	21	-	-	-	-
Nitrite-N	g/m³	< 0.002	-	-	-	-
Nitrate-N	g/m³	2.1	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	2.1	-	-	-	-
Sulphate	g/m³	6.7	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-

Sample Type: Aqueous						
Sample Name:		GND 2239 27-Jan-2015 10:45 am				
Lab Number:		1377810.1				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	0.013	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1

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

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

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1377810	SPv1
Contact:	Regan Phipps	**Date Registered:**	28-Jan-2015	
	C/- Taranaki Regional Council	**Date Reported:**	11-Feb-2015	
	Private Bag 713	**Quote No:**	47915	
	STRATFORD 4352	**Order No:**		
		Client Reference:	Turangi B- Post HF	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:		GND 2239 27-Jan-2015 10:45 am				
Lab Number:		1377810.1				
Individual Tests						
Sum of Anions	meq/L	1.18	-	-	-	-
Sum of Cations	meq/L	1.17	-	-	-	-
pH	pH Units	6.0	-	-	-	-
Total Alkalinity	g/m³ as $CaCO_3$	14.5	-	-	-	-
Bicarbonate	g/m³ at 25°C	17.7	-	-	-	-
Total Hardness	g/m³ as $CaCO_3$	28	-	-	-	-
Electrical Conductivity (EC)	mS/m	14.1	-	-	-	-
Total Dissolved Solids (TDS)	g/m³	94	-	-	-	-
Dissolved Barium	g/m³	0.029	-	-	-	-
Dissolved Bromine*	g/m³	0.100	-	-	-	-
Dissolved Calcium	g/m³	5.6	-	-	-	-
Dissolved Copper	g/m³	< 0.0005	-	-	-	-
Dissolved Iron	g/m³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m³	3.4	-	-	-	-
Dissolved Manganese	g/m³	0.0029	-	-	-	-
Dissolved Mercury	g/m³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Potassium	g/m³	3.6	-	-	-	-
Dissolved Sodium	g/m³	11.8	-	-	-	-
Dissolved Zinc	g/m³	0.0062	-	-	-	-
Chloride	g/m³	21	-	-	-	-
Nitrite-N	g/m³	< 0.002	-	-	-	-
Nitrate-N	g/m³	2.1	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	2.1	-	-	-	-
Sulphate	g/m³	6.7	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.0010	-	-	-	-
Toluene	g/m³	< 0.0010	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-

Sample Type: Aqueous						
Sample Name:		GND 2239 27-Jan-2015 10:45 am				
Lab Number:		1377810.1				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m³	< 0.003	-	-	-	-
Ethylene	g/m³	< 0.003	-	-	-	-
Methane	g/m³	0.013	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	-	-	-	-
C10 - C14	g/m³	< 0.2	-	-	-	-
C15 - C36	g/m³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m³	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m³ as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	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) 22nd ed. 2012.	10 g/m³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m³	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m³	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m³	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m³	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012.	0.002 g/m³	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m³	1

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

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

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

Appendix IV

Results of physiochemical analysis

Site	GND1125									GND1673						
	Pre-frac	Post-frac								Pre-frac	Post-frac					
Date	11 Nov 2011	23 Nov 2011	20 Dec 2011	16 Apr 2012	14 Mar 2012	26 Oct 2012	09 Nov 2012	13 Nov 2013	20 Nov 2014	11 Nov 2011	23 Nov 2011	20 Dec 2011	16 Apr 2012	14 Mar 2012	09 Nov 2012	10 Apr 2013
Sample Number	112816	112974	113250	121414	121430	-	123895	137846	1412081	112815	112973	113249	121415	121429	123896	135576
pH	7.4	7.3	7.4	7.7	7.5	-	7.4	7.2	7.3	7.2	7	7.2	7.7	7.2	7.2	7.4
Temperature (ºC)	16.9	15.5	15.8	15.8	16	-	15.9	15.3	15.4	16.1	15.3	15.9	15.3	16	15.6	15.8
Electrical Conductivity (EC)	30.6	30.3	29.9	33.1	29.9	-	30.3	30.5	30.2	30.5	30.2	28.8	30.8	30	30.8	32.4
Total Alkalinity (g/m³ as $CaCO_3$)	132	132	133	-	132	-	132	120	132	137	138	131	-	141	142	153
Bicarbonate (g/m³ at 25 ^{o}C)	161.04	161.04	162	-	161	-	161	146.4	160	166	168	159.82	-	172.02	173	-
Total Hardness (g/m³ as CaCO3)	97	95	96	-	96	-	92	95	99	91	88	87	-	89	89	-
Suspended Solids (g/m³)	310	47	82	-	55	-	-	-	-	142	18	129	-	190	-	-
Total Dissolved Solids (g/m³)	-	-	-	-	-	-	250.7	240	210	-	-	-	-	-	210	-
Barium (g/m³)	-	-	-	-	-	-	0.021	-	0.023	-	-	-	-	-	0.021	-
Bromide (g/m³)	-	-	-	-	-	-	<0.05	0.057	0.057	-	-	-	-	-	<0.07	-
Dissolved Cadmium (g/m³)	<0.00005	<0.00005	<0.00005	-	<0.00005	-	-	-	-	<0.00005	<0.00005	<0.00005	-	<0.00005	-	-
Dissolved Calcium (g/m³)	21	21	21	-	21	-	21	21	22	19.2	18.6	18.5	-	18.9	18.9	-
Dissolved Copper (g/m³)	<0.0005	<0.0005	<0.0005	-	0.0006	-	<0.0005	0.0007	<0.0005	<0.0005	0.0006	<0.0005	-	0.0009	<0.0005	-
Dissolved Iron (g/m³)	0.33	0.55	0.67	-	4.9	-	5.3	5.0	7.6	0.24	0.25	0.3	-	6.7	8.3	-
Dissolved Magnesium (g/m³)	10.6	10.6	10.4	-	10.3	-	9.9	10.2	10.5	10.4	10	10	-	10.2	10.1	-
Dissolved Manganese (g/m³)	0.142	0.147	0.146	-	0.157	-	0.163	0.163	0.169	0.184	0.18	0.163	-	0.184	0.2	-
Dissolved Nickel (g/m³)	0.0009	<0.0005	<0.0005	-	0.0007	-	<0.0005	<0.0005	<0.0005	0.0072	0.0019	0.0007	-	0.0022	<0.0005	-
Dissolved Potassium (g/m³)	6.9	6.6	6.6	-	6.8	-	7.1	6.9	7.3	5.2	5.1	4.7	-	5.2	5.3	-
Dissolved Sodium (g/m³)	23	22	22	-	22	-	24	22	24	28	27	26	-	27	30	-
Dissolved Zinc (g/m³)	0.00127	0.028	0.0167	-	0.073	-	0.108	0.052	0.40	0.053	0.0195	0.043	-	0.049	0.014	-
Chloride (g/m³)	17.4	17.6	17.6	-	18.9	-	16.5	17.3	17.2	15.4	14.9	15.4	-	15.6	13.8	25.6
Nitrite (g/m³)	0.003	<0.002	<0.002	-	<0.002	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	<0.002	<0.002	-
Nitrate (g/m³)	0.002	<0.002	<0.002	-	0.01	-	<0.002	0.003	<0.002	0.004	<0.002	<0.002	-	0.003	<0.002	-
Nitrate + Nitrite (g/m³)	0.005	<0.002	0.003	-	0.01	-	<0.002	0.004	<0.002	0.005	<0.002	0.003	-	0.003	0.002	-
Sulphate (g/m³)	3.3	<0.5	<0.5	-	<0.5	-	<0.5	13.9	<0.5	4.5	<0.5	1.8	-	<0.5	0.5	-
Ethylene Glycol (g/m³)	-	-	-	-	-	-	<4	<0.003	<0.003	-	-	-	-	-	<4	-
Methanol (g/m³)	-	-	-	-	-	-	<2	<2	<2	-	-	-	-	-	<2	-
Formaldehyde (g/m³)	<0.02	0.02	<0.02	-	<0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02	<0.02	-
Ethane (g/m³)	<0.003	<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	-
Ethylene (g/m³)	<0.004	<0.004	<0.004	<0.004	<0.004	-	<0.004	<0.003	<0.003	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-
Methane (g/m³)	1.86	1.93	1.99	0.71	0.44	-	0.78	0.96	1.87	2.2	3.5	2.4	2.3	0.86	<2.2	-
δ^{13}C Analysis (‰)	-	-	-	-	-	-87	-	-	-86	-	-	-	-63	-	-	-
Total Petroleum Hydrocarbons (g/m³)	<0.7	<0.7	<0.7	-	<0.7	-	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	-	<0.7	<0.7	<0.5
Benzene (g/m³)	<0.0005	<0.0005	<0.0005	-	<0.0005	-	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	-
Toluene (g/m³)	<0.0010	<0.0010	<0.0010	-	<0.0010	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0010	<0.0010	-
Ethylbenzene (g/m³)	<0.0005	<0.0005	<0.0005	-	<0.0005	-	<0.0005	0.0010	<0.0010	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	-
Xylene (g/m³)	<0.0005	<0.0005	<0.0005	-	<0.0005	-	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	-

					GND2229								GND2230						
					Pre-frac	Post-frac							Pre-frac	Post-frac					
22 Oct 2013	13 Nov 2013	28 May 2014	23 Oct 2014	05 Nov 2014	11 Nov 2011	23 Nov 2011	20 Dec 2011	16 Apr 2012	14 Mar 2012	09 Nov 2012	13 Nov 2013	20 Nov 2014	11 Nov 2011	23 Nov 2011	20 Dec 2011	14 Mar 2012	09 Nov 2012	13 Nov 2013	20 Nov 2014
137392	137848	1410100	1412069	-	112817	112975	113251	121413	121431	123894	137845	1412080	112813	112971	113247	121427	123897	137849	1412082
7.2	7.3	7.3	7.3	-	7.3	7.1	7.3	7.3	7.3	6.6	6.5	7.3	5.9	6	5.9	6.3	6.5	6.3	7.0
15.7	15.8	15.2	16.1	-	16.5	15.9	16.1	15.7	16.7	15.7	16.4	12.2	19.3	15.5	15.2	16.6	15.4	17.7	15.3
31.7	28.8	30.9	31.7	-	34.6	35.4	32.5	35.6	32.1	22.3	10.9	14.6	10.7	10.8	10.3	11.7	10.7	10.6	10.8
145	125	139	143	-	151	156	146	-	144	86	15.3	37	13	13	12	15	13.6	14.2	13.0
176.9	152.5	169	174.5	-	184	190	178.12	-	175.68	105	18.7	45.1	15.4	15.5	14.64	18.3	16.6	17.3	15.8
89	82	86	94	-	111	113	105	-	101	71	24	39	25	24	24	25	24	25	26
-	-	-	-	-	3	<3	15	-	9	-	-	-	<3	<3	<3	4		-	-
220	230	230	220	-	-	-	-	-	-	171	91	71	-	-	-	-	77	91	74
-	-	0.021	0.023	-	-	-	-	-	-	0.0167	-	0.0085	-	-	-	-	0.0171	-	0.0160
0.07	0.065	0.062	0.07	-	-	-	-	-	-	0.11	0.077	0.082	-	-	-	-	0.11	0.082	0.077
-	-	-	-	-	<0.00005	<0.00005	<0.00005	-	<0.00005	-	-	-	<0.00005	<0.00005	<0.00005	<0.00005	-	-	-
19.1	17.2	18.5	19.6	-	25	24	24	-	22	15.4	4.5	8.7	4.5	4.3	4.5	4.8	4.4	4.6	4.8
<0.0005	<0.0005	<0.0005	<0.0005	-	0.0006	<0.0005	0.0005	-	0.0005	<0.0005	0.0052	<0.0005	<0.0005	0.0006	<0.0005	<0.00005	<0.0005	0.0022	<0.0005
8.2	7.1	7.8	8.1	-	0.77	2.2	1.84	-	4.4	5.4	0.19	3.9	<0.025	<0.02	<0.02	<0.02	0.06	0.10	0.02
10	9.4	9.7	10.8	-	12.1	12.6	11.1	-	11	8	3.1	4.2	3.2	3.2	3.2	3.3	3.3	3.2	3.3
0.2	0.169	0.195	0.192	-	0.188	0.22	0.178	-	0.162	0.25	0.038	0.27	0.0034	0.0057	0.0025	0.025	0.0136	0.021	0.0095
<0.0005	0.0006	<0.0005	0.0006	-	<0.0005	0.0007	0.0006	-	0.0006	0.0014	0.0008	0.0011	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
5.9	4.7	4.9	5.4	-	8	7.1	7.5	-	7.7	2.3	2.1	3.2	1.97	1.92	1.8	3.2	2.2	10.5	2.3
34	26	25	30	-	26	24	25	-	25	15.9	9.6	12.0	9.5	8.6	8.4	9.2	10.4	9.7	10.2
0.0045	0.011	0.0077	0.015	-	0.23	0.27	0.162	-	0.12	0.115	0.030	0.0086	0.0038	0.012	0.004	0.0097	0.0035	0.031	0.0025
14.3	17.1	14.4	14.2	-	19.7	19.2	18.4	-	19	19	19.2	21	19.8	20	18.9	21	21	19.1	19.4
<0.002	<0.002	<0.002	<0.002	-	<0.002	<0.002	<0.002	-	<0.002	<0.002	<0.002	0.004	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
<0.002	0.28	0.002	<0.002	-	<0.002	<0.002	<0.002	-	0.009	<0.002	0.37	<0.002	0.41	0.36	0.5	0.35	0.26	0.31	0.35
<0.002	0.28	0.003	<0.002	-	0.002	<0.002	<0.002	-	0.009	<0.002	0.37	0.005	0.41	0.37	0.5	0.35	0.26	0.31	0.35
<0.5	1.1	2.1	<0.5	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	4.9	1.2	6	5.7	4.6	5.4	5.2	4.8	5.7
<0.003	<0.003	<0.003	<0.003	-	-	-	-	-	-	<4	<0.003	<0.003	-	-	-	-	<4	<0.003	<0.003
<2	<2	<2	<2	-	-	-	-	-	-	<2	<2	<2	-	-	-	-	<2	<2	<2
<0.02	<0.02	<0.02	0.02	-	<0.02	0.02	<0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
<0.003	<0.003	<0.003	<0.003	-	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.003	<0.003	<0.004	<0.004	<0.004	<0.004	<0.004	<0.003	<0.003
<3.7	2.8	4.4	2.8	-	3.6	<0.002	3.3	6.1	2.4	1.93	0.011	0.43	<0.002	<0.002	<0.002	0.003	0.004	<0.013	0.011
-	-	-	-	-74	-	-	-	-49	-	-	-	-92	-	-	-	-	-	-	-
<0.7	<0.7	<0.7	<0.7	-	<0.7	<0.7	<0.7	-	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010
<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010
<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0005	<0.0005	<0.0005	-	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.0010

GND2231							GND2239							
Pre-frac	Post-frac						Pre-frac	Post-frac						
11 Nov 2011	23 Nov 2011	20 Dec 2011	14 Mar 2012	09 Nov 2012	13 Nov 2013	20 Nov 2014	11 Nov 2011	23 Nov 2011	20 Dec 2011	14 Mar 2012	09 Nov 2012	13 Nov 2013	06 Dec 2013	27 Jan 2015
112814	112972	113248	121428	123898	137850	1412083	112812	112970	113246	121426	123893	137847	138139	150476
5.9	5.7	5.9	6	5.8	5.8	6.0	5.9	5.9	5.9	6.1	6.1	6.1	6.0	6.0
17.4	15.2	15.2	16.4	15.4	16.3	15.4	16	15.4	15.2	15.7	15.5	15.5	16.6	16.1
12	11.9	11.3	12.1	12.9	16.1	15.4	12.5	13.1	12.2	13.4	13	12.7	12.6	14.1
15	10	14	20	9.2	13.5	13.5	14	14	14	16	14.4	14.8	15.5	14.5
18.3	12.2	17.2	19.6	11.2	16.5	16.5	17.08	17.08	16.5	19	17.6	18.1	18.9	17.7
26	25	25	26	27	38	37	25	25	24	25	27	26	26	28
26	11	6	<3	-	-	-	<3	<3	<3	3	-	-	-	-
-	-	-	-	95	142	108	-	-	-	-	82	105	90	109.1
-	-	-	-	0.0196	0.021	0.021	-	-	-	-	0.026		0.026	0.029
-	-	-	-	0.1	0.094	0.092	-	-	-	-	0.1	0.084	0.078	0.100
<0.00005	<0.00005	<0.00005	<0.00005	-	-	-	0.00006	<0.00005	0.00008	<0.00005	-	-	-	-
4.9	4.7	4.6	4.9	5.2	7.4	7.6	5	4.5	4.5	4.8	4.7	4.8	5.0	5.6
0.0008	0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	0.0042	0.0009	0.0011	0.0009	0.0007	0.0009	0.0014	<0.0005
<0.02	<0.02	<0.02	0.06	<0.02	0.04	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
3.3	3.1	3.3	3.3	3.4	4.7	4.4	3.4	3.3	3.2	2.7	3.8	3.4	3.2	3.4
0.0177	0.0184	0.0093	0.036	0.0108	0.021	0.0180	0.0035	0.0026	0.004	0.056	0.0083	0.0036	0.0054	0.0029
<0.0005	<0.0005	<0.0005	0.0008	<0.0005	<0.0005	<0.0005	0.0035	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
2.7	2.4	2.5	2.8	2.2	3.2	2.9	3.8	3.1	8.5	4	3.6	3.3	11.0	3.6
11.2	10.1	10.3	10.4	10.4	12.1	13.1	12.5	11.6	11.8	9.7	13	13.0	11.3	11.8
0.084	0.0074	0.0052	0.0063	0.0048	0.0048	0.0023	0.048	0.0142	0.0176	0.0135	0.0054	0.0122	0.034	0.0062
22	21	19.3	22	24	35	33	23	23	22	23	22	23	18.5	21
<0.002	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
0.29	0.21	0.25	0.27	0.27	0.24	0.24	1.09	1.31	1.08	1.53	1.25	1.0	1.39	2.1
0.29	0.21	0.26	0.27	0.27	0.24	0.24	1.09	1.31	1.08	1.54	1.25	1.0	1.39	2.1
11.4	12.2	5.8	6.5	11.2	6.0	6.3	6.1	6.1	5.1	6.7	6.1	5.7	6.8	6.7
-	-	-	-	<4	<0.003	<0.003	-	-	-	-	<4	<0.003	<0.003	<0.003
-	-	-	-	<2	<2	<2	-	-	-	-	<2	<2	<2	<2
<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
<0.004	<0.004	<0.004	<0.004	<0.004	<0.003	<0.003	<0.004	<0.004	<0.004	<0.004	<0.004	<0.003	<0.003	<0.003
0.003	<0.002	0.002	0.002	<0.002	0.003	0.004	<0.002	<0.002	<0.002	0.019	<0.002	<0.002	<0.002	0.013
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010
<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010
<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0010	<0.0010	<0.0010